FY 2014 Specialty Crop Block Grant Program- Farm Bill

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#141623

Specialty Crop Block Grant FINAL Report

UDAF Project: 141623

PROJECT TITLE

Peach Twig Borer Mating Disruption Evaluation and Demonstration

PROJECT SUMMARY

This project demonstrated and evaluated the use of mating disruption for control of peach twig borer, the primary pest of peaches and apricots in Utah. Without any intervention, peach twig borer can cause 50% to 80% crop loss. Insecticides effectively manage this pest, but mating disruption has been shown to cost less and have no adverse environmental or human effects. Mating disruption works by saturating the air with the female moth's attractant pheromone, "deadening" the scent to males so that they cannot find a mate, and thus preventing injury to fruit. The two brands we evaluated for peach twig borer were Checkmate PTB-XL, which are small dispensers that are hung in trees by hand, at a rate of 200/acre, and Puffers, an unregistered aerosol device that is hung in trees at a rate of 1.2 per acre.

The objectives of this project were:

1. Determine and demonstrate the most efficacious and profitable use of Checkmate PTB-XL for mating disruption of peach twig borer
2. Determine whether Puffer technology works to control peach twig borer in Utah so that it can become registered in the U.S.

The reason we evaluated the Checkmate brand is that it only lasts 90 days, which is 30 or more days shy of a full season, leaving fruit vulnerable to attack close to harvest. Because it only lasts 90 days, and warming summers are leading to longer time periods in which mating disruption is needed (often 120 days), growers need to know the most effective and cost-efficient use of this product.

In addition to the Checkmate dispensers, the same manufacturer will be introducing a new product called a Puffer. Puffers release pheromone from a battery-operated aerosol can, and are placed at 1.2 devices per acre (as opposed to 200/acre for Checkmate), potentially saving growers $32/acre in labor costs. The Puffers have been shown to last 180 days in trials in Italy and France (personal communication). Utah was the only state in the U.S. trialing this product. Results from the trial will be used to help get the product registered for fruit specialty crop producers.

From this project, we found that the Checkmate PTB-XL is a useful tool for Utah growers, but works best if applied on June 15, so that it will last until September 15, when peach twig borer larvae are no longer a threat. We also found that the Puffers work as well as the Checkmate PTB-XL product in preventing peach twig borer injury, and can save growers in labor costs.

PROJECT APPROACH

Project start and end dates: January 2014 – October 2014

In January 2014, the project investigator (Marion Murray) prepared a fact sheet outlining step by step instructions on using peach twig borer mating disruption. The fact sheet was printed and distributed to growers at the two Utah fruit growers' winter meetings in February (approximately 250 growers). The fact sheet was also posted to the USU Extension website (http://extension.usu.edu/files/publications/factsheet/ptb-MD.pdf).

The trials were conducted from May to September 2014.

The Checkmate PTB-XL evaluation was carried out on a peach farm in Box Elder County. The farm was divided into three, 10-acre blocks, with the following treatments:

- CE: Murray and a student assistant hung Checkmate dispensers on May 7. This early application was based on the historically recommended timing of shuck-split stage.
- CL: Murray and a student assistant hung Checkmate on June 15, later in the season.
- C-non: Only insecticides were applied (by the grower)

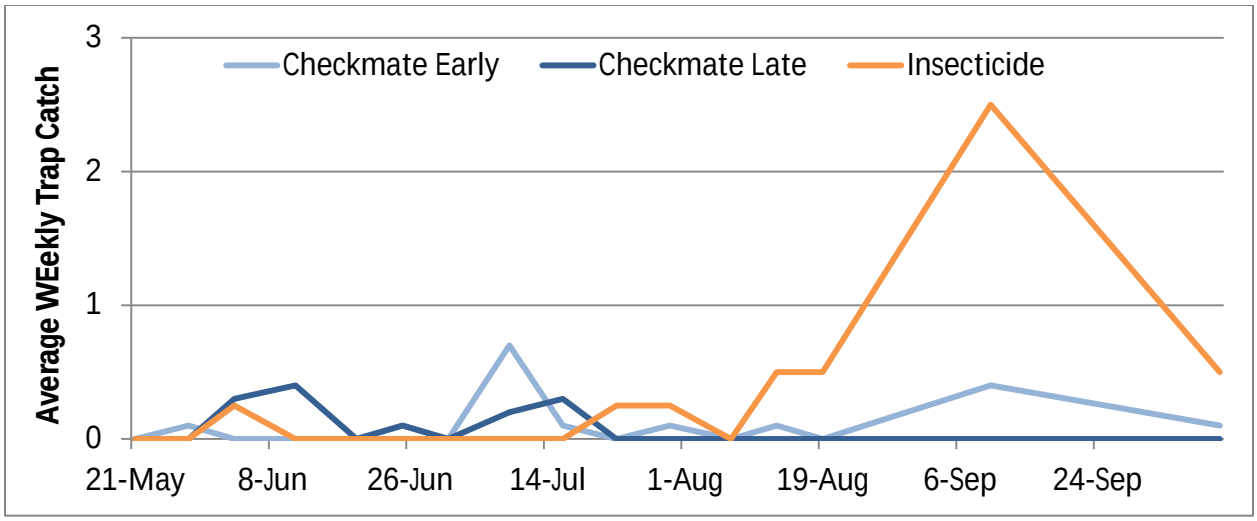
The Puffer trial was carried out on a farm in Utah County, with the following treatments:

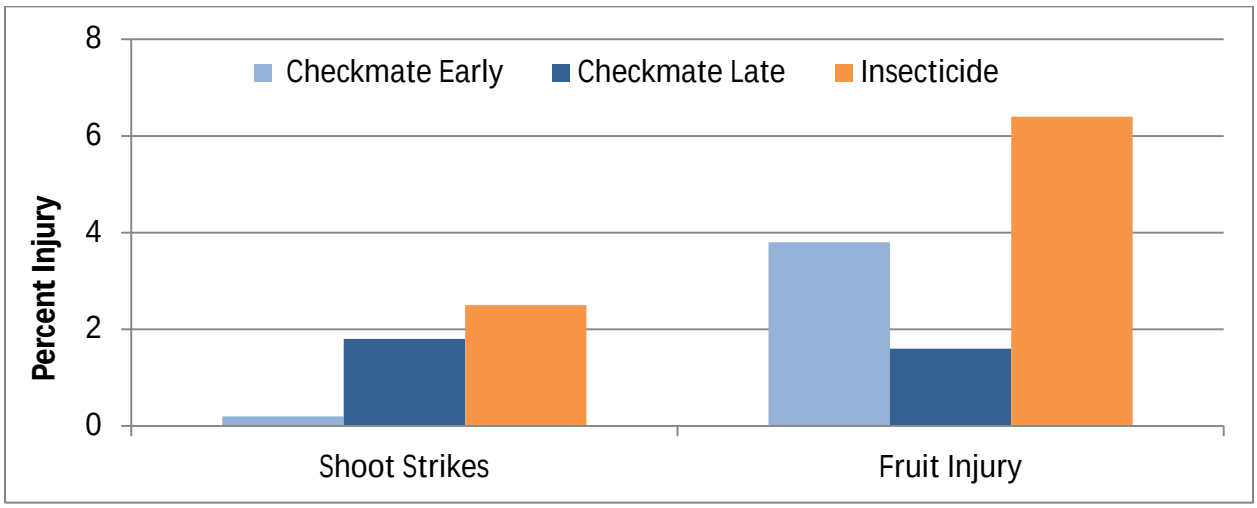
- Puffer: Murray and a student assistant hung Puffers in a 50-acre block of peaches on May 3
- P-Checkmate: The grower hung Checkmate dispensers in a nearby 30-acre block on May 8
- P-non: The grower used insecticides only in a third, 10-acre block.

For both trials, Murray and the student assistant hung peach twig borer monitoring traps: 10 traps in each of the CE, CL, and C-non blocks; 25 in the Puffer block, 15 in the P-Checkmate block, and 8 in the P-non block. We traveled to the farms each week to count the moths caught in each trap and to service them. (On blocks that are using mating disruption, the trap catch should ideally be zero.) In early July, we inspected 10 branches on 200 trees in each block of each trial for shoot injury ("shoot strikes") caused by peach twig borer, and in late August, we inspected 250 - 500 fruits in each block for larval damage.

For the Checkmate trial, we found that the optimum time to apply the Checkmate dispensers is June 15, which is contrary to the recommended timing of peach shuck-split stage (usually early May). Figures 1 and 2 show that both Checkmate treatments worked to keep moth flight and crop injury low. The most important result is that in the Checkmate Late treatment, the crop injury was only 1.6%, whereas in the Checkmate Early and Insecticide treatments, it was 3.8% and 6.4%, respectively.

Figures 1 and 2. Average weekly trap catch and crop injury of the three treatments in the Checkmate PTB-XL trial. Trap catch and crop injury for both Checkmate treatments was significantly less than the insecticide block. Fruit injury for the Checkmate Late treatment was lower than the other two treatments.





This new recommendation of applying the product later allows not only for improved protection of the fruit crop, but an increase in savings. We conducted a cost analysis (Table 1), and showed that using Checkmate from June 15 – September 15 saved growers $85/acre over the traditional Checkmate recommendation. In addition when insecticides are reduced, growers see an additional savings of up to $146/acre over insecticides alone.

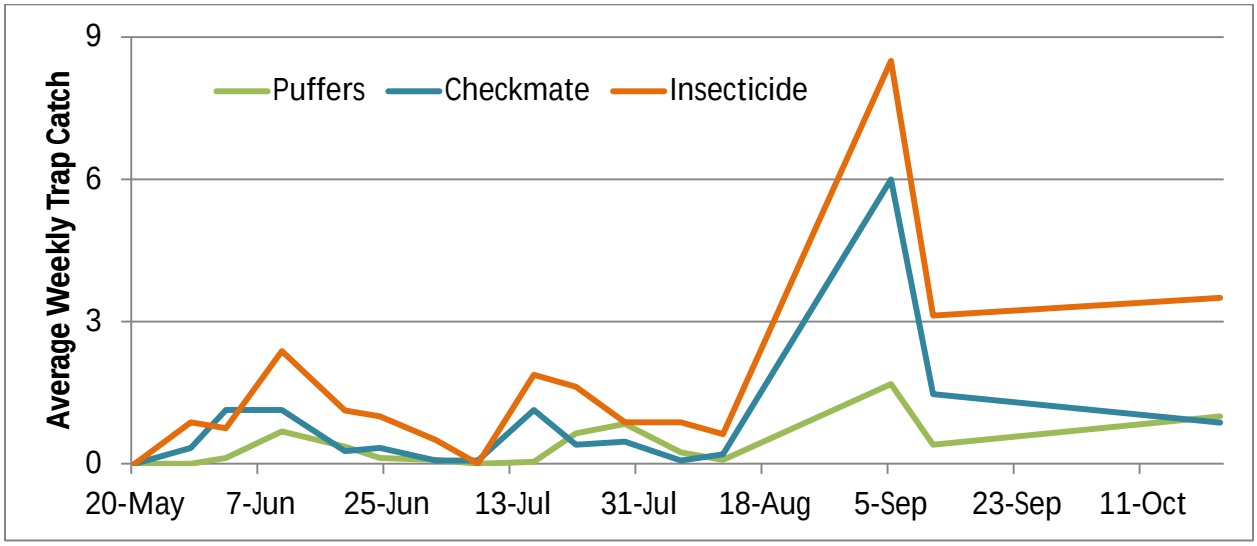
Table 1. Cost comparison of using Checkmate late (June 15 – Sept 15), Checkmate early (starting at shuck split for 90 days), and Insecticides only for managing peach twig borer. Growers that use Checkmate mating disruption are able to reduce pesticide inputs, and most switch to a "Partial Program", as shown in the middle row.

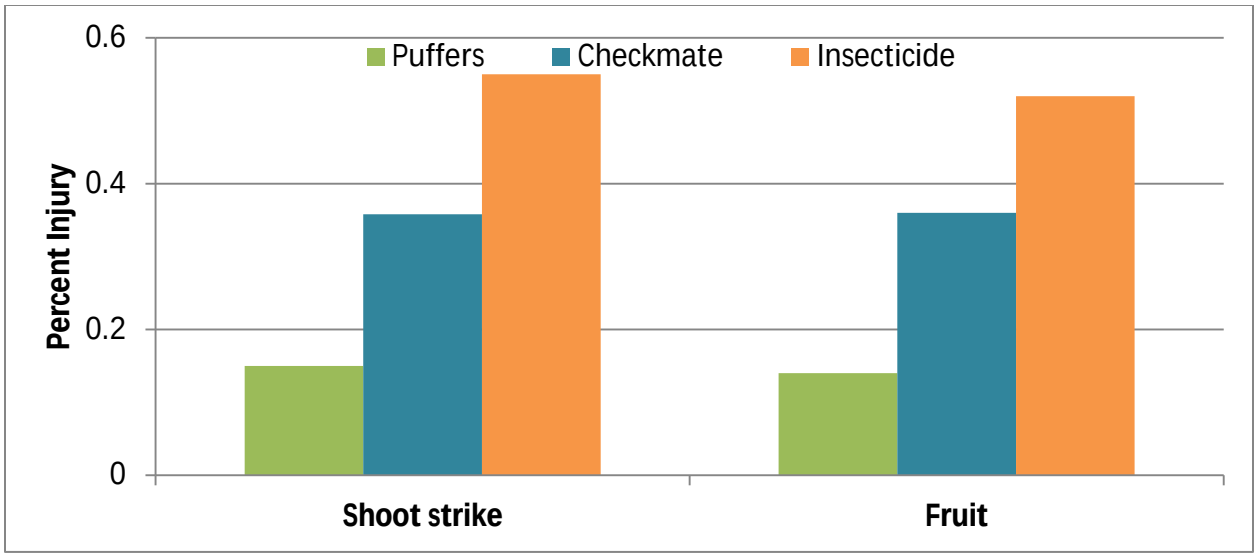
	Checkmate ($100/acre)		Insecticides Only
	Applied June 15	Applied at Shuck Split Stage	
Full spray program:	$379	$464	$355

dormant spray ($60/acre), bloom spray ($40/acre), plus 3-5 cover sprays			
Partial spray program: dormant plus 1-3 covers	$169	$254	$315
No sprays	$109	not possible	not possible

For the Puffer trial conducted in Utah County, the results showed that the Puffers work as well as the Checkmate option, where trap catch and injury were similar (Figures 3 and 4). The Puffers, however, will provide a savings in labor of $32/acre due to the savings in time to hang the devices.

Figures 3 and 4. Average weekly trap catch and crop injury of the three treatments in the Puffer trial. The Puffers performed the best in reducing trap catch numbers and crop injury.





In late July 2014, Marion provided a demonstration and update of the Puffer and Checkmate projects to growers attending the summer field meeting (40 growers). Copies of the fact sheet were distributed again. In winter 2015, Marion will present the results to two fruit grower meetings (attendance for each meeting ranges from 65-85 growers), and in spring, will include an article in the Fruit IPM Advisory (subscription of 7,000). This information will also be incorporated into the 2015 edition of the Intermountain Tree Fruit Production Guide.

GOALS AND OUTCOMES ACHIEVED

From a survey of tree fruit growers conducted in 2010, we know that approximately 30% of Utah's 1,700 acres of peach production is currently under mating disruption, and that most growers are aware of this low-spray option for managing peach twig borer. We found that farms using mating disruption have been able to reduce pesticide use by over 76%.

In late summer 2014, Murray conducted an anonymous, online survey of 80 fruit operations. The survey included questions about knowledge of mating disruption, use of mating disruption in 2013 and 2014, and expected use in 2015, and use of the fact sheet. The outcomes we saw from this project include:

1. **Increased use of mating disruption for peach twig borer in Utah, and decreased pesticide use**. From the survey, we found that due to the fact sheet and training sessions, 88% of growers had a clearer understanding of how mating disruption works, on what type of orchard it could be used, and how to implement it successfully. The survey also revealed that the use of mating disruption on Utah peach farms increased by 10% from 2013 to 2014, and that 27% of respondents plan to implement or expand mating disruption on their farms in 2015. This potential increase from 2013 to 2015 equates to an additional 410 acres, which means that 53% of the potential peach acreage in Utah is using mating disruption. We have shown in Table 1

that the cost of using mating disruption is less than or almost equal to a full spray program, and the trickle-down effect of its use means a decrease in the application of pesticides. This in turn means less human exposure to pesticides and fewer chemicals entering our groundwater.

2. **Greater yield (and profits) due to improved use of mating disruption**. The survey found that of those already using Checkmate PTB-XL mating disruption, 48% reported losses in excess of 10% in the year 2013. Over half of those farms said that they plan to change their practices to the new application recommendation for 2015, which can bring losses down to less than 2%. This amounts to a potential revenue benefit of approximately $400-600/acre. The on-farm demonstrations provided a clearer picture for these growers and will help them to improve their practices.

3. **Potential savings in materials and labor costs**. The Puffer mating disruption option (once it is registered) will save growers labor costs because it is applied at 1.2 units per acre as opposed to 200 per acre, and can be deployed by one person on a 4-wheeler. This project showed that a crew of two takes a full day to hang hand-applied dispensers on 35 acres, whereas those same two take just 1-2 hours to hang Puffers in the same acreage, resulting in a savings of approximately $32/acre. The Puffer product is expected to be available in 2016.

BENEFICIARIES

This project benefits the peach, nectarine, and apricot operations in Utah that are 5 acres in size or larger. This totals 1,700 acres, valued at $3.04 million, and represented by 80 operations. Peach twig borer is the top economic pest of these crops in Utah. Larvae tunnel into succulent shoots and into ripening fruit, causing terminal dieback and losses in yield. For those growers using insecticides, it requires 5 or more applications to protect their fruit. Pesticide use has created concerns for contamination of resources, human exposure, and loss of ecosystem diversity, especially loss of pollinators. Mating disruption is slowly being adopted by Utah peach farms, leading to reduced reliance on pesticides. For these growers, this means improved environmental, social, and health benefits, opportunities for niche marketing, and costs savings from $32 - $85/acre.

LESSONS LEARNED

This project has resulted in a revision of the recommendations for using Checkmate PTB-XL in Utah. This change will help growers to save money and better protect their crop. Because of our work on this project, the manufacturer of the Puffer product (Suterra LLC) is now in the process of registering the product for use by fruit specialty crop growers in the U.S.

We are fortunate that we could test these treatment options on actual grower farms. Murray worked closely with both the farm operations throughout the process, and sent trapping and injury data

throughout the season. Both farms were satisfied with the results and appreciate the opportunity to collaborate on a research project with Utah State University.

And finally, we learned from the field day activities that specialty crop growers learn much more about topics when they can see a demonstration of a treatment option, rather than read about it. There was much interest in the new application recommendation for Checkmate PTB-XL and in use of Puffers for peach twig borer to help reduce losses and/or save on labor costs. The growers learned about their effectiveness, how they are applied, and their operation and maintenance.

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#141625

Specialty Crop Block Grant FINAL Report
UDAF Project: 141625

Project Title

Sustainable Pest Management in Greenhouses Using Biocontrol

Project Summary

Project start and end dates: November 2013 – October 2016

In 2011, the Utah IPM Program surveyed the nursery industry and found that one of the most common requests for assistance was how to use biological control. The enclosed environment of greenhouses creates a unique pest scenario that allows for releasing beneficial insects to control pests. This practice of biocontrol minimizes human exposure to pesticides, and creates a niche market that may help improve profits. Of the 136 nursery operations in Utah, this project introduced biocontrol for pest management to 49 of them (36%) through trial demonstrations and hands-on learning. By the end of this project, we determined that approximately 10% of those greenhouse operations successfully adopted biocontrol. They reported that their costs did not increase, and they reduced pesticide use by 45%. In addition, 75% of the 49 operations we reached either tried biocontrol for one pest, or were considering using biocontrol in the future. The use of this alternative pest management in the Utah greenhouse industry will allow for increased marketing options (such as plant labeling), leading to a greater profit potential.

Project Approach

The main objectives of this project were to:

1. *Demonstrate that biological control is effective in a greenhouse setting in Utah.*
2. *Provide hands-on training for the use of biological control.*

Objective 1) Demonstration

In 2014, we identified two locations to implement biocontrol demonstrations. The demonstrations were conducted in 2015-16. For each operation (A and B), we met with the head grower to determine the primary pest problems, and where the biocontrol practices could be implemented. The pests to be controlled in Operation A included aphids, fungus gnats, thrips, and spider mites. Operation B grew mostly vegetables, and the primary pest was whitefly.

Starting in March in each of 2015 and 2016, we installed blue (thrips) and yellow sticky cards within each of the selected areas in the greenhouse operations, and scouted the crops once/week with the greenhouse pest manager. For some pests biocontrols were released as a preventive measure, and for other pests, biocontrols were released when the pest threshold was reached, as determined by scouting results. The table below shows the pests and beneficials used.

Biocontrol Agents Used in Greenhouse Demonstrations. Agents were chosen for their efficacy in arid climates and their cost effectiveness.

Pest	Operation A	Operation B
aphids	*Aphididus colemanii* (parasitoid) Barley plants (to sustain *Aphididus*)	---
fungus gnats and thrips	*Steinernema feltiae* (parasitic nematode) *Stratiolaelaps scimitus* (predatory mite)	---
spider mites	*Neoseiulus californicus* (predatory mite, preventive) *Phytoseiulus persimilis* (predatory mite, curative)	---
whitefly	---	*Encarsia formosa* (parasitoid wasp)

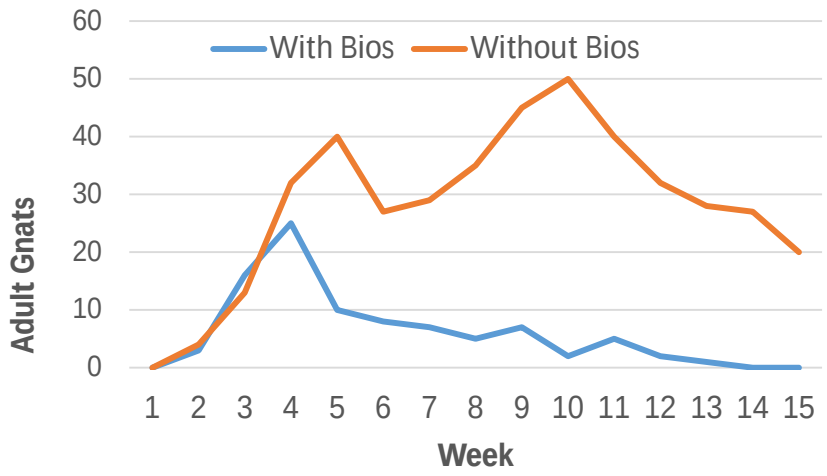
We scouted for pests throughout the release period to determine their spread and efficacy (March through late June). We measured crop injury, trap catch, prolonged presence of biocontrol organisms, and total costs of using biocontrol.

In general, the biocontrol agents that were applied in Operation A were successful. The primary pests were fungus gnats and thrips, while aphids and spider mites were minimal. Control of fungus gnats was most obvious, where gnats in the biocontrol greenhouse were reduced below threshold levels. In addition, plants in the biocontrol greenhouse were healthier, with thicker

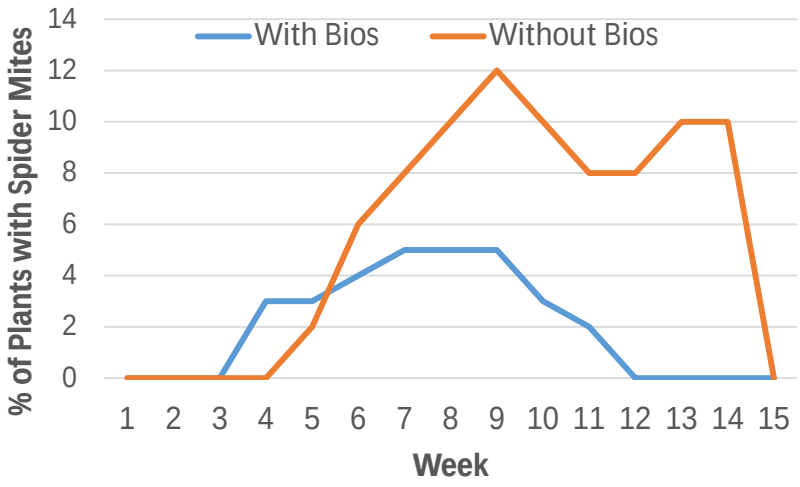
root symptoms. The biocontrols for spider mites also worked successfully (as compared to management using horticultural oil), but the overall spider mite populations in the greenhouses were not high enough in 2015 and 2016 to show significant differences.

For aphids, we found that it is not economically feasible to use biocontrol agents (parasitoids) without also using a "banker plant system." Banker plants help to maintain the population of the beneficial without having to make reintroductions. We demonstrated the barley/bird cherry oat aphid system for maintaining the aphid parasitoid, *Aphidius colemani* (hanging barley plant shown at right). The bird cherry oat aphids only feed on the barley, and provide extra food for the parasitoid. Infested barley plants can be purchased, and new barley plants with aphids are started and released into the greenhouse weekly. The plants in the greenhouse with the banker plant system remained clean of aphids during the monitoring period.

Weekly Trap Catch of Fungus Gnats with Nematode and Predatory Mite Application Versus None (Averaged over 2 years)



Percentage of Plants Infested with Spider Mites under Predatory Mite Control versus Control via Horticultural Oil (Averaged over 2 years)



Operation B grew primarily tomatoes and other vegetables, with whitefly as the major pest. The parasitoid wasp, *Encarsia*, was used for control. Unfortunately, the whitefly population was too high for the *Encarsia* alone to manage it. This particular greenhouse had too many openings to the outside, such that there was constant re-entry of whiteflies, and the *Encarsia* was escaping.

Objective 2) Training

There were several different tactics used in this project to train greenhouse operations and to get the word out about biocontrol, including seminars, workshops, newsletter articles, and a printed guide. The workshops focused on instructional training, including the economics of biocontrol, plus hands-on learning (scouting for pests and natural enemies with hand lenses, viewing insects under microscopes, releasing biocontrol agents, and performing quality checks. Each participant received a packet of handouts and references, including detailed information on the costs of using biocontrols. Two of the workshops were held in the demonstration greenhouse, Operation A, and showcased the biocontrol activities going on there. At each workshop, the attendees were surveyed for their knowledge and experience of biocontrols, and their responses were averaged over the two years.

The training and outreach activities included the following:

- February 2014: Seminar on IPM and greenhouse biocontrol at the Utah Nursery and Landscape Association's Green Conference, to an audience of approximately 150 participants.
- April 2014: Article on "Using Biocontrol in High Tunnels or Greenhouses" in the spring issue of *Utah Pests News*, reaching over 5,000 readers in Utah.
- July 2014: Half-day workshop in a Salt Lake City greenhouse that has been using biocontrol for several years. There were 18 attendees.

- April 2016: Article on "Scouting and Monitoring in Commercial Greenhouses and High Tunnels" in the spring issue of *Utah Pests News*, reaching over 7,000 readers in Utah.
- May 2015: Half-day workshop in Operation A, teaching 14 greenhouse growers. Participants were able to scout for beneficials that had been released in the earlier trial.
- May 2016: Half-day workshop in Operation A, teaching 17 greenhouse growers.
- August 2016: Production of book, *Greenhouse Biocontrol in Utah: Beneficial Insects and the Pests they Target*. This book covers concise instructions for releasing biocontrol agents in Utah, and is loaded with full-color images. Over 200 copies will be distributed to greenhouse operations and others at the Utah Nursery and Landscape Association Green Conference in January 2017.

Cover, and Sample Pages in the book, *Greenhouse Biocontrol in Utah***.**

Goals and Outcomes Achieved

To determine outcomes, we distributed a baseline survey, and also surveyed the audience of the workshops. The baseline survey determined number of pesticide sprays, level of biocontrol use, and amount of pest monitoring in greenhouses. It was filled out anonymously by the 150 attendees of the greenhouse biocontrol presentation at the 2014 Utah Nursery and Landscape Association Green Conference, resulting in 45 usable responses from actual greenhouse operations. We used data from the workshop surveys to determine changes in behavior from the baseline. At the end of the project, we contacted the 49 operations that participated in the workshops to determine adoption of biocontrol, and were able to get information from 36 of them.

Pertinent Outcomes

1. 204 people were directly reached by this project, and 12,000 were reached indirectly.
2. In the baseline survey, respondents said that they do not trust biocontrol because it is not effective (67%), they do not understand it (42%), or it is too expensive (45%).
3. Of the workshop attendees (49), we found that:
    a. Before the workshops, 50% were familiar with the idea of biocontrol, but most (90%) did not know how biocontrol agents were used.
    b. After the workshops, 75% agreed that when used properly, biocontrol is an effective option for pest control.
    c. After the workshops, 83% confidently understood the beneficials for controlling aphids, fungus gnats, thrips, and whitefly, and how to apply them.
    d. After the workshops, 76% felt that the use of biocontrol would not be more expensive than chemical control.
4. By the end of this project, 10% of the operations that attended the workshops reported that they used biocontrol successfully from start to finish.
    a. These operations were able to reduce the number of pesticide sprays from an average of 11 applications to 5 per crop cycle (consisting of preventive sprays and clean-up sprays), which is a 45% reduction.
    b. These operations reported no increase in cost, and 100% planned to continue the biocontrol to help protect workers and avoid re-entry intervals into the houses.
5. By the end of this project, a majority of operations (75%) reported that they have "experimented" with biocontrol for one pest, and/or that they plan to use biocontrol in the future. The most common experimental practices included nematodes for fungus gnats and predatory mites for spider mites.
    a. A majority of the operations (77%) changed their monitoring practices and have started conducting regular monitoring using visual inspections, sticky traps, and other techniques, all of which are important pre-cursors to a successful biocontrol program.

Beneficiaries

The majority of Utah greenhouses will likely not adopt biocontrol a lone pest management practice due to the fact that they do not deal with heavy pest pressure. The pest pressure is low due to the number and type of crops and the quick crop turnover. However, we have shown that most Utah operations can successfully adopt partial biocontrol. We helped to clarify the growers' common barriers to this adoption by providing hands-on training (including economics of biocontrol), and by demonstrating efficacy.

This project was able to reach 49 people in the commercial greenhouse industry (representing 36% of all nursery operations in Utah), and an additional 12,000 in the

general Utah public. Based on the 2011 UDAF Agriculture Statistics and Annual Report, the approximate value of these operations is $46 million. Major pests that affect greenhouse crops include aphids, thrips, fungus gnats, whiteflies, and spider mites, with thrips being one of the most economically damaging. Feeding by these pests can cause thousands of dollars in losses to an individual grower, but repeated pesticide applications results in human exposure, loss of time in the greenhouses, and the possibility of pest resistance. By using biocontrol as an alternate and effective pest management strategy, the operations targeted by this project can safely produce healthier plants and potentially fill an "organic" niche that can result in increased profits.

Lessons Learned

- We found that the best way to implement biocontrol in Utah operations is to focus on the most common and easiest to manage, such as fungus gnats, thrips, and spider mites.
- Although, one of the biocontrol "demonstrations" did not work (*Encarsia* for whitefly in Operation B), we gained valuable information. It showed the importance of preventing entry of pests from outside (through vents and doorways), and of when to decide to use biocontrol, as it will not work when the pest population is too high.
- This project did not reach high tunnel growers for a variety of reasons. One is that the crop cycle of greenhouses and high tunnels is very different, making it essential that they be addressed as separate audiences. Another is that the pest complex for each scenario is different, and the movement of pests into and out of high tunnels is a challenge. For these reasons, this project focused only on commercial greenhouse operations.
- We were able to show good results of changes in behavior and attitude by getting baseline data.

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#141620

Final Performance Report

Project title: Evaluation of new products for management of fire blight in apple and pear orchards in Utah

Principal Investigator: Claudia Nischwitz, Associate Professor and Extension plant pathologist, Dept. of Biology, John Takemoto, Dept. of Biology, Utah State University, Logan, UT 84322

Activities performed:

Fire blight trial 2014:

In 2014, we relied on natural infections for the fire blight trial at the Kaysville research farm. We had eight treatments applied to three apple varieties (Gala, Golden and Fuji). The treatments consisted of untreated control, streptomycin, Kasumin, copper soap-based product (1%), copper soap-based product (0.5%), copper soap-based product (0.5%) plus an experimental product (developed by Dr. Takemoto and his team), streptomycin plus an experimental product (developed by Dr. Takemoto and his team), and copper soap-based product (0.5%) with additional treatments of the copper soap-based product (0.5%) every two weeks to prevent foliar infections. The copper soap product was included as an alternative to antibiotics and had been reported as efficacious in other states. Dr. Nischwitz and her field technician applied the treatments during full bloom and monitored the trees for infection from may until August. @014 was a very low fire blight year and due to good clean-up of infected branches in 2013 we did not get any fire blight infections and treatments could not be evaluated for efficacy. The trees and fruit were evaluated for phytotoxicity especially of the copper soap-based product and the experimental product. Copper products have been reported to cause russeting on sensitive apple varieties. At the concentrations we used no russeting was observed.

Fire blight trial 2015:

The same eight treatments were used in 2014 were used in the trial in 2015. This time. However, Dr. Nischwitz and her field technician inoculated the trees one day prior to treatment applications to ensure infection. The trees were again evaluated on a weekly basis by Dr. Nischwitz and her field technician and the number of infected flower clusters per tree recorded.

Statistical evaluation was not possible due to the high variation of flower clusters per tree and treatment. At the time of treatment assignment for flower clusters it was not possible to tell if they were all viable and a cold snap the evening after treatment application with snow fall and hard frost killed additional blossoms. Re-assignment due to a limited number of trees was not possible.

However, we were able to determine that in the 'Gala' variety the most susceptible variety of the three tested none of the products worked well. The untreated control had 73% infection. The best treatment but with a still unacceptable control rate was streptomycin with 68%. None of the copper soap product treatments worked with infection rates ranging from 79-98%. The variety 'Fuji' had the lowest number of flower clusters and is the least susceptible to fire blight of the three varieties. Streptomycin was the best performing product with an infection rate of 29%, followed by Kasumin and streptomycin with experimental product with 36% infection each. The value for streptomycin with the experimental product is based on one tree with 212 flower clusters. The other 'Fuji' trees in this treatment had zero or one flower cluster each. The 1% copper soap performed better as well as Kasumin in 'Fuji' with an infection rate of 36%. There were insufficient flower clusters for an evaluation of the 0.5% rate. In the third variety, 'Golden' the results Kasumin (9.6% infection) being better than streptomycin (21%). The coper soap products did fairly well as well with 17% (based on one tree) for 0.5% copper soap and 32% for the 1% copper. Interestingly, in all three varieties the 0.5% copper treatment with additional copper applications was the worst with an infection rate of 66-81%.

Fire blight trial 2016:

In 2016, Dr. Nischwitz and her field technician inoculated the trees 24 hours prior to treatment application at full bloom. The Utah State University fire blight forecasting level for that day was "Extreme". This time 10 flower cluster per tree were flagged and inoculated to avoid the problems from 2015. We had five chemical treatments and one untreated control. The chemical treatments consisted of streptomycin, Kasumin, copper soap-based product (1%), copper soap-based product (0.5%), copper soap-based product (0.5%) plus an experimental product (developed by Dr. Takemoto and his team) and copper soap-based product (0.5%) with additional treatments of the copper soap-based product (0.5%)

every two weeks to prevent foliar infections. On the day of treatment application the forecasting system had an "exceptional" risk level for fire blight infection indicating that any wetness of flowers could lead to an infection regardless of the fire blight history of the orchard. Dr. Nischwitz and her field technician evaluated the trees for disease incidence and phytotoxicity once a week. The trees were monitored for three weeks for disease incidence. After that infections of branches would not have been due to blossom infections. The trees were monitored for phytotoxicity of fruit and foliage until September. The treatments were analyzed for disease incidence using SAS PROC GLIMMIX program. All treatment except for the copper soap products (were significantly better than the untreated control (33% incidence) when results from all three varieties were combined. Streptomycin and Kasumin were the best with 16% incidence each. The copper soap (1%), copper soap (0.5%)and the copper soap (0.5%) with additional treatments had 21%, 25% and 32% incidence, respectively. The results confirmed that copper soap treatments at a 0.5% concentration after bloom made fire blight incidence worse compared to a single application. Single copper soap applications at full bloom reduced incidence compared to the untreated control but not to a level that would be acceptable to a grower. As in 2014 and in 2015 , we did not see any phytotoxicity on foliage or fruit from any of the treatments.

The trees were pruned and maintained every year by my field technician.

Goals and Outcomes Achieved:

The goal of this project was to determine the efficacy for chemical products registered for use in Utah to control fire blight. We showed that the antibiotics streptomycin and Kasumin worked best to control fire blight in Utah with a single application at full bloom and that the copper soap applications regardless of the concentration did not work as well as had been reported from other states. The results were presented to apple and pear growers at the field day at the Kaysville Research Farm on June 28, 206. There were approximately 35 tree fruit growers. The results will also be presented at the Utah State Horticultural Society meeting in January 2017.

Beneficiaries:

Beneficiaries of the project were apple and pear growers of Utah as well as county Extension faculty and crop consultants that provide management recommendations to growers. Due to time constraints at the 2017 Utah State Horticultural Society meeting we were not able to conduct a formal survey as planned. Most apple and pear growers already use streptomycin and Kasumin in their operations and will continue to do so. There was disappointment among the apple and pear growers at the meeting and the field day in 2016 over the mediocre performance of the copper soap but consensus among the growers was that it may be useful to prevent foliar infections later in the summer. Interest among the growers was great to explore a biological control product as an option for fire blight control in the 2017 fire blight trial.

Lessons Learned:

A lesson learned is that products that work well in one state and climate may not work as well in another, and should be tested in a trial situation before large scale recommendations to growers. Another lesson is that to ensure fire blight will occur in trials inoculations are necessary regardless of the history of the trial. A third, more indirect, lesson we learned in 2014 is that if you prune your trees well and remove fire blight you may not have a problem with the disease.

Problems and delays:

Relying on natural infections in 2014, we did not get any fire blight infections and could not evaluate the treatments. In 2015, we had high fire blight incidence but we could not be sure if the efficacy of the

treatments was affected by inclement weather that followed five hours later (it was 70F when we finished treatment applications and five hours later it was 38F and snowing).

Future project plans:
We will continue to test registered products and work with companies and scientists who are developing new products to determine efficacy. It would be beneficial for growers if they had efficacious products other than antibiotics available.

Funding expended to date:

Labor: $3,319.70
Benefits: $212.35
Travel: $1,967.47
Supplies: $505.48
Total: 6,005

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#141627

Final Performance Report

Project title: Identification of insect-vectored viruses and *Candidatus* Liberibacter and their vectors on vegetables in Utah

Principal Investigator: Claudia Nischwitz, Assistant Professor, Dept. of Biology, Diane Alston, Professor and Extension Entomologist, Dept. Of Biology and Dan Drost, Horticulture and Extension Vegetable Specialist, Dept. of Plant, Soils and Climate,, Utah State University, Logan, UT 84322

Activities performed:
Survey:
From 2014-2016, vegetable and potato fields were surveyed by Dr. Nischwitz and her field technician across Utah in Box Elder, Cache, Carbon, Davis, Grand, Kane, Juab, Morgan, Salt Lake, Utah, Washington and Weber counties from planting until the first frost killed the plants. Fields are still being surveyed at this time. Additional samples were sent in from the county offices in Garfield, Iron, Millard and Uintah counties for diagnosis.

Vegetable viruses:
Over the three years of the survey, viruses were detected in green beans, chard/beets, pepper, tomato, potato, squash (both summer and winter squash), gourd, pumpkin, zucchini and sweet corn. Curtoviruses varied over the three years. We saw a lot of tomato and pepper samples in 2014 across the state but fewer samples in 2015. In 2016, Curtoviruses came in later (mid-July) and caused a lot of damage in tomato (40% yield loss in some tomato fields) and gourds (25% yield loss in a commercial field). We did not see Curtoviruses in peppers in 2016 even if they were right next to infected tomatoes. It was the first time that we detected Curtoviruses in green beans and chard/beet (one sample each) in

Utah. Dr. Nischwitz and undergraduate student workers conducted PCR (polymerase chain reaction) to confirm Curtovirus infection.
Another major virus we found in all three years was Tomato spotted wilt virus (TSWV). TSWV was always considered a minor problem in Utah coming in on transplants from out of state but not being established in the farmscape Two big outbreaks occurred during the time of the grant that clearly indicated in was established in the farmscape. In 2014-2015, one farm lost 20% of their tomato and pepper plants to TSWV. Testing over 350 weeds, alfalfa and perennial ornamentals from gardens close to the greenhouse where the transplants were produced, we were able to find the source plants in the garden. The infected plants were removed and the grower had no problem with TSWV in 2016. In 2016, a garden center from central Utah sent tomato transplants he purchased for resale that were dying for diagnosis and they tested positive for TSWV. The gardencenter discarded thousands of plants and notified the transplant producer who is in-state. A third virus causing major problems in Utah was Watermelon mosaic virus (WMV) in cucurbits with yield losses of 10-25% in 2014. WMV was not a big problem in 2015 and 2016. It may be due to reduced aphid populations due to weather and growers following recommendations. Outbreaks of Alfalfa mosaic virus (AMV) occurred in tomatoes, potatoes and pepper. AMV was found in tomatoes and peppers in Davis county and in potatoes in Cache county. The potatoes had been planted adjacent to an alfalfa field and aphids transmitted the virus to the potatoes. The yield loss from AMV in potatoes was 10-15% because infected plants produce symptomatic tuber and were removed.
Seedborne viruses were also of concern. Tobacco mosaic virus was found in tomato plants that was traced back to contaminated seed. The first occurrence of Potato virus Y NTN strain was found in Cache county originating from infected seed potatoes. This is the most severe strain because it causes brown rings on potato tubers that extend into the flesh making potatoes unmarketable. In 2015 and 2016, sweet corn was infected with High plains virus. The virus can be transmitted by wheat curl mites from infected wheat to corn. However, no wheat curl mites or infected wheat was found near the corn field. Grow out tests of leftover seed conducted in a greenhouse by Dr. Nischwitz and student workers showed that the infections originated from seed. The infection rate was about 1.5% which is fairly low but a lot higher than what has been reported in the literature. The main concern is not immediate yield loss but establishment of the virus in the farmscape causing significant yield loss in wheat and corn in the future.
A few minor outbreaks of new viruses in Utah were identified. Pepper mottle virus and Tobacco etch virus were found in peppers in Davis county and Tobacco streak virus was identified in yellow zucchini also in Davis county. Even though the outbreaks were confined to individual farms, it is important to know they are present to prevent the spread and establishment in the state.

All the samples for virus testing were processed by student workers, Dr. Nischwitz and her field technician. Dr. Nischwitz conducted the ELISA tests. Molecular confirmation of the newly reported RNA viruses was also conducted by Dr. Nischwitz

Candidatus Liberibacter*:*
The spread of the non-culturable bacterium *Candidatus* Liberibacter solanacearum expanded every year since its first discovery in 2013. The bacteria were detected in tomatoes in Washington county in 2014 and 2015, in potatoes in 2014 and 2015 in Carbon county and in Davis county. Psyllids collected in October 2015 in Cache and Box Elder counties did not carry the bacteria *Candidatus* Liberibacter. The most common occurrence of the bacteria in 2014 and 2016 was in bell peppers in Davis county. Dr. Nischwitz and her field technician were evaluating yellow sticky cards from potato fields for the presence of potato psyllids. Her student workers conducted PCR to determine the presence of the bacteria in plants and psyllids. It is unclear if there is an increase in potato psyllids and *Candidatus*

Liberibacter in the last few years or if our survey and presentations and fact sheets on the topic made growers and Extension agents more aware of the symptoms.

Goals and Outcomes Achieved:

The goal of this project was to determine the presence of viruses that affect vegetables in the Utah and make growers aware of management options to minimize yield and quality loss. A second goal was to determine the presence and distribution of the non-culturable bacterium *Candidatus* Liberibacter solanacearum in Utah. We identified five viruses in Utah that were reported for the first time and identified two new hosts for *Candidatus* Liberibacter solanacearum in Utah. In addition, we determined the establishment of TSWV in a couple of locations in the farmscape and were able to remove the source in one location. We increased the knowledge of the pathogens present in the state, the symptoms they cause, and management options growers have. There was no significant yield loss in cucurbits after growers started following recommendations of crop rotation and the use of resistant cultivars to manage Watermelon mosaic virus increasing income by $600—1,500 per acre (based on previous 10-25% yield loss). We also had more samples submitted by growers and county Extension faculty of virus symptomatic plants and were able to provide recommendations and minimize yield loss or distribution of infected plants.

Two fact sheets on Candidatus Liberibacter on potato and pepper have been published as well as a newsletter article on the topic. In addition, I published newsletter articles on High plains virus in corn, Tobacco streak virus in squash and Alfalfa mosaic virus in potato. A survey on adoption rates was conducted at the Utah State University Urban and Small Farms conference. Unfortunately, due to a computer glitch with the survey program, the grower answers did not get recorded. 100% of the large and small vegetable producers (30 growers) I talked with at the conference and in field visits indicated they would implement some or all the recommendations. During field visits in summer 2016 50% had already implemented recommendations including better weed control and use of resistant varieties. Talking with Master gardener class attendees, about 25% indicated they would not compost infected plants or produce. In the next few years the adoption rate will increase as commercial growers and home owners see the benefit (higher yield, higher quality produce) other growers and home owners have after implementing recommendations.

Beneficiaries:

Beneficiaries of the survey were approximately 600 large and small commercial growers including underrepresented groups and minorities, home owners, county extension faculty and crop consultants.

Lessons Learned:

Due to weather changes in the last two years we learned that now not only viral diseases cause problems in Utah but also more bacterial and fungal diseases that had not been a problem during the usually dry summers in Utah in the past. Another lesson learned is that more and more viral diseases we see are coming from infected seed and imported transplants from out-of-state.

Problems and delays:

One of the problems we encountered was to determine where nurseries bought transplants that were infected with viruses or bacteria in from and in cases in which we did get the information the transplant growers were not interested in help solving the problem.

A second problem is to convince growers that the cheapest vegetable seed may not be best if the seed company does not test for the presence of viruses and other pathogens and that it may cost them more in the long run from yield loss due to infected plants.

Future project plans:
We will expand the vegetable disease survey to include fungal and bacterial pathogens as well as survey produce at grocery stores (you can buy TMV or TSWV infected heirloom tomatoes frequently at stores). We will educate home owners through the Master gardener program and newsletters about safely discarding spoiled produce to minimize accidental introduction of new plant diseases into the state.

Funding expended to date:

Labor: $10,406.55
Benefits: $699.65
Travel: $3,377.38
Supplies: $11,631.90
Total: 26,115.48

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Specialty Crop Block Grant (Sponsor #UTG141626)

November 10, 2016

Index:

PROJECT TITLE

Coping with the Cold: Conditioning Transplants for Better Survival in Tunnels and the Field

Project Summary:
With the increasing demand for early produce, vegetable growers often transplant crops earlier in the year to produce early fruiting and harvest. One risk associated with early planting dates is exposure

to more cold weather conditions. In the arid West, plant growth is influenced more by extreme day-night temperature fluctuations, particularly in the early spring. From our experience and in consultation with local growers, some plant losses (10-15%) occur when warm weather crops like tomato and peppers are planted in mid-March in high tunnels (HT) and when these crops are commonly transplanted early out in the field. Growers regularly report some frost/freeze damage that does not completely kill the plants but causes sufficient leaf damage that slows up growth (see photo's 2a and 2b). This project evaluated the impact of chilling and partial frost/freeze conditions on plant establishment, early growth and productivity of tomato, pepper, and melons when grown in HT or under field conditions.

Warm season crops like tomatoes, peppers, and melons grow best at temperatures between 60-90°F. At temperatures below 50°F, warm season vegetables are subject to chilling injury which slows growth and leaf expansion. At temperatures less than 40°F, tomatoes, melons, and peppers are very chilling sensitive and growth is severely reduced. For early planted peppers in HT and outdoor transplanted (or seeded) melons, very cool conditions are known to impact crop uniformity and plant populations. Since uniformity and plant stands both impact productivity, exposure to cold condition results in the loss of earliness. While tomato tolerates some cold, as temperatures approach the mid-30's damage does occurs. None of these species can tolerate temperatures below freezing.

Plants exposed to freezing temperatures may be killed outright, may have partial leaf loss or may tolerate the cold (Photos 1ab & 2ab). It is not always clear why some plants are damaged and others are undamaged. It has been know that plants can be "conditioned" or "hardened" prior to transplanting in order to survive the variable environmental conditions of the field or tunnel. Conditioning is reported to help plants recover from cold stresses encountered during transplanting or early growth periods and plants are less likely to be damaged. Conditioning can be accomplished by mechanical approaches, through nutrient or water management, or by temperature regulation. When "conditioning" plants, the treatments should improve establishment, ensure they grow vigorously, and that early yields are not delayed. Better recommendations on how to condition plants are required to ensure that optimal stands are achieved (in field or tunnels), that early growth is optimized, and that yields are comparable to non-stressed conditions.

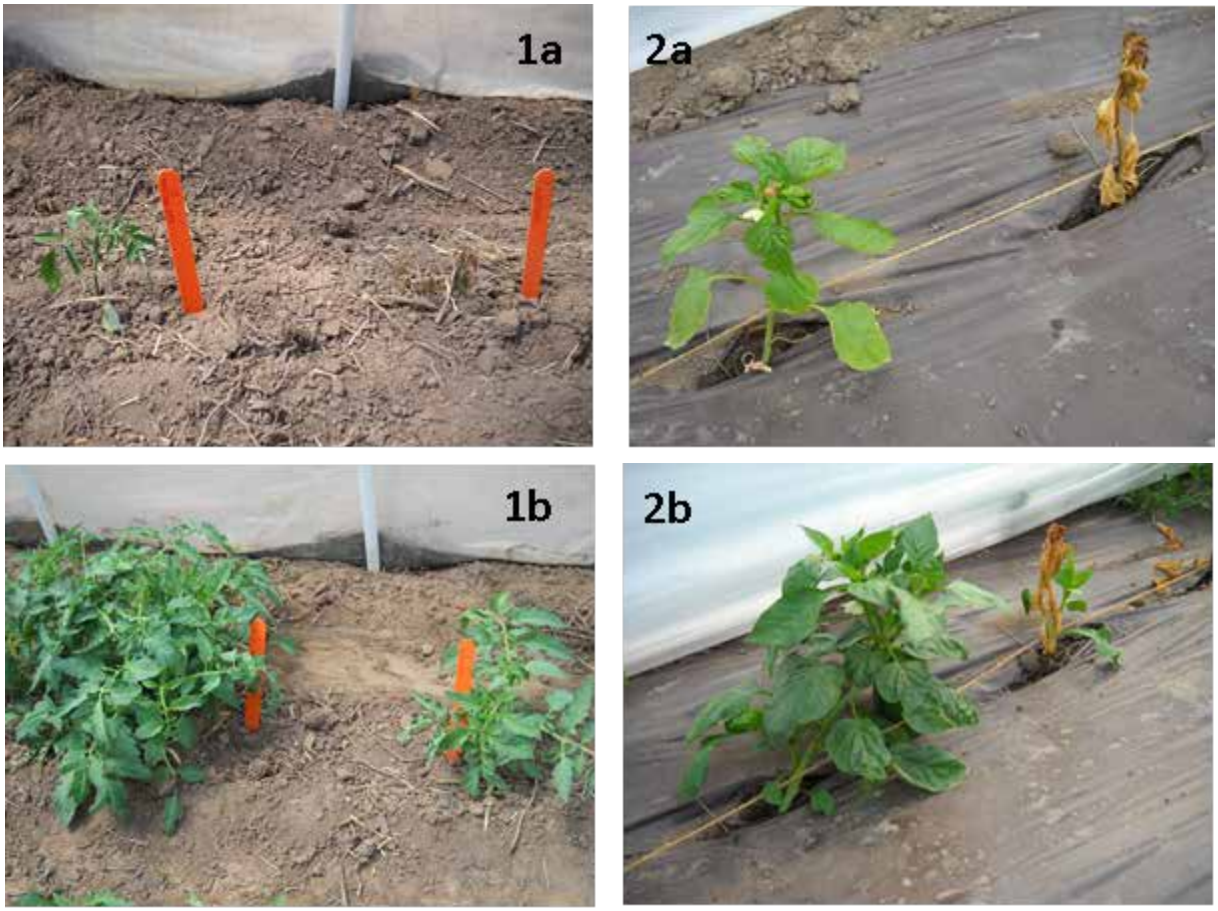
The primary objective of this project was to better understand how cold conditions (in the field or high tunnel) impact early plant growth and development. In tunnels it is common for plants to experience very cold conditions after transplanting which result in noticeable cold injury. In the field, cold generally does not impact transplants when planting occurs at the optimal time for the location but does impact crops that are planted earlier. Utah growers require better recommendations on how to condition plants to ensure that optimal stands are achieved (in field or in tunnels) so that early growth is maximized and that early yields are comparable to non-stressed conditions.

The specific goals and objectives of this research project were to:

Goals and Objectives:

1. Expose a variety of warm season vegetable transplants to different cold conditions and evaluate their tolerance and recovery from cold exposure.
2. Evaluate common "conditioning" techniques to improve tunnel or field survival.
3. Use the collected information to assess if a change in plant production practices is warranted (economical or practical) under field and HT conditions. Use this information to create production guides for Utah's vegetable growers.

Photo 1a & 1b (April 22, 2013). High tunnel grown tomato and peppers; undamaged (left) and frost damaged (right) growth. Plants were damaged but not dead. **Photo 2a & 2b** (May 20, 2013) Re-growth of frost damaged plants. Development and maturity was significantly delayed.



PROJECT APPROACH

Goal #1: Expose vegetable transplants to different cold conditions.

Transplants of tomato (*Lycopersicon esculentum* L), watermelon (*Citrullus lanatus* L), cantaloupe (*Cucumis melo* L), and pepper (*Capsicum annuum* L) are grown in a climate regulated greenhouse at Utah State University. Plants were seeded in 72 cell trays and grown for 4 (melons) or 8 weeks (tomato/pepper) prior to exposure to various cold treatments. Transplants were then exposed to various cold treatments which mimicked possible field or tunnel conditions at night. Temperatures evaluated were 60°F (control-greenhouse), 50°F (minor chilling), 40°F (modest chilling) and 30°F (minor frost). Transplants were exposed to cold condition for different durations (2, 4, or 8 hrs) in climate regulated growth chambers. After each cold period, transplants were returned to the greenhouse and then re-exposed to these conditions for 1, 3 or 7 days simulating potential field conditions commonly experienced in the spring. After the final chilling exposure, plants were moved back into the greenhouse and grown for 4 weeks. We monitored plant survival and growth (height, leaf emergence and area, biomass, and quality).

Findings:

Simulated night time temperature exposure for different durations (hours and days) had a consistent effect on transplant survival collected 4 weeks after treatment (Table 1). For all vegetable exposed to 30F, plants did not survive those conditions. Tomato (100%) and pepper (91%) survived exposure to 40F better than melons (59-65%). Repeated exposure to 50F had no effect on transplant survival for any of the vegetables tested. For all the species, as exposure temperature decreased, survival decreased quadratically, with the largest reduction in survival at the lowest temperature.

Table 1. Plant survival and growth 4 weeks after exposure to various chilling temperatures (30-60F) for different durations of exposure (2-8 hrs.).

	Tomato		**Pepper**		**Watermelon**		**Cantaloupe**	
	% survival	Dry Wgt (g)	% survival	Dry Wgt (g)	% survival	Dry Wgt (g)	% survival	Dry Wgt (g)
60F	100	5.12	100	3.7	100	9.92	100	9.51
50F	100	5.08	100	3.53	98	9.01	97	8.58
40F	100	4.83	91	3.08	65	6.49	59	6.43
30F	0	1.57	1	0.99	0	1.77	0	1.83
	Q*	L*	L*Q*	L*	L*Q*	L*	L*Q*	L*
2 hr	100	4.95	100	3.34	100	7.41	100	7.18
4 hr	94	3.28	95	2.24	92	5.12	93	4.92
8 hr	81	3.26	79	2.02	69	4.74	68	4.65
	L*	L*	L*	L*	L*	L*	L*	L*
F * hr	ns	ns	ns	ns	ns	ns	ns	ns
F * days	ns	ns	ns	ns	ns	ns	ns	ns

Four weeks after exposure, there was a linear decrease in plant dry weight when all vegetables were exposed to colder treatments. The dry weight measured for the 30F treatment was related to the weight of the plant prior to its exposure to freezing conditions. These results show that repeated exposure over several days has a negative effect on future crop performance that would lead to lasting changes in growth and productivity.

When vegetable transplants were exposed to cold for longer durations (2, 4, 8 hr.), there was a linear decreases in survival and dry weight. Plants seem to be able to cope with shorter exposure durations which warrants further evaluation.

We did not find any interactions between exposure temperature (60-30F) and duration (2, 4, 8 hr.) or to differences in the number of days plants were exposed to cold (1, 3, 7 days). This tells us that it is the actual cold temperature that is critical and that longer durations of exposure are more harmful. In general, all of the warm season vegetables tested are sensitive to cold and if possible, protective measures to minimize the amount of cold and the level of cold is more important if high survival and good early plant growth is desired.

Goal #2: Evaluate Common "Conditioning" Techniques.

Four conditioning treatments were evaluated to determine how plants tolerate stress.

Treatments included mechanic, nutritional, water, and cold temperature stresses which are reported to improve plant survival after transplanting. These were compared to a control (no-stress) to determine how conditioning impacts plant establishment in tunnels or the field. Conditioning treatments for all experiments were the same and once transplants achieved their appropriate developmental stage they were exposed as follows:

1) Mechanical conditioning (brush for 7 days; 2x/day; 4 strokes per time)
2) Nutritional conditioning (low NPK – 1 fertilization per week; 50% of control)
3) Water-stress conditioning (50% less water per day; for 7 days)
4) Temperature conditioning (chilling @ 50°F; for 7 days)
5) Control (no treatments, daily watering; recommended NPK (3x/week))

Replicated flats of tomato, pepper, and watermelons were grown in a heat greenhouse (75F/65F) before applying the conditioning treatments. Tomato and peppers were always grown for 8 weeks and watermelons were 4 weeks before conditioning. Once plants achieved a size appropriate for transplanting, the different treatments were initiated for one week (7 days). Plants were then planted in high tunnels or commercial fields in either the spring (cool, early conditions) or summer (hot, stressful weather conditions). At various times after transplanting, survival and growth potential (height, dry weight, etc.) was determined.

Findings:
Five separate field based research trials were organized and conducted in 2014-2015 and these are summarize below. Field trials evaluated how various plant conditioning treatments would impact survival and growth in real-world conditions.

Trial #1: Conditioned tomato and pepper transplants grown and then transplanted to four (replicates) high tunnels in Logan. Tunnels were planted on April 7, 2014. Plants were evaluated for 6 weeks for survival and growth. All conditioning treatments preformed equally well to the control (Table 2). There was no effect of conditioning on transplant survival or on plant growth.

Table 2. Influence of various conditioning treatments on tomato and pepper survival and dry weight when transplanted into high tunnels. Data collected 46 days after planting.

Conditioning Treatment	Tomato		Pepper	
	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)
Control	100	14.47	100	1.40
Mechanical	98	13.00	100	1.80
Nutritional	100	14.94	100	1.49
Water Stress	100	9.29	98	1.70
Temperature	98	10.10	100	1.41
	ns	ns	ns	ns

Trial #2: Conditioned tomato, pepper and watermelon transplants grown and then transplanted in mid-May and late July 2014 under field conditions in Logan. Planting dates represent normal spring (Table 3) and hot mid-summer (Table 4) conditions when excessive temperatures are

expected. May transplants were grown for the full season as both growth and yield assessed. For the July planting we only assessed establishment and early growth.

Table 3. Influence of transplant conditioning treatments on tomato, pepper and watermelon survival and dry weight when field transplanted in the spring (May).

Conditioning Treatments	Tomato* -May 15		Pepper* - May 16		Watermelon* - May 20	
	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)
Control	100	18.61	98	4.31	100	10.12[ab]
Mechanical	100	17.08	100	4.50	100	11.73[a]
Nutritional	100	15.91	100	3.66	100	8.17[bc]
Water Stress	98	15.96	100	4.60	100	10.60[ab]
Temperature	100	19.57	98	4.02	100	6.25[c]
	ns	ns	ns	ns	ns	

* data collected 45 days after transplanting date.

Table 4. Influence of transplant conditioning treatments on tomato, pepper and watermelon survival and weight when field transplanted in the summer (Jul-Aug).

Conditioning Treatments	Tomato* - Jul 8		Pepper – Jul 18		Watermelon – Aug 1	
	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)
Control	100	12.12[a]	98	11.93	100	30.05[a]
Mechanical	100	11.25[ab]	100	11.79	100	24.43[ab]
Nutritional	100	11.36[ab]	100	10.80	100	22.07[b]
Water Stress	98	11.26[a]	100	9.48	100	23.49[b]
Temperature	100	7.47[b]	98	11.60	100	11.85[c]

* data collected 17 days later; others collected 33 days after transplanting dates.

Findings: There was no difference in survival between the conditioning treatments for all crops planted either in the spring or summer. However, in general, transplants mechanically conditioned tended to be larger than all other conditioning treatments when plants were planted both early and late in the season. Plants subjected to 7 days of cold prior to planting were significantly smaller for tomato and watermelon particularly when planted during the hottest part of the summer. Peppers seem to be less effected than tomato or watermelon to the various conditioning treatments.

Trial #3: Conditioned watermelon transplants grown and then transplanted on two cooperator's farms in Utah (Table 5). Early melons were transplanted in Hurricane, Utah on April, 11 2014. Plants were evaluated after 4 and 12 weeks for survival, growth and yield. A similar trial was set up in Green River UT but was planted on May 10 but only establishment and early growth was evaluated. Late melons were transplanted on June 6.

Table 5. Influence of transplant conditioning treatments on watermelon survival and stem length when field transplanted in commercial production fields during 2014.

Conditioning	St George – Apr 11		St George – Jun 6		Green River – May 10	
		Stem		Stem		Stem

Treatments	Survival	Length (in)	Survival	Length (in)	Survival	Length (in)
Control	96	41.7[a]	96	36.7[ab]	96	29.2[ab]
Mechanical	96	43.1[a]	100	38.3[ab]	92	35.2[a]
Nutritional	100	40.7[a]	96	40.8[a]	96	34.8[a]
Water Stress	96	37.7[ab]	100	39.4[ab]	92	33.6[a]
Temperature	100	34.3[b]	72	31.8[b]	92	30.5[ab]
Grower Std	100	36.8	96	37.4	96	30.7

Plant survival measured one month after transplanting were not different between the various conditioning treatments for any date or location in 2014. However, vine length (measures of early vigor) of control, mechanical and fertilizer conditioned transplants were longer than plants conditioned by temperature stress. Some of the conditioning treatments performed better than the grower's plant production methods. Later in the season we counted fruit number per plot, measured fruit length and width (proxy for yield) and these showed that there was no differences in yield performance between the various treatments (data not shown).

Trial #4: Conditioned tomato and pepper transplants grown and then transplanted to three (replicates) high tunnels in Logan in 2015. Transplants were set out in early April and evaluated for survival and growth about 6 weeks later.

Table 6. Influence of various conditioning treatments on tomato and pepper survival and dry weight when transplanted into high tunnels. Data collected 42 days after planting.

Conditioning Treatment	Tomato – planted Apr 1		Pepper – planted Apr 6	
	Survival	Dry Wgt (g)	Survival	Dry Wgt (g)
Control	100	12.48[ab]	100	2.36[a]
Mechanical	98	13.54[a]	98	2.41[a]
Nutritional	100	12.23[ab]	100	2.20[ab]
Water Stress	100	11.58[bc]	96	2.12[b]
Temperature	96	9.89[c]	96	2.01[b]

Survival of tomato and peppers transplanted in high tunnels early in the spring was very good and there was no difference between the different conditioning treatments. For both tomato and peppers, conditioning with low temperatures resulted in reduced plant dry weights compared to the control and mechanical stimulation. Nutritional and water conditioned plants were intermediate in their response but still grew well.

Trial #5: Conditioned watermelon transplants were grown and then transplanted in May and June 2015 under field condition in Hurricane, UT. Field planting represented normal mid and late season planting conditions when hotter temperatures would be expected. Melons planted in Hurricane were grown to maturity alongside the cooperators planting and compared to the grower's standard practice.

Table 7. Influence of transplant conditioning treatments on watermelon survival, stem length and estimated fruit weight when field transplanted in commercial production fields during 2015.

	St George – May 26			St George – Jun 23	
Conditioning		Stem	Ave. Fruit		Stem

Treatments	Survival	Length	Wgt (lbs)	Survival	Length
Control	100	43.6[ab]	13.3	100	43.1[ab]
Mechanical	95	42.3[ab]	13.9	95	44.7[ab]
Nutritional	100	47.8[a]	13.0	95	46.4[a]
Water Stress	100	49.9[a]	13.9	100	45.4[a]
Temperature	100	46.4[a]	14.9	95	40.6[b]
Grower Std	100	45.6	9.6	95	44.7

Plant survival measured one month after transplanting were not different between the various conditioning treatments for any date in 2015. Vine length (measures of early vigor) were similar for the early plantings from all conditioning treatments and plants produced similar fruit weights. Later in the summer when planting in hotter conditions, some of the conditioning treatments (nutritional, water) performed better than cold conditioning. In general, all conditioning treatments performed as well or better than the grower standard.

Goal #3: Use this information to create production guides for Utah's vegetable growers.
In the 2016 Utah Vegetable Production and Pest Management Guide we have modified chapters to include findings from this project. The chapters including information are Chapter #1) General Vegetable Production Methods (includes transplant production), Chapter #6) Cucurbit - Melon Production, and Chapter #9) Solanaceous – Tomato, Pepper, and Eggplant Production.

In early 2015, we published an extension bulletin titles “Vegetable Transplant Production” which outlines how to grow quality transplants capable of withstanding the transition from the greenhouse to the field. The bulletin included a short section on hardening or conditioning transplants. A more extensive and comprehensive extension bulletin on “Vegetable Transplant Conditioning” is being drafted and should be available in early 2017.

Beneficiaries:

Findings were presented to vegetable growers, industry and government persons at regional meetings in Utah during the 2013-2016 period. Presentations (see below) highlighted study results and provided participants with up-to-date information on production. In informal audience surveys conducted at the workshops, attendees reported they had limited (2.1) understanding of the subjects before the presentation and very good understanding (4.2) after the presentation. When asked if they were going to “use this information”, 15% said definitely, 46% (probably) and 23% (maybe). Additional follow-up is planned for the 2017 Urban and Small Farms Conference.

Approximately 200 growers toured the USU vegetable research sites during the time of this project (see dates below). We also worked with individual growers across Utah and assessed improvements to their tomato-pepper cropping systems.

Significant Outcomes (2013-2016)

Grower Outreach (245 contacts):

Grower visits (25 grower interactions) to collect research data and assess productivity and share information. Green River, UT (6 visits); St. George, UT (8 visits); Layton, UT (5 visits); Springville, UT (3 visits); Logan, UT (primary production/research location).

Urban and Small Farm Workshop and Field Day. Workshop on Organic Production Practices with Farm Tour. Opportunity for growers to see research/outreach in action. Discussed transplant production issues and conditioning plants. 30 growers. Hurricane, Utah (April 16, 2014). http://extension.usu.edu/sustainability/htm/programs/utah-farm-chef-fork/

Kaysville Horticulture Research Field Day. 2014. Tour and discuss USU vegetable research. Exposed growers to concepts of conditioning vegetable transplants and how to use them. 65 growers. Kaysville, Utah (August 13).

Kaysville Horticulture Research Field Day. 2016. Tour and discuss USU vegetable research. Demonstrate use of vegetable transplants other new technologies. 125 growers. Kaysville, Utah (June 28).

Presentations (~1330 contacts):

Drost, D. 2014. Organic Vegetable Production. Urban and Small Farms Conference (Apr 16, 2014). Hurricane, Utah. (30 attendees)

Drost, D. 2015. Improving Vegetable Transplant Production. Urban and Small Farms Conference (Feb 18, 2015). Salt Lake City, Utah. (190 attendees)

Heflebower, R. and D. Drost. 2015. Impact of Conditioning Treatments on Melon Transplants: Field Evaluations. Urban and Small Farms Conference (Feb 18, 2015). Salt Lake City, Utah. (190 attendees)

Heflebower, R. and D. Drost. 2015. Conditioning Transplants Affects Early Growth but Not Final Productivity. American Society for Horticultural Sciences Annual Conference, New Orleans, LA. HortSci. 50(9):S322. (700 attendees)

Drost, D. 2016. Vegetable Management Guide: Updates and Survey. Urban and Small Farms Conference (Feb 17, 2016). Salt Lake City, Utah. (220 attendees)

Publications (plus download information):

Utah Vegetable Production and Pest Management Guide: 2016. Editor: C. Cannon. USU Extension. (300 printed copies: all distributed) plus 125 downloads since March 2016). https://utahpests.usu.edu/IPM/files/uploads/Publications/UT-veg-guide-2016.pdf

Maughan, T., and D. Drost. 2016. Use of Plastic Mulches for Vegetable Production. USU Extension Bulletin. (237 downloads since January 2016) http://digitalcommons.usu.edu/extension_curall/786/

Drost, D. 2015. Vegetable Transplant Production. USU Extension Bulletin. (169 downloads since April 2015) http://digitalcommons.usu.edu/extension_curall/704/

Lesson Learned:

1) Our finding show that mechanical, nutritional and water stress conditioned transplants performed as well as plants that were not conditioned. This suggests that there is little advantage to implementing these treatments. Conditioning plants (brushing, changing watering patterns, and altering nutrient additions, implementing cooling treatments) requires time and attention to detail. The can be costly and if the transplant grower gets it wrong, could have serious long-term consequences for the crop being grown. Since the CONTROL treatments in this study always performed as well as any of the conditioning treatments, we are advising growers that they don't need to harden or condition plants prior to planting out into a variety of field conditions.
2) We did note that cold condition should not be used as a hardening off treatment for

tomatoes, peppers or melons. All of our results show that cold stress prior to planting transplants into cold or warm field environments significantly slowed growth and may contribute to lower productivity.

3) Finally, growers indicated that they are using this information but generally, adoption is slow and incremental. Over the next couple of years we will continue to ask and seek feedback from the end-user about integration of funded research into their standard production practices. As this becomes available it will be shared with the granting agencies.

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Utah Specialty Crop Block Grant Final Performance Report
2016

Project title: Tree fruit leafroller pests in Utah: determination of biology and phenology, and development of outreach timing tools to improve management

Principal Investigators: Diane Alston, Entomologist, diane.alston@usu.edu, 435-797-2516
Marion Murray, IPM Project Leader, marion.murray@usu.edu, 435-797-0776

Activities Performed:
During the 3-year project, we scouted for five leafroller species in 30 commercial and 10 unmanaged fruit orchards in northern Utah (Objective 1). Scouting included deploying pheromone-baited traps to monitor adult moth populations, and beating tray and visual observations of trees to monitor caterpillar populations from late April or early May to September in 2014 and 2015. Additionally, we compared the attractiveness of two different pheromone lures for the obliquebanded leafroller (OBLR): a general and a western population-specific lure.

Next, we compared the phenology (timing of moth flight) of OBLR populations with orchard phenology (bud development) and degree-days (progression of insect development based on heat units; lower temperature threshold of 50°F and upper threshold of 86°F) (Objective 2). Finally, we compared a predictive OBLR degree-day model developed in the Pacific Northwest with timing of observed Utah populations (Objective 3), and added a revised version of the model to the Utah Climate Center pest management toolbox, Temperature Resource and Alerts for Pests (TRAPs) website (https://climate.usurf.usu.edu/traps/), for use by commercial and amateur orchardists.

Goals and Outcomes Achieved:

In our proposal we identified one measureable outcome: "Increase in grower and gardener understanding of tree fruit leafroller management". We accomplished this goal through the activities described above. Our benchmark: "Current status is growers spray on a calendar schedule to prevent leafroller damage, or they wait too late until damage has already occurred" was identified as the current standard practice. With our defined outcome above, our goal was to improve upon the benchmark established at the beginning of the project. We defined two performance measures:

1. Numbers of tree fruit growers and gardeners who attend presentations where results of the study are shared, and who indicate in a post-project survey how their leafroller recognition and management behaviors have changed.
2. Numbers of tree fruit growers and gardeners who receive leafroller scouting and management information in the Utah Tree Fruit IPM Advisory newsletter.

More than 350 commercial fruit growers were trained in recognition and management of tree fruit leafrollers at the Utah State Horticultural Association (USHA) annual convention in 2015 and 2016 (January 21-23, 2015; January 20-22, 2016), the Northern Utah Fruit Grower annual meeting in 2015 and 2016 (February 12, 2015; January 28, 2016), and the Utah Urban and Small Farms Conference in 2016 (February 17-18, 2016). More than 250 home gardeners were trained on leafrollers in five Master Gardener classes. This resulted in a total of more than 600 face-to-face contacts in leafroller training lectures and classes. A post-project impact survey was conducted at the 2016 USHA convention; 31 responses were received. For assessment of general leafroller knowledge, 97% of respondents stated that they are familiar with leafroller insect pests; however, only 58% felt comfortable in recognizing leafroller damage to fruit crops. Ninety-four percent were aware of research conducted by our team, and 29% reported that leafrollers had been an economic problem on their farm in the last five years. For those growers who experienced leafroller problems, 665 acres of fruit trees had crop injury from leafrollers in 2014 while 0 acres had injury in 2015. On these farms, 1,435 acres were treated with insecticide sprays targeted at leafrollers in 2014 while 1,835 acres were treated in 2015. The most common fruit crop treated was tart cherry (62%) with apple (31%) and sweet cherry (7%) less common. For growers with leafroller problems, 100% responded that they started using targeted insecticide programs once they became aware of leafroller damage to their crops. The primary changes in behavior reported were use of specific insecticides to effectively target leafollers (50%), changes in insecticide rotation programs (20%), and increased scouting and trapping for leafrollers (30%). Although we were disappointed that no more than 58% of survey respondents had confidence in recognizing leafroller damage to fruit crops, we were pleased that growers had reduced leafroller damage on their farms from 665 acres in 2014 to 0 acres in 2015 as a result of awareness and education promoted by this project.

The Utah Tree Fruit IPM Advisory newsletters in 2014-2016 included regular information on leafroller recognition, monitoring and management. For an example, see page 3 in the following 2016 advisory: http://utahpests.usu.edu/IPM/files/uploads/AdvisoryUpdates/Advisory16/Fruit-IPM-06-08-16-2.pdf

Advisory subscribers are a mix of commercial producers, home gardeners, federal and state agricultural agency professionals, crop consultants, agricultural and garden product suppliers, and other interested parties. The Tree Fruit IPM Advisory subscription rate increased during the course of the study as follows:

Season	Number of subscribers	% Increase
Fall 2013	6,600	
Fall 2014	7,800	18.2
Fall 2015	8,820	13.1

Fall 2016	9,777	10.8

An online survey of advisory subscribers was conducted in November 2014. Major findings from the survey included that the adoption rate of IPM among subscribers is high, 86% (medium and high users of IPM). Of those medium and high IPM users, 59% have increased their use of IPM methods in the past two years. Fifty percent now apply a dormant spray, which is a critical control method for OBLR over-wintering larvae. Seventeen percent use the Temperature Resource and Alerts for Pests tool, TRAPs website, to time treatments with degree-day models. Use of pesticides was reduced among subscribers: 44% stopped using broad-spectrum insecticides, and 42% switched to using only low-risk and organic materials. Growers also reported that they are saving money: 33% reported increased profits from following IPM practices, and none reported profit losses. The next IPM advisory subscriber survey will be conducted in winter 2016, but results will be too late to be included in this final report.

The TRAPs website tools were updated with a revised version of the OBLR degree-day model validated in northern Utah (https://climate.usurf.usu.edu/traps/). An article reporting on the tree fruit leafroller project was published in the Winter 2016 Utah Pests News (http://utahpests.usu.edu/files/uploads/UtahPests-Newsletter-winter16.pdf) which was received by 7,838subscribers as of Fall 2016. A new fact sheet on tree fruit leafrollers in Utah is in preparation.

Beneficiaries:

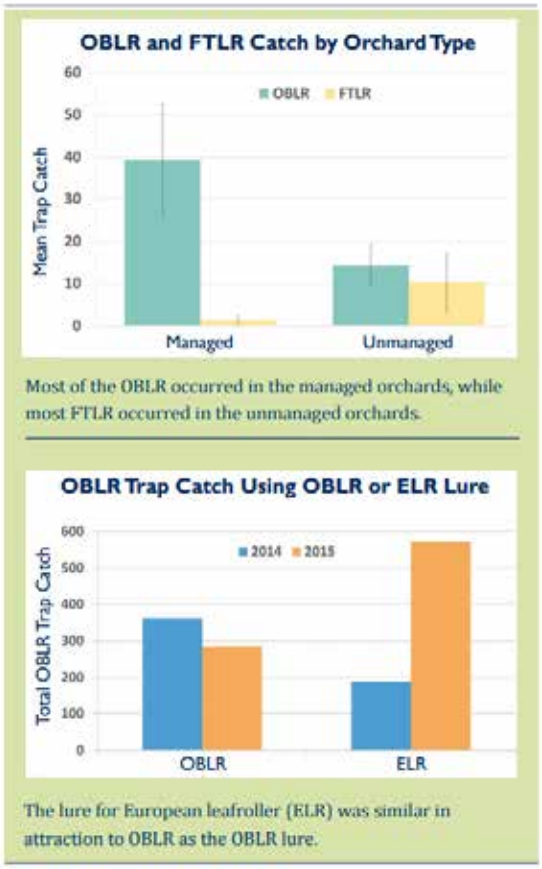
The primary project beneficiaries are the commercial and amateur fruit growers in Utah. There are approximately 373 commercial fruit farms in Utah (USDA NAS 2006), and hundreds of thousands amateur fruit gardeners. As of fall 2016, 9,777 people subscribed to the Utah Tree Fruit IPM Advisory; these subscribers received new research and extension information on tree fruit leafrollers. Additionally, fruit industry support-personnel benefit from improved education and resources to serve their clientele. Support entities include Utah State University extension personnel (county and specialist faculty, and county and state plant pest diagnosticians), Utah Department of Agriculture and Food field inspectors, private crop consultants, USDA Natural Resource Conservation Service field agents, agricultural and garden product suppliers, and others. Finally, the project leaders and others who work with USU Extension IPM programs benefit from the project due to the development of new leafroller IPM resources to meet our stakeholder needs for critical pest management information. An estimate of the total number of people who directly benefited from this project is 10,000.

Lesson Learned:

1. We learned the make-up of the tree fruit leafroller complex in northern Utah: primarily obliquebanded leafroller (OBLR; *Choristoneura rosaceana*) and fruittree leafroller (FTLR; *Archips argyrospilus*), and a very low number of European leafroller (ELR; *Archips rosanus*). No omnivorous leafroller (OLR; *Playnota stultana*) or Pandemis leafroller (PLR; *Pandemis pyrusana*) were detected in the survey of 40 orchards during two years.
2. We learned accurate leafroller moth species identification through assistance from tortricid moth specialists with Washington Department of Agriculture, and we were able to determine OBLR biofix (first moth capture) to run a Washington state degree-day model to help growers and gardeners better time their leafroller management tactics.
3. The majority of OBLR moths captured were in commercially managed orchards, whereas the majority of FTLR moths captured were in unmanaged/abandoned orchards (see first figure below). This confirms that OBLR is primarily a pest of commercial orchards, and it is likely that management practices used to target other pests, such as insecticide applications, elevate OBLR

as a pest due to harm to natural enemies or other mechanisms. In contrast, it appears that FTLR is easily suppressed in commercially managed orchards, whereas, nonexistent to minimal insecticide programs in unmanaged orchards allow FTLR to occur.

4. An interesting discovery of the project was that the lure used for European leafroller was equal to or more effective than the OBLR lure in capturing OBLR moths (see second figure below). This finding supports our recommendation that the ELR lure placed in a trap could be used to monitor both ELR and OBLR in orchards. In addition, when comparing the standard OBLR lure to the western OBLR lure, trap capture was similar with slightly more OBLR moths caught with the western lure in the first generation, and the reverse in the second generation (in one year of comparing the lures).



Problems and Delays:

The major problem encountered in both years of data collection was the lack of leafroller larvae present in orchards. Despite our inability to monitor larval activity, we were able to use adult trap capture data to determine moth flight periods for each generation of OBLR and FTLR.

Future Project Plans:

We will conduct our semi-annual Tree Fruit IPM Advisory subscriber survey in winter of 2016, and will gather more post-project impact data in this upcoming survey. Additionally, we will publish a new fact sheet on tree fruit leafrollers in Utah. We will include information on the common species encountered in commercial and unmanaged orchards, and monitoring and management recommendations, including

the revised degree-day model available on TRAPs and referenced in the Tree Fruit IPM Advisory newsletters.

Funding Expended to Date:
The budget has been completely spent out; the remaining balance is $0.

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#141621

SPECIALTY CROPS BLOCK GRANT FINAL PERFORMANCE REPORT 2016

Larry A. Rupp
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PROJECT TITLE

Nursery Propagation of Gambel Oak and Serviceberry for Niche Market Use

PRINCIPLE INVESTIGATOR

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ACTIVITIES PERFORMED

Project 1. Budding propagation of Gambel oak selections.

Experiment 1.

Preliminary budding of Cottam and Scipio oak accessions done in 2013 showed that T-bud or chip budding techniques appeared equally successful in the spring following summer budding. Overall, 83% of buds from the Cottam and 33% of the Scipio accessions appeared healthy. Unfortunately, the budded shoots had to be pruned before budbreak so there was no verification of bud take. We did, however, find that covering buds with a conifer shaving mulch resulted in failure of every bud.

Experiment 2.

As a follow-up experiment, on 31 July 2014 approximately 30 buds were returned budded (removed and replaced in the same spot) on larger, nursery grown Gambel oak at the USU Botanical Center. Additional budding was done on 13 August 2014 when approximately 55 return buds were completed. Budding was done with a crew of 5 (3 budding and 2 tying). Budding success was evaluated on May 14, 2015. Results indicated that overall 28% of bud shields (the woody base of the grafted bud) were successfully grafted and 11% of the buds leafed out. The results indicate that budding can be successful with Gambel oak, but that it is difficult and extra care should be given to preventing damage to the bud

itself. A success rate of 11% is not commercially viable and verifies the challenge found with budding oaks. It is also likely that using relatively inexperienced student labor contributed to the poor success rate.

Experiment 3.

On August 10, 2015 a replication of the 2013 experiment was done by collecting budwood from the same Cottam oak (A-6540; a hybrid of *Q. gambelii* and *Q. turbinella*) from Red Butte Gardens. Budwood of current season's growth from the tree canopy (no suckers) was collected at 11:30 AM, leaf blades removed, wrapped in moist paper towel and placed in a cooler at ambient temperature. Buds were applied to two coppiced seedling Gambel oak rootstocks in a layer bed environment using chip buds and Buddy® tape using roughly 2-3 layers of tape. All buds were applied in the afternoon of the same day. Similar budding was done on seedling oaks in Cache Valley.

Evaluation of budding in Kaysville as determined by breaking buds on 26 May 2016 showed only one of 18 buds survived and broke (4%). In contrast, 17 of 18 bud shields (the woody part holding the bud) were viable (94%). This would indicate that the grafting technique was adequate, but additional requirements were needed for bud survival. Evaluation of budding in Cache Valley on 21 April 2016 showed two of 17 buds survived (12%). It is important to note that successful grafting of bud shields is not an adequate indicator of successful bud take.

It is interesting to note that during the heat of the summer the leaves on the shoot growing from the single surviving bud at Kaysville dried out and the shoot completely died in late June. Also in late June one of the two successful shoots in Cache Valley had all its leaves dry up, but the shoot did not die and viable axillary buds survived. The remaining shoot (which was shaded underneath the canopy of surrounding rootstock leaves) survived. Apparently, even if the buds survive, the vascular connections are so weak that the evaporative demand of summer conditions exceeds the ability of the graft union to transport water to the leaves. This hypothesis is supported by the fact that the leaves on the shoot growing in a more shaded environment (which would have had less evaporative demand) did wilt. This condition may be unique to Cottam A-6540 when grafted on Gambel oak rootstock and further testing will be required to see if it is common to grafts with other selections.

Project 2. Layer propagation of dwarf serviceberry (*Amelanchier* spp.)

Experiment 1.

A slow growing, dwarf selection of serviceberry obtained from Steve Love at the Aberdeen Research Station in Idaho has been grown in the mound layer bed at the Kaysville Agricultural Research Station. In 2015 a total of five plants were large enough to propagate by layering. The layering process was done by mounding wood shavings around the shoot bases while being careful not to cover the shoot tips (previous research indicates that covering the tips with mulch reduces shoot growth.

On July 7, 2015 shoots within individual plants (8, 5, 30, and 4 shoots per plant) were randomly divided into control and treatment groups. Treated shoots had the wood shavings removed and a liquid rooting hormone (4000 ppm IBA and 2000 ppm NAA as Dip-N-Gro in 25% ethanol) applied to 3 cm of the shoot base. The shoots were too narrow in diameter to be girdled. After treatment, the wood shavings were replaced and kept moist by irrigation as needed.

On November 20, 2015 the shoots were harvested by removing the wood shavings and cutting the shoots off at the base of the 2015 season's growth. Preliminary results indicate that only 2 of 26 treated layers rooted (8%) and 2 of 21 control layers rooted (9%). None of the rooted cuttings had a commercially acceptable root system.

It is interesting to note that during the period of time we have been endeavoring to propagate this serviceberry by layering, we have also been digging propagules from the parent plant in Idaho to increase the plant numbers for research. The propagules are typically rhizomes with multiple suckers which have etiolated shoot bases. On June 9, 2015 rhizomes were dug from the mother plant in Aberdeen, Idaho. On June 11 they were divided into 30 propagules and placed under mist until July 18 when they were moved to a standard greenhouse environment. In this case, 29 out of 30 propagules (97%) survived. Based on the success of our cuttings from rhizomes and etiolated suckers, and the lack of success with layering, we have determined that this plant is not a good candidate for layering and would be more efficiently propagated by cuttings.

Project 3. Layer propagation of Gambel oak

Gambel oak (*Quercus gambelii* Nutt.) is native to the American southwest, readily hybridizes with other white oaks, and has potential as a small, drought tolerant landscape tree. However, seedling trees are variable and production of superior selections of the species or its hybrids is limited by difficulties in asexual propagation. During 2012-2015, vegetative propagation of Gambel oak by mound layering was examined at the Utah Agricultural Experiment Station Farm in Kaysville, Utah.

Stock plants of Gambel oak were established by planting a row of 18, 5-gallon plants on 3-foot spacing in 2011 (Fig. 1). Irrigation was done with pop-up spray heads using a variety of timing configurations depending on the season and supplemented with hand irrigation as needed to keep shavings moist. Plants were fertilized with 0.5 lb. N per 1000 square feet annually. Layering was done by pruning trees to their base each year and then gradually mounding conifer shavings around the base of each tree as new shoot growth occurred throughout the season. Appropriate shoots were selected for layering and randomly assigned for controls or treatment within trees. A combined treatment of girdling (4 x 0.10-inch cable tie 1 cm above the shoot base) and auxin (4000 ppm indolebutyric acid and 2000 ppm naphthalene acetic acid as Dip'N Grow® in 25% ethanol applied to the 3 cm of stem immediately above the girdle) was applied in early July of each year. The data for 2013 was pooled from shoots given the 4000/2000 ppm auxin treatment or 8000/4000 ppm since there was no apparent difference in rooting between the two. As stock plants grew, the number of shoots used for layering increased from one to five per plant.
Rooted layers were harvested in late October or November by cutting the stem as close as possible to the base and then held in moist shavings at 4°C until transplanted. The number of roots per shoot, stem length, and stem diameter was measured each year. In 2015, layers were harvested on Nov. 20 and held at 4°C until transplanted on Mar. 4, 2016. Prior to transplanting, the diameters of the largest 3 roots per shoot were measured. Rooted layers were transplanted into 1-gal pots with a 2:1 perlite:peat substrate and randomly placed in a greenhouse at 65/60 DT/NT until budbreak, after which they were grouped by parent tree for observation.

There was a marked increase in rooting of layers from 2012-2015 for both the control (4, 8, 21, 49% per year, respectively) and the treatment (17, 35, 56, and 65% per year, respectively) (Fig. 2). Analysis of the probability of rooting over the 4-year period using PROC GLIMMIX in

SAS/STAT (0.05 level) showed a significant effect of both time and the girdle/auxin treatment (Fig. 3). The reason for increased rooting with age of stock plant is unknown. A similar analysis

Fig. 1. Mound layer bed showing conifer shaving substrate.

of the number of roots per rooted layer showed no statistical significance due to time or treatment. Among the rooted layers transplanted, there was no significant impact of treatment on survival. However, there was a correlation between the average diameter of the largest three roots/shoot and subsequent survival (Fig. 4). On an observational level, only 13% of controls and 21% of treated shoots from 2015 survived and grew, indicating that improvements are needed before this method is commercially viable for propagation of Gambel oak.

Additional research on the effect of early, complete etiolation on rooting of Gambel oak layers in 2014 failed to show an increased benefit as compared to un-etiolated plants. Since this method required more labor and equipment, it was discontinued in favor of the previously used system.

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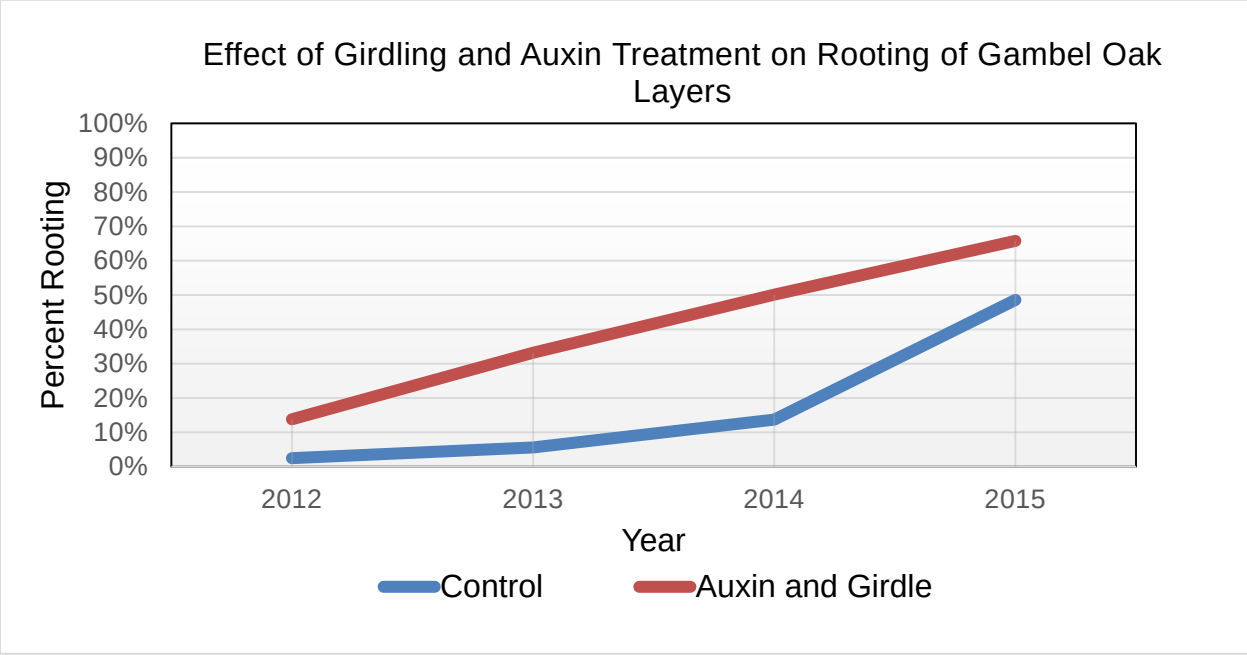

Fig. 3. The effect of girdling and auxin treatment on rooting of Gambel oak layers. Statistical analysis indicates a significant effect of both time and treatment.

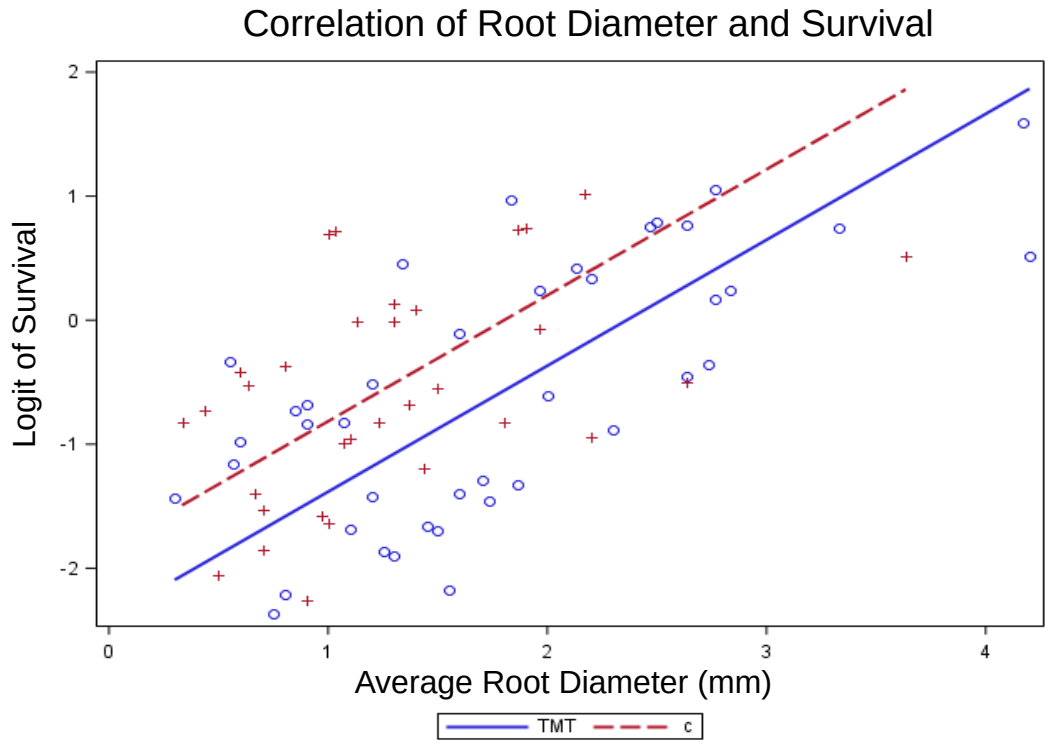

Fig. 4. The correlation of average root diameter of the three largest roots/shoot and layer survival. The correlation was significant at the 0.05 level.

Project 4. Lignotubers as a source of propagules for Gambel oak

Lignotubers are swollen areas at the base of Gambel oak trunks containing adventitious buds that are an important means of vegetative regeneration. The purpose of this research was to evaluate rooted oak layers to see if lignotubers will form adventitiously similarly to their formation in seed propagated oaks. The first portion of the experiment was to cut and polish cross sections of wild, mature Gambel oak trunks to help elucidate lignotuber morphology (Fig. 1 & 2).

Figure 5. Mature Gambel oak cross sections progressing from primary stem tissue down through the crown and into the roots.

Figure 6. Close up of crown portion of oak stem with undifferentiated regions indicative of lignotuber.

We also analyzed a rooted layer of Gambel oak (Fig. 7) in an attempt to verify whether lignotubers can occur in rooted layers. It is difficult to say if the wild material was from a seedling or a rhizome. If it was from a rhizome, it would seem to indicate that lignotubers form on stems that do not arise from a seedling. The cross section shown in Figure 8 is suggestive of a lignotuber forming in a rooted layer, but additional analysis of older, rooted layers must be evaluated before conclusive evidence can be obtained. The next step in this research is to determine if shoots arising from lignotubers are more prone to adventitious rooting than seedling or other stems.

Fig. 7. Container grown, 4-year-old rooted layer of Gambel oak.

Fig. 8. Cross section of a 4-year-old rooted layer (top) with magnified segment corresponding to outlined region (bottom). Arrows indicate tissue that appears similar to that of cross sections of wild-collected plants.

GOALS AND OUTCOMES ACHIEVED

Goals	Outcomes
1. Successful budding of Gambel oak a. Evaluation of budding	We have found that only 11% of return buds on Gambel oak were successful. Further we have found only 4-12% success when grafting a Cottam oak selection onto a Gambel rootstock, and that 2/3 of those buds died during the heat of the summer. This data indicates that budding may be a difficult means of commercial propagation, but that it does have potential for producing limited numbers of plants. It also indicates that additional work is needed to enhance the success rate.
2. A 70% success rate for propagating Gambel oak and serviceberry a. Evaluation of early etiolation	We have determined that the dwarf serviceberry accession used in this research is not amenable to propagation by layering and would be better propagated by digging etiolated rhizomes and suckers for propagation as cuttings. Gambel oak appears to have limited benefit from girdling and/or hormone treatments. The most positive thing is that the percent rooting has increased annually from 10, 31, 37, to 59% in 2015. While the reason for this increase is unknown, it may be due to the constant pruning back of the stock plants each year. We have also found that the size of the roots is more indicative of successful growth of layers than the number of roots.
3. Verification of lignotubers in rooted layers a. Potential use of lignotubers in oak propagation	We have established a technique for viewing stems of Gambel oak and have evaluated both wild and layer-propagated container grown plants. Further work is necessary for fully describe these unique structures and their impact on rooting of layers.
4. Evaluate layering for propagation of dwarf serviceberry	In our research, this serviceberry selection is not amenable to propagation by layering and should be done as cuttings of etiolated suckers.
5. Publishing results overall	· Buhler, M. and L.A. Rupp. 2014. Propagation of native woody plants in Utah using Nearing frames. Report of the Intermountain Native Plants Cooperative, WERA-1013. pp. 5-10. · Wheaton, A. and L.A. Rupp. 2014.

	Nurturing Native Plants – A guide to vegetative propagation of native woody plants in Utah. Report of the Intermountain Native Plants Cooperative, WERA-1013. pp. 39-43. · Buhler, M. and L.A. Rupp. 2014. Late fall propagation of native woody plants in Utah using Nearing frames. Proc. International Plant Propagators Society, British Columbia, Canada. · Rupp, L. and A. Wheaton. Combinations for conservation – Plant groupings for water conserving landscapes. In manuscript. · Rupp, L.A. 2016. Propagation of Gambel Oak (Quercus gambelii) by Layering. International Plant Propagators Society – Western Region Annual Conference, Phoenix, Arizona.
6. Increased awareness and interest in asexual propagation of natives	· Rupp, L.A. 2015. Master Gardener presentations on plant propagation (Iron, Kane, Washington, Summit, Wasatch, Cache, and Tooele Counties). · BYU-Idaho tours of native plant propagation program (March and June of 2015). · Rupp, L.A. et al. 2015. Salt Lake County Watershed Conference presentation of "Are Utah Landscapes Worth the Water". · Rupp, L.A., W.A. Varga, and M. Maynes. 2015. Presentation at the Utah Small Farms Urban Agriculture Conference on "Alternative crop research at Utah State University." Salt Lake City, Utah. · Snowden, C. and L.A. Rupp. 2015. Presentation on cutting propagation of native *Shepherdia* hybrids with leaf wetness sensors. WERA-1013 Meeting, Boise, Idaho. · Rupp, L.A. 2015. Presentation on "Propagating singleleaf ash (*Fraxinus anomala*): A Proof of Concept." WERA-1013 Meeting, Boise, Idaho. · Rupp, L.A. et al. 2015. Presentation on Extension water conservation initiative for Five County Association of Governments, Six County Association of

	Governments, Bear River Association of Governments, Utah League of Cities and Towns. Utah. · Rupp, L.A. 2015. Booth representing USU Extension water initiative at the Utah Association of Conservation Districts meeting, St. George, Utah.
7. Number of presentation attendees interested in growing natives	Approximately 40 people attended the Utah Small Farms Urban Agriculture Conference. No specific interest was shown by attendees in growing native woody plants.
8. Number of growers implementing propagation techniques	High Mountain and Perennial Favorites nurseries are currently working with us on propagation methods.

BENEFICIARIES

1. While layering has not proven to be successful for serviceberry, the method of digging etiolated suckers as rooted cuttings has enabled us to increase the number of plants to the point that they are being used in another research project with Dr. Brent Black to determine if the fruit of these dwarf plants can be harvested mechanically.

2. We have worked with High Mountain Nursery and Perennial Favorites nursery on these projects (using different plant material). This work is currently in the developmental stage and has not shown commercial benefit yet.

3. We have been able to use our methodology in an attempt to clone a unique Cottam oak from the University of Utah that has been removed as a result of a construction project. Hopefully we will be able to successfully restore this unique plant to their botanical garden.

The material itself has not been released, so there were no direct beneficiaries there. But, the work was presented at a meeting and will be published. It was also used for various types of instruction. I would guess a conservative estimate would be 30 people.

LESSONS LEARNED

1. Extreme efforts to etiolate oak layers to enhance rooting have not proven effective.
2. Rooting of Gambel oak by layering is possible, and it definitely benefits from maintaining stock plants over a number of years.
3. It is difficult to maintain the conifer shaving rooting substrate at appropriate moisture levels. Too much water is as harmful as too little and that balance seems difficult to find. Also, over time the shavings become infested with fungal mycelia that renders them hydrophobic and makes it hard to keep the moisture balance correct. The system requires constant monitoring, which can be challenging.
4. Even if buds are successful, they can succumb to summer season moisture stress.
5. It appears that different Gambel oak selections have varying abilities to form adventitious roots.

6. It appears that rooted layers can form lignotubers, though we don't have enough data to definitively state that to be the case.

PROBLEMS AND DELAYS

1. We had a difficult time finding a student who could tackle the lignotuber project.
2.

PROBLEMS AND DELAYS

Problems and delays, and their resolution, include the following:

1. After examining the data on early etiolation of Gambel oak to enhance rooting, it is apparent that the benefits do not justify the extensive effort required. This is good to know, but it was somewhat of a delay in determining it.
2. We finally got enough plant material to evaluate layering of serviceberry and were disappointed in the very low percentage rooting. As a result, this effort will also be shifted, but in this case from layering to cuttings of rhizomes and suckers from stock plants.
3. The work with the lignotubers lagged due to difficulty in finding qualified labor to do the work.
4. Oaks and other native plants just grow slowly and it takes time to get results.
5. It has been challenging to get rooting substrate moisture at the level we want it.

FUTURE PROJECT PLANS

Our plans for the future include the following:

1. Continued development of a protocol for evaluating lignotubers to determine their presence or absence in rooted Gambel oak layers.
2. Determining if the increase in rooting over years is a result of shoots arising from lignotubers.
3. Shift efforts on propagation of dwarf serviceberry from layering to cutting propagation of etiolated suckers. Specifically, we need to develop baseline data on rooting hormone requirements and overwintering requirements.
4. We have done more budding of two different Cottam oaks in the summer of 2016 and will be interested in evaluating them in the spring of 2017. Also, we will be looking at technology to reduce the stress on new buds cause by summer evaporative demand.
5. We hope to get Cottam oaks grafted into our layer bed and then use it to propagate them by layering. But, this has taken much longer than we hoped. It would be worth it if we could find a way to successfully clone these very unique hybrids.
6. We have found that some seedlings of Gambel oak seem to root better than others. We hope to get a sufficient number of plants from one clone that we can use for more in-depth research with genetically uniform material. Such work is especially needed to determine how to best grow on the rooted layers following rooting.

FUNDING EXPENDED TO DATE

We have used 100% of the project funds of $6,919.00.

CONTACT INFORMATION

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Personnel: Jennifer Reeve, Brent Black, Corey Ransom, and Diane Alston

Final Report December 2014 for the 2012-2013 funding cycle

1. Project summary

With rising costs of inputs, concerns over unintentional herbicide injury to trees and projected increased competition for scarce water resources, reduced input management strategies that decrease costs and remain practical to manage are of growing interest to fruit growers. Use of cover crops is the logical solution to reducing nitrogen inputs, protecting the soil, and managing weeds. Managing cover crops in orchards can be particularly challenging, however, in arid climates where groundcover competes with trees for water. The goal of this project is to document the benefits and or tradeoffs of reducing/substituting inputs in peach production in Utah as a means of improving resource use efficiency and improving net income to growers. This report outlines the findings and conclusions from the 2013 growing season which represents the sixth year of this long-term project.

2. The project approach, significant results, accomplishments and recommendations

Five different combinations of organic and inorganic fertilizers and mulches have been established and the third crop of fruit harvested. These treatments were compared for their effects on fertility, tree growth and yield, weeds, and water use. Results from the project were presented to 130 growers and industry personnel at the Colorado Fruit Growers meeting on January 15th to 17th 2013, the Utah Horticultural Association Winter meeting on January 29th and 30th 2013, to 50 growers and industry personnel the Northern Utah Fruit Growers meeting February 5th 2013 and to 100 small and urban farmers in Salt Lake City on February 26th 2013. A grower advisory meeting was also held on January 30th 2013. A train the trainer workshop on organic and integrated orchard management was held on June 11th 2013. The workshop consisted of morning presentations followed by an afternoon tour of the orchards. Attendance at the workshop was capped at 40 for space reasons and all places were filled. Extension and other industry professionals who attended the workshop indicated the information received was useful and of high quality and that the information learned would be applied to advising total of 754 individuals covering 2719 acres in their respective jurisdictions. A fact sheet on earwig population dynamics and management from data collected under this project was published. Four research presentations were made to the Entomological Society of America, Pacific Branch Entomological Society of America the 87th Orchard Pest and Disease management Conference, the Utah State University Graduate Student Symposium in March (see section 7 below).

Tree growth and yield: In 2013 we saw a positive effect of paper mulch on tree growth for the first time. Greatest tree growth was seen in the urea nitrogen treatment with paper mulch ($p<0.0030$) and the mulched trees were larger than either the conventional treatment (urea + herbicide) or the integrated treatment with compost + herbicide. The conventionally managed trees did not differ in size from

herbicide with compost treatment, showing that the additional tree growth seen in 2012 in this treatment as a result of an accidental additional N application was temporary. The weakest tree growth was seen in the organic treatment with paper mulch and the transitional organic treatment with mowed tree rows. Strong tree growth could be maintained with compost and feather meal alone in combination with conventional herbicide suggesting that differences in tree-growth between organic, integrated and conventional trees was attributed to weed competition not lack of fertility.

Peach yields were highest in the conventional and urea + paper mulch treatments (55kg per tree respectively), intermediate in the compost + herbicide and transitional treatments (40 and 35kg kg per tree) and lowest in the organic with paper mulch treatment (23kg per tree). However, the fruit in the two highest yielding treatments was smaller suggesting the trees were slightly over cropped. Unfortunately these results are somewhat confounded by the greater tree growth in the NPK based treatments after receiving additional N in 2012. This mistake makes direct treatment comparisons on yield in 2013 difficult to make. Clearly there is a strong relationship between peach yield and tree growth, however.

Peach quality was assessed with basic physical and chemical charactersistics (size, firmness, brix acidity) and through a consumer taste panel for both varieties (Starfire and Coralstar). All treatments produced very high quality peaches with only few and inconsistent differences between treatments. For example consumers identified the compost + herbicide treatment Starfire variety as being slightly less sweet and flavorful than the other treatments but for the Coralstar variety the organic and conventional treatments were least liked.
The spray on paper mulch was also successful in reducing the need for herbicide applications, only a single herbicide (roundup) application was needed in these plots in 2013 as a result.

Soil fertility and quality: Soil nitrate and ammonium was significantly lower in the compost treatments. Lower available soil N did not translate into a reduction in tree growth in the absence of weeds, so this represents a reduction in leaching potential to the environment. There were no differences in soil nitrate an ammonium as a result of paper mulch. Total soil N was greatest in treatments receiving compost with the newly transitioned treatment equal to the other two treatments in 2013. Again, this shows that in the absence of weed pressure, compost can provide sufficient slow release N to meet tree growth needs. Soil organic carbon was greatest in the paper mulch with compost treatments. However, all treatments receiving composted resulted in greater soil carbon. There was no effect of paper mulch on soil carbon. Changes in soil bulk density reflected soil carbon with bulk density lowest in plots receiving compost. Starting as early as 2009, soil pH has trended downwards compared to treatments receiving compost. This effect was most pronounced in 2012 and 2013. Soil electrical conductivity is also greatest in treatments receiving NPK fertilizer.

We continue to see an effect of falling pH on soil macronutrients (cations). In the first three years of the study soil available phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) were higher in treatments receiving compost. Starting in 2011 this effect has been reversed. In 2012 and 2013 available Ca and Mg was higher in treatments receiving urea. There are now no differences in soil P, K, S. A similar story is reflected in soil trace elements. While there were few differences in soil available Copper (Cu), Iron (Fe), Manganese (Mn) and Boron (B) early in the study, in 2013 urea resulted in the highest levels of soil available Mn and Fe. This is likely due to reduced compost rates applied to the orchard starting in 2011 together with a downward trend in soil pH as a result of urea applications. The exception to this trend is zinc (Zn). Zinc has always been higher in composted treatments and remained so in 2013. There were no significant treatment effects in Cu, Na or B.

Tree leaf N was lower in treatments receiving compost than urea (2.51 vs 2.86%) but was nevertheless well within the range considered adequate for good growth. All macro and micronutrients were within sufficiency range for all treatments except for sulfur. It appears that periodic soil sulfur applications are necessary on this soil type. Tissue leaf Zn was highest in treatments receiving sulfur.

Integrated and organic treatments with compost fertilizer resulted in the greatest improvements in soil organic C ($p<0.0001$) and total N ($p=0.003$). Microbial biomass was also significantly greater in treatments with compost applied versus urea ($p<0.0001$). There was also a positive effect of paper mulch on microbial biomass compared with herbicide ($p=0.023$). A positive relationship was seen between soil microbial indicators and tree growth as described above.
There was no effect of soil quality or mulch on water use. This was surprising; with time we expect improved soil quality and use of mulch to improve water infiltration, and water holding capacity leading to reduced water use in those treatments.

Arthropod response to mulch and compost:
Collembola, mites and thrips were the three most prevalent groups. Methods for suppressing weeds in the tree row had variable effects on arthropod abundance and diversity. Early in the study the compost plots were markedly more diverse than the NPK treatments but there was no apparent effect of treerow. All treatments peaked in 2011 but the relative effect of fertilizer flipped (NPK diversity estimates became higher than those of the compost) and a treerow effect emerged (herbicide was slightly higher than paper). These patterns were consistent for the remainder of the study. In 2012, diversity declined by approximately 25% throughout the orchard and stayed at that level in 2013. These temporal dynamics are typical of a young establishing orchard; such begin with low diversity early after planting (pre-2010), there is a period of rapid growth (2010, when monitoring began), an over-shooting climax (2011), a compensatory decline (2012), and eventually, a stable state (2013 and on). Preceding the peak, insect community structure was more variable as they, and plant populations, established their respective niches. The effect of transitioning the treatments from conventional to organic, severely degraded the diversity in those plots. In fact, these began with the greatest and ended with the least. This shift is likely the result of increased N availability in the conventional treatments.

Analysis of the dry-weight biomass repeated measure found no evidence of a three-way (year-by-treerow-by-fertilizer, $P=0.280$) or a year-by-treerow ($P=0.200$) interaction. Year-by-fertilizer ($P=0.075$) did not quite meet the alpha criterion of 0.05. Assessment of the effect of year on biomass was most apparent in the transitional treatment, as would had been expected; after the transition from NPK to compost, weed biomass irrupted. There was a highly significant treerow-by-fertilizer interaction ($P<0.0001$). Compost consistently had more but less diverse weeds than NPK treatments (six to eight times as much), except in the herbicide treated compost, which was not significantly different.
Weed management influenced cat-facing injury to peach fruits: herbicide treatments had significantly higher cat-facing damage than transition organic, organic and paper-mulch treatments. The greater weed diversity and N content in the herbicide-treated plots may have been more attractive to insects that cause cat-facing injury, particularly lygus bugs. This resulted in greater fruit-feeding injury from lygus bug. These results provide good support for the use of paper or other mulches that can consistently suppress broadleaf weed populations through the growing season. Interestingly the two organic treatments had the least fruit damage although overall yield was lower.

Arthropod abundance and diversity in ground cover treatments at the Tintic tart cherry orchard showed variable trends when comparing grass versus legume alleyways; however, not surprisingly, the plots with the highest plant diversity, a mixture of grass, alfalfa and vetch, had the highest abundance and diversity of arthropods.

Novel cover crops for orchard grown fertility: Novel alleyway cover crops continued to be monitored at the 5-year-old tart cherry orchard in Tintic to determine the amount of on-farm fertility that could be generated within the orchard. In 2012, grass provided equal weed suppression to the alfalfa and mixed treatments (~92-95% suppression); however, grass produced the least biomass. The alfalfa plots planted at the Capitol Reef National Park historic orchard were heavily grazed by marmots during the 2013 growing season. Tree leaf and soil N were significantly enhanced in the alfalfa plots but due to the heavy grazing it was difficult to determine the role of alfalfa versus tilling in the existing grass cover. We decided to see if alfalfa could be successfully established in existing stands of grass in order to bring a legume component to the understory and hopefully still enhance soil and tree N.

Overall, diversity differed by alleyway treatment: legume plots had greater indices of diversity than grass plots. The mix of grass and legume ground covers in the 24-year-old tart cherry orchard had the greatest diversity index, while grass alone had lowest arthropod diversity. All beneficial functional groups (predators, parasitoids, pollinators, and detritivores) had higher abundance in grass than legume. This is opposite of what was expected. Weeds, such as clover and dandelion, may attract these beneficials into grass treatments. Crop pests (specifically lygus bug) were greater in legumes. Leguminous plants are attractive hosts for lygus bug, and other studies have shown that legumes planted in orchards can increase lygus bug populations and cat-facing injury to fruit. There was no significant difference between grass and legume plots in densities of non-crop herbivores, which are unlikely to feed on peach trees. These non-pest arthropods can serve as alternate hosts for predators and parasitoids, and can provide benefits to peach crop pest management.

3. Goals and outcomes achieved

We have been successful in meeting the sixth year's goals (3rd year of phase 2) of this long-term project. Details of our progress under each of our goals is presented below.

Goal A. *Optimize fertility and evaluate pest dynamics*

Orchard Establishment: The new organic and reduced input peach orchard was established in April 2008. All treatments were reapplied in the spring of 2009, 2010 and 2011 as planned: **1)** conventional herbicide + conventional fertilizer (NPK) as a check, **2)** conventional herbicide + NPK to be converted to organic after tree establishment, **3)** compost + conventional herbicide, **4)** NPK + spray on paper mulch + reduced herbicide, and **5)** compost + spray on paper mulch + organic herbicide.

Tree growth and yield, and leaf and soil nutrients: Soil nutrient data (nitrate, ammonium, P, K, Ca, Mg + trace elements, pH, electrical conductivity, and texture) were taken at 0-30 cm from each plot in May 2013. In addition, soil nitrate and ammonium was measured at 0-30 cm in June, July and August. Leaf nutrient data was collected in June and July and trunk diameter, and shoot elongation measured at the end of the growing season. Trees were supplied with 29 g N per tree in the form of 16-16-16 NPK or 6.1 kg steer manure compost applied in mid-March. To avoid excess accumulation of P and K in the compost treatments compost rates were based on equivalent P application of conventional fertilizer. Additional N was applied in the form of urea or Nature Safe 12-0-0 in June for a total of 148g N per tree.

Weed dynamics: Weed control was achieved in 2013 with either spray on paper mulch and or herbicide applications. Weed densities, percent cover, and biomass were determined in the tree row and alleyway. Biomass and percent coverage monitoring was conducted five times in 2013 at the conventional Kaysville orchard and once at the Tintic site. Samples were taken before mowing. A total of 1,200 vegetation samples have been taken to-date.

Peach Yield: Yield was determined in terms of number of fruit, fruit size and weight. Damage due to insect and disease was recorded and marketable yield calculated. Yields were good so 2013 represents

the first year of full production. Fruit quality (fruit size, firmness, brix sugars, acidity) and consumer sensory evaluation was conducted on all treatments.
Arthropod ground cover dynamics: Sweep net samples of arthropods in understory vegetation were collected approximately monthly from May to September in alleyways, and pitfall samples were taken in the tree rows of plots. Arthropods were sorted into nine major functional groups (pest herbivores, non-pest herbivores, detritivores). In total, 260 sweepnet samples yielded 120,939 arthropods categorized into 100 taxonomic groups. Earwig populations were monitored weekly. Earwig, cat-facing insect, and aphid injury to tree leaves and fruits was monitored. Ground vegetation samples were collected monthly during the growing season from alleyways and tree rows in each plot. All above ground vegetation within a randomly placed 15 cm diam circular frame was removed, and the arthropods extracted on Berlese funnels (use heat from a light bulb to drive arthropods out of vegetation and down a funnel into ethyl alcohol).

Goal B. *Optimize water use and soil quality:*
Water use: Soil moisture was recorded on a weekly basis starting in June and using capacitance probes installed in the soil. Tree stem water potential was recorded periodically using pressure bomb readings.
Soil quality: Soil quality (soil organic matter, pH, electrical conductivity, microbial biomass, enzyme activity) measurements were taken at a depth of 0-10cm in June. Bulk density was determined in September.

Goal C. *Farm generated fertility:*
Different legume combinations were monitored at the Tintic Valley location to test the possibility of growing fertilizer within an orchard. The treatments were **1)** alfalfa, **2)** clover alfalfa mix, **3)** hairy vetch, and **4)** orchard grass. A second treatment, grass inter-seeded with alfalfa, was established at the Capitol Reef National Park historical orchard. Each treatment was evaluated for cover crop and weed biomass twice during the 2013 growing season before mowing. The treatments were assigned to 6 replicate plots measuring 12 x 15 ft, in a randomized complete block design.

4. Beneficiaries
Students: Four undergraduate students (Mari Lindstrom, Ashley Salisbury, Gaia Nafziger and Esther Thomsen) were trained in research methods and data collection as a result of this project. One hourly worker assisted with data collection and orchard maintenance.

Workshops: Two workshops were held on February 26th 2013 and June 11th 2013 to showcase the project. Approximately 100 tree fruit growers and industry and extension personnel attended in February and a further 40 in June. The June workshop included an in-depth orchard tour. Extension and other industry professionals who attended the June workshop indicated the information learned would be applied to advising total of 754 individuals covering 2719 acres in their respective jurisdictions.

Grower advisory meeting: A grower advisory meeting was also held on January 30th 2013.

Winter meetings: Results from the project were presented to growers at the Colorado Fruit Growers meeting on January 15th and 17th, to the Utah Horticultural Association Winter meeting on January 29-30th, 2013 and the Northern Utah Fruit Growers meeting on February 5th 2013. Approximately 130 growers and industry personnel attended the Colorado meeting and a further 130 attended the Utah meetings.

Fact sheets and articles: A newsletter article on the functional roles of the European earwig was published. See below: Section 7 Additional Details.

5. Lessons Learned

Successfully collecting the sixth year of data from this orchard has positioned us to be successful towards meeting out long-terms goals of testing and developing organic and reduced-input management strategies for tree fruit production in arid climates with cold winters, and in developing an outreach program for the projects. The 2013 season was the first year that the trees entered peak production. We saw benefits in tree growth from paper mulch for the first time in 2013 when combined with a single herbicide application to control mostly grass weeds. Yields closely tracked tree growth and were highest in the conventional and urea + paper mulch treatments. Fruit quality was high in all treatments with only small and inconsistent differences among treatments.

We are continuing to see benefits of compost use and mulch in terms of improved soil quality. Data show that without regular inputs of carbon (in terms of compost or mulch) soil quality is starting to degrade under the conventional NPK + herbicide treatment. Compost had a greater effect at reducing soil bulk density than did mulch. Interestingly, soil pH is starting to come down in treatments receiving urea fertilizer and has resulted in greater available trace elements in these treatments. Tree leaf nutrient status is starting to reflect these increases. We have still not seen significant reductions in water use as a result of using mulch. This is surprising and indicates it might take several years in improved soil quality before expected water savings are realized. The cost of mulch and lack of water savings may prove prohibitive unless a premium can be obtained for the fruit such as in certified organic production. The compost plus herbicide treatment may prove to be the most beneficial in terms of tree growth, soil quality and weed control although the paper mulch is showing promising results here also.

Fruit injury from earwigs and lygus bug was increased in plots treated with NPK versus compost fertilizer. This is an interesting finding as it suggests that slower release of nutrients and less soluble nitrogen in peach tree tissues can reduce the incidence of earwig fruit damage. Unlike 2012, paper mulch also reduced fruit injury. Populations of the cat-facing insect, lygus bug, were increased in plots where herbicides were applied to the tree rows as compared to application of paper mulch. Weeds regrew into tree row strips in between herbicide applications and provided an attractive plant source for lygus bug and other arthropods. The paper mulch was superior to the herbicide alone in suppressing lygus bug.

6. Contact person for the project.

For additional details and questions regarding the project please contact:

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7. Additional information available (e.g. titles of presentations, publications, and websites).

Alston, D. and A. Tebeau. 2013. European earwig biology in peach orchards. 87th Orchard Pest and Disease Management Conference, January 9-11, Portland, OR.

Alston, D. G. and A. Tebeau. 2013. European earwig in peach orchards: the good and the bad. Western Colorado Horticultural Society, January 15-17, Grand Junction, CO. (130)

Alston, D and A. Tebeau. 2013. European earwig in peach orchards: the good and the bad. Utah State Horticultural Association Annual Convention, January 29 and 30, Spanish Fork, UT. (80)

Culumber, C.M. 2013. Organic and integrated stone-fruit orchard floor management: project update. Utah State Horticultural Association Annual Convention, January 29 and 30, Spanish Fork, UT. (80)

Alston, D. G. 2013. Cat-facing insects, earwigs, and insect management update. Northern Utah Fruit Grower Meeting, February 5, 2013, Brigham City, UT. (50)

Reeve, J. R. 2013. Organic and integrated orchard floor management. Urban and Small Farms Conference February 26-27th. Salt Lake City, UT. (100)

Tebeau, A, D. Alston, J. Reeve, B. Black, and C. Ransom. 2013. European earwig (Dermaptera: Forficulidae) population dynamics and their response to understory treatments in peach orchards of northern Utah. Utah State University Graduate Student Research Symposium, April 12, Logan, UT.

Culumber, C.M. 2013. Organic orchard nutrient management. Organic Fruit and Vegetable Workshop, June 11, Kaysville UT. (40)

Tebeau, A. 2013. Arthropod management in organic orchards. Organic Fruit and Vegetable Workshop, June 11, Kaysville UT. (40)

Tebeau, A, D. Alston, J. Reeve, B. Black, and C. Ransom. 2013. The effects of orchard-floor management on the density, dispersal, and distribution of European earwigs (Dermaptera: Forficulidae) in peach orchards of northern Utah. Entomological Society of America, National Meeting. Nov 11, Austin, TX.

Alston, D. and A. Tebeau. 2013. Update: European earwig biology and management in peach orchards. Utah Pests News Vol. 7, Winter: 7-8. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory, Logan, UT.
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Roper, T., M. Rowley, M. Murray and B. Black. 2012. Orchard Floor Management. In: The Utah-Colorado Commercial Tree Fruit Production Guide. Eds. M. Murray and H. Larson. Utah State University Extension and the Western Colorado Research Center, Colorado State University.

Reeve, J.R. B.L. Black, C.V. Ransom, D.G. Alston, M. Culumber, A. Tebeau, T. Lindstrom 2012. Approaches for establishing organic stone-fruit orchards in Utah and the Intermountain West. American Society for Horticultural Sciences. July 31- Aug 3, Miami. FL.

Alston, D. and A. Tebeau. 2011. European earwig. Utah State University Extension ENT-145-11 (3 pp.), Logan, UT.
http://extension.usu.edu/files/publications/factsheet/earwig-orn.pdf

#141628
Project title:
Reaping economic and ecological benefits from growing stress-tolerant succulents as food crops for flourishing ethnic and specialty-food markets in Utah: Evaluation of the productivity of *Agave* and *Opuntia* grown for agave nectar, nopales, and cactus pear

Principal investigator:
Ryan Stewart

Activities performed:
We monitored plant survival and growth in plantings of four *Agave* species (*A. murpheyi*, *A. utahensis*, *A. weberi*, and *A. tequilana*) and three *Opuntia* species (*O. basilaris*, *O. ficus-indica*, and *O. engelmannii*) in field plots in Holden, Provo, and Spanish Fork, Utah. All were arranged in a randomized complete block design.

Goals and outcomes achieved:
Objective 1: Several replicates of different species and varieties of Agave and Opuntia will be evaluated over a 2-year period to measure growth, photosynthetic rate, annual yield, seasonal phenology, winter survival, water use, water-stress tolerance, and insect and disease incidence. Starch levels will also be measured in the Agave plants. Fruit quality will be assessed in the cactus pears. Environmental factors that will be accounted for include soil type, soil nutrient levels, soil moisture content, and microclimate to determine the optimal growing conditions for these plants.

Achievements: Of the *Opuntia* species, *O. basilaris* and *O. engelmannii* demonstrated high winter survival levels and water-stress tolerance. The plants were also largely free of insect pests and diseases. However, several *O. ficus-indica* plants had high mortality, except for some plants, which we later discovered were actually another species, *O. ellisiana*.

Of the *Agave* species, *A. murpheyi*, *A. weberi*, and *A. tequilana* had poor winter survival. However, *A. utahensis* exhibited high survival levels. The species also demonstrated high water-stress tolerance and low pest and disease incidence.

Goal 1: Determine which accessions of Agave and Opuntia demonstrate superior traits to use as specialty crops in commercial settings.

Given the small size and the spiny nature of *O. basilaris* and *O. engelmannii* plants, they have low potential to use as crops. However, the serendipitous discovery of *O. ellisiana* plants in our study, which appear to have at least modest levels of cold hardiness, opens up new avenues of research into identifying superior selections to use as specialty crops. As with *O. ficus-indica*, *O. ellisiana* is spineless and appears to be high-yielding.

A. utahensis has modest potential to be used as a crop, but larger selections will have to be identified. The average yield of most *A. utahensis* plants is low.

Beneficiaries:
Utah specialty crop growers, the growing Hispanic population in Utah, and health food consumers are the primary beneficiaries.

Lessons learned:
We learned that we should have focused largely on spineless *Opuntia* species in our study. We also think we should have included high tunnels in the study. Regarding *Agave*, we learned that we should have worked with older *Agave* plants to increase the chance of cold hardiness.

Problems and delays:
We experienced no problems or delays in the last year of the study.

Future project plans:
We have no future plans for this project. However, we plan to build upon it in other studies.

Funding expended to date:
Up to now, $15,133 has been spent on undergraduate worker wages, plant material, supplies, and travel.

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#141629

State of Utah (UDAF) Specialty Crop Block Grant
Final Performance Report

To: State of Utah (UDAF)
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From: Utah Red Tart Cherry Marketing Board
Marc Rowley
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USDA AMS Agreement # 141629

July 22, 2014

Project Title:

1. **Reintroducing Dried Tart Cherries to Utah Market**
   Contract #141629

Project Summary:

In 2012 the U.S. tart cherry crop was devastated by an early spring warm up followed by a series of frosts. The tart cherry industry has the capacity to produce more than 300 million pounds annually and in 2012 produced a mere 85.1 million pounds. With the large crop loss in 2012, the industry lost significant market shares and we needed to aggressively go back after these markets.

In Utah, specifically, 95% of the tart cherries grown are dried. Dried cherries are uniquely identified in the "Super Fruit" category because they are nutritious, convenient and very portable. Dried cherries are the fastest growing category in the cherry industry and are an added value product that creates numerous jobs in Utah. After the decrease in available dried tart cherries in 2012, several of our buyers converted to other dried fruit because we simply could not supply the demand. Therefore, we needed to reintroduce dried cherries and announce to the trade that U.S. tart cherries are available and remind food service buyers that cherries are on trend and one of today's hot "Super Fruits". Trade ads were the best way to get our customers' attention and get dried cherries back on the minds of our buyers and back on the shelf.

Given the continued increase in demand for dried tart cherries over the last five years and following a tough year for the tart cherry industry in 2012, this was a key time and great opportunity to communicate that U.S. tart cherries, especially dried tart cherries, are broadly appealing and **available** year round**.**

Therefore, we implemented a strategic trade advertising media plan and purchased advertisements in key publications (*Baking & Snack, Food Business News, Food Processing, Food Product Design, Snack Food & Wholesale Bakery* and *Prepared Food*) for "dried tart cherries" to drive demand and awareness and ultimately recapture markets and/or increase dried tart cherry sales. This plan significantly helped the cherry industry rebound from the devastating market losses in 2012.

The Cherry Marketing Institute created two trade advertisements (*images of both are included in the additional information section*) to highlight the different usage applications for dried tart cherries.

Project Approach:

With partial grant funding awarded ($22,968), the Cherry Marketing Institute secured seven print advertising insertions and two bonus insertions (*full insertion list is in the additional information section*), generating more than 250,000 impressions. Additionally, the fostered trade relationships secured two pieces of added value editorial content.

Goals and Outcomes Achieved:

We plan to build the momentum for dried tart cherries as an on-trend ingredient – which is why a strong trade media presence will be crucial to reaching ingredient decision makers.

- **Project Goal:** Re-introduce dried tart cherries as a powerful and available ingredient to target ingredient decision makers, supported by trade advertising in strategic trade publications. Our goal is to increase dried tart cherry sales by 20%.

- **Performance Measure:** A key performance measure with ingredient decision makers and this trade ad campaign will be driving people to the industry supplier directory website, CherryProcessor.com. We will use the website analysis and Google analytics to monitor and track the increased traffic, and indirectly, interest in using/purchasing dried tart cherries for product ingredients. Sales will be based on industry analysis and statistics.

- **Benchmark:** For the trade advertising campaign, we hope to secure 7-10 paid insertions and up to five bonus insertions. The total outreach we expect with this project is more than 250,000 impressions. We are targeting 20% increase sales dried cherry sales for the calendar year starting July 1, 2013. A strong industry comeback program is critical for the entire cherry industry and most important to the growers in Utah.

- **Target:** We will target ingredient decision makers at food manufacturers and foodservice to support renewed interest in choosing dried tart cherries as an ingredient. The trade advertising campaign will support 7-10 paid insertions and up to five bonus insertions between January 2014 and December 2014. CMI has strong relationships with trade magazines and will likely receive added value editorial placements via this campaign.

- **Monitoring:** We will obtain a copy of each trade publication to ensure that the advertisements were placed. We will also use website analysis/back-end monitoring tools to assess traffic and drivers to CherryProcessor.com (a website maintained by CMI). Sales will be measured and compared to previous year's movement based on USDA figures.

- **Outcome:** With the grant funding awarded ($22,968.00) the Cherry Marketing was able to meet the outlined goals. We secured seven paid insertions and two bonus insertions for a total of nine trade advertisement insertions for $22,860. This generated more than 250,000 impressions and helped facilitate two added value opportunities. Additionally, we saw more than 25,000 visits to CherryProcessor.com over the course of the media plan.

Beneficiaries:

The trade advertising plan executed strengthened the demand for dried tart cherries in many different facets:

- **Jobs/Sales:** Utah grows 33 million pounds of tart cherries annually. There are approximately 25 growers and 3 processors. If we include input suppliers (chemicals, petrol, nurseries, transportation, farm equipment, etc.), the Utah cherry industry helps employ more than 1,500 people. Therefore, the healthier and more robust the tart cherry industry, the more jobs and income will flow to families in Utah. The reintroduction of tart cherries to ingredient decision makers helped reignite interest in the tart cherry industry through targeted advertising placements.

- **Awareness/Usages:** Increased awareness with buyers in the trade is absolutely essential to rebuild demand and continue to grow the industry. We aggressively want to take our message back to manufacturers that dried tart cherries are available, that their sweet-tart flavor is on-trend, that they make a great addition to most any product, are easy to use, and are deemed a "Superfruit" due to their various health and nutrition benefits. By generating more than 250,000 impressions, we successfully engaged with key ingredient decision makers, increasing awareness of tart cherries' health properties and availability. Additionally, we accessed more than 25 ingredient decision makers, offering up our materials and key messaging continuously over the course of the year.

- **Economic Impact:** Increasing the awareness of dried tart cherries helped develop highly positive attitudes toward the fruit and lead to increased utilization and consumption, the cornerstones of growth.

Lessons Learned:

Diverse and robust media plan: We learned that the best way to reach a broad range of ingredient decision makers is by purchasing a diverse media plan in a variety of food, beverage and baking publications across the industry. A steady consistent message was critical to reach our target audience. As a result of our strategic placements, dried cherry sales are rapidly growing.

Contact:
Cherry Marketing Institute (CMI)
Philip J. Korson II, President
12800 Escanaba, Suite A, DeWitt, Michigan 48820
(P) 517-669-4264, (F) 517-669-3354
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Additional Information:

Paid Insertions:
1. February Food Business News
2. February Food Processing
3. February Snack Food & Wholesale Bakery
4. March Baking & Snack
5. March Prepared Foods
6. March/April 2014 Food Product Design
7. May 2014 Snack Food & Wholesale Bakery

Bonus Insertions:
1. May Baking & Snack
2. September Baking & Snack

Added Value:
1. February 2014 Snack Food & Wholesale Bakery Ingredient Inclusions Update

March 2014 Food Processing Ad Readership Study

#141630

Final Performance Report

Project title:

Raising Awareness of Specialty Crops through a USDA Peoples Garden at Thanksgiving Point, maintained and managed by 4-H Growing Leaders.

Principal Investigator:

Thanksgiving Point Institute

Activities performed:

The project purpose was to raise public awareness and in-depth hands-on learning experiences for youth with specialty crops that can be grown and purchased in Utah. Additionally, the project showcased a variety of ways that youth can incorporate specialty crops in their diet, furthering public awareness of specialty crops.

The following activities were performed in relation to the project and include:

- Weekly summer camps with 13 students focusing on the care, cultivation, and culinary use of specialty crops
- Larger family events where Junior Master Gardeners, their families and guests at the farm contributed in Farm County renovation and planting projects. Participants planted 20 varieties of specialty crops including greens, squashes, tomatoes and more.
- Specialty Crops produce was used to teach the "Learn, Eat, Grow" curriculum in the Junior Master Gardner program as well as in several summer camps/classes
- Junior Master Gardeners sold specialty crops, and distributed cooking suggestions at public events and farmers markets. The Junior Master Gardeners also contributed specialty crops produce to local restaurants.
- Other programs at Thanksgiving Point such as preschool classes, Farm Country public events and summer classes/camps utilized the garden space and produce for plant science activities, noting the importance of specialty crops in Utah.
- Growing Leader teens contributed to building boxes and renovating the garden which featured specialty crops produce.

Goals and Outcomes Achieved:

Overall, this project improved a high producing, functional USDA Peoples Garden which was managed by youth. Through this garden, youth learned about effective gardening of Specialty Crops and healthy living skills. The garden program demonstrated the three goals of the USDA Peoples Garden Project which are: benefit the community, demonstrate community collaboration, and incorporate sustainable practices.

Increasing Children and Youth Involvement in Specialty Crop Awareness

- Within the Goals and Outcomes Achieved
  - Please provide the results of the below goal outlined in the project proposal:
    - At the beginning of the program, each participant will be surveyed to determine where they are on the scale. At the end of the program, participants will be surveyed again to see what growth occurred in each area. Our estimation is that we will see about a fifty percent increase in participants' knowledge, skills, and attitudes towards specialty crops.

Clarification Response:

Youth in the program were surveyed at the beginning of the program, to determine where they were on the scale of understanding healthy living/diet, gardening and fruits and vegetables including specialty crops. This pre-program survey determined that most participants had little to no prior knowledge to these learning categories and specialty crops. The post program evaluation showed that 82% of program participants agreed to eating more specialty crops (both fruits and vegetables) as a result of the program, 88% reported that they eat a more diverse diet of fruits and vegetables due to their participation in the program; 81% reported that they prepare snacks and meals that include specialty crops (both fruits and vegetables) as a result of the program and 100% reported that they are more likely to maintain a healthy diet that includes specialty crops (fruits and vegetables) as a result of their participation in the program. The results from this post-program participant evaluation show that our programming was effective and we exceeded our original estimation of increase in participants' knowledge, skills and attitudes towards specialty crops.

In relation to this goal, some outcomes that achieved through this project were:

☐ More than 20 Junior Master Gardener events focus on specialty crops cultivation and usage.

☐ 10, 4-H and Growing Leader club meetings were held which included an activity to teach youth about specialty crops and how to incorporate them into a summer day camp and Junior Master Gardner meetings. The meetings were as follows:

- February 1, 2016- Planting Planning Party: Junior Master Gardener students helped choose which plants to grow and studied seed science
- February 20, 2016- Indoor Gardening Gurus: Junior Master Gardener students started growing specialty crops indoors to transplant into the garden
- March 12, 2016- USDA People's Garden Renovation: 4-H Growing Leader Teens from across the state gathered to build boxes in the USDA People's Garden.
- April 16, 2016 - Tulip Tear Out: Junior Master Gardener students planted cold weather crops such as broccoli, lettuce and cabbage
- May 21, 2016 - Family Planting Day: Junior Master Gardener students and their families planted spring crops such as tomatoes, zucchini, peppers, and a "mystery garden."
- Weekly Friday Summer Camps 2016: Junior Master Gardener students attended weekly day camps to tend the garden and engage in inquiry based plant science activities
- September 14, 2016 - Harvest Festival: Junior Master Gardener students and 4-H Growing Leader teens harvested vegetables to sell at the Harvest Festival Farmers Market
- Sept 17, 2016 - Family Harvest Day: Junior Master Gardener students and their families harvested vegetables to take home to incorporate into their diets
- October 15, 2016 - Farm Face Lift Teen Event: 4-H Growing Leader Teens, Junior Master Gardener students, and adult volunteers helped to winterize the garden, and complete the USDA People's Garden renovation with additional boxes.

☐ Teen Growing Leaders and Junior Master Gardeners worked together to plan, maintain and harvest the garden

☐ 15 grow boxes were built and installed by Junior Master Gardeners, Growing Leaders, and other volunteers in the USDA People's Garden. Boxes are a variety of formats to instruct the public in a variety of growing techniques and generate interest in specialty crops.

Beneficiaries:

☐ 13 Junior Master Gardeners and 35 members of their families

☐ More than 100 teens contribute in building and installing grow boxes.

☐ More than 200 visitors to farmers market and public demonstrations about specialty crops.

☐ 142,318 visitors and guests to Farm Country, as well as 3,201 of field trip students experience the USDA People's Garden.

Lessons Learned:
The most valuable lesson was the very real need for agricultural instruction in this area. Thanksgiving Point Institute is located in the heart of the geographical location known as Silicon Slopes, a rising technology hub in Lehi, Utah. This area though, was not always technology centered and was once a major farming and agricultural area for the community. Now as cultural focuses begin to shift, technology is becoming a prominent presence in this community; however, agriculture will always need a place in the community as humans depend on farming as a major food source method.
Utah residents live on only 1% of the land mass and with that urban environment, residents need help connecting how the food they eat is produced. We learned that utilizing youth to demonstrate the agricultural connection was extremely effective. When Farm Country guests witnessed youth tending the garden they frequently asked questions and shared their experiences with their children. At times, guests would even choose to help weed the garden with their families.
We also learned the value of connecting the food grown in the garden with ways to prepare it. Junior Master Gardener students frequently prepared their own snacks using produce from the garden. This connected growing produce with a broader healthy lifestyle.

Problems and delays:
The largest problem faced was the unpredictability inherent with outdoor event programming. Planting and remodel days were often subject to weather extremes. We had to postpone planting days due to thunderstorms. It was a long, hot summer that also took a toll on cool season specialty crops. This was a good lesson for the children to learn.

Future project plans:
Future plans for the USDA People's Garden project include increased entrepreneurship and philanthropy. We want the Growing Leaders and Junior Master Gardeners to take increased leadership roles in selling, preserving and donating specialty crop produce from the garden. These outlets will also serve as educational venues to increase community awareness of specialty crops.

Funding expended to date:
To date, all funding granted for this project. Below is a detail of the funds that were expended in each category: Specialty Crops Block Grant Expenses/Budget 2015-2016

Personnel	$8,000
Fringe Benefits	$800
Travel	$0
Equipment	$0
Supplies	$6,575
Contractual	$0
Other	$0
Indirect Costs	$0
Total	$15,375

Larry.Rupp@usu.edu
435-232-1158

Specialty Crop Block Grant Report 141631
Final Report

PROJECT TITLE
South Salt Lake Community Connection to Agriculture Project-Central Park

PRINCIPAL INVESTIGATOR/REPORTER:
Ashley Babbitt

PROJECT SUMMARY
o Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.

South Salt Lake Community Connection to Agriculture Project is designed to increase child and adult nutrition knowledge and consumption of fruits and vegetables, and to assist residents and local producers in improving efficiency of the distribution chain. Project efforts will be directly focused in the Central Park area (2700 So-2900 So & State St. to 300 East)—a persistently distressed, highly urbanized South Salt Lake neighborhood.

This project was greatly needed in the Central Park Neighborhood for the following five reasons:

1. Utah IBIS data indicate that approximately 60% of the population is overweight or obese, having a BMI of 25 or greater. Being overweight increases the risk of many chronic diseases, including heart disease, stroke, hypertension, type 2 diabetes, osteoarthritis, and some cancers. Obesity is the second leading cause of preventable death in the U.S.
The obesity epidemic among South Salt Lakers threatens to reverse the decades-long progress made in reducing death from chronic disease. Additionally, fewer than 30% of the adults in South Salt Lake get adequate servings of fruits and vegetables on any given day.

2. The Central Park Neighborhood is an area of extreme poverty. Most recent data show the per capita income in South Salt Lake as $ 16,375, as compared to the state statistic of $24,344 and well below the national figure of $25,804.

3. Many of the residents are international refugees who have come here to seek a better life. Approximately 1,450[1] of Utah's international refugees reside in South Salt Lake, making up approximately 7% of the total city population.[2] Many of these families face enormous barriers related to language, culture, and institutional knowledge that leave them with little information about how to navigate through the school system, legal/justice system, and how to access other available services.

4. The Central Park Neighborhood hosts a high number infants, toddlers, and children under the age of 5, and also a disproportionate number of individuals with disabilities live in this volatile and at-risk neighborhood. There is also a high concentration of graffiti and other gang activity, but on the positive side, a brand new community garden at Granite Park Jr. High and the presence of the Police

[1] Gerald Brown, Director of Refugee Services, Utah Department of Workforce Services
[2] Jensen, Derek; Manson, Pamela: The Salt Lake Tribune, "2010 Census: Utah Wears a Coat of Many Colors"

Athletics/Activities League Youth Boxing program and the conversion of the formerly abandoned Woodrow Wilson Elementary school into the Central Park Community Center, where the PAL programs are held, and a new Head Start Center (all within the target area), along with this project, will provide a positive foundation on which to revitalize the health and wellbeing of this neighborhood and provide new access to fruits and vegetables and new outlets for growers.

5. Farmers need to have an outlet to sell their fruits and vegetables. Prior to the last 3 years, South Salt Lake had not hosted a farmers market, and the markets delivered in 2010-2012 were very limited and small in size as there were no staff available for the assignment of organizing, plan, recruit farmers and supervise the market.

o Establish the motivation for this project by presenting the importance and timeliness of the project.

The motivation of the South Salt Lake Community Connection to Agriculture Project was to make a collective impact on the wellness of our residents through addressing the needs of child and adult nutrition knowledge and consumption of fruits and vegetables and assisting residents and local producers in improving efficiency of the distribution chain.

The timeline for this project was critical, as the Central Park Neighborhood was the selected as the 2014 neighborhood of the Community Connection program in South Salt Lake. The City has launched the initiative Community Connection to revitalize targeted at-risk neighborhoods. The Community Connection project has brought together experienced, inspired partners to establish and maintain relationships with community members who have the desire and capacity to improve the quality of life residents. Through leveraging existing relationships and resources of the Community Connection initiative, the Community Connection to Agriculture program was able to hit the ground and make an impact to address time-sensitive issues, including the following: geographically, the Helm Avenue Neighborhood of South Salt Lake has been designated by the USDA as a "Food Desert" due to limited access to fresh food; prior to the last three years, South Salt Lake had not hosted a farmers market, and the markets delivered in 2010 and 2011 were very limited and small in size as there were no staff available for the assignment of organizing, plan, recruit farmers and supervise the market.

o If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complimented and enhanced previously completed work.

This project complimented the work of the 2012 Community Connection to Agriculture Helm Avenue Project by increasing awareness of fruits and vegetables in the targeted neighborhoods of the Community Connection Project. This project helped to drive momentum for the farmers market as well as increase visibility and recognition for fruits and vegetables during city-sponsored events and gatherings. Our 2013 project was able to harness the previous momentum from the Helm Avenue Neighborhood by building on knowledge of fruits and vegetable consumption additionally in our city outreach materials, including our city newsletter, bulletin boards, and afterschool program staff, who have previously attended the 2012 farmers market and farm stand and were able to share the news with local families about their experiences.

PROJECT APPROACH

o Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative

terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.

Four strategic activities were employed to assure project success:

1) Creation of a Farm Stand by partnering with a local business to lead collaboration among local farmers and producers to bring fruits and vegetables into the neighborhood to sell

2) Assist residents interested in producing fruits and vegetables connected with existing programs such as the Granite Park Jr. High Community Garden, SL County Extension, SL County Refugee Services Office's "New Roots" program, and/or growers groups (such as Utah Fruit and Vegetable Growers Association)

3) Organize, recruit local fruit and vegetable growers to participate in the South Salt Lake Farmer's Market

4) Support municipal development of a local food policy.

The farm stand was created through partnering with the Central Park Community Center, home of the PAL Boxing Program, located in the Central Park Neighborhood, with high exposure to the 200 East traffic and the recreational leagues on the site of the targeted neighborhood. The collaboration with local farmers included a local Girl Scout Troop 2492, two local produce growers from Salt Lake City, a family-owned farm (3 Squares Produce), and a community garden in the Sugarhouse Neighborhood (Sugarhouse Community Gardens). Different vendors participated in the farmers market, with the weekly customers ranging from 40 to 100 in attendance. The farm stand sold more than 3/4 of the available produce weekly with customer count ranging from 15 to 50 in attendance. We recommend beginning the farm stand and farmers market earlier in the growing season to continue to encourage returning customers and to expand the variety of produce diversity available.

If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops.

N/A

o Present the significant contributions and role of project partners in the project.

The South Salt Lake Urban Livability Department Director Glenn Smith was responsible for directing this project. The Community Connection to Agriculture program utilized the Community Connection committee comprised of marketing and research partner Social Marketing Consultants, South Salt Lake Public Works, South Salt Lake Attorney's Office, Community Development, and Mayor's Office who met weekly and who are all invested in the success of South Salt Lake Community Connection to Agriculture Project. Social Marketing Consultants designed the community deliverables, messaging, and surveys for the project as well as managed the project intern. Public Works and the South Salt Lake Attorneys Office assisted with reviewing site plans to ensure they were meeting city code and expectations. The Community Development department consulted with the project intern to apply for a business license, to change city code, to make the farm stand possible, and to specify what signage meets city standards. The Mayor's Office showed public support, such as the Mayor's family appearance at the market and encouraged residents to

get involved through existing resident groups including the Neighborhood Advisory Committee (NAC).

The Community Connection to Agriculture Project involved over 20 partners, some of whom have been working together in various capacities since 2007. United Way of Salt Lake (UWSL) was a primary partner along with research partner Social Marketing Consultants (SMC). Additional partners included the following: South Salt Lake residents, the Mayor's office, Salt Lake County Community Development Block Grants (CDBG), Granite School District, K2 the Church, The Church of Jesus Christ of Latter Day Saints (Mormon), The RAIN Foundation, Community Development Corporation of Utah (CDC), Assist, Zion's Bank, SL County Refugee Services, Latinos in Action, and AmeriCorps. Public safety practitioners served as key participants in South Salt Lake Community Connection to Agriculture Project. All grant partners worked toward the goals and objectives through a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and utilizing backbone support organizations.

GOALS AND OUTCOMES ACHIEVED

o Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments

The South Salt Lake Community Connection to Agriculture activities that were completed to achieve the performance goals and outcomes were as follows:

1. Selected intern to work on the project
    a. Formed Committee to oversee project
    b. Recruited at local colleges and universities
    c. Selected and oriented intern
    d. Created detailed task plan
    e. Documented accomplishments and measured progress
2. Partnered with local farmers to bring a Farm Stand to the target neighborhood
    a. Work with Committee to formulate farmer outreach plan
    b. Implement the farmer outreach plan
    c. Develop relationships with local farmers and evaluate the outreach efforts
3. Worked with a local produce Company to bring a Mobile Produce Market into the Neighborhood
    a. Collaborated with committee and local Chamber of Commerce to brainstorm produce companies and outreach strategy to find local produce company interested in this project
    b. Communicated with zoning department to coordinate with Produce Market operations, routes, and locations
    c. Created detailed plans for distribution
    d. Selected Company based on previous research on routing, distribution, and produce availability (Action Locksmith)
4. Helped residents of the neighborhood to get connected to extension services and other resources
    a. Conduct an assessment of extension services and resources available to residents and neighbors

b. Met with Committee to develop neighborhood outreach plan; collaborate with larger Community Connection initiatives to spread the neighbor outreach plan
c. Followed up with service partners to measure progress
d. Evaluated neighbor outreach plan through connections made and residents accessing resources

5. Organized and recruited local fruit and vegetable growers to participate in the South Salt Lake Farmer's Market
    a. Worked with Committee to develop recruitment plan to network with local fruit and vegetable growers
    b. Developed and distributed promotional materials for SSL Farmer's Market
    c. Survey local fruit and vegetable growers who participated to inform future planning and production of the market
6. Assess, report, coordinate planning for future year
    a. Assign research partner to assess all evaluations of residents, participation, sales, health statistics, and information gathered during implementation
    b. Report by research partner to committee about the project year to date
    c. Coordinate action plan for the future year based on committee feedback and statistical analysis

o If outcome measures were long term, summarize the progress that has been made towards achievement.

The potential impacts of this project were great, with both immediate a future implications (Please also see quantification in section below):

1) Improve overall health through <u>increased resident consumption of fruits and vegetables</u> through greater availability were provided through the Farm Stand, the Mobile Produce Market and the South Salt Lake Farmers Market. The USDA Food Desert Map indicates that this neighborhood sits on the border of one of Utah's "Food Deserts." This is especially significant because of the economic conditions in the targeted neighborhood, where residents don't have access to cars. The food that is readily available to residents is fast food sold at 7-11.
2) The project aimed to <u>increase the knowledge about specialty crops through demonstrations and creating connections to supports for those interested in growing fruits and vegetables</u>. Residents had the opportunity to see how to store, prepare, and best utilize available fruit and vegetables in season to maximize their own household incomes.
3) <u>Support the distribution chain</u> through increasing earning potential for local growers through increased opportunities for local producers to sell what they grow at the Farm Stand, the Mobile Produce Market and the South Salt Lake Farmers Market. Through having enough outlets to sell their products, it increases the likelihood that farmers and growers can make a livelihood or supplement their incomes enough to continue their enterprises.

o Provide a comparison of actual accomplishments with the goals established for the reporting period.

GOAL: Increase consumption of fruits and vegetables in the target neighborhood

Performance Measure	Benchmark/ Target	Actual Accomplishments
Number and percent of residents who know the Recommended amount of fruits and vegetables to consume daily	10% increase in consumption from pre to post project survey. Pre survey delivered in June 2014, Post survey delivered October 2014.	11% increase in knowledge of consumption of fruits and vegetables (recommended values) in the target neighborhood

GOAL: Increase knowledge regarding specialty crops access (farmers market) in the target neighborhood

Performance Measure	Benchmark/ Target	Actual Accomplishments
Number and percent of target neighborhood residents surveyed who report increased knowledge of South Salt Lake Farmers Market	20% increase in consumption from pre to post project survey. Pre survey delivered in May 2014, Post survey delivered October 2014.	Surveys at beginning and end of project reported a 22% increase in the knowledge of the South Salt Lake Farmers market.

GOAL: Improve efficiency in the distribution chain

Performance Measure	Benchmark/ Target	Actual Accomplishments
Number of farmers and growers engaged to participate in a) Farm Stand, b) Farmers Market	# of farmers and growers who participate in the project components at the time of delivery- Target: 20 farmers/growers	21 farmers market vendors throughout the season

o Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Highlight the major successful outcomes of the project in quantifiable terms.

Of 58 participants in the June survey, 44.1% responded correctly that 2 cups of fruit and 2.5 cups of vegetables were recommended daily; in the October 2014 survey, out of 82 survey participants, 55.6% responded correctly about fruit and vegetable consumption recommended daily values.

Of 58 participants in the June survey, 42.4% responded that South Salt Lake has a farmers market; in the October survey, out of 104 participants, 63.8% of respondents responded correctly, showing a 19% increase in knowledge.

Twenty-one vendors became involved and participated in the South Salt Lake farmers market throughout the season.

BENEFICIARIES

o Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.

Groups who directly benefited from the Community Connection to Agriculture project included the following: South Salt Lake youth and families gained access to fresh produce through the new farm stand and the newly organized farmers market; local farmers and community gardens were able to sell locally, cutting down on transportation costs and increasing local customer base; project partners, such as Sugarhouse Community Gardens, were able to decrease the amount of produce that isn't utilized through immediate neighbors; refugee gardens were supported and encouraged local farming that supports culturally diverse backgrounds.

Groups who indirectly benefited from the Community Connection to Agriculture program included the following: Central Park Community Center gained exposure through hosting the farm stand as the host site partner; the Scott School (location of the farmers market) was able to attract and welcome new artists and residents through the farmers market; future entrepreneurs who are interested in producing other farm stands can now be up to city code thanks to adjustments that were made during this project; the Community Connection project was able to reach out to neighbors in a new way through connecting through food.

o Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Nearly 6,000 South Salt Lake youth and families gained access to fresh produce through the new farm stand and the newly organized farmers market; 21 local farmers, vendors, and community gardens were able to sell locally, cutting down on transportation costs and increasing local customer base; project partners, such as Sugarhouse Community Gardens, were able to decrease the amount of produce that isn't utilized through immediate neighbors by 40 pounds of produce.

LESSONS LEARNED

o Offer insights into the lessons learned by the project staff as a result of completing this

project. This section is meant to illustrate the positive and negative results and conclusions for the project.

As we learned last year, start organizing the farmer's market as early as possible. People are very busy in the summer and can sometimes be unreliable. Several of the vendors we really wanted at South Salt Lake's farmer's market were already signed up with other markets around town. Start calling at least 3 months in advance.

With the farmer's market, make a plan for community vendors who simply show up to participate without contacting the market coordinators. Next time, we will have extra tables and be sure to have extra applications on file. We could ask some vendors to attend for 2 weeks and then have another vendor to fill their spot for the remaining two weeks.

o Describe unexpected outcomes or results that were a effect of implementing this project.

Through establishing the farm stand, the project was able to interrupt established walking routes to convenience stores, such as 7-11. Many of the first customers were on their way to get a Mountain Dew for breakfast walked away from the stand with a few apples instead. The farmers market appealed to an unexpected audience: the afterschool program at the Scott School ended during the beginning of the farmers market, and youth and staff members were able to take home fresh produce to their families. Another unexpected outcome was creating a community space on the Scott School Great Lawn for other healthy activities, such as yoga, that was able to take place alongside the farmers market.

o If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem solving.

Outcome measures were achieved. We learned that early planning helps to expedite problem solving. Through our project intern communicating via a daily email, we were able to establish the frequent communication and attention needed to achieve successful outcomes.

FUNDING EXPENDED:
No Department of Agriculture funds were expended for this project. All expenses for the project this year were covered by the Union Pacific Foundation.

CONTACT INFORMATION
o Name the Contact Person for the Project
Kari Cutler

• Telephone Number
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• Email Address
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Final Performance Report 141633

Project title: Utah Family Farm Exhibit Enhancement

Principal Investigator: Discovery Gateway Children's Museum

Activities performed: Discovery Gateway worked with the following community partners to design specialty crops graphics and interactives in the Utah Family Farm Exhibit:
· Young Living Lavender Farms
· Utah Pork Producers
· USU
· Utah Dairy Council
· Utah Beef Council
· USDA

The following activities occurred:
· Large scale specialty crops graphics were installed
· Lavender (Seed to Seal) and honey bee interatives were created, focusing on plant growth cycle and harvest, hive building (math), and the importance of pollination.
· Research was conducted and a Utah county map was created focusing on educating about specialty crops produced in each county
· A silo was fabricated to house a Farm Bureau Agency touch screen kiosk with educational computer games, focusing on agriculture and specialty crops
· Discovery Gateway's education staff created pre-and post-test handouts, to be administered by teachers, as a way to gauge initial knowledge about specialty crops. As students visit and interact with the exhibit and museum educators, their knowledge of specialty crops are tracked and measured to show impact. Educational workshops include learning about specialty crops with the use of a county map, participating in fun educational exercises, and learning how bees pollinate specialty crops.
· Agricultural props (fruits, vegetables, lavender) were added to the farm exhibit and adjacent grocery store exhibit to facilitate educational play.

Goals and Outcomes Achieved: Because of the Specialty Crops partnership, Discovery Gateway able to connect with other community partners to gather more information and funding to update the Utah Family Farm Exhibit to truly and accurately reflect the Utah agricultural community, as well as educate a broad audience (over 250,000 visitors annually) about Specialty Crops. Discovery Gateway educators also developed and administered educational workshops, pre and post-tests, and handouts with to visiting students. Discovery Gateway's education department sent pre and post-test handouts to teachers as a way to gauge initial knowledge about specialty crops. As students visited and interacted with the exhibit and museum educators, their knowledge of specialty crops was tracked and measured to show impact. Educational workshops included learning about specialty crops with the use of a county map, participating in fun educational exercises, and learning how bees pollinate specialty crops. Students have since shown a 50% increase in knowledge pre vs. post test. Going forward, the museum hopes to continue to grow community partnerships to introduce our early childhood audience to more information about Utah agriculture and production, as well continue to improve and maintain the Utah Family Farm space.

Beneficiaries: The main beneficiaries of the project are young children (ages 18 months to 10 years old), their families, and Utah students (including Head Start and Title I students). We have also partnered with community organizations that serve refugee and underserved groups to provide free admission and field trips to broaden our reach and impact.
· In 2014: 182,018 children and families and 33,680 field trip students benefited from the project.

- In 2015: 145,630 children and families and 26,754 field trip students benefited from the project.
- In 2016: 132,665 children and families and 30,226 field trip students benefited from the project.

Lessons Learned: Gathering very specialized information and formulating it to educate and inform an early childhood demographic requires coordination from many diverse groups. Deciding on an end goal that will benefit both our visitors and our community partners has been valuable, in that we have opened up a new child-centered audience to organizations that have typically had low to moderate traction with young children. We also learned that not many people were aware of the vast array of specialty crops being produced in Utah. Visitors are now more motivated to look for local businesses when consuming specialty crops.

Problems and delays: The biggest delay was designing and fabricating the silo that houses the educational touch screen interative. Issues with materials and size – as well as access within the exhibit slowed the building process. Process was also slowed by creating and maintaining a constant connection to the game application. Another problem was communicating the level of maintenance needed for a museum exhibit to our community partners. Typically the need is great, and this is something that should have been communicated up front.

Future project plans: Working with other community partners to promote more interaction with Utah Specialty Crops. Creating more educational information and interactive about honey bees, pollination, and their hives. Building a new exhibit called the Honey Comb Climber in the museum's Garden Gallery. The climber will tie Utah's state symbol for industry, the beehive, to our museum mascot, the honey bee, while highlighting specialty crops, honey, and the plants that make pollination possible. The project will include building a honey comb climbing structure that surround the space and allows young visitors to explore educational interactives along their journey.

Funding expended to date: $22,008.22 Contact Information:

Rachel Tibolla, Senior Development Manager – 801-456-5437 x115, rtibolla@discoverygateway.org

FINAL PERFORMANCE REPORT

Wasatch Community Gardens
2013-2014 Specialty Crop Block Grant Program

PROJECT TITLE

2. Youth Gardening Program: City Roots Classes
   Contract # 141632

PROJECT SUMMARY

Low-income youth in Utah lack opportunities to discover and consume fresh, healthy fruits and vegetables. Most children eat far less than the daily-recommended servings of fruit and vegetables, and childhood obesity is on the rise. Childhood obesity has been linked to other diseases, such as Type II diabetes, and has been linked to negative outcomes for children such as poor school performance, bad behavior, and health complications. These problems affect not only individual youth but also the entire community.

Specialty Crop Block Grant Program (SCBGP) funding supported our Youth Gardening Program – specifically our City Roots after-school and summer gardening classes for youth from low-income families. In 2014, City Roots classes provided 584 youth with opportunities to grow, eat, and prepare fresh fruits and vegetables in our two youth teaching gardens. Youth participants come to us through our partnerships with social service agencies that serve low-income youth. These partnerships capitalize on our respective strengths and ultimately serve to build each organization's capacity. Our partner agencies interact directly with families, recruit youth participants, and provide the necessary infrastructure, such as transportation to and from the garden. WCG complements this by maintaining dynamic and productive youth gardens as outdoor classrooms, and developing and running a unique garden-based education program that our partner agencies do not have the expertise or capacity to run.

SCBGP funding has supported this program previously. Funding in 2014 allowed us to continue the program, revise existing curriculum, create new curriculum, refine the program's goals and objectives, and continue to improve our evaluation process. With the additional funding we were awarded, we were able to reach a more diverse audience of low-income youth with the goal of promoting fruits and vegetables.

Continuing our City Roots classes year after year allows WCG to develop ongoing relationships with partner agencies, work with the same groups (and even some of the same youth participants) for consecutive years, and continue to work with new youth each year.

PROJECT APPROACH
Specific activities and tasks performed in 2014 (per our original work plan) were as follows:

1) Develop/revise curriculum and teach/document City Roots classes

City Roots classes are taught by our City Roots Youth Educator. The Youth Educator position is filled each year with a 1,700-hour Utah Conservation Corps (UCC) AmeriCorps member. Our 2014 Youth Educator was Emma Kroon Van Diest. The Youth Educator develops and revises curriculum, with assistance and supervision from our Youth Program Director, Bill Stadwiser.

City Roots classes take place in our Grateful Tomato Garden in the Central City neighborhood and our Fairpark Garden in Salt Lake City's west side. Partner agencies bring a group of kids to the garden for a weekly, one-hour class. Attendance is at the discretion of partnering agencies, so some individual participants come every week and others attend fewer classes. In 2014, we held four 5-8 week sessions: Winter (late February – early April), Spring (mid-April – late May), Summer (mid-June – early August), and Fall (mid-September to late October).

In 2014, our Youth Educator focused on making her lesson plans easily relatable for the youth participants, recognizing that not all kids drink wheatgrass juice or smoothies. Some examples from the past year are as follows:

- Planting peanuts, watching them grow, and determining that, yes, they do actually come from a plant in the ground!
- Growing and eating the seeds from giant sunflowers.
- Planting watermelons and learning how to tap on them to figure out if they are ripe. This evolved into using watermelons as musical instruments!

- Digging for "gold," otherwise known as harvesting potatoes with toddlers. This lesson taught the kids that French fries come from the ground!
- Pureeing local, in-season apricots to make healthy popsicles.

2) Garden planning, care, and maintenance
Ongoing garden maintenance in the youth gardens is performed by the Youth Educator with assistance from the Youth Program Director and numerous volunteers. In 2014, our youth staff and volunteers also completed the following special projects at the Grateful Tomato Garden – the primary location for our City Roots classes:

- Installed a white, weatherproof metal roof over our main teaching patio to repel rain and reflect sun during the hot summer months.
- Repaved our brick patio where we conduct the majority of our youth classes.
- Partnered with a local artist/builder and the Utah Museum of Contemporary Arts to replace our old chicken coop with a beautiful new coop that can house more birds.
- Repaired and lime washed the exterior walls of our straw-bale greenhouse.
- Built/planted an herb spiral to be used by our youth programs.
- Organized a compost courier volunteer group that rescues compostable material from Salt Lake City businesses and delivers it to our youth compost bins.

3) Build and maintain relationships with partner agencies and market the program
Our Youth Program Director oversees partner agency communication and recruitment. In 2014, we recruited three new agency partners: Peer Court, Promise South Granite Park Jr. High, and Salt Lake Housing Authority. We continued working with the following long-time partners agencies: Boys & Girls Clubs, Northwest Children's Learning Center, Youth City, YMCA, and YWCA.

Given our limited resources, we don't anticipate being able to bring on significant numbers of new agency partners in the coming year. However, we have identified a possible way to increase our reach without substantial additional resources. It would involve making our Youth Educator available to travel to our partner agencies' onsite gardens, in additional to having agencies bring their youth to our gardens. We will be doing a feasibility study of this in 2015 and may offer it as an option in the future if it proves to be useful to our partners and effective in helping us reach additional youth.

4) Program evaluation
The Youth Educator compiles quotes, stories, photos, and evaluations from City Roots classes and works in collaboration with the Youth Program Director to review and revise goals/outcomes/evaluation for future programming.

Our Youth Program Director is currently having conversations with the University of Utah's Family & Consumer Studies Department to implement a peer-reviewed research project aimed at evaluating the effectiveness of City Roots programming with respect to kids' attitudes towards gardening and specialty crops. In the event that the project moves forward, research would take place in 2015 with peer-reviewed publication likely in 2016.

GOALS AND OUTCOMES ACHIEVED

Goal #1: Increase participants' knowledge about the connection between food choices and health. City Roots classes educate participants about the role that vitamins, minerals, fruits, and vegetables play in health. Youth participants learn about "healthy calories" and the impact of their food choices on their activities, such as running, jumping, playing, and thinking. They learn that eating plenty of fresh fruits and vegetables can help prevent disease and injuries.

In one of our 2014 City Roots lessons, participants learned about the nutritional value of apricots, then they ate popsicles made from local pureed apricots. After eating the popsicles, youth participants made comments such as:
"Look, I can pick up my brother after eating THAT [garden-fruit] popsicle!"
"Where are all the weeds to pull? I'm ready!"
"Now I can harvest ALL of the giant squash!"

In addition, a preschooler from Northwest Learning Child Center made the connection that "if the garden is healthy, I will be too!"

2014 ACCOMPLISHMENTS:

- 95% of participants can explain at least one way that nutrients in fruits/vegetables help their body/health (based on pre/post tests).

Goal #2: Provide opportunities for youth participants to harvest and taste fresh fruits and vegetables from the garden. In our experience, exposing youth to fruits and vegetables is the first – and often most important – step in getting then to make long-lasting, healthy nutritional choices. In each City Roots lesson, participants explore the sensory attributes of a wide variety of edible plants, including fruits, vegetables, herbs, and flowers.

In 2014, our Youth Educator experimented with growing strawberry popcorn with the youth participants. Together, they planted, watered, harvested, and dried the popcorn. The last class of the year, they celebrated by popping their homegrown popcorn. Says our Youth Educator Emma: "Students were blown away by the amount of work, time, and patience that went into growing and preparing popcorn – a favorite snack that before they only knew as coming in a microwavable bag. Through these lessons, kids learned where popcorn comes from. They also learned a healthy cooking technique using a pot, stove, and vegetable oil – not a microwave and butter. The students all commented that it was the best popcorn they had ever had! They were so excited about taking some home to share with their families."

Being involved in growing and harvesting fruits and vegetables helps youth participants feel ownership and enthusiasm about the results of their efforts, and inspires them to try new foods. In 2014, one lesson involved making salsa from all ingredients (except salt) that were in season and in the garden. This included tomatoes, tomatillos, peppers, basil, chives, and green onions. Youth participants helped harvest, wash, and chop all of the ingredients. With one exception, every time, the bowl was licked clean, and 100% of the students enjoyed it. The exception was a day when the kids did not come to the garden due to rainy weather. Instead, our Youth Educator traveled to their on-site center (that does not have a garden), bringing with her the ingredients that she had already harvested and chopped. Out of the 12 kids that day, only two of them liked the salsa, and two wouldn't even try it. Says Emma: " I am convinced that, had they been in the garden, the kids absolutely would have had a different reaction to

the salsa. They would have been more excited, and more willing, to try something new if they had been involved in harvesting and preparing it."

2014 ACCOMPLISHMENTS:

- 100% of participants had the opportunity to help harvest and/or taste fresh produce (fruits, vegetables, or herbs) during a City Roots class.

Goal #3: Provide opportunities for participants to practice recipes and creative food preparation.

Our City Roots Youth Educators create lesson plans and recipes based on their experiences and what is in season in the garden. Says Emma: "This summer, I cooked caramelized sunflower seeds with the kids from our crop of huge, 12-foot sunflowers. Together, we harvested over 20 pounds of seeds and used every last plant. The kids loved this snack and it had a huge impact on their ability to make the connection between garden and food. It was fun to watch a number of kids having an 'ah-ha' moment when they realized 'oh, THIS is where sunflower seeds come from!'"

In addition, we made homemade popsicles from fruit and juices, with no added sugar. Along with the apricot popsicles described above, we also made apple and honey popsicles. Says Emma: "The kids couldn't get enough of them!"

Youth participants also used a juicer to make juices from carrots, cucumbers, and grapes. Says Emma: "It was amazingly sweet and delicious and the kids declared it 'the best juice EVER!'"

The kids also learned that pickles are really cucumbers by making their own refrigerated pickles to take home. They were responsible for picking cucumbers, hot peppers, and garlic; doing the slicing and dicing; and making the brine.

Finally, youth participants learned that pizza sauce is made from vegetables by picking all their ingredients (tomatoes, onions, oregano, basil, and garlic) and pureeing them to put on pizzas cooked in a solar oven.

2014 ACCOMPLISHMENTS:

- 100% of participants had the opportunity to help prepare and eat a healthy dish or snack involving fruits and vegetables from the garden when in season [excludes classes held in February and November].

Goal #4: Provide opportunities for participants to share fresh fruits and vegetables with their families and the greater community.

In 2014, our staff, youth participants, and volunteers harvested over 4,500 pounds of produce from our youth program plots. City Roots participants had the opportunity to take home produce that they helped grow or harvest to share with their family. Excess produce was donated to local food pantries to help reduce hunger and improve access to healthy, organic food in Salt Lake County.

2014 ACCOMPLISHMENTS:

- 90% of participants were given at least one opportunity to bring home fresh organic fruits or vegetables from the garden to share with their family when in season [excludes classes held in February and November].

Goal #5: Provide the opportunity for participants to learn organic gardening skills and grow their own fresh, healthy food.

By digging beds, planting seeds and transplants in the soil, and caring for their plants, participants become empowered with the skills and knowledge to grow their own fruits and vegetables as a low-cost means of eating healthy food. Youth participants also learn to identify parts of plants, as well as understand life cycles of plants, animals, and other natural cycles in a garden ecosystem.

2014 ACCOMPLISHMENTS:

- A majority of participants demonstrated increased organic gardening knowledge and skills, and 100% of youth participants reported participating in at least one the following gardening activities for the first time: planting, watering, weeding, harvesting, composting, mulching, trellising, fertilizing, insect identification, and backyard chicken care.

While these quantitative results help us measure the success of our City Roots classes, quotes from the youth participants also underscore that our garden-based education helps develop a generation of happy fruit and vegetable eaters. Here are some of the statements we overheard in the garden this year:

"This is the best carrot of my whole life!" ~Kelly, age 6

"These tomatoes are like garden candy!" ~Xavi, age 5

"Two thumbs up. Six thumbs up! I have to teach my mom how to make this salad." ~Kira, age 8

"Who knew strawberries and basil could be best friends?" ~Sam, age 8

"We grew *all* of this??? I don't believe it!"

"I didn't know pickles were really cucumbers!"

"If I was a carrot, I'd be purple."

"My favorite part about coming [to the garden] is eating the fresh tomatoes."

BENEFICIARIES

In 2014, 584 youth, ages 3-17, participated in our City Roots classes. Of those 584 youth, approximately 55% came to us from households with "extremely low" incomes as defined by Federal guidelines. Another 35% were from households with "very low," "moderately low," or "low" incomes. Roughly 40% of these participants were Hispanic or Latino, and about 60% came to us from single female-headed households.

LESSONS LEARNED

Says Emma, our 2014 City Roots Youth Educator: "The lesson I learned this year is to remember PLAY as an educational tool. Kids spend plenty of time sitting and listening to adults. I worked hard to develop lessons that enable students to use the act of playing as an investigative tool that naturally creates curiosity and the desire for knowledge. Some of these lessons included dressing up in disguise to be secret pest detectives to capture bad guys, playing capture the flag to protect the delicate parts of a garden like the harvest, pretending to be garden critters to see under and over and all around. All of these lessons led to discoveries about how plants grow and how fruits and vegetables make us strong and healthy."

Another lesson is one that we have known but that was reinforced for us again this year. Although our evidence for this is somewhat anecdotal, we find it repeatedly true that if a child participates in some aspect of caring for a fruit or vegetable plant, he or she is much more likely to volunteer to eat that plant and is much more likely to describe it as "tasty" or "delicious." The more aspects of gardening, plant-care, or harvesting a child participates in over time, the stronger the correlation. Once again, we witnessed this year that, when teaching kids about fruits and vegetables, we see the best results when they are involved in as many steps of the cultivation process (i.e., planting, watering, harvesting, and food preparation) as possible.

CONTACT PERSON

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ADDITIONAL INFORMATION

Please see e-mail with photos from our 2014 Youth Gardening Program.
Specialty Crop Block Grant Annual Performance Report

#SBCS14

Project title: Managed Honey Bee Survey in Tree Fruit Production Areas of Utah

Principal Investigator: Kristopher Watson

Activities performed:

Over two years, this project has resulted in 347 inspections of beehives for health issues. Hives were heavily sampled from the fruit growing counties of Washington, Utah, Davis and Box Elder. This far exceeded the target number of apiaries to inspect.

Before each health inspection, beekeepers were asked a series of management questions and this data was recorded. At least three frames from every colony in the apiary were inspected for AFB and other

brood diseases. A powdered sugar roll was performed to determine the Varroa mite (*Varroa destructor*) load and the presence/absence of Tropilaelaps mites (*Tropilaelaps clareae; T. mercedesae*). The surveyor also looked for the exotic small hive beetle (*Aethina tumida*). If diseases could not be field diagnosed a sample of brood comb or bees were taken for lab analysis. All data on Varroa loads and field diagnosed/lab confirmed pathogens were recorded.

The data collected was sorted according to its proximity to fruit orchards. Any beehives inspected within four miles of an orchard were considered in a "fruit growing area," whereas any colonies more than four miles away will be regarded as "outside a fruit growing area." This distinction is made in order to make a comparison of health between honey bees which may be pollinating orchards and those which are not providing specialty crop pollination.

Public outreach was also accomplished, per the guidelines of the approved project proposal. A UDAF Apiary Specialist discussed the goals of the survey, recruited beekeepers to participate and presented an overview of honey bee health threats at four meetings in 2014 (see "2014 Annual Performance Report" for a list of meetings attended) and at four meetings in 2015 (see below). Web-based outreach and education was also performed as prescribed in the project proposal; data collected for this survey was published online in both the 2014 Tree Fruit Report and in the 2014 Insect Report. The latter report was distributed to 419 people in 2015. Links to both of these resources were posted on http://ag.utah.gov/plants-pests.html and this page was visited 456 times during the 2015.

Presentations

Below is a detailed summary of the meetings where information about the project and recruitment for participation in the survey were presented:

Utah State Horticulture Association Convention
January 21st, 2015
Hosted at Payson Fruit Growers, Plant B
5912 West 11600 South, Payson
Contact: Diane Alston diane.alston@usu.edu
Attended by 59 people

Weber County Beekeepers Association
May 28th, 2015
Hosted at Deseret Hive Supply
1516 Washington Blvd, Odgen
Contact: Rick Davis (801) 668-3502
Attended by 40 people

The Honey Bee Festival
June 6th, 2015
Hosted at Sorensen Unity Center
1383 South 900 West, Salt Lake City
Contact: Tatiana Subbotin (801) 244-9592
http://slowfoodutah.org/programs/honeybee-festival/
Attended by 220 people

Davis County Beekeepers Association
September 10th, 2015
HOA Clubhouse
2937 E 125 N, Layton
Contact: Richard Homer homersbeez@gmail.com
Attended by 15 people

Goals and Outcomes Achieved:

Over the two year period, the survey was responsible for identifying nine cases of American foulbrood, 10 cases of European foulbrood, 38 cases of Nosema spp., 37 cases of Parasitic Mite Syndrome and eight cases of chalkbrood. Beekeepers were assisted in effectively treating these maladies. If colonies had a transmittable disease, the beekeeper was given guidance on how to prevent transmission to other hives. Consequently, the survey improved aggregate honey bee health in sampled areas and improved beekeeper understanding of diseases and pests.

This survey also assisted Brigham Young University's Hope Laboratory (https://hopelab.byu.edu/) by providing numerous cases for the lab to test their experimental AFB phage therapy. Over the two year period four active apiaries infected with AFB were located by the survey and treated by BYU with phage therapy. Brood frames from three destroyed apiaries were also given to their lab for research.

Beneficiaries:

Hundreds of beekeepers
Fruit growers in the survey area
BYU Hope Lab

Lessons Learned: This project helped facilitate better cooperation between two different industries: the tree fruit growers and honey producers. The impact of this collaboration cannot necessarily be measured statistically, but is nonetheless meaningful. As our Insect Program moves forward we will seek additional opportunities to build such relationships.

Problems and delays: No problems or delays were experienced.

Future project plans: All project plans are complete.

Funding expended to date:

$ 14,193.27 in hourly wages
$ 2,472.73 in benefits
$16,666 spent

100% of allocated funds have been spent to date.

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Precision irrigation management in Utah Tart Cherry and Apple Orchards Using Continuous Recording Infrared Temperature Sensors
Contract # 141757

Bruce Bugbee
Principal Investigator
Brent Black
Co-Principal Investigator
Lance Stott
Graduate Research Assistant

Department of Plants, Soils and Climate
Utah State University

Abstract

Irrigation scheduling for fruit trees is extremely challenging because their relatively deep roots can access water even when the top layers of soil are dry. Mild water stress saves water and increases fruit quality. A rapid, inexpensive method for determining fruit tree water status in the field would help conserve water and improve the health of the trees. The most reliable method for tree water status has required the use of a pressure chamber to determine stem water potential. A pressure chamber is slow and requires significant expertise to make an accurate measurement. Direct measurements of the leaf to air temperature difference have the potential to indicate plant water status. Here we report the results from using state-of-the-art automated monitoring techniques to determine water stress in tart cherry and apple trees. The results will be applicable to all fruit orchards. In previous years of this project we made leaf temperature measurements of individual trees. These measurements were not completely successful because the infra-red sensors viewed, and averaged, the fruit, the leaves, and the ground under a single tree. During the summer of 2014 we changed our approach. We made automated measurements of canopy temperature of entire orchards using infra-red sensors positioned one to two meters above the top of the trees. The sensors were positioned at a slight downward angle, which allowed us to view primarily leaves at the top of multiple trees in the field of view of the sensors. Measurements were made every 10 seconds and averaged every 10 minutes from dawn to dusk from June to the end of August in six orchards. This approach allowed us to reproducibly quantify leaf to air temperature differences of less than 1 C. As this method is refined, it has the potential to be a useful tool for commercial growers.

Introduction

Description of the problem

Water use is critically important in Utah orchards and we have long sought methods to manage irrigation for fruit trees. We now have improved methods of measuring soil water content in surface soils, but the deep roots of fruit trees mean that they can access water that is not measured by the soil sensors. Direct measurement of soil water has thus not been an effective technique for managing irrigation in fruit trees. Direct methods of measuring the water status of the tree are necessary.

Several years of research has indicated that we can determine the water status of fruit trees using an instrument called a pressure bomb. Two photos of this instrument are shown below.

The first step is to cover a leaf with a shaded plastic bag until it equilibrates with the stem of the tree. It is then cut and immediately placed in a chamber where the pressure is gradually increased until the fluid in the xylem is pushed backward to the top of the cut end of the leaf petiole. At this moment, the pressure in the chamber indicates the stem water potential. This is a time honored and effective technique, but it is time consuming and requires a skilled operator. A faster, easier technique is needed.

We know that decreased water uptake reduces transpiration and increases leaf temperature. The leaf or canopy temperature thus has the potential to be used to as a sensitive indicator of plant water stress. This technique is now being been used to schedule irrigation in agronomic crops like corn and soybeans.

We conducted preliminary studies to determine the effectiveness of this technique in Utah tart cherry trees. Infrared sensors were placed at the edge of water stressed tart cherry trees to continuously measure canopy temperatures during the day. On sunny days, the temperature increase of the canopy above the air temperature correlated well with the degree of water stress as measured with the pressure bomb.

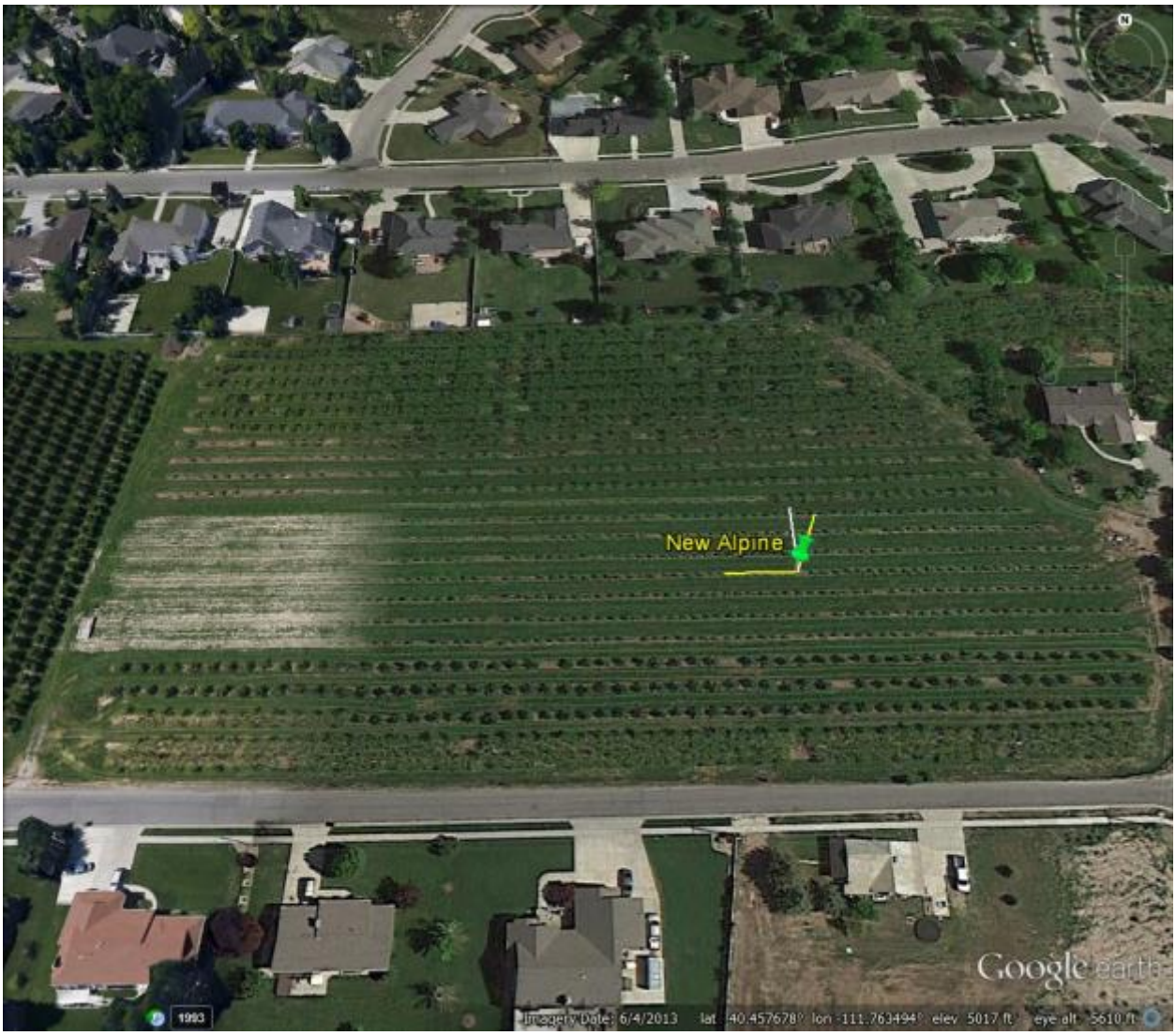
When plants are actively transpiring, leaf temperature can cool below air temperature. As plants experience water stress, stomata close, causing the leaf temperature to increase.
Determining plant water status in large fruit trees is challenging. Variation in leaf position causes differences in temperature, water potential, and stomatal conductance so measurements of single leaves do not represent the entire tree. Measuring the temperature of the entire canopy might better represent the tree.

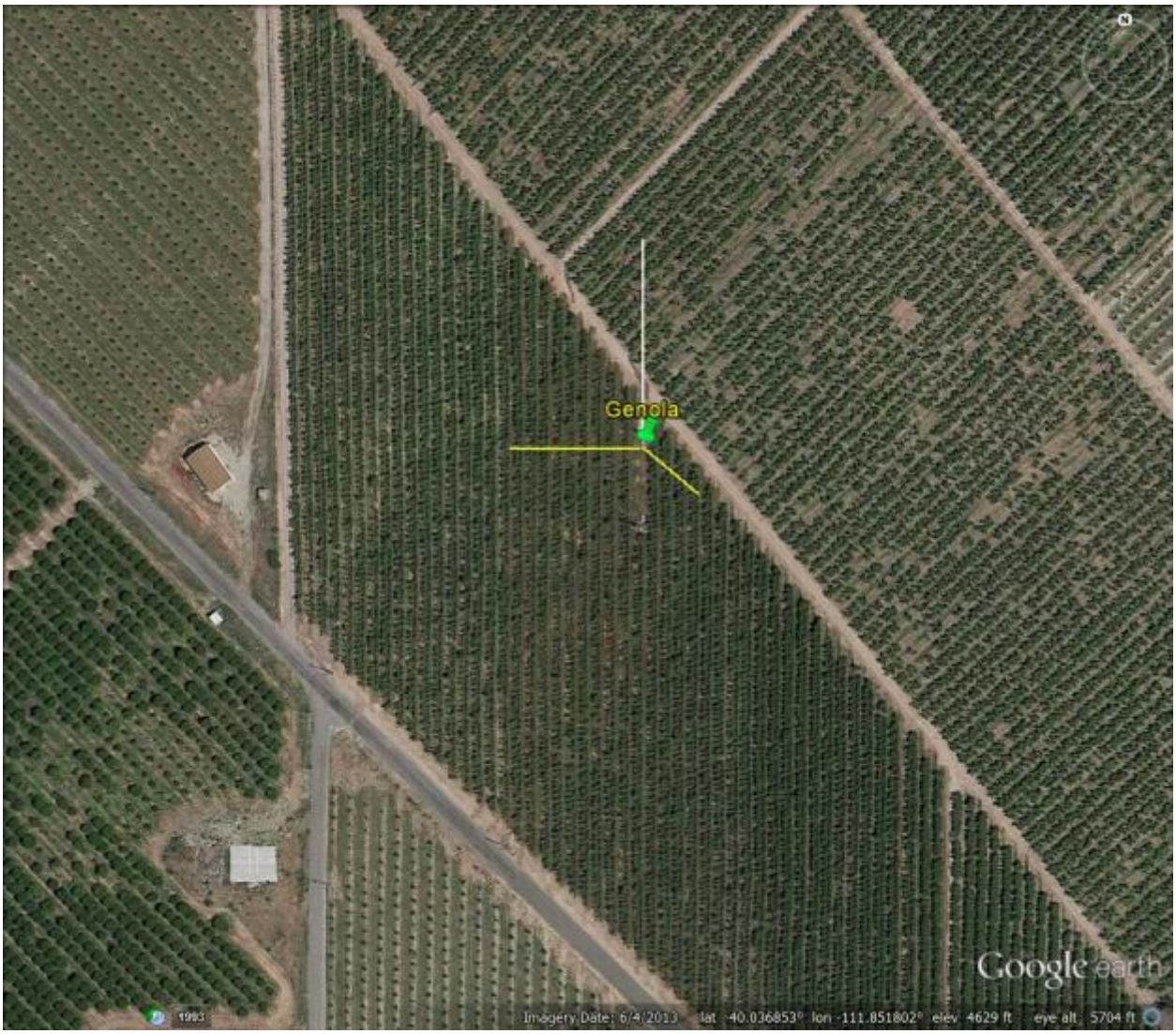
The long-term objectives of our research are to:
1. Implement a system to create gradient of irrigation to create multiple levels of water stress in tart cherry trees.
2. Compare estimates of tree water status based on infra-red measurements of tree canopy temperature.
3. Determine the optimal amount of water stress to maintain yield and increase sugar concentration in fruits.
4. From this data, begin to develop a real-time decision support system for irrigation management based on automated measurement of canopy temperature.

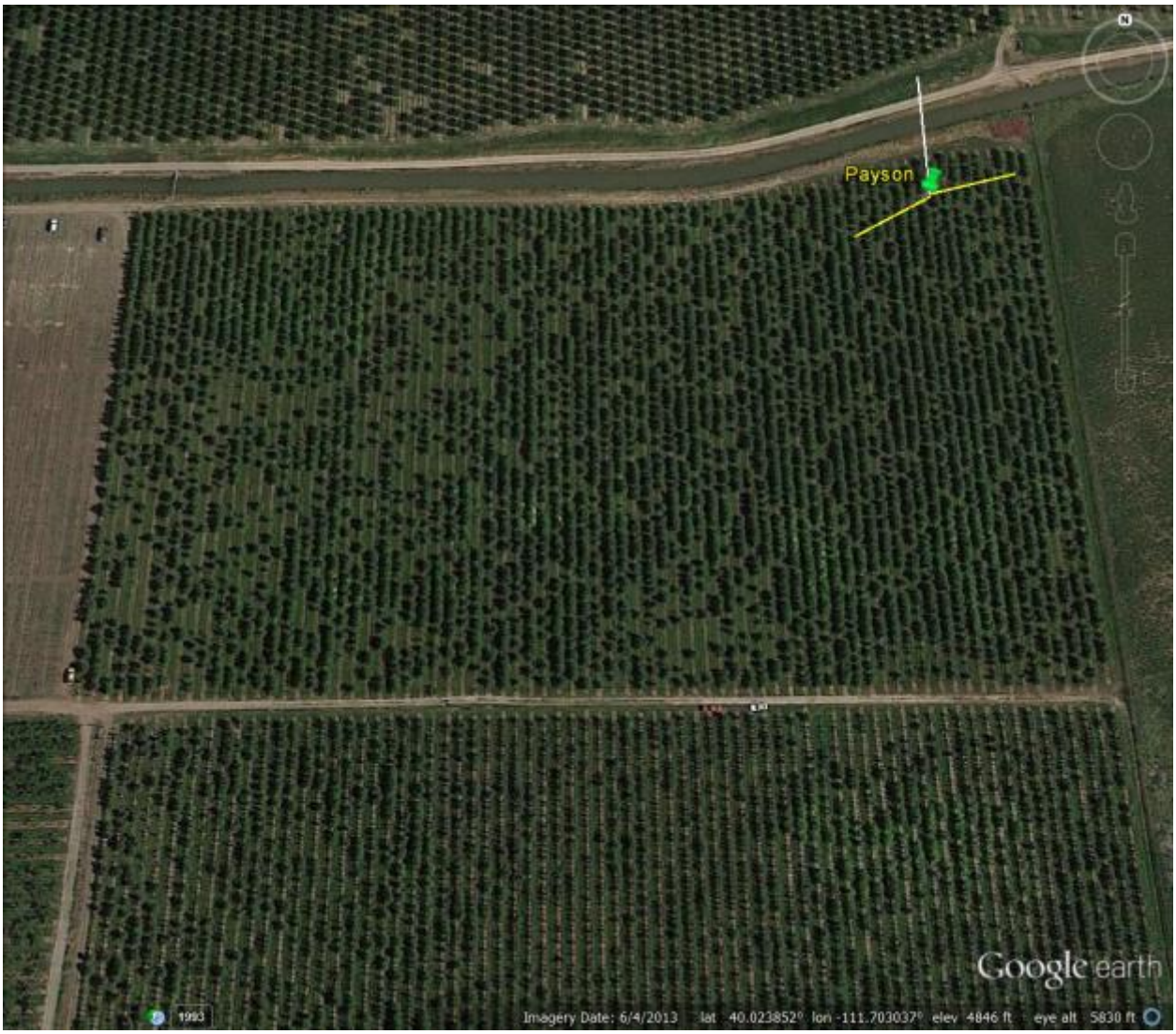
Methods – 2014 growing season

Infra-red sensors and thermistors were positioned above the top of the canopy. Two sensors were mounted in each of six orchards. One sensor generally faced east, one sensor faced west. Canopy and air temperatures were measured every 10 seconds, averaged, and recorded at 10-minute intervals using Campbell Scientific data acquisition systems.

An aerial view of the location of each of the weather towers in each of the six orchards is shown in the following images. The yellow lines in the images show the direction of the two sensors in each orchard.




Genola
Google earth
Imagery Date: 6/4/2013 lat 40.036853° lon -111.851802° elev 4629 ft eye alt 5704 ft


Payson
Google earth
Imagery Date: 6/4/2013 lat 40.023852° lon -111.703037° elev 4846 ft eye alt 5830 ft

Alpine (Peaches)

The following images sow the portion of the canopy that was measured by each of the sensors in each of the locations.

Alpine (Peaches) install west facing. This is on the edge of the peaches so the slit is vertical and pointed straight down a row. This orientation maximized the view of the trees and minimized the view of the area between the rows.

Another picture of the Alpine (peaches) west sensor.

East Gap S Cherries east facing sensor.

EastGapS (cherries) west facing sensor.

EastGapS (cherries) west-facing sensor

EastGapS (cherries) east-facing

Genola (apples) west-facing sensor

Payson (apples) east-facing sensor

Payson (apples) west facing sensor

Santaquin (peaches) east-facing sensor

Santaquin (peaches) west-facing sensor

Ground level view of the sensor at SantaWest (cherries)

Close up of installed infra-red sensor showing horizontal slit to focus the field of view

SantaWest (cherries) east-facing sensor

SantaWest (cherries) west-facing sensor

Results

The graphs on the next three pages show the critical data collected at Santaquin on peaches. The fist page shows June, the second July, and the third, August. The top box in each graph shows all of the temperature data collected. The day and night cycles of leaf to air temperature difference are apparent. The middle box in each graph shows the dataz filtered for radiation levels above 200 Watts per m2, and wind speed above 1 meter per second. These are the conditions that provide the most reliable data for water stress measurements. Th bottom graph shows the daily average temperature difference for each day. The standard deviation of the measurement son that day are also shown. Rainfall is in mm is shown in red. This orchard was irrigated byt the data on the timing of irrigation swas not available at the time of this writing fo rthis orchard.

Summary data for each of the six orchards – 20 June to 31 August

Daily mean leaf-to-air temperature difference (delta-T) is shown (next two pages, pages 27 and 28). It is important to note that each of the six orchards was irrigated to minimize drought stress. None of the orchards was deficit irrigated. The irrigation intervals are shown as purple bars. We assumed an

irrigation event was equivalent to 30-mm deep of water. Rainfall events and depth are shown as red bars. At the time of this writing irrigation data were available for only two of the six orchards. Error bars represent ± one standard deviation.

Ample water in the root-zone typically increases transpiration and causes a more negative leaf to air delta-T. A small decrease in the dalta-T is apparent after many, but not all of the irrigation or rainfall events.

Conclusions

1. **The changes in leaf to air delta-T were small, but reproducible from day to day. This indicates that this approach is capable to detecting small amount of water stress.**
2. **At the two sites with irrigation data, patterns of leaf to air delta T appear to decrease after irrigation or rainfall events. This indicates the potential of this approach.**
3. **Irrigation data for the remaining orchards will be important to more fully determining the potential of this approach**

Future research

1. **Investigate the use of capacitance moisture sensors in tree trunks to establish the relationship between trunk hydration status and tree water status.**

Potential Impact

1. This research should help us refine procedures for using low cost sensors to continuously monitor water stress in fruit trees. These can provide a user friendly method of monitoring drought stress in Utah orchards.

2. This work will lead to the development of a decision support system to more precisely determine when irrigation is necessary. The primary beneficiaries of this project are over 100 Utah Fruit Growers, who will benefit by an economic savings in irrigation water costs. Conserving water in orchard management is also of great value to the general public because a precious resource is conserved for other uses. Growers will also benefit by using precision water stress to increase fruit quality.