SAES-422 Multistate Research Activity Accomplishments Report

Approved

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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, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) - During 2012 the Colorado team reevaluated the following germplasm with significantly greater plant vigor after season-long exposure to thrips and the virus in 2011: selections from Plant Introduction (PI) lines 258956 (Calderana), 288909, 343049, 546188 (Winegar), dpSeeds Mesquite, Crookham 05-05, and B5336C (M. Havey selection from P53-364-2C). However, high temperature stress affected seedling development and survival, so the field experiment was abandoned; these and other promising lines will be evaluated as greenhouse-grown transplants under field conditions in 2013.

New Mexico (C. Cramer) - Eighty-two onion breeding lines selected for IYSV tolerance, 18 plant introduction (PI) accessions from the U.S. germplasm collection, 11 experimental breeding lines from the New Mexico State University (NMSU) breeding program, and 9 commercial cultivars were evaluated for the number of thrips per plant, leaf color, leaf waxiness, IYS disease symptoms, and bulb yield. For those entries tested as transplants, numbers of onion thrips adults and larvae per plant were highest at 12 and 15 weeks post transplanting. Among those breeding lines selected for IYSV tolerance, plants of NMSU 10-577-1, NMSU 10-591-1, NMSU 10-593-1, NMSU 10-628-1, and NMSU 10-646-1 had lower thrips densities at 12 and 15 weeks than the susceptible check, ‘Rumba’. In addition to these selected lines, plants of PIs 172702, 172703, 239633, 258956, and 264320 also had fewer thrips than plants of ‘Rumba’.
Of those entries tested, plants of 27 selected lines and 7 PI accessions were rated as having light to dark green leaf color. With regards to leaf waxiness, plants of 26 selected lines and 6 PI accessions were rated as having semi-glossy to glossy leaves.

For those entries tested as transplants, plants of NMSU 10-591-1 and NMSU 10-593-1 exhibited a lower IYS disease severity at 12, 14, 16, and 18 weeks post transplanting than plants of ‘Rumba’. Plants of NMSU 10-575-1, NMSU 10-577-1, NMSU 10-582-1, NMSU 10-646-1, PI 239633, and PI 258956 exhibited a lower IYS disease severity at 14, 16, and 18 weeks post transplanting than plants of ‘Rumba’. NMSU 10-593-1 and NMSU 10-646-1 were selections made from PI 239633 and PI 258956, respectively. In addition, plants of NMSU 10-592-1 and NMSU 10-596-1 when evaluated at 14 weeks and plants of NMSU 10-589-1 and NMSU 10-629-1 when evaluated at 18 weeks had less severe disease symptoms than ‘Rumba’ evaluated at those same dates. Plants of NMSU 10-591-1 exhibited no disease symptoms at 12 weeks that was lower than the disease incidence of plants of ‘Rumba’. At 14 weeks post transplanting, plants of NMSU 10-575-1, NMSU 10-593-1, NMSU 10-596-1, and NMSU 10-629-1 exhibited a lower disease incidence than plants of ‘Rumba’ that exhibited 100% disease incidence. By 16 weeks, disease incidence had reached 100% for all entries.

For those entries tested as transplants, NMSU 10-592-1, NMSU 10-593-1, NMSU 10-620-1, NMSU 10-632-1, NMSU 10-643-1, and PI 239633 exhibited a colossal market class bulb yield that was greater than the yield of other entries. With regards to jumbo bulb yield, NMSU 10-607-1, NMSU 10-632-1, NMSU 10-643-1, NMSU 10-646-1, NMSU 10-658-1, NMSU 10-708, and PI 264320 exhibited a jumbo bulb yield that was greater than the yield of other entries. Individual plants, that exhibited few IYS disease symptoms, were selected at bulb maturity from 45 different selected lines, 7 NMSU experimental breeding lines, and 6 PI accessions for a total of 169 bulbs. These bulbs are being pollinated in the hopes of finding progeny that possess a higher level of IYS tolerance.

Seed was produced from 59 unique selections made in the previous year. These 59 unique lines have received two cycles of selection for resistance to IYS. These 59 lines originated from 34 first generation selection lines that in turn originated from 16 unique lines that were first evaluated during the summer of 2008. Progress for resistance to IYS in these 59 unique lines will be determined in 2013. Seed of numerous first generation selection lines was produced in 2012 so that seed could be distributed to the onion seed industry for evaluation.

New York (B. Nault) - An IPM program for onion thrips that combines a partially thrips-resistant cultivar and insecticide applications timed using action thresholds was evaluated in a commercial onion field near Elba, NY in 2012. Dry bulb onion seeds, cv ‘Santana’ (thrips susceptible) and cv ‘Advantage’ (partially thrips resistant), were planted on 1 May. Season total densities of onion thrips in untreated plots were similar between ‘Advantage’ and ‘Santana’. Thrips pressure was higher in ‘Santana’ plots than ‘Advantage’ plots early in the season, but higher in ‘Advantage’ plots than ‘Santana’ plots later in the season. Onion thrips were controlled effectively in both ‘Advantage’ and ‘Santana’ plantings following either the weekly insecticide spray program or the action threshold program. However, half the number of insecticide applications was applied in the action threshold program compared with the weekly spray program for both cultivars. Marketable bulb yield for ‘Advantage’ was significantly greater than bulb yield for ‘Santana’, indicating that the yield potential for ‘Advantage’ is greater than ‘Santana’. For ‘Advantage’, there were only minor differences in marketable bulb yield among the three insecticide treatments, 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 plots. Perhaps, the reason for the negative effect of thrips feeding on ‘Santana’ yield has something to do with greater pressure earlier in the development of the crop.

Oregon (C. Shock, S. Reitz, E. Feibert, and M. Saunders) - Two early-season yellow varieties and 49 full-season varieties (40 yellow, 6 red, and 3 white) were evaluated for maturity and severity of thrips leaf damage in 2012. Plots were harvested and during grading, bulbs were separated according to quality including those with neck rot (bulbs infected with the fungus

Botrytis allii in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). Varieties varied in thrips damage, botrytis, plate rot, black mold, but not IYSV. Four onion varieties were grown at five plant populations under “conventional” drip irrigation, “intense bed” drip irrigation, and furrow irrigation. Varieties, populations, and irrigation systems were not related to IYSV or bulb decomposition. Bulb yields by market class were strongly affected by variety and plant population. Populations interacted with irrigation systems to cause a small amount of bulb decomposition, with more bulb decomposition at 160,000 plants per acre with furrow irrigation (1.1%) and “intense beds” (1.4%) than with “conventional” drip irrigation (0%).

Utah (D. Drost) – Twenty-eight commercially available Spanish onion cultivars were assessed for productivity, maturity and rated for IYSV. Symptom expression of IYSV in 2012 was very low; however, all varieties evaluated showed visual evidence of IYSV under field conditions. Severity in 2012 was not high enough to impact onion bulb yield. Further evaluation of storage materials will occur in February 2013 to assess losses. Work on correlations between IYSV incidence and storage needs further evaluation.

Wisconsin (M. Havey) - Onion bulbs that appeared least affected after evaluation under thrips and IYSV pressure in Colorado in the summer of 2011 were planted in Wisconsin and seed produced by selfing individual plants, or mass pollinations among two to four plants (depending on the vigor of the bulbs after storage and vernalization). Selected plants were also testcrossed to a susceptible male-sterile line. Due to excessive temperatures and poor pollinator survival, seed production was very poor on these plants. If more than approximately 50 seeds were produced, they were provided back to H. Schwartz (CSU) for re-evaluation. Plants producing fewer than 50 seeds will be planted in Wisconsin for bulb production and seed increase. An F2 family from the cross of semi-glossy (reduced epicuticular waxes) and waxy (wild-type phenotype) was evaluated for amounts and types of epicuticular waxes. The lower waxy phenotype is associated with lower damage by thrips and IYSV. Over 300 single nucleotide polymorphisms (SNPs) were mapped in this cross to tag gene(s) associated with lower waxes on leaves.

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

Colorado (H. Schwartz, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) - During 2012, onions were monitored during leaf development and bulb expansion for the presence of thrips and IYSV. Thrips numbers increased from 1 to more than 60 per plant in commercial fields; and over 300 thrips per plant in experimental nurseries, where IYSV incidence reached 100% with a severity of 3.5 of 4.

A Vaquero seed treatment comparison revealed that IYSV incidence reached 100% in all plots, but IYSV severity (1 – 4) was lower for Vaquero + T/C/A/S (3), followed by Vaquero + T/C/A (3.5), when compared to Vaquero + T (4). Total yield was higher for Vaquero + T/C/A/S (73 percent), followed by Vaquero + T/C/A (57 percent), when compared to Vaquero + T [T = Thiram, C = Coronet (pyraclostrobin + boscalid), A = Allegiance (metalaxyl), S = Sepresto (clothianidin]. The jumbo yield component was also doubled by the seed treatments when compared to the Vaquero + T only. Cyantraniliprole and Vydate (oxamyl) reduced larval and/or adult onion thrips populations on transplanted and seeded onions under experimental conditions in the field.

Live thrips adults and larvae were recovered during the 2010-2011 and 2011-2012 winters from onion cull piles, onions left standing in the field, and *Malva neglecta* (common mallow) despite temperatures that fell below freezing. IYSV was detected by RT-PCR in these thrips, indicating that IYSV infected thrips surviving the winter are a likely source of inoculum for the next growing season. Temperature and thrips activity in onion culls were monitored in subsequent months during fall of 2011 and winter of 2011-2012. Temperature changes in the cull piles were more gradual and less dramatic than those of the outside air. The internal temperature of cull piles was conducive to thrips survival, however, very few live thrips were found after the onset of onion decay within the cull piles. Thrips activity was monitored by sticky traps around the cull piles and thrips were active until early December 2011 when the outside temperature fell below -17° C.

Reducing thrips populations can sometimes help reduce infection rate of IYSV in onions. In Colorado, companion crops (living mulch) such as barley and spring wheat planted with onions to reduce wind and water erosion, has sometimes had an effect on thrips populations. The objectives of this 2012 study were to determine: which thrips predators and parasites inhabit the barley or spring wheat companion crop and what other insects/arachnids dwell in this living mulch; if there is a relationship between predator/parasite and thrips populations; if there is a relationship between thrips populations and IYSV incidence and severity; and if there is a relationship between predator/arachnid populations and onion market yields. Two farm locations had both companion crop and non-companion crop treatments replicated four times. Up to six beneficial predator and parasite families and seven plant feeding arthropod families were identified from both field locations. There were numerically more thrips and beneficial arthropods in the companion crop treatment compared with the non-companion crop treatment. There were significantly more beneficial populations in the companion crop treatment than the non-companion crop treatment at one field location. There was a positive trend between thrips populations and IYSV incidence at both locations. Numbers of thrips per plant, incidence and severity of IYSV, and onion market yields in the companion crop treatment did not differ from those in the non-companion crop treatment at either location. An observation made more than thirty feet from an onion field where thrips were seen flying six to 10 feet above the ground in the early morning hours, leads us to believe that the size of the onion plots used were too small to truly measure the impact of the companion crop on thrips and beneficial population dynamics. Future work should incorporate large scale plot design to better determine what effect companion crops like mulch has on thrips and beneficial population dynamics.

Oregon (C. Shock, S. Reitz, E. Feibert, and M. Saunders) - Fifteen insecticide rotations plus an untreated control were evaluated for their effectiveness in controlling thrips and IYSV. Thrips populations and onion bulb yield varied significantly between treatments, suggesting that thrips were a limiting factor. Movento and Agri-mek were effective in early season thrips control. Lannate and Radiant were effective in mid to late season thrips control. Other materials (Aza-direct, M-Pede) may help early in the season. Onions grown with the fifteen insecticide rotations and the untreated control did not vary in IYSV symptoms in 2012. Alternatives to conventional pesticides such as combinations of Mycotrol O, kaolinite clay, and diatomaceous earth were tested, but they were not successful in controlling thrips.

Idaho (S.K. Mohan) - Five sentinel plots in selected commercial onion fields in the Treasure Valley were monitored periodically throughout the growing season for incidence and severity of IYS and infestation levels of onion thrips. Samples collected every two weeks were evaluated for IYSV and other disease symptoms and thrips. IYSV symptoms were first observed in the third week of June but incidence was very low (less than 1%) until the second week of August, after that point the incidence increased to 80% plants infected by the end of August. Generally low numbers of thrips (6 to 29 thrips/plant) were observed in the beginning of June, increasing with time and reaching high levels (up to a maximum of 290/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.

New York (S. Beer, M. Fuchs, C. Hoepting, and B. Nault) – Foliar-applied insecticides that performed best against onion thrips in 2012 included spinetoram (Radiant SC), spirotetramat (Movento), cyantraniliprole (Benevia) and abamectin (Agri-Mek SC). A Section 18 for Movento was granted by EPA in 2012 in New York; Benevia should receive a Section 3 label in 2013.

Co-applications of insecticides (Agri-Mek and Movento) with chlorothalonil fungicides (Chloronil) reduced thrips control by 25 to 48% compared with control levels provided by the insecticides alone in several trials. Inclusion of a penetrating surfactant at recommended rates with the insecticide and chlorothalonil fungicide mixture did not consistently overcome this problem. Co-applications of insecticides with other commonly used fungicides did not interfere with thrips control. To manage onion thrips in onion most effectively, insecticides should be applied with a penetrating surfactant, and should be applied separately from chlorothalonil fungicides.

Season-long management of onion thrips was provided using a series of products beginning with Movento (2 applications) followed by Agri-Mek (2 applications), Lannate (2 applications) and Radiant (2 applications). Movento, Benevia and Agri-Mek were most effective controlling onion thrips when applied following a 1 thrips larva per leaf threshold. When combining the sequence of products listed above with this action threshold, the total number of applications used during the season was reduced from 17 to 58%.

In mid-July 2010, onion plants cv. 'Candy' with typical IYSV symptoms were found in New Holland, Lancaster County, PA. Leaf tissue from five symptomatic plants tested positive for IYSV using ELISA. The presence of IYSV was verified by RT-PCR in a subset of symptomatic leaf samples. Sequence analysis of a 402 bp DNA amplicon showed an 87 to 100% nucleotide sequence identity with other IYSV N gene sequences that are available in GenBank. The highest nucleotide sequence identity (100%) was with an IYSV isolate from Texas (GenBank Accession No. DQ658242) and the lowest was with an isolate from India (GenBank Accession No. EU310291). This finding confirmed further spread of IYSV within North America.

Utah (D. Alston, D. Drost and C. Nischwitz) – Field crops and weeds growing in proximity to onion fields and onion plants and onion thrips were sampled during main cropping season (May-Sept) and tested for their role as alternate hosts or the presence of IYSV. Samples were analyzed using ELISA kits. By identifying plants in the farmscape surrounding onion fields that serve as virus reservoirs and onion thrips reproductive hosts, these plants could be targeted and treated or removed thus reducing the amount and source of IYSV inoculum near onion fields. Preliminary results showed that alfalfa and several weeds tested positive for IYSV. Crop fields (corn, wheat, alfalfa) adjacent to onion fields harbored onion thrips in varying amounts and most were reproductive hosts for thrips. Thrips and crop tissue testing is on-going as significant numbers of samples were collected.

Sustainable, profitable onion production occurs when seasonal inputs (planting dates, nutrients, water), onion thrips (control strategies), and IYSV are properly managed. Several onion growers in Utah have noted improved thrips management and reduced IYSV severity through alternative crop rotations and improved nitrogen management. Our research has shown that these alternative cultural practices reduce thrips numbers thus altering IYSV incidence with minimal impact on onion productivity. The goals of a six year university study are to determine the effects of unique crop rotations and improved nitrogen management strategies on thrips populations; to evaluate crop rotations and nitrogen (N) inputs on onion yield and quality; and to disseminate our findings through extension bulletins, the Internet, trade journals and scientific literature to onion producers (local, regional, national and international audiences).

Washington (T. Waters) - Six research trials evaluated insecticide efficacy for thrips control in dry bulb onions. The goals of the trials were to determine which insecticides best control onion thrips, and the timing during the season in which to use those compounds for best efficacy.

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

Colorado (H. Schwartz, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) - Disease incidence of pink root was decreased by nearly 30% with treatments of Serenade and TerraClean, compared to 20% more discolored roots in the Quadris treatment. Average weight prebulbing of roots and basal plates was increased by 10% (TerraClean) to 19% (Serenade Soil, Quadris) with the treatments, compared to the untreated control. Total and jumbo yield components were also increased by the treatments. Total yield was increased 11, 16 and 31%; and the jumbo yield component was increased 11, 32 and 75% by Quadris, TerraClean and Serenade, respectively.

Botrytis infection was detected in 3 to 74% of transplanted bulbs or 39 to 80% of seeded bulbs in storage rot experiments during 2012. A sequential fungicide program combined with good curing practices reduced the 60-day loss from Botrytis in the yellow and red transplanted onions; and in the white seeded onions.

Georgia (R. Gitatis) – The mean percentage of thrips that tested positive for *Pantoea ananatis* after acquisition periods (on peanut leaves) 1, 6, 12, 24 and 48-h tested positive for *P. ananatis* was 0, 4.2, 25.0, 45.9 and 70.8, respectively. A positive exponential relationship between acquisition access period and mean percentage of *P. ananatis* positive-thrips was observed. Bacterial colonies were not recovered from thrips that fed on PBS-inoculated-peanut leaves. After being exposed for 72-h to epiphytic populations of *P. ananatis*, the bacterium persisted in 70.8, 50.0, 33.3, and 33.3% of thrips after 0, 6, 24, 48, and 96 hpe to healthy peanut leaves respectively. Even after 120 and 168 hpe to healthy peanut leaves, *P. ananatis* persisted in 16.7 and 4.2% of thrips. The relationship between persistence period and percentage of *P. ananatis*-positive thrips was better represented by an exponential decay regression model. *P. ananatis* populations were not recovered from negative control thrips assayed similarly.

One hundred percent of the onion seedlings that were inoculated with *P. ananatis* displayed typical center rot symptoms after 5 days post inoculation. Seedlings inoculated with sucrose solution remained asymptomatic. Sixty four percent of onion seedlings that were inoculated with thrips-feces developed center rot symptoms. A subset of seedlings associated with each treatment that led to putative center rot symptoms was confirmed to be infected with *P. ananatis* by pathogen isolation followed by real time PCR assay.

Immunolabeled micrographs of *F. fusca* showed bacterial localization in the head, thorax, hind gut and hemolymph after 48-h of acquisition access period. *Pantoea ananatis* cells were not observed in the sections of negative control thrips.
Onion plants exposed to individuals of *T. tabaci* fed either Pna or Png developed typical center rot symptoms. In two independent trials, 60.0 and 75.0% of the seedlings exposed to bacteria-fed thrips developed center rot symptoms, respectively. Identities of bacteria isolated from suspect lesions were confirmed. An exponential positive relationship between thrips acquisition access periods and Pna or Png acquisition existed with 100 and 91.7% of the thrips acquiring Pna and Png, respectively. These results demonstrate the potential of *T. tabaci* to serve as a vector of either Pna or Png.

New York (S. Beer and C. Hoepting) - Based on microbiological and molecular biological techniques, the most important bacteria associated with symptomatic growing and unmarketable onion bulbs from storage in NY were identified as *Burkholderia cepacia*, *Pantoea ananatis* and *Enterobacter cloacae.* Several other bacteria of the genera *Pseudomonas, Burkholderia, Pantoea* and *Rahnella* also were identified. Several of the isolated strains of *Rahnella* species were inoculated into apparently healthy onion bulbs. They caused symptoms similar to those caused by *E. cloacae.* Thus, further research is in progress to determine the pathogenic properties of the *Rahnella* strains, since this bacterium had not been established previously as a plant pathogen.

A technique aimed at identifying bacteria associated with onions quickly and without first isolating and purifying bacterial cultures was developed. The PCR-based technique uses novel rigorously identified and highly specific primer pairs for amplification of specific bacteria affecting onion including *Pantoea ananatis*, *Enterobacter cloacae, Burkholderia* spp. *and Rahnella* spp.

Approximately 100 samples of muck-land soils were collected close to onion-planting time from fields in which onions were planted or had grown. Variations of the techniques used for onion samples were developed for use with muck soils. These samples generally yielded evidence of the presence of the important bacterial pathogens of onion encountered in the symptomatic growing onions and cull onion bulbs assayed earlier. Thus, muck-land soil was implicated as the source of over-wintering bacterial pathogens of onion. Additionally, ditch and creek waters at the periphery of muck-land onion fields were collected and assayed for the presence of important bacterial pathogens of onion in NY.

A spray trial was carried out in a commercial onion field designed to evaluate the potential of registered resistance-inducing materials to effect bacterial disease development. Spray trials also were carried out in commercial onion fields designed to evaluate the effect of spray adjuvants, of different types, on the development of bacterial disease of onion. Preliminary results indicate that above label rates of adjuvants containing organosilicones can cause significant leaf injury,

which in turn resulted in higher incidence of bacterial bulb decay. Further research in this area is warranted.
A large observational survey was conducted in NY to elucidate the most important factors driving bacterial diseases of onions grown in muck soil. Three sub-plots were set up in 32 fields consisting of six varieties in five locations with nine onion growers. Factors including crop rotation, planting configuration, onion thrips damage, soil compaction, soil and tissue nitrogen, and yield will be correlated with bacterial bulb decay. Preliminary results from 2011 showed the strongest positive correlation between available soil nitrate-nitrogen in mid-July at the 7-9-leaf stage and incidence of bacterial bulb decay. Extensive data analysis planned for these data sets in 2013.

An on-farm small-plot field trial was conducted to evaluate the effect of row and plant spacing, and area per bulb on bacterial bulb decay. Thirteen planting configurations were evaluated using in transplanted onions, c.v. 'Candy', in mineral soil. Incidence of bacterial bulb decay was very low (< 4%) in this trial and there were no significant differences among treatments. However, preliminary data suggests that plant spacing is a stronger predictor of yield and bulb size than row spacing or bulb area. Further research under higher disease pressure is warranted.

Pennsylvania (B. Gugino) – Survey plots for bacterial pathogens were established in 30 onion fields on 30 farms in Pennsylvania in 2012. Average farm losses ranged from 0 to 15% at harvest and 6 to 64% out of storage. Warmer mid-season soil temperatures and visual disease ratings were positively correlated to in-field losses from bacterial disease at harvest. More losses also occurred when onions were grown on black as opposed to white plastic; however, this practice is not recommended due to increased pressure from thrips. The bacterial pathogens commonly associated with center rot at harvest were also found as epiphytes and endophytes on onion transplants as well as epiphytes on weeds while the bacteria that cause surface rots were more commonly associated with soils.

The efficacy of alternative in-season products for managing onion bacterial diseases was evaluated in two field trials. The treatments consisted of variable rates and combinations of the following applied either as a soil drench at planting or an in-season foliar spray: copper hydroxide tank mixed with mancozeb (grower standard for bacterial diseases), hydrogen dioxide (OxiDate), acibenzolar-S-methyl (Actigard), *Bacillus subtilis* GB03 (Companion) as well as harpin αβ protein (Employ). Onion transplants cv. 'Candy' were planted on standard black plastic with a double row of drip irrigation. Based on the results, the standard grower practice of preventative applications on copper hydroxide tank mixed with mancozeb is still recommended for management of bacterial diseases of onion and should be used in combination with other cultural practices for managing bacterial diseases.

Washington (L. du Toit and B. Schroeder) - Impact of the onion postharvest curing process (temperature and duration of curing) on development of bulb rots caused by *Burkholderia* *cepacia* and *B. gladioli* pv. *alliicola*, causal agents of sour skin and slippery skin of onion bulbs, respectively, was investigated. Onion bulbs were harvested from grower fields for two cultivars, inoculated with *B. cepacia* or *B. gladioli* pv. *alliicola*, cured at 25, 30, 35, or 40°C for 2 or 14 days, placed in storage at 5°C, and evaluated for bacterial rot after 1, 2, and 3 months in storage. As curing temperature increased, for both durations of curing, each pathogen caused greater severity of rot. Results indicate stakeholders should attempt to cure bulbs at lower temperatures, or avoid long durations of curing if higher curing temperatures are used.

In addition, a DNA macroarray for the detection and differentiation of 14 fungi, 12 bacteria, and 1 yeast capable of causing onion bulb rots in storage is being developed to include oligonucleotide sequences specific for each target pathogen. Currently, genus-specific oligos have been designed for *Botrytis*, *Penicillium*, and *Fusarium*; and species-specific oligos have been developed for *Aspergillus flavus, Kluyveromyces marxianus*, *Fusarium oxysporum, Botrytis aclada, B. allii,* and *B. byssoidea.* The oligos for *Aspergillus, B. cinerea, B. squamosa,* and various *Penicillium* species are being redesigned because of problems with cross-reaction to non-target fungi. Oligos specific for the bacterial pathogens *B. gladioli, Pantoea agglomerans, Pseudomonas marginalis, Pseudomonas aeruginosa, Pectobacterium carotovorum*, and *Dickeya dadantii* have been developed. For detection of some onion bacterial pathogens, cross-reaction problems have been encountered, so a combination of oligos is being developed to detect the *B. cepacia* complex consisting of *B. ambifaria, B. cenocepacia*, *B. cepacia*, and *B. pyrrocinia*; a second combination of oligos is being developed to detect *Pantoea ananatis, P. alli*, and *Salmonella enterica*; and a third combination to detect *Erwinia rhapontici and E. persicina*. Efforts to increase the specificity of these oligos are in progress. Finally, oligos for detection of *Enterobacter cloacae* and *Pseudomonas viridiflava* are in the process of being redesigned.

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

New York (S. Beer, C. Hoepting, and B. Nault) - Several meetings were held in 2012 to inform NY's onion industry about results from this project: the Empire State Fruit and Vegetable EXPO in Syracuse in January, the Orange County Onion School in Middletown in March, the Oswego Twilight Meeting in Oswego in June, the Annual Summer New York Onion Industry Council Meeting near Sodus in July and the Elba Muck Onion Meeting in Elba in August. Information pertaining to this subject was also presented at the National Allium Research Conference and W2008 Meeting in Las Cruces, NM in December and at the Annual Entomological Society of America Meeting in Knoxville, TN also in December. Cooperative Extension Educators worked with 3 growers and scouted 6 onion fields. Each week, onion thrips and diseases were quantified and summarized into a weekly scouting report, which included Cornell research-based recommendations for insecticides and fungicides. Through these on-farm demonstrations, onion growers observed research-based recommendations in action and were able to make informed spray decisions. All farms saved on insecticide sprays by following spray thresholds, compared with a weekly calendar approach. Pest activity reports and research-based recommendations were made to onion growers via a weekly newsletter, *Veg Edge Weekly*. Similarly, several newsletter articles regarding strategic management of onion thrips and progress towards managing bacterial diseases of onions were published in the monthly issue of *Veg Edge*. The majority of large-scale onion growers had access to these newsletter articles.

Pennsylvania (B. Gugino) – Research results were disseminated at several vegetable grower meetings/conferences including the Northeast Vegetable Grower's Meeting and New Holland Vegetable Day. Results were also disseminated throughout the season through one-on-one with the growers collaborating in the intensive field survey project. Participated in the Onion ipmPIPE and continued to disseminate the Diagnostic Pocket Series to interested growers and other stakeholders.

Oregon (C. Shock, S. Reitz, 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 11, 2012 and August 27, 2012, grower meetings on February 7, 2012, internet web sites, and results being reported in Onion World.

Utah (D. Alston, D. Drost and C. Nischwitz) – For the Onion ipmPIPE project, 5 sentinel plots/survey sites were monitored in the Davis, Weber, and Box Elder County production onion areas in Utah by Bonnie Bunn in 2012. Fields were evaluated from early June until early September for thrips, other insects, and IYSV. Reports were submitted periodically, along with regional reports summarizing weather conditions, Sentinel Plot reports, growth observations, and other insect and disease comments. Several meetings were held in 2012 to inform Utah's onion industry about results from this project. These included the Utah Onion Associations winter educational meetings (Feb. 14), the summer onion field day (Aug 16), and the fall Utah Onion Associations board meeting (Nov. 14).

Washington (L. du Toit, B. Schroeder and T. Waters) – Interaction and information transfer among W2008 participants from Washington State University (WSU) and the Pacific Northwest onion industry was facilitated by the WSU Onion Field Day held on August 30, 2012, where growers heard reports from researchers and extension personnel working on various onion projects, and by sharing results of the 2012 WSU Onion Cultivar Trial with stakeholders at the Pacific Northwest Vegetable Association (PNVA) Annual Convention and Trade Show on November 14-15, 2012. Bulbs harvested from the WSU Onion Cultivar Trial were on display at the PNVA conference. In addition, stakeholders participated in storage evaluation on February 10, 2012 of bulbs harvested for all the cultivars grown in the 2011 WSU Onion Cultivar Trial and stored for 4 months. Results of the cultivar trial and storage evaluations were shared with the PNW onion industry.

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 foliage characteristics that are associated with onion thrips feeding nonpreference. In addition, germplasm was identified that possessed a reduced number of thrips per plant than the untreated control. Both of these characteristics suggest that there is the genetic potential for reduced thrips feeding and possibly reduced *Iris yellow spot virus* spread. Entries were identified that exhibited less severe IYS disease symptoms than the control. 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 IYSV.

Pantoea ananatis transmission to healthy onion plants may be a passive process that occurs through tobacco thrips (*F. fusca*) feces in the vicinity of feeding wounds rather than by regurgitation and active feeding. *P. ananatis* do not colonize the gut of *F. fusca* and after prolong feeding on healthy tissues bacteria are purged from the gut. Therefore, thrips can cleanse their digestive system by feeding on a non-contaminated food supply for at least 196 h. This information gives us greater knowledge regarding the biology of thrips serving as a vector of the bacteria associated with the center rot complex. Finally, this study demonstrated that onion thrips (*T. tabaci*) are also capable of transmitting center rot bacteria *P. ananatis* and *P. agglomerans*. In fact, onion thrips appear to be even a more efficient vector. Thus a shift in population from tobacco thrips to onion thrips may have the potential of increasing center rot incidence in Georgia. It also demonstrates that in other areas of the world where *T. tabaci* dominates as the pest species on onion, there is the potential of onion thrips serving as a vector of center rot bacteria.

In New York, on-farm demonstrations of managing onion thrips with research-based recommendations with regards to sequences, thresholds and tank mix considerations, resulted in reducing the number of sprays used to control onion thrips by 20 to 50%, representing savings of $40 to $120 per acre in reduced input costs. In response to Cornell’s research showing that reduced nitrogen inputs resulted in reduced onion thrips pressure, one onion grower in Elba reduced his nitrogen input from 125 lb/A to 90 lb/A and saw his number of insecticide sprays drop from 7 to 5, representing a savings of $130 per acre and $21,450 on their farm. This represents the potential for a savings of $1.3 million dollars in reduced insecticide and fertilizer costs if all onion growers are able to reduce their insecticide sprays by 2 applications with reduced nitrogen inputs on all 10,000 acres of onions grown in New York. Another reason for onion growers to reduce their rates of nitrogen is that several Cornell research studies have demonstrated a relationship between high levels of soil nitrogen and bacterial bulb decay.

An extensive data set on the potential factors associated with onion bacterial diseases has been collected and a comprehensive analysis of this data set promises to elucidate 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.

In Oregon, more growers are adopting onion varieties with greater tolerance to IYSV and are irrigating in a manner that seems to reduce IYSV severity. Fewer growers are planting over-wintering onions and are disposing of cull onions, breaking the natural green bridge for IYSV so that IYSV levels are reduced from one production year to the next. Growers are using Movento early in the season and getting adequate control.

Growers in Utah who used lower nitrogen levels (130-150 lb. N/A) applied 4-5 fewer insecticide sprays, saving them nearly $200/A compared with growers using the normal N input amounts of >250 lbs of N/A. Lower N use also saves on fertilizer costs at a time when N prices are increasing for an additional savings of around $100/A. We estimate that more than 350 acres of onions in Utah are now being grown using lower N level system recommended by Utah State University.

Research conducted by Utah State University (2009-2012) has shown that onions rotated after corn have fewer thrips than when onions are rotated after wheat. Historically, growers plant onions after wheat as this helps with their onion weed control program. In 2012, five growers were using this system and approximately 120 acres were grown after corn. Future monitoring of onion thrips pressure in the corn-onion rotation compared to the wheat-onion rotation is required to assess the economic impact of this change.

Onion bulb producers in Washington State, and from the greater Pacific Northwest, have been using information conveyed to them from the six insecticide thrips trials completed in Washington State in 2012 to design their IPM plans for thrips control in onion bulb crops. As a result, commercial producers have reported decreased thrips densities and crop damage resulting from thrips. The number of insecticides registered for use in onion crops in Washington State that are effective for thrips control has increased in the last five years, and two additional products will be labeled for use by 2014. The increase in registered insecticides will increase producers' ability to control thrips, and reduce the likelihood of thrips developing resistance to currently used insecticides. Stakeholders also have become more informed of the impact of curing parameters on the development of bacterial storage rots, and how to minimize losses to bacterial storage rots by modifying curing parameters.

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Other Activities

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

Fok, E.J., and Nault, B.A. 2012. Natural enemies of onion thrips (*Thrips tabaci*) in New York onion agroecosystems. Entomological Society of America Annual Meeting. November 12, 2012. Knoxville, TN.

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du Toit, L.J. 2012. Steps towards effective management of *Botrytis* in onion seed crops. Columbia Basin Vegetable Seed Association Annual Meeting. January 17, 2012. Moses Lake, WA.

du Toit, L.J., and Poudyal, D.S. 2012. *Rhizoctonia* control in dry bulb onions. Pacific Northwest Vegetable Association 26th Annual Conference & Trade Show. November 14-15, 2012. Kennewick, WA.

du Toit, L.J., Poudyal, D.S., Paulitz, T., Porter, L., Hamm, P., and Eggers, J. 2012. Rhizoctonia seedling blight of onion crops in the Columbia Basin. Pp. 8-9 in: 2012 WSU Onion Cultivar Demonstration and Field Day Handout. Washington State University, Pullman, WA.

Gugino, B.K. 2012. Growing onions: Options for disease management. Schuylkill County Ag Day and Trade Show. February 9, 2012. Schuylkill Haven, PA.

Gugino, B.K. 2012. Onion disease management. Northeast Vegetable Grower's Meeting, Newton Ransom Fire Company. January 26, 2012. Clarks Summit, PA.

Gugino, B.K. 2012. Onion disease management. New Holland Vegetable Day, Yoder's Restaurant. January 16, 2012. New Holland, PA.

Foley, K.M., Doniger, A.R., Harden, J.L., Parris, C.A., and Shock, C.C. 2012. Technology for Yourth. Summer Farm Festival, OSU Malheur Experiment Station. July 11, 2012. Ontario, OR.

Hoepting, C.A. 2012. Onion program update featuring bacterial diseases of onions. Cornell Cooperative Extension of Wayne County Board of Directors Meeting. September 4, 2012. Newark, NY.

Hoepting, C.A. 2012. Field demonstration: Exploring the role of adjuvants in the development of bacterial diseases of onions. 2012 Annual Elba Muck Onion Twilight Meeting, Cornell Vegetable Program. August 2, 2012. Elba, NY.

Hoepting, C.A. 2012. Exploring the relationship between nitrogen and bacterial diseases of onion in New York. 2012 Empire State Fruit and Vegetable Expo, Cornell Cooperative Extension and New York State Vegetable Growers Association. January 26, 2012. Syracuse, NY.

Hoepting, C.A. 2012. An IPM approach to managing bacterial diseases of onion. Great Lakes Fruit, Vegetable and Farm Market EXPO. December 5, 2012. Grand Rapids, MI.

Hoepting, C.A. 2012. Exploring the relationship between nitrogen and bacterial diseases of onions. Oswego Onion Twilight Meeting, Cornell Cooperative Extension of Oswego County. Oswego, NY, USA: June 18, 2012 (38 attendees).

Hsu, C.L., C. A. Hoepting, C. R. MacNeil and B. A. Nault. 2012. How low can you go? The economics of controlling onion thrips with reduced inputs. Empire State Fruit & Vegetable EXPO. January 26, 2012. Syracuse, NY. Speaker. Duration: 20 minutes. Attendance: 60.

Nault, B. A. 2012. Field demonstration of managing onion thrips. 2012 Elba Muck Onion Twilight Meeting. Cornell Cooperative Extension, Cornell Vegetable Program. Elba, NY. August 2, 2012.

Nault, B. A. 2012. Considerations for managing maggots and thrips in onions. Oswego County Onion Twilight Meeting. Cornell Cooperative Extension of Oswego County. Oswego, NY. June 18, 2012.

Nault, B. A. 2012. Insect management for 2012 – maggot and thrips control. Orange County Onion School. March 1, 2012. Middletown, NY. Speaker. Duration: 60 minutes. Attendance: 50.

Nault, B.A., Shelton, A.M., Hsu, C.L., and Hoepting, C.A. 2012. How to win the battle against onion thrips. Empire State Fruit & Vegetable EXPO. January 26, 2012. Syracuse, NY. Speaker. Duration: 45 minutes. Attendance: 60.

Nischwitz, C. 2012. Thrips Food Sources and IYSV Hosts in the Utah Farmscape. Utah Onion Association winter meeting. Brigham City, Utah. February 14, 2012.

Schroeder, B.K., Vahling-Armstrong, C., Humann, J.L., Knerr, A.J., and du Toit, L. J. 2012. Development of a DNA Macroarray for the Detection of Bulb Rot Pathogens of Onion. Pacific Northwest Vegetable Association Annual Conference. November 14-15, 2012. Kennewick, WA.

Schwartz, H.F. 2012. Onion disease management and updates. Annual Education Meeting of the Colorado Crop Consultants Association. January 11, 2012. Denver, CO.

Schwartz, H.F. 2012. Onion virus management and updates. Annual Education Meeting of the Colorado Onion Association. January 26, 2012. Eaton, CO.

Schwartz, H.F. 2012. Onion virus management and updates. Annual Education Meeting of the Wisconsin Onion Association. February 1, 2012. via Skype.

Shock, C.C. 2012. Onion Thrips Control. Idaho/Malheur County, Oregon Onion Growers 52nd Annual Meeting. February 7, 2012. Ontario, OR.

Shock, C.C. 2012. Progress on Cleaning up Groundwater through BMPs. Idaho/Malheur County, Oregon Onion Growers 52nd Annual Meeting. February 7, 2012. Ontario, OR.

Shock, C.C. 2012. Onion Production Tour. Summer Farm Festival, OSU Malheur Experiment Station. July 11, 2012. Ontario, OR.

Shock, C.C. 2012. Water Quality and Farm Practices. Summer Farm Festival, OSU Malheur Experiment Station. July 11, 2012. Ontario, OR.

Shock, C.C., and Feibert, E.B.G. 2012. Irrigation Criteria and Systems for Onions. Pacific Northwest Vegetable Association. November 14, 2012. Kennewick, WA.

Shock, C.C., and Feibert, E.B.G. 2012. Onion varieties, production, and thrips control. Onion Variety Day. OSU Malheur Experiment Station. August 28, 2012. Ontario, OR.

Shock, C.C., Feibert, E.B.G., and Saunders, L.D. 2012. Onion Plant Population Studies. Pacific Northwest Vegetable Association. November 14, 2012. Kennewick, WA.

Shock, C.C., Klauzer, J., and Neufeld, J. 2012. Irrigation Water Management with Dataloggers and Soil Moisture Sensors. Treasure Valley Irrigation Conference. December 6, 2012. Nampa, ID.

Ward, R. 2012. Onion Budgets – Do Small Changes in Practice Affect the Bottom Line? Brigham City, Utah. February 14, 2012.

Waters, T.D. Thrips Control in Sweet Onions. Walla Walla Farmers Co-Op Grower Meeting. January 17, 2012. Walla Walla, WA.

Waters, T.D. Insect Management in Onions. Columbia Basin Crop Consultants Annual Short Course. January 18, 2012. Moses Lake, WA.

Waters, T.D. Onion Thrips Management in Onions. Utah Onion Grower Annual Meeting. February 14, 2012. Brigham City, UT.

Waters, T.D. Thrips Control Strategies on Onion. Far West Agri-Business Association Annual Meeting. December 11, 2012. Pasco, WA.

Waters, T.D., and Walsh, D. Thrips Control in Dry Bulb Onions. Pacific Northwest Insect Management Conference. January 8, 2012. Portland, OR.

Waters, T.D., and Walsh, D. Thrips Control Strategies for Onions. Pacific Northwest Vegetable Association. November 14, 2012. Kennewick, WA.

Waters, T.D., and Wohleb, C. 2012. Washington State University Onion Cultivar Storage Demonstration Trial. February 10, 2012. Pasco, WA.

Internet Resources

Schwartz, H.F. 2012. 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/

Schwartz, H.F., and Gent, D. H. 2012. 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

Information on onions and pest management is posted on the website of the Regional Cornell Cooperative Extension Vegetable Program in New York: http://cvp.cce.cornell.edu/

http://mtvernon.wsu.edu/path_team/onion.htm#thrips

http://mtvernon.wsu.edu/path_team/onion.htm#irisyellowspot

Other Related Activities

New York (B. Nault and C. Hoepting) – Nault was invited to give a seminar titled, “Onion thrips and *Iris yellow spot virus* interactions and their management in an onion ecosystem”, in the Department of Entomology, Cornell University, NYSAES on April 24, 2012 in Geneva, NY. Hoepting also was invited to give a seminar titled, “Iris yellow spot virus: The New York Story”, in the Department of Plant Pathology and Plant Microbe Biology, Cornell University, NYSAES in September 2012 in Geneva, NY. Nault submitted a package to the New York State Department of Environmental Conservation for their consideration of a Specific Emergency Exemption (FIFRA Section 18) for the use of spirotetramat (Movento) on onion for onion thrips control for the 2012 season. The Crisis Exemption request was granted by NYSDEC from May - September 2012.

Pennsylvania (B. Gugino) – Presented a one-hour, invited seminar titled, “Elucidation and management of bacterial diseases of onion”, in the Department of Plant Pathology and Plant-Microbe Biology, NY State Agricultural Experiment Station, Cornell University, Geneva, NY on November 20, 2012.

Washington (L. du Toit) - Invited speaker. Disease management for sustainable onion seed production: What? Who? How? Why? Onion Seed Safari, organized by Klein Karoo Seed Production. Oct. 10, 2012. Oudtshoorn, South Africa. Also, invited guest speaker for a day-long tour of onion seed crops/farms in the Klein Karoo, South Africa, to examine diseases and discuss disease management. Seed Safari, 9-10 Oct. 2012, Klein Karoo, South Africa. Organized by Klein Karoo Seed Production. http://www.agrieden.co.za/gallery.php?Gallery=119 and http://www.agrieden.co.za/news.php?id=533