SAES-422 Multistate Research Activity Accomplishments Report

Approved

Project No. and Title: W1008 Biology and Management of *Iris yellow spot virus* (IYSV) and Thrips in Onions
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Accomplishments (limited to 30,000 characters)

Objective 1. Screen onion germplasm for improved levels of tolerance to *Iris yellow spot virus* (IYSV) and thrips

Colorado (H. F. Schwartz, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) - During 2011, the Colorado team identified the following germplasm with significantly greater plant vigor after season-long exposure to thrips and the virus: selections from Plant Introduction (PI) lines 258956 (Calderana), 288909, 343049, 546188 (Winegar), DP Seeds Mesquite, Crookham 05-05, and B5336C (Mike Havey selection from P53-364-2C). These lines were selected as candidates for the translational genomics study coordinated by colleagues involved with the USDA-SCRI Project 2008-04804. The evaluation design verified that screening nurseries planted in fields with a history of problems from onion thrips and IYSV could provide moderate to severe pest and disease pressure to enable the identification of less susceptible onion entries (varieties, breeding lines or germplasm).

Idaho (S.K. Mohan and R.S. Sampangi) - In collaboration with C. Shock, 50 commercial onion cultivars were screened for resistance to IYSV. All the varieties were susceptible under field conditions to varying degrees, none showing total resistance.

New Mexico (C. Cramer) - Eighty-eight onion breeding lines selected for IYSV tolerance, 25 plant introduction (PI) accessions from the U.S. germplasm collection, 11 experimental breeding lines from the New Mexico State University (NMSU) breeding program, 10 commercial cultivars, and 12 experimental commercial breeding lines were evaluated for the number of thrips per plant, leaf color, leaf waxiness, IYSV disease symptoms, and bulb yield. For those entries tested as transplants, adult and juvenile onion thrips number per plant was highest at 9 weeks post transplanting while the number decreased afterwards up to 15 weeks. Among those breeding lines selected for IYSV tolerance, plants of NMSU 10-592-1, NMSU 10-594-1, NMSU 10-596-1, NMSU 10-597-1, NMSU 10-634-1, NMSU 10-737, and NMSU 10-778 averaged less than 25 thrips at 9 weeks that was less than the susceptible check, ‘Rumba’. In addition to these selected lines, 22 additional selected lines and 19 PI accessions had fewer thrips per plant than ‘Rumba’ at 9 weeks. Plants of PIs 344392 and 289689 had less than 25 thrips at 9 weeks. At 12 weeks post transplanting, plants of 46 selected lines and 17 PI accessions had fewer thrips than plants of ‘Rumba’. Plants of 11 selected lines (NMSU 10-589-1, 10-592-1, 10-593-1, 10-594-1, 10-597-1, 10-618-1, 10-619-1, 10-702, 10-712, 10-737, 10-767), PI 289689, and PI 391509 averaged less than 13 thrips per plant. At 15 weeks post transplanting, plants of 35 selected lines and 8 PI accessions averaged fewer thrips than plants of ‘Rumba’. Of these entries, plants of 19 selected lines (NMSU 10-580-1, 10-589-1, 10-593-1, 10-594-1, 10-597-1, 10-615-1, 10-618-1, 10-619-1, 10-696-1, 10-697-1, 10-702, 10-710, 10-711, 10-732, 10-734, 10-737, 10-767, 10-778, 10-817), PI 179627, PI 183660, and PI 289689 averaged less than 9 thrips per plant.

For those entries sown directly in the field, numbers of thrips per plant remained unchanged from 13 to 21 weeks post sowing. At 13 weeks, plants of 20 selected lines, 1 NMSU experimental line, 1 commercial cultivar, and 4 experimental commercial breeding lines averaged fewer thrips per plant than plants of ‘Rumba’. Of those entries, plants of NMSU 10-795, NMSU 10-800, and NMSU 10-814 averaged less than 6 thrips per plant. At 17 weeks post sowing, no entry averaged fewer thrips per plant than ‘Rumba’. At 21 weeks post sowing, only 5 experimental commercial breeding lines averaged fewer thrips per plant than plants of ‘Rumba’.

Of those entries tested, plants of 71 selected lines, 5 PI accessions, 11 NMSU experimental lines, 3 commercial cultivars, and 12 experimental commercial breeding lines were rated as having light to dark green leaf color. With regards to leaf waxiness, plants of 36 selected lines, 4 PI accessions, 5 NMSU experimental lines, 2 commercial cultivars, and 4 experimental commercial breeding lines were rated as having semi-glossy to glossy leaves. Plants of NMSU 07-54-1, NMSU 10-592-1, NMSU 10-593-1, NMSU 10-594-1, NMSU 10-597-1, NMSU 10-613-1, NMSU 10-618-1, NMSU 10-619-1, NMSU 10-737, NMSU 10-778, NMSU 10-814, and NMSU 10-816 possessed glossy foliage that was light green in color.

For those entries tested as transplants, plants of NMSU 10-597-1, NMSU 10-796, and NMSU 10-817 exhibited a lower IYS disease severity at 12 weeks post transplanting than plants of ‘Rumba’. At the same time, NMSU 10-597-1 and NMSU 10-796 exhibited a lower disease incidence than ‘Rumba’. At 14 weeks post transplanting, plants of 13 selected lines and 7 PI accessions exhibited a lower disease severity than plants of ‘Rumba’. NMSU 10-589-1, NMSU 10-718, and PI 391509 exhibited a lower disease incidence at 14 weeks than ‘Rumba’. At 16 weeks, no selected lines or PI accessions exhibited a lower disease severity than ‘Rumba’. By 16 weeks, disease incidence had reached 100% for all entries. At 18 weeks, plants of 19 selected lines and 6 PI accessions exhibited a lower IYS disease severity than plants of ‘Rumba’.

For those entries sown directly in the field, plants of 23 selected lines, 5 NMSU experimental lines, and 4 experimental commercial breeding lines exhibited a lower IYS disease severity at 21 weeks than plants of ‘Rumba’. At the same time, NMSU 10-782, NMSU 10-799, NMSU 10-800, NMSU 10-807, NMSU 10-813, NMSU 10-814, NMSU 10-833, NMSU 07-54-1, and E204IYSV2011 exhibited a lower disease incidence than ‘Rumba’. At 23 weeks post seeding, plants of 17 selected lines, 2 NMSU experimental lines, 2 commercial cultivars, and 2 experimental commercial breeding lines exhibited a lower disease severity than plants of ‘Rumba’. NMSU 07-54-1, NMSU 07-55-1, NMSU 10-776, NMSU 10-782, NMSU 10-799, NMSU 10-813, NMSU 10-814, NMSU 10-816, and NMSU 10-833 exhibited a lower disease incidence than ‘Rumba’.

For those entries tested as transplants, NMSU 07-30-2, NMSU 07-35-1, NMSU 10-768, NMSU 10-778, and PI 546201 exhibited a colossal market class bulb yield that was greater than the yield of other entries. NMSU 07-30-2, NMSU 07-35-1, NMSU 10-634-1, NMSU 10-768, NMSU 10-778, NMSU 10-784, NMSU 10-817, and PI 546192 exhibited a jumbo bulb yield that was greater than the yield of other entries. For those entries sown directly in the field, NMSU 07-30-2 and E208IYSV2011 exhibited a jumbo bulb yield that was greater than the yield of other entries. Individual plants, that exhibited few IYSV symptoms, were selected at bulb maturity from 43 different selected lines, 11 NMSU experimental breeding lines, 3 commercial cultivars, and 2 PI accessions for a total of 520 bulbs. These bulbs are being pollinated in the hopes of finding progeny that possess a higher level of IYSV tolerance.

Utah (D. Drost) - As part of yearly conducted variety trials, 31 commercially available Spanish onion cultivars were assessed for productivity, maturity and rated for IYSV. While symptoms expressed in 2011 were low, all the varieties were susceptible to IYSV under field conditions and all had visual virus symptoms to some degree.

Objective 2. Study the biology and epidemiology of IYSV and thrips, and impacts of chemical, cultural and biological tactics that can reduce their impacts upon onions.

Colorado (H. F. Schwartz, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) - During 2011, volunteer onions were monitored after leaf and bulb expansion for the presence of thrips and IYSV in the vector and plants. Thrips numbers increased from 1 to nearly 100 per plant over a 5-week period; with IYSV incidence at 30% (of 16 thrips/plant) early, reaching 100% (of 98 thrips/plant) 4 weeks later. Volunteer onion plant incidence varied from 20% with IYSV in the early season to 100% 4 weeks later. This high incidence of IYSV in thrips and volunteer onions coincided with bulb initiation in transplanted onion and mid vegetative growth in seeded onion crops planted nearby.

During 2010, scapes, umbels and seed from individual plants (of Pentium, Solid Gold and Red Defender) exhibiting typical symptoms of IYSV with confirmation by ELISA were harvested. Seed number was correlated with size of the umbel, and seed weight was correlated with number of seeds. IYSV has not been detected in 3-4 week old plants grown from seed harvested from infected plants; however, germinated seed from a few umbels have tested positive for IYSV by ELISA. Additional testing is underway with seed and umbel samples from 2010 and 2011, and results need to be confirmed by PCR.

In the arid West, onions are often grown with companion crops such as barley (living mulch) to protect seedling onionss from wind injury. Both farmers and researchers have observed lower thrips injury in onion/companion crop fields in the past. In an effort to find out why, an onion companion crop insect and arachnid population dynamics field study was initiated in the spring of 2011. The objectives were to determine which thrips predators and parasites are found inhabiting the barley companion crop; determine what other insects/arachnids dwell in this living mulch; determine if there is a relationship of predator/parasite and thrips populations; and determine if living mulch reduce thrips injury and IYSV. Four field locations in Colorado were sampled once during mid-June using a Stihl gas powered BG56 Shredder and Vacuum with a no thrips insect screen. The sampled area was 10 row feet (25 square feet), with four samples taken at each field location. Eight beneficial predator and parasite families were identified from the field samples. The average of all populations of insects and arachnids at all locations revealed that ladybird beetle larvae were the most numerous found followed by spiders, braconid wasps, syrphid flies, big eyed bugs, ladybird beetle adults, nabids, lacewings and predacious mites. Six plant feeding insect families and one phytophagous mite family were found in the field samples. The average of all populations of insects and arachnids at all locations revealed that phytophagous mites were the most numerous followed by aphids, thrips, leafhoppers, leaf beetles, flies, one grasshopper and one box elder bug adult. Generally, fewer thrips were found on onion plants when at least 0.3 ladybird larvae were found per square foot of vegetation. Later in the season, an evaluation of thrips populations from the four field locations ranged from 1 to 15.4 thrips per plant in companion crop planted fields. In one non companion crop planted field located next to one test location, 20.5 thrips were found per onion plant compared with 9.2 thrips per plant in the onion companion crop field. Little to no IYSV was found at any field locations.

Florida (S. Reitz) - Laboratory studies were conducted to determine the repellency of kaolin to thrips and the effect of kaolin on the amount of thrips feeding. No choice trials were conducted by exposing adult female thrips to either kaolin treated foliage or control foliage. Leaves were treated with a 6.25% aqueous mixture of kaolin (Surround WP) and Tween 80 (1%) as a spreader/sticker, or a control solution of water plus Tween. The amount of kaolin coverage was determined by measuring white areas of the leaf surface through the use of digital analysis software (Sigmascan Pro). Repellency and feeding were evaluated at two time intervals following treatment. Treated foliage was allowed to dry for 1 hour or 24 hours after treatment. Leaf sections were placed in arenas (3.5 cm diameter) lined with agar, and individual female thrips were introduced into arenas for 24 hours. At the end of the 24 hour trials, the location of each thrips was recorded. Foliage was rinsed with tap water, and the amount of feeding damage measured through the use of digital analysis software. Data were analyzed with generalized linear models. Kaolin treatments resulted in significantly more thrips being located off of the leaf surface for both time intervals. Sixty-three percent of thrips exposed to kaolin treated foliage were found off of the foliage at the end of the test, compared with 46% of the thrips exposed to control foliage.

Georgia (R. Gitaitis, R. Srinivasan) - Lisianthus (*Eustoma russellianum*) was used as an indicator host and a platform for transmission studies of IYSV to study mechanical transmission. Mechanical inoculation tests from IYSV-infected onion plants to non-infected lisianthus plants resulted in a mean transmission rate of 82.5%, and from IYSV-infected lisianthus plants to non-infected lisianthus plants resulted in a mean transmission rate of 89.2%. *T. tabaci* adults transmitted IYSV at a rate of 80% from infected onion plants to non-infected lisianthus plants. To assess IYSV distribution in infected lisianthus plants, leaf sections, stems, and roots were tested by enzyme-linked immunosorbent assay (ELISA). All the plant parts tested positive for IYSV, but not on every plant assayed. More severe symptoms developed on inoculated plants incubated at 18 and 23°C or 25 and 30°C temperature regimes than at the 30 and 37°C regime. Symptoms were observed earliest on plants incubated at the 25 and 30°C. Besides improving our understanding of virus–vector interactions, lisianthus can be useful to monitor disease incidence from an epidemiological standpoint. Lisianthus could be used as a sentinel plant in agricultural settings to monitor the initial incidence of IYSV and assess inoculum pressure. Monitoring of results could prompt appropriate management measures such as insecticide applications.

Onion bulb culls imported from Peru are the source of IYSV in Georgia. These culls also harbored live onion thrips (*Thrips tabaci*), also most likely from Peru since they were found inside bulbs in the packinghouse. Later a potential shift in the makeup of thrips populations from tobacco thrips (*Frankliniella fusca*) to onion thrips in Georgia fields led to a hypothesis that a more aggressive *T. tabaci* biotype was introduced from Peru. Thus, a survey was conducted to identify the origin of *T. tabaci* populations collected from onions in Georgia. Origin of thrips was based on polymorphisms in mitochondrial cytochrome oxidase 1 (CO1) and ribosomal ITS2 sequences. Parsimony and Bayesian analysis of CO1 sequences indicated all Peruvian thrips fell in to a single clade that contained only one sample from Georgia. All the other Georgia taxa clustered in a different clade. It was concluded that CO1 sequences had potential use to identify geographical origin for intraspecies variation of thrips. On the other hand, ITS2 sequences indicated Peruvian and Georgia taxa were found in numerous clades with no discernible pattern to indicate geographic origin. Therefore, ITS2 sequences were not useful to assess intraspecies variation among thrips. Also, the data did not support theory that an introduced, more aggressive biotype accounted for the temporary shift from tobacco thrips to onion thrips in Georgia onion fields.

Tobacco thrips is the major thrips pest of onion in Georgia. Hence, experiments were conducted to test the vector status of *F. fusca* in comparison with *T. tabaci.* The detection rates for *F. fusca* larvae and adults reared on IYSV-infected hosts were 4.5 and 5.1%, respectively, and for *T. tabaci* larvae and adults detection rates were 20 and 24%, respectively, indicating that both *F. fusca* and *T. tabaci* can transmit IYSV. Further, transmission efficiencies of *F. fusca* and *T. tabaci* were evaluated by using an indicator host, lisianthus. Both *F. fusca* and *T. tabaci* transmitted IYSV at 18 and 77%, respectively. Results confirmed that *F. fusca* also can transmit IYSV but at a lower efficiency than *T. tabaci*. Transmission data with *Tomato spotted wilt virus* (TSWV), another tospovirus, and *F. fusca*, resulted in 90% efficiency demonstrating the *F. fusca* population used in the onion experiment was a competent vector. These results suggest the transmission efficiency of a competent thrips vector can vary widely between two closely related viruses.

Iris yellow spot virus (IYSV) continues to be detected annually since its introduction into Georgia from Peru in 2003. During a weed survey near an onion cull pile with a history of IYSV, spiny sowthistle (*Sonchus asper*) was identified as an asymptomatic host. Spiny sowthistle is widespread in Georgia, thereby presenting an opportunity to survey the spread of IYSV both within and outside onion-growing areas of the state. A total of 2011 sowthistle samples were tested using ELISA in this 3-yr study. Selected ELISA positive samples were confirmed with RT-PCR, and sample sequences were compared with known IYSV isolates deposited in GenBank. All IYSV sequences obtained from spiny sowthistles, regardless of county of origin, were most closely related to IYSV sequences from samples previously collected from onion in either Georgia or Peru. By the third year of the survey, IYSV-infected sowthistles were found in 79% of the counties in the onion-growing region and in 61% of the counties along transects running to the north, northwest and west of the onion-growing region. No positive samples were found in counties to the east of the onion-growing region. Since sowthistles are considered an annual plant and do not occur in the summer in Georgia, spiny sowthistles were initially dismissed as a possible "green bridge" for the virus between winter-grown onion crops. However, during the course of this survey a few spiny sowthistles were observed to act as a perennial in the mild, southern Georgia climate. At least one of those samples was positive for IYSV in two consecutive years. The presence of IYSV was also confirmed in spiny sowthistle roots, thus allowing for the possibility of IYSV over-summering between onion crops. Furthermore, spiny sowthistles supported *T. tabaci* survival and reproduction. Thrips-mediated transmission assays also confirmed that *T. tabaci* can efficiently transmit IYSV from onion plants to sowthistles. These findings demonstrate that IYSV has infected at least one weed widely throughout Georgia and has the potential for long distance spread, particularly in a northern and western direction.

Idaho (S.K. Mohan and R.S. Sampangi) - More than 100 weed plants (leaves and roots) were sampled during the main cropping season (May-Sept) and fall (Oct-Dec) and tested for their possible role in serving as alternate hosts for both virus and vector (*T. tabaci*) in collaboration with H. Pappu. The samples were analyzed using two commercial ELISA kits (AGDIA, USA and DSMZ, Germany) for IYSV testing. Preliminary results showed varying absorbance values between the two kits employed and also among the weed species tested. A few weed species showed elevated values suggesting the presence of IYSV. Further testing by PCR is envisaged for determining the degree of reliability of the two ELISA test kits.

New York (B. Nault, C. Hoepting, C. Hsu and S. Beer) – The performance of foliar-applied insecticides against onion thrips was examined in several studies. The best products included cyantraniliprole (HGW86 10OD), spinetoram (Radiant SC), spirotetramat (Movento) and abamectin (Agri-Mek 0.15EC). Section 18s for Movento and Agri-Mek were granted by EPA in 2010 in New York. The performance of new insecticides when tank mixed with fungicides containing spreader stickers was also investigated. Movento and Agri-Mek did not consistently work as well when tank mixed with fungicides that contained spreader stickers. The concern is that the spreader stickers in the fungicide formulation is interfering the penetrant used to assist getting the insecticide into the plant tissue. There is also concern that the penetrant may allow the fungicide to enter plant tissues to cause phytotoxicity. Research is needed in 2010 to resolve this issue. Action thresholds for new insecticides were examined. Although Movento and Agri-Mek controlled the thrips population when applied following a 3 thrips larvae per leaf threshold, these results may not be applicable in a "bad" thrips year. The thrips infestation was low for half the season due to cold and wet weather. Thus, until more research is conducted, growers should consider using a more conservative threshold such as 1 thrips larva leaf. This more conservative approach will be even more important if these products are tank mixed with fungicides and spreader stickers.

The impact of nitrogen on onion thrips populations also was evaluated in 2011. The season total numbers of thrips and marketable bulb yield in plots applied with N rates at 75 and 150 lbs per acre were compared. The result was a 20 to 40% reduction in thrips densities over the season in plots that had 75 lbs per acre compared with 150 lbs per acre. More thrips were found on plants in the high N treatment, indicating that either more eggs were laid on these plants, more larvae survived on these plants, or both. There were no significant differences in marketable yield between the two treatments.

Associations between bacteria that are pathogenic to onion and onion thrips, which may vector bacterial pathogens, were examined in 2011. The first step was to identify the suite of bacterial species causing decay in onion in New York. Known pathogens of onions were identified from symptomatic tissues in cull onions including *Burkholderia cepacia*, *Pantoea ananatis*, *P. agglomerans* and *Enterobacter cloacae.* In addition, *Rahnella* species, which have not been reported as pathogens of onion, were isolated from about 40% of the culls. *E. cloacae*, the pathogen that causes *Enterobacter* bulb decay in storage, as reported from California, Colorado and Washington, was isolated and characterized for the first time from onions grown and stored in New York. In addition, the presence of the pathogen was documented in symptomatic mid-season growing onions. Apparently the pathogen that results in unmarketable stored onions begins to develop in the field. In preliminary tests, several strains of *Rahnella* spp. that had been inoculated into putatively healthy bulbs, caused decay. These results suggest that this genus warrants a more intensive assessment of its pathogenic potential to onions. Additional work was done to learn more about the epidemiology of these bacterial pathogens.

In limited analyzes of thrips collected from onion foliage rather late in the growing season, we identified strains of *P. ananatis, P. agglomerans, B. cepacia* and *E. cloacae* that were present both on the surface of the thrips and internally. However, further analyses are indicated before reaching a definite conclusion in regard to the possible presence of the several bacteria early in the season and the possible role of onion thrips in vectoring bacteria that cause decay in onion.

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 varying absorbance values among crops, weeds and thrips tested. Weed species tested had variable absorbance values suggesting the presence of IYSV. Testing is on-going as significant numbers of samples were collected.

Washington (L. du Toit, H. Pappu, B. Schroeder and T. Waters) - The incidence and severity of IYSV in onion seed crops in WA state was much less than in previous years, which probably reflects the exceptionally cool and moist conditions from early spring through mid-summer (end of July) in central WA. Most onion seed crops were harvested by early August, and thrips pressure was low through July, only increasing significantly in August when temperatures became exceptionally warm (warmest Aug. and Sept. in about 20 years for central WA, after the coolest April through July in the past ~50 years). No significant losses to IYSV were reported by onion seed crop stakeholders in WA in 2011. The disease was observed in many fields, but at low incidences and/or severities that did not result in economic losses. Similarly, although IYSV was observed in many onion bulb crops, there were no reports of significant economic injury from this disease.

IYSV-plant and IYSV-vector interactions were studied to generate important information about the biology, pathogenicity, and epidemiology of the virus. Experimental hosts that provide differential response to IYSV infection were identified and described. This information will facilitate future studies on the nature of the host reaction to IYSV infection and the underlying factors that determine the outcome of IYSV infection. Role of onion thrips in virus epidemiology is being studied by determining the proportion of virus transmitters among field-collected thrips by using a rapid and sensitive, ELISA-based assay that targets a viral protein that could be found only upon viral replication in the insect.

Efficacy of insecticides for thrips (primarily *T. tabaci*) control was examined in several trials. In a standard efficacy trial, Radiant performed the best, followed by Lannate and then Agri-Mek. In a trial evaluating organically approved insecticides, only Entrust was effective in reducing thrips densities. In trial that examined different sequences of insecticides applied throughout the season to manage thrips, many of the sequences worked well. Based on that study, the following recommendations were determined when early-season thrips populations are low or high. When low at beginning of season, the following sequence should be considered: Movento, Movento, Radiant Agri-Mek, Radiant and then Lannate. In contrast, if initial populations are high, the following sequence should be considered: Radiant, Movento, Movento, Radiant, Agri-Mek and Lannate.

Objective 3. Transfer information on progress dealing with IYSV and thrips biology and IPM strategies to the onion industry and other interested parties.

Colorado (H. F. Schwartz, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) – Led the nationwide Onion ipmPIPE project and disseminated scouting information from all participants to stakeholders via the Onion ipmPIPE website. An 8-card set of diagnostic cards was produced with support from agribusiness donors, and 8,000 sets were distributed nationwide to project personnel, growers, consultants and others involved with agribusiness related activities. Topics were relevant to the W1008 and included Bulb Growth Stages, Storm Damage Effects, Virus Diseases, Insect Pests, Soil-Borne Diseases, Bacterial Diseases, Foliar Fungal Diseases, and Storage Fungal Diseases. Conference calls among participants of the Onion ipmPIPE project were held every two weeks during the season. Thrips and disease scouting information collected by participants can be found at the following website: http://apps.planalytics.com/aginsights/pipehome.jsp.

Idaho (S.K. Mohan and R.S. Sampangi) – Participated in the Onion ipmPIPE project and disseminated information to growers.

Michigan (M. Hausbeck and J. Morrice) - Participated in the Onion ipmPIPE project. Additionally, pocket guides were disseminated to 100 growers and biweekly visits were made to 11 sentinel plots to identify pests. Information was conveyed to growers.

New Mexico (M. Uchanski) - Participated in the Onion ipmPIPE project and disseminated information to growers.

New York (B. Nault, C. Hoepting, C. Hsu and S. Beer) - Several meetings were held in 2010 to inform NY's onion industry about results from this project: the Empire State Fruit and Vegetable EXPO in Syracuse in January, the Onion School in Middleburg in March, the Oswego Twilight Meeting in June and the Elba Muck Onion Meeting in Elba in August. Information pertaining to this subject was also presented at the Mid-Atlantic Fruit and Vegetable EXPO in Harrisburg, PA in February and the Wisconsin Potato and Onion Annual Meeting in Stevens Point, WI in February. Also, we participated in the Onion ipmPIPE project, shared results with growers and submitted scouting information on pests and diseases for inclusion on the Onion IPM PIPE website.

Utah (D. Alston, D. Drost and C. Nischwitz) – Participated in the Onion ipmPIPE project. Five sentinel plots and five survey sites in the Davis, Weber, and Box Elder County production onion areas in Utah were monitored by Bonnie Bunn. Fields were assessed from early June till early September for thrips, other insects, and IYSV. Reports were submitted periodically, along with regional reports summarizing weather conditions, Sentinel Plot reports, and other insect and disease observations. Several meetings were held in 2010 to inform Utah's onion industry about results from this project. These included the Utah Onion Associations winter educational meetings (Feb. 15), the summer onion field day (Aug 16), and the fall onion association board meeting (Nov. 29).

Washington – Participated in the Onion ipmPIPE project. Five sentinel plots in the Columbia Basin of Washington State were monitored by Tim Waters and Carrie Wohleb, WSU Extension Educators, twice monthly for thrips counts and other insects. Reports were submitted twice monthly, along with regional reports summarizing weather conditions, Sentinel Plot reports, and other insect and disease observations, by Lindsey du Toit, WSU vegetable seed pathologists. For details of the WA reports, refer to the Onion ipmPIPE website.

Impacts

A conservative estimate of 10% yield loss to the U.S. onion industry due to the combined effects of thrips and IYSV damage, as well as the cost of mitigation (insecticides) was valued at more than 75 million dollars during 2011. The following activities and accomplishments of the W1008 project participants have individually and collectively contributed to reducing these negative impacts on U.S. onion growers and the industry at large.

As a result of this project, onion breeders, plant pathologists, entomologists, virologists and integrated pest management specialists are providing research-based information to onion growers that have helped them more effectively manage thrips and IYSV.

Advancements in identifying onion lines that are less susceptible to thrips and IYSV damage are being used in onion breeding programs for developing new onion cultivars that will be more effective than existing tolerant cultivars for mitigating yield losses caused by thrips and IYSV.

Growers are adopting onion varieties that have greater tolerance to thrips and IYSV.

New and selective insecticides and application strategies identified from this project were adopted by growers that kept onion thrips populations under control, decreasing the frequency of sprays applied per season and reducing control costs and the threat of insecticide resistance.

More growers are using selective insecticides to control thrips, especially early in the season, and this change in insecticide use might be allowing natural predators to help control thrips.

Due to better knowledge of the transmission of IYSV, fewer growers are planting over-wintering onions. With fewer overwintering onions and better cull onion disposal, growers are breaking the natural green bridge keeping IYSV pressure high from one production year to the next. Some growers continued to suffer IYSV related yield losses due to over-wintering onion bulb or seed fields close to their summer production fields.

More growers are adopting drip irrigation and careful irrigation scheduling resulting in fewer losses to IYSV.

In the Idaho-Oregon Treasure Valley, IYSV has declined from 2005/2006 levels as growers practice greater vigilance in destroying onion culls and planting over-wintering fields further from summer production fields, actions that help to break the natural "bridge" that can perpetuate IYSV infestations.

More growers are reducing the amount of nitrogen fertilizer they apply to onions and this has benefitted them by significantly reducing thrips populations, reducing fertilizer costs and reducing potential problems associated with excess nitrogen in the environment.

In Utah, growers using low nitrogen input system (130-150 lb. N/A) reported they applied 0-1 insecticide sprays in 2010 which saved them nearly $200/A compared to growers using the normal N input amounts of 250 lb. N/A.

Growers have greater access to information about thrips biology, IYSV epidemiology and their management provided by participants from this project. Information has been made available via via presentations at meetings, publications and web sites such as http://www.alliumnet.com/index.htm.

Publications

Beer, S. V., Zaid, A. M., and Bonasera, J. M. 2011. Studies of bacterial problems of onion in New York – 2010. Onion World 27:(3) 12-15.

Boateng, C.O., and Schwartz, H.F. 2010. Relationships of *Iris yellow spot virus* and onion thrips (*Thrips tabaci*) to onion production and yield. Allium and Umbelliferae Improvement Newsletter Vol. 20:16-20.

Buckland, K. 2011. Evaluating Fertilizer Rate, Crop Rotation, and Trap Crops for Effects on Onion Growth and Yield, Soil Health, Thrips Densities, and Iris Yellow Spot Virus Incidences. M.S. Thesis. Utah State University.

Cramer, C.S., Bag, S., Schwartz, H.F., and Pappu, HR. 2011. Susceptibility of onion relatives (*Allium* spp) to *Iris yellow spot virus*. Plant Disease 95:1319.

Diaz-Montano, J., Fuchs, M., Nault, B.A., Fail, J., and Shelton, A.M. 2011. Onion thrips (Thysanoptera: Thripidae): A global pest of increasing concern in onion. J. Econ. Entomol. 104(1): 1-13.

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Mohseni-Moghadam, M., Cramer, C.S., Steiner, R.L., and Creamer, R. 2011. Evaluating winter-sown onion entries for *Iris yellow spot virus* susceptibility. HortScience 46:1224-1229.

Nault, B. A., and Hessney, M.L. 2011. Onion thrips control in onion – Trial I, 2010. Arthropod Management Tests, 2010. 36: E51.

Nault, B. A., and Hessney, M.L. 2011. Onion thrips control in onion – Trial II, 2010. Arthropod Management Tests, 2010. 36: E52.

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Nault, B., Cranshaw, W., and Alston, D. 2011. Onion Insect Pests. Onion ipmPIPE Diagnostic Pocket Series - 2 page diagnostic card, distributed nationally): http://www.alliumnet.com/IPMPipe.html

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Nault, B.A., Hsu, C.L., and Hoepting, C. 2011. Maximizing the level of onion thrips control using insecticides, 4 pp. *In*: Proceedings of the 2011 Mid-Atlantic Fruit and Vegetable Convention. February 1-3, 2011. Hershey, PA. Pennsylvania Vegetable Growers Association.

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Shock, C.C., Feibert, E.B.G., Saunders, L.D., Jensen, L.B., Mohan, S.K., Sampangi, R.S., and Pappu, H.R. 2011. Management of onion cultural practices to control the expression of Iris Yellow Spot Virus, pp. 23-41. *In* Shock C.C. (Ed.) Oregon State University Agricultural Experiment Station, Malheur Experiment Station Annual Report 2010, Department of Crop and Soil Science Ext/CrS 132. http://www.cropinfo.net/AnnualReports/2010/OnionIYSV.html.

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Srinivasan, R., Guo, F., Riley, D., Diffie, S., Gitaitis, R., Sparks, A., Jr., and Jeyaprakash, A. 2011. Assessment of variation among *Thrips tabaci* populations from Georgia and Peru based on polymorphisms in mitochondrial cytochrome oxidase 1 and ribosomal ITS2 sequences. J. Entomol. Sci. 46:191-203.

Szostek, S. A., and Schwartz, H. F. 2011. A new research technique for thrips and IYSV. Onion World, Vol. 27:14-15.

Waters, T., and Walsh, D. 2011. Thrips control in onion, pp. 10-11. Washington State University Onion Cultivar Field Day, 26 August 2011, Skone & Connors Produce, Frenchman Hills, WA.

Waters, T. 2011. Thrips control in onion. Presentation at 25th Pacific Northwest Vegetable Association Annual Convention & Trade Show, 16-17 November 2011, Kennewick, WA. http://www.pnva.org/files/files/ThripsControlinOnion-Tim.pdf

Zaid, A. M., Bonasera, J. M. and Beer, S. V. 2011. First Report of Enterobacter Bulb Decay of Onions Caused by *Enterobacter cloacae* in New York. Plant Disease 95:1581.

Other Activities

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

None reported.

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

Boateng, C.O., and Schwartz, H.F. 2011. Effects of *Iris yellow spot virus* and Onion Thrips on onion physiology, growth and productivity. Proc. National Meeting of the American Phytopathological Society, Honolulu, HI, August 6-10, 2011. Poster Presentation.

Boateng, C.O., Schwartz, H.F., and Otto, K. 2011. Onion cultivar resistance to *Iris yellow spot virus* and Onion Thrips in Colorado. Proc. National Meeting of the American Phytopathological Society, Honolulu, HI, August 6-10, 2011. Poster Presentation.

Cramer, C.S. 2011. Evaluation of onion plant introduction accessions for leaf characteristics, onion thrips number per plant, and Iris yellow spot disease severity. HortScience 46:S280. (Abstr.).

Cramer, C.S. 2011. In search of onion germplasm tolerant to *Iris yellow spot virus*. HortScience 46:S281. (Abstr.).

Cramer, C.S. 2011. (SCRI-3) Evaluation of onion plant introduction accessions for leaf characteristics, onion thrips number per plant, and Iris yellow spot disease severity. HortScience 46:S294. (Abstr.).

Cramer, C.S. 2011. In search of onion germplasm tolerant to *Iris yellow spot virus*. 5th Annual Plant Breeding Workshop. Annual Meetings of the Plant Breeding Coordinating Committee and National Association of Plant Breeders. May 23-25, 2011. College Station, TX. p. 13.

Cramer, C.S. 2011. Screening winter-sown onion entries for *Iris yellow spot virus* resistance. W1008: Biology and management of *Iris yellow spot virus* (IYSV) and thrips in onions. Regional research project annual meeting. Las Cruces, NM. Dec. 8-9, 2011.

Feibert, E.B.G., Shock, C.C., Saunders, L.D., and Simerly, B. 2011. Early Onion Harvest Options in the Pacific Northwest. Annual Conference of the American Society for Horticultural Science, 25-28 September 2011. Waikoloa, HI.

Hsu, C., Hoepting, C., Fuchs, M., Shelton, A.M., and Nault, B.A. 2011. Changes in the spatial distribution of onion thrips (*Thrips tabaci*) and Iris yellow spot virus in onion fields over time. Entomological Society of America Annual Meeting, November 13, 2011. Reno, NV. Invited workshop presentation.

Hsu, C., Hoepting, C., Fuchs, M., Shelton, A.M., and Nault, B.A. 2011. Changes in the spatial distribution of onion thrips (*Thrips tabaci*) and Iris yellow spot virus in onion fields over time. Entomological Society of America Annual Meeting, November 15, 2011. Reno, NV. Poster presentation.

Nault, B. A. 2011. Thrips IRM in onions. Entomological Society of America Annual Meeting, November 15, 2011, Reno, NV. Invited symposium presentation.

Nault, B.A., and Shelton, A.M. 2011. IPM for onion thrips (*Thrips tabaci*) in onion. Entomological Society of America Annual Meeting, November 13, 2011. Reno, NV. Invited workshop presentation.

Shelton, A.M., and Nault, B.A. 2011. Spatial and temporal insecticide resistance in onion thrips (*Thrips tabaci*) populations in onions. Entomological Society of America Annual Meeting, November 13, 2011. Reno, NV. Invited workshop presentation.

Shock, C.C., Feibert, E.B.G., Saunders, L.D., Jensen, Pappu, H., L.B., Mohan, S.K. and Sampangi, R.S. 2011. Influence of Selected Cultural Practices on the Expression of *Iris yellow spot virus* in Onion. Annual Conference of the American Society for Horticultural Science, 25-28 September 2011. Waikoloa, HI.

Smith, E. A., DiTomasso, A., Fuchs, M., Shelton, A.M., and Nault, B.A. 2011. Weed hosts of onion thrips (*Thrips tabaci*) and implications for *Iris yellow spot virus* epidemiology in onion, Entomological Society of America – Eastern Branch Meeting, March 20, 2011, Harrisburg, PA. Asa Fitch Award Winner Presentation.

3. Reports at Grower meetings and field days

Alston, D. 2011. Insecticide rotations for onion thrips suppression. Utah Onion Association winter meeting, Brigham City, Utah. February 15, 2011.

Cramer, C.S. Screening winter-sown onion entries for *Iris yellow spot virus* resistance. New Mexico Dry Onion Commission meeting. Las Cruces, NM. March 10, 2011.

Cramer, C.S. Screening onion entries for tolerance/resistance to Iris yellow spot virus. NM Onion Field Day. Las Cruces, NM. July 20, 2011.

Drost, D. 2011. Growing Onions in a Reduced Nitrogen System: Effects on Productivity and Thrips. Empire State Fruit and Vegetable EXPO. Syracuse, NY. January 27, 2011.

Drost, D. 2011. Nitrogen and a Whole Farm Approach to Iris Yellow Spot Virus Management. Utah Onion Association winter meeting, Brigham City, Utah. February 15, 2011.

Feibert, E.B.G. and Shock, C.C. 2011. Effect of timing of harvest on onion yield and storability. Malheur County, Oregon and Idaho Onion Growers Annual Meeting. Ontario, OR. February 1, 2011.

Hsu, C. L., Nault, B. A., Reiners, S., and Hoepting, C.A. 2011. Reduced inputs workshop: Relationship between nitrogen fertilizer rate, onion thrips and yield in NY. Empire State Fruit and Vegetable EXPO. Syracuse, NY. January 27, 2011.

Jensen, L.B., E.B.G. Feibert, and C.C. Shock. 2011. Onion thrips research. Malheur County, Oregon / Idaho Onion Growers 51st Annual Meeting. Ontario, OR. February 1, 2011.

Nault, B.A., Hsu, C.L. and Hoepting, C.A. 2011. Do tank mixes of insecticides and fungicides affect thrips control? Empire State Fruit and Vegetable EXPO. Syracuse, NY. January 27, 2011.

Nault, B.A., Hsu, C.L. and Hoepting, C.A. 2011. Maximizing the level of onion thrips control using insecticides. Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA. February 1, 2011.

Nault, B.A., Hsu, C.L. and Hoepting, C.A. 2011. Maximizing insecticide use to manage onion thrips on onion. University of Wisconsin Extension and Wisconsin Potato and Vegetable Growers Association Grower Conference. Stevens Point, WI. February 2, 2011.

Nault, B.A., Hsu, C.L., and Hoepting, C.A. 2011. Onion thrips management: Preserving insecticides as an effective strategy. Orange County Onion School. Middletown, NY. March 2, 2011.

Nault, B.A., Hsu, C.L., and Hoepting, C.A. 2011. Impact of co-applications of insecticides and fungicides on thrips control in onion. Disease and insect update meeting sponsored by Syngenta Crop Protection. Dundee, NY. March 23, 2011.

Nault, B.A. 2011. Update on onion insect pests. Oswego County Onion Growers Twilight Meeting. Cornell Cooperative Extension of Oswego County. Oswego, NY. June 22, 2011.

Nault. B.A., Hsu, C.L., and Fok, E. 2011. Latest developments in management of onion thrips management. 2011 Elba Muck Onion Twilight Meeting. Cornell Cooperative Extension and Cornell Vegetable Program. Elba, NY. August 2, 2011.

Nischwitz, C. 2011. Management of IYSV: Targeting Thrips Reproductive Hosts and IYSV Reservoirs in the Farmscape - New Research Project. Utah Onion Association winter meeting. Brigham City, Utah. February 15, 2011.

Reeve, J. 2011. Cultural Management of Onion Thrips and Iris Yellow Spot Virus. Utah Onion Association winter meeting. Brigham City, Utah. February 15, 2011.

Reitz, S. R. 2010. New pest management concerns in vegetable production. Gadsden County Tomato Forum, Quincy, FL. December 2010.

Schwartz, H. F. 2011 Onion virus management and updates. Annual Education Meeting of the Colorado Onion Association. Eaton, CO. January 27, 2011.

Schwartz, H. F. 2011. Onion virus management and updates. Annual Field Day of the Colorado Onion Association. Brighton, CO. September 8, 2011.

Schwartz, H. F. 2011 Onion virus and other disease/insect pest management and updates. Summer Meeting of the National Onion Association. Reno, NV. July 21, 2011.

Shock, C.C., Feibert, E.B.G., Saunders, L.D., Jensen, L.B., Mohan, S.K., Sampangi, R.S., and Pappu, H.R. 2011. Irrigation, N fertilization and varietal effects on the expression of Iris Yellow

Spot Virus in onion. Malheur County, Oregon and Idaho Onion Growers Annual Meeting. Ontario, OR. February 1, 2011.

Shock, C.C., Feibert, E.B.G., Saunders, L.D., Jensen, L.B., Mohan, S.K., Sampangi, R.S., and Pappu, H.R. 2011. Onion variety trial report, 2010. Malheur County, Oregon and Idaho Onion Growers Annual Meeting. Ontario, OR. February 1, 2011.

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Shock, C.C., Feibert, E.B.G., Saunders, L.D., Mohan, S.K., Sampangi, R.S., and Pappu, H.R. 2011. Management of IYSV. Summer Farm Festival and Annual Field Day, OSU Malheur Experiment Station. 13 July 2011. Ontario, OR.

Waters, T.D. 2011. Insect Management of Onions in Washington. Pacific Northwest Insect Management Conference. Portland, OR. January 10, 2011.

Waters, T.D. 2011. Thrips Control in Dry Bulb Onion. Columbia Basin Crop Consultants Association Short-Course. Moses Lake, WA. January 20, 2011.

Waters, T.D. 2011. Insect Pest Management of Onion. Walla Walla Sweet Onion Growers Meeting. Walla Walla, WA. January 24, 2011.

Waters, T.D. 2011. Onion Research Project Update and Review. Clearwater Supply Growers Meeting. Othello, WA. February 24, 2011.

Waters, T.D. 2011. Thrips Control in Dry Bulb Onions in Washington State.
Western Region County Agricultural Agents Meeting. Kennewick, WA. October 12, 2011.

Waters, T.D. 2011. Insect Management of Onions in the Pacific Northwest. Hermiston Area Farm Fair. Hermiston, OR. December 2, 2011.

Internet Resources

Onion Disease Management strategies, reports and publications, including those on IYSV and thrips. 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

Schwartz, H. F. 2011. Web site dedicated to information and resources on onion pest management and/or thrips and IYSV. http://www.alliumnet.com/index.htm

Other Related Activities

New York (B. Nault) - Submitted a package to the New York State Department of Environmental Conservation (NYSDEC) 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 2011 season. The Crisis Exemption request was granted by NYSDEC from June-September 2011. Additionally, a second package was submitted to the NYDEC for their consideration of a Section 18 for the use of abamectin (Agri-Mek 0.15EC) on onion for onion thrips control for the 2011 season. The Crisis Exemption request was granted by NYSDEC from June- September 2011.