FY 2009 Specialty Crop Block Grant Program

Utah Department of Agriculture and Food

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Final Report

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Projects	Report	Page
1. Lamp Testing	Final	2
2. Currant Borer Mating Disruption	Final	5
3. Wolfberry	Final	9
4. Youth Gardening	Final	14
5. High Tunnel	Final	17
6. Caneberries	Final	25
7. High Density	Final	32
8. Nutrient Management	Final	34
9. Fire Blight	Final	38
10. Stone Fruit	Final	43
11. Fruit Fly Control	Final	47
12. Ear Wig Traps	Final	53
13. Tart Cherry Concentrate	Final	59
14. Tree Clones	Final	60
15. Floor Orchard Management	Final	68
16. Red Raspberries	Final	73
17. Mechanical Harvest	Final	76
18. Early Varieties	Final	78
19. Cherries Competitiveness	Final	82

Projects –

1. Project Title: Using LAMP Testing to Help Determine Spray Timing for FireBlight

Utah Apple Marketing Board and Utah State University Extension

Project Summary

Fire blight has become a severe disease for Utah apple growers over the last several years. Losses in some orchards have reached up to 20%. The disease spreads quickly, especially due to the fact that market demands require that orchardists grow certain varieties that are more susceptible to the disease, often in high density orchards that promote rapid spread. Utah growers are limited in treatment options due to the buildup of resistance to the most effective antibiotic. The only other antibiotic option is less effective, and must be applied at an optimal timing to work. As a result, growers need to know, in a timely manner, if their trees are harboring the bacterium (*Erwinia amylovora*) that causes fire blight.

This project used a new DNA test called LAMP (loop-mediated isothermal amplification) to detect bacteria in open blossoms of apple trees in Utah County. Using LAMP, the bacteria can be detected in a few hours using reagents and equipment that are relatively cheap and safe. We set up a "grower lab" at an apple processing plant, and compared results from the grower lab to the same test run at the Utah State University cooperator lab. Historically, this processing plant has detected fire blight bacteria by blotting flower stigmas onto expensive growth media called CCT, and if present, bacteria are detected in 36-48 hours, a timeframe that is too late to implement proper control.

Project Approach

In late winter 2010, one representative from each of the two partner organizations on this project received LAMP training from Oregon State University plant pathologists, Dr. Ken Johnson and Todd Templeton, who originally developed the LAMP methodology for fruit growers in Oregon. After the training we purchased all lab equipment and materials to set up the grower lab at Mountainland Apples processing plant. The grower lab and the USU lab then ran several test rounds of LAMP to practice the technique.

At the start of bloom time (May 5), six participating growers in Utah County began collecting 100 flowers from selected blocks every day through the end of bloom (May 21). Blossoms were delivered to the grower lab where they were immediately processed into wash water. The wash water was then driven to USU in Logan that same morning. Both labs used the same wash water to run LAMP tests every day except Sundays and then the two labs compared results. We also sent material from the first week of blossom collection to the Oregon State lab to run LAMP so that we could have a third comparison.

Upon initial detection of the fire blight pathogen growers were notified, and were suggested to use the fire blight risk model, called Cougarblight, to determine whether a treatment was required. We inspected orchards at the end of the summer and communicated with participating growers and found that 5 of the 6 orchards had light infestation (less than 1 infection per tree), and one grower had a severe infestation (more than 6 infections per tree).

The LAMP protocol to detect the presence or absence of bacteria in blossoms was hit or miss with both the USU and grower labs. The results of these two labs matched the results from Oregon State only 30% of the time for the first week of testing. Unfortunately, due to budget concerns and staff changeover, the USU lab was without a faculty plant pathologist during the testing. The person in charge of the LAMP procedure at USU, although trained, does not have experience in molecular techniques. The inconsistent results could have been due to human error, contamination, or a "bad batch" of molecular primers used in LAMP testing. Molecular work takes time to perfect, and by the end of bloom time, results of the USU and the grower lab started to show some consistency (with 73% matching results).

After a new plant pathologist was hired, the samples were tested later in the summer using real-time PCR. Again, results were inconclusive and did not consistently match. Comparing LAMP and PCR in 2009 showed that inhibitors in PCR reactions are more likely to cause problems in the real-time PCR reactions, but not in LAMP reactions. The reasons for this are not clear but LAMP detection appears to be promising, especially when conducted from a grower lab that is located in close proximity to the apple growers of Utah. Data from LAMP testing can be compared to weather data and fire blight forecast models to verify and improve predictive models. We have received a second year of funding to transition the grower lab to a self-sustaining entity.

Goals and Outcomes Achieved

1. This project trained a representative of the Utah Apple Marketing Board in the use of LAMP and set up a trial grower lab inside Mountainland Apples, a processing facility located in the heart of apple production in Utah County. We have received a second year of funding for this project that will allow us to refine our skills in LAMP technique and determine the feasibility of the grower lab and whether it can be self-sustaining through fee testing services. Providing this LAMP testing, which is quick and effective, in a facility within miles of most apple growers should allow for rapid turnaround and implementation of control measures when necessary. If successful, this would be the only lab of its kind in Utah, and possibly in the U.S.

2. This project determined that real-time PCR is not as accurate as LAMP and is more costly.

3. Once the use of LAMP testing is perfected and adopted, it will enable optimization of antibiotic treatments, where applications will be applied only when bacteria are active. LAMP allows growers to combine risk models with near real-time detection of *Erwinia amylovora* during apple bloom to effectively time antibiotic applications. In personal communications with apple growers participating in this project, they applied slightly fewer

antibiotic sprays in 2010 than in 2009. We will continue to measure changes in application frequency and rates in the coming years.

4. LAMP technology will improve the sustainability of apple production in Utah by improving the profitability of production and by lowering production inputs. The growers mentioned above that applied fewer sprays saved, on average, $50/acre for each reduced spray. We will continue to measure improvements in profitability in the coming years.

5. The LAMP technology should improve the market availability of lower cost, locally grown, healthy fruit, for the Utah public. Keeping production costs down will improve the likelihood that food will be of high quality and affordable to the public.

Results of this project will be shared with growers at the winter 2011 annual Utah State Horticultural Association growers meeting.

Beneficiaries

This project directly benefits apple growers in the Utah County region (approximately 1056 acres and 70 operations). Grower organizations in other states can benefit from the success of Utah's grower-operated lab through direct training or personal communication.

Lessons Learned

1. Molecular techniques such as the LAMP procedure can take several weeks to months to master. The amount of time dedicated to training and practice trial runs was not sufficient for the grower lab or USU lab to be proficient in the LAMP procedure. The first week of blossom testing was more "trial and error" and the second week was more successful. A second year of testing should result in more precise results.

2. Real-time PCR is not as good as the LAMP technique in detecting the bacteria that causes the fire blight disease. It is far more sensitive to inhibitors of amplification and often failed in our tests of direct comparisons.

3. It is important to compare results of molecular testing with direct culturing of the bacteria onto specialized growth media. In next year's LAMP project, we plan to plate out the wash water onto media for the fire blight bacteria for a final confirmation of the results.

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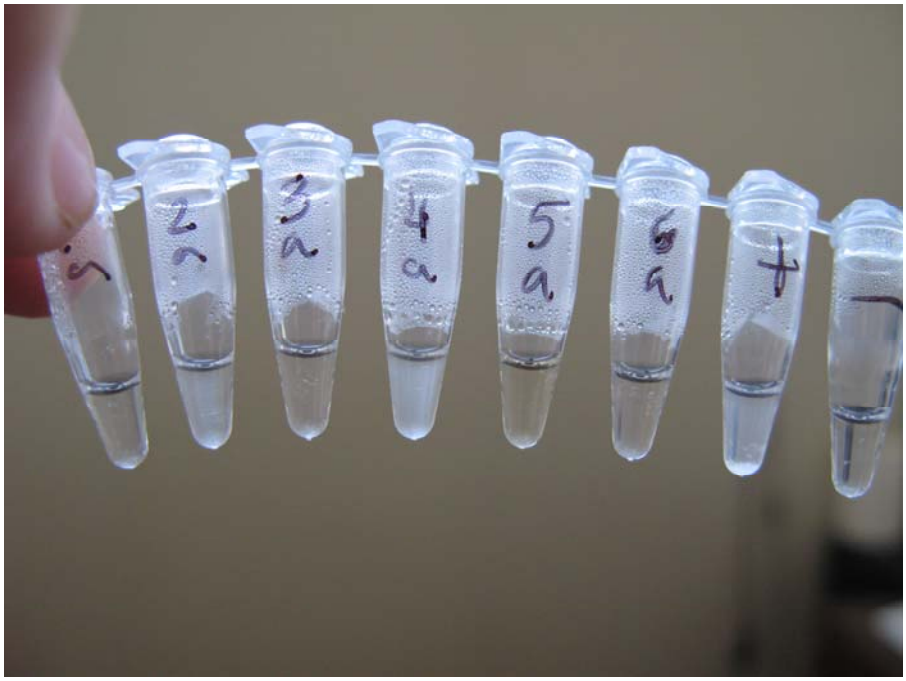

In LAMP testing, sample tubes that are positive will have cloudy water while negative samples will have clear water. The sample numbers with cloudy water represent the detection of *Erwinia amylovora*, the bacterial pathogen that causes fire blight, from within healthy-looking flower clusters collected that same day. Using this test, results can be seen within 3-4 hours and growers can be better prepared to implement treatment based on the fire blight risk prediction model.

2. Project Title: Determining Effectiveness of Currant Borer Mating Disruption in Utah

Marion Murray, IPM Project Leader Utah State University Extension
Diane Alston, Extension Entomologist, Utah State University Extension

Project Summary

Production of black and red currants in the U.S. is limited due to infestation by the clearwing moth, currant borer (*Synanthedon tipuliformis*). It causes stunted plants, weak canes, shoot dieback, uneven bud break, and fruit yield reduction by up to 50%. There are very few insecticides available for control of currant borer, and often peak moth flight usually occurs during bloom, so chemical treatment is not always an option. A five-acre site in northern Utah (Paradise, Cache County) is one of the few currant-producing sites in this state. It is heavily infested with currant borer, and if left untreated, could result in losses up to $250,000.

This study looked at the effectiveness of mating disruption on a five-acre block of black currants in northern Utah over a period of two seasons. Mating disruption uses high loads of pheromone to delay mating, and hence, prevent egg-laying. Using mating disruption to control this pest not only reduces pesticide use, but has been shown to be economically effective in Washington, Connecticut, Italy, New Zealand, Tasmania, and other locations.

Although this study targets one large operation and several small operations, Utah has an ideal climate for growing currants, and improved control options for currant borer could pave the way to increased production. Currants (red and black in particular) are hardy, high value crops that serve both the fresh and processed markets. Interest in growing currants has swelled among US small fruit growers due to the health benefits of the fruit, their ease of growth, and the potential for income. Growers in Utah can do very well with small plots geared to either the fresh market or value-added products such as syrup, jams, jellies, juice, or wine.

Project Approach

The test site was a heavily infested, five-acre black currant block located in northern Utah. An isolated 1-acre white currant block was used as the untreated control, located approximately ½ mile away. In mid-June, we applied twist-tie mating disruption dispensers onto currant stems at a rate of 300 per acre in the interior, and 400 per acre in a 20-foot perimeter area within the block. We also hung dispensers along an additional 10-foot border outside the block. No dispensers were hung in the control block. In 2010, the grower applied the insecticide Sevin for control of an additional pest, rose stem girdler.

In both spring (pre-treatment) and fall (post-treatment), we cut 100 canes from the treated block and 40 canes from the control block. We recorded cane injury level, number of larvae within each cane, and occurrence of predators or parasites. We also cut 30 canes from the adjacent raspberry field in the fall to determine if the raspberries could be asymptomatic hosts. We determined adult moth population by using pheromone traps in the treated and control blocks. We hung five traps in the treated block, two in the control, and additional traps between the two test fields. We counted moths every 7 days. Ideally, the traps in the mating disruption block would have zero moths.

Like our results from 2009, results in 2010 were not as we had hoped. We expected to see a decrease in borer infestation in the mating disruption treated field whereas instead, the infestation increased from spring to fall by 27% (Figure 1). In 2009, we saw an increase in 50%.

Table 1 shows the differences in cane injury characteristics in 2009 and 2010. There were no significant differences in cane rating between years or between treatments.

Figure 1. Percentage of canes infested with currant borer larvae or pupae in the mating disruption (MD) treated and untreated fields in spring (pre-treatment) and fall (post-treatment) in 2009 and 2010.

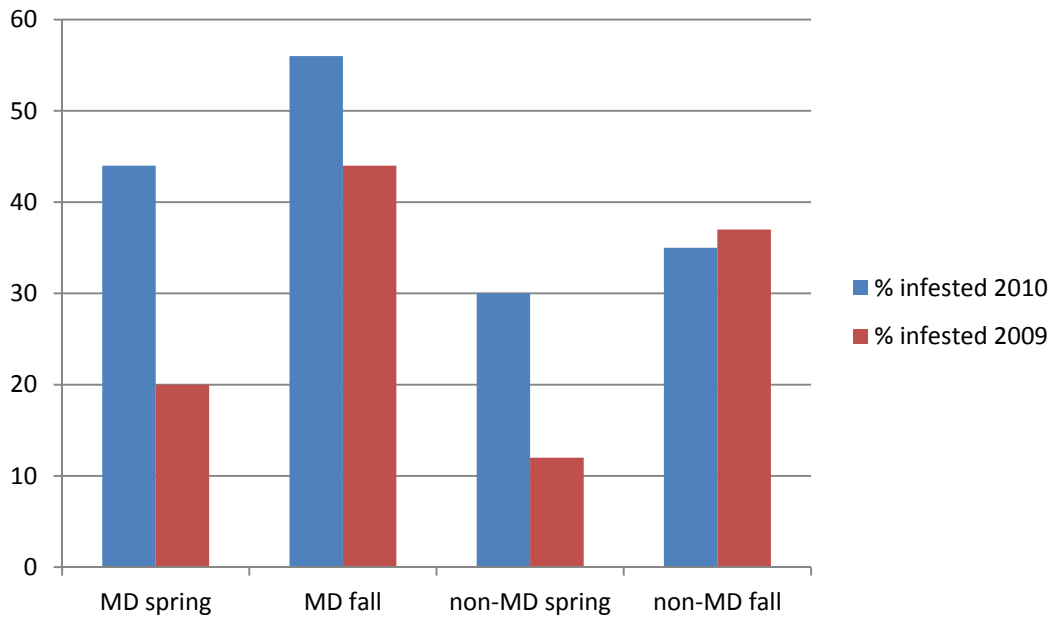

Table 1. Average characteristics of cut canes from the mating disruption treated field and untreated fields, in spring (pre-treatment) and fall (post-treatment) for 2009 and 2010.

Treatment	2010 Cane Rating[1]	2009 Cane Rating	2010 # Exit Holes per Cane	2009 # Exit Holes per Cane
MD-spring	1.99	2.54	1.27	1.93
MD-fall	1.69	1.79	0.941	2.51
non-MD-spring	2.2	2.36	1.23	2.41
non-MD-fall	1.53	1.77	0.58	2.24

[1] cane injury on a scale of 1-4 (1=healthy and no obvious borer injury, 2=1-25% leaves injured or missing, 3=26-50% leaves injured or missing, 4=>50% of leaves injured or missing, or cane is dead)

Trap catch is an important indicator of whether the mating disruption dispensers are working. Most traps in the treated block caught zero moths throughout the season except for the outside traps which had stray captures. The traps in the control field and in the area between treatment fields caught anywhere from 30-100 moths per 7 days. These results suggest that the mating disruption dispensers were effective in preventing mating WITHIN the treated field. But the high trap catch numbers just several hundred yards away suggested that mated females were blown into the currant borer field. After females have mated, mating disruption has no effect on control.

Interestingly, we found currant borer larvae inside 5% of the raspberry canes, which suggests that the raspberries are serving as a secondary host of the currant borer.

The problem with the mating disruption failure and with this test site is threefold: the moth population is too high to be controlled by mating disruption alone, the adjacent (untreated) raspberries were serving as a secondary host, and daily breezes blow mated currant borer females from other infested areas into the treated field.

Goals and Outcomes Achieved

With this project, we achieved the following **goals**:

1. We have determined that currant borer mating disruption will not work on 5 acres where the initial population is high.
2. Through a separate grant, a colleague is working on getting this product registered in the U.S. Information from this project will be used in helping to develop the labeling for currant borer mating disruption.
3. Once the product is registered in the U.S., producers growing enough currant acreage to use mating disruption will be able to reduce pesticide use significantly and increase yield. Mating disruption is an organically approved product, and if they so choose, will allow these growers to fill a niche in the market to increase profitability. In addition new growers with enough acreage will not be hesitant to start currants knowing this control technology is readily available.
4. A horticulture student was trained by the project co-leaders to assist with dissecting the canes, taking measurements, counting larvae, identifying predators and parasites, and photography. He has since graduated and moved on to managing a greenhouse.
5. Our greater knowledge in currant borer biology and natural enemies can be used by Extension specialists and agents to assist growers in management practices and prevention of insect spread. Knowing that raspberries can also serve as a host is important to know in management.

Beneficiaries

All agricultural producers in the state will have access to this information when this report is posted online at utahpests.usu.edu. In addition, growers attending the Utah Berry Growers Association annual meeting in January 2011 will receive a copy of the report and can see a poster presentation of the results (approximately 75 attendees). We will also report results to the Western Orchard Pest and Disease Management Conference in Portland, OR in January 2011, in which over 150 professionals attend. We will prepare a fact sheet that will be posted online, and provide results in our IPM pest advisory that is emailed weekly during the growing season to the berry growers in the state.

My colleague, Dr. Lorraine Los, at the University of Connecticut, will use Utah's results in training growers in her state. She has conducted several years worth of work on mating disruption for currant borer (with success), and has received grant funding to help defray new product registration costs. Results of Utah's project will be used to help develop the currant borer mating disruption label.

Lessons Learned

1. Even at application rates that are higher than recommended, currant borer mating disruption is not effective in fields that are within 1 mile of non-treated fields. There is evidence that moths can fly or be blown up to 1.5 miles away.

2. Raspberries can serve as a secondary, asymptomatic host. Pheromone traps that were placed in neighboring raspberry fields caught between 52 and 97 moths per 7 days during peak flight. Five percent of the canes we examined were infested.

3. When initial pest populations are high, it is best to use multiple tactics to reduce the population before using mating disruption alone, including insecticides and heavy pruning.

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3. Project Title - Wolfberry Production Feasibility Study

Project Summary

Prior to this project no information was available on the nutrient profile of locally grown wolfberries. It is assumed that soil conditions, climate, and plant variety, post harvest handling and processing, and assay prep techniques all influence nutrient profiles. Maturation of fruit also affects the nutrient profile. These factors were investigated.

Wolfberries are widely marketed in Europe and the United States as health foods, often accompanied by undocumented claims for purported health benefits. Many goji juice formulations contain only a small percentage of goji juice and are largely apple juice with pomegranate for red color. Since 2005 wolfberry has received acclaim as a "Superfood," implying nutrient richness and potential health benefits. Though documentation of these health and nutritional claims is not a goal of this project, one can't discount the hype and demand generated by existing marketing strategies as having an impact on demand for both plants and berries. One executive of a marketing company indicated the market potential for wolfberry juice alone would be valued at more than $1 billion dollars by 2013. Add to the juice market dried berries, berry pieces in granola bars, skin soap with seed oils, whole fruit puree, whole seeds, seed oils, and pet product additives the potential market for berries and plants present rare opportunities ranging from small farm diversification to large scale production of both plants and berries.

The data from leaf analysis opened a whole new area of potential crop diversificaion.

Project Approach

Biogenetic Services, Inc., Brookings, South Dakota, conducted DNA testing. Genotyping analysis was done on leaf samples submitted on October 15, 2009. New growth samples were supplied from three different varieties. One sample was the Phoenix Tears variety originating on the Kunzler Ranch in the Utah West Desert, referred to as Phoenix Tears Wolfberries. This is the variety, which will be marketed by Phoenix Tears Nursery and has been propagated at the Nursery for the past five years. The second leaf sample was from plants grown from seed. The seeds were obtained from fruit originating in China and identified as Lycium barbarum from Ningxia Province, the supposed "best" variety of wolfberry. These plants were greenhouse grown and transplanted outdoors the spring of 2009. Sample three consisted of leaves from a local patch of wolfberry that was referred to as English Teaberries and were planted by pioneers from England. All three varieties were essentially identical with respect to external features, including fruit size, quantity, and taste.

Initial comparisons were done on over 1000 gene loci, with the final report concentrating on 20 loci. The Ningxia and Phoenix Tears plants were genetically essentially identical. The finial report on 20 loci showed no differences. Verbal feedback from the technician indicated only one difference in nearly 1000 loci. The English Teaberry sample had profiles that varied from the other two samples at loci 3 and 4 and at other undocumented loci.

The near perfect match of the Phoenix Tears wolfberries and Ningxia plants was unexpected, but highly desirable. Unexpected because the two varieties had grown independent of each other for at least 150 years, the Kunzler plants originating from Chinese transcontinental railroad workers and the Ningxia plants coming from fruit recently imported from China. As remarkable as it may seem, it can be inferred that these two varieties are identical, and are Lycium barbarum, not Lycium chinense. The other factor indicating barbarum is that neither variety is very thorn prone, one of the characteristics of chinense.

Fresh fruit, frozen fruit, dried fruit, and dried leaves were submitted to Brunswick Laboratories, Norton, Massachusetts for nutrient analysis.

Of special interest was the antioxidant potential, as measured by ORAC (oxygen radical absorption capacity). Both ORAC-hydro and ORAC-lipo were conducted on some samples. With a score of 436 the Phoenix Tears leaves far exceed anything found in current literature. Leaves have been used as teas and in soups for centuries in China. The importance of the 436 score can't be overestimated and identifies a whole dimension of wolfberry use that is undocumented for plants grown in the United States, namely the use of leaves and roots as medicinal and food products. Clearly this area needs further research and documentation.

The Phoenix Tears dried fruit ORAC score of 110 ranks it above pomegranate, one of the most highly ranked antioxidant foods.

Total polysaccharides were also assayed in the Phoenix Tears dried fruit. Polysaccharides also play a major role in reducing oxidative stress and are another "signature" nutrient found in wolfberries. Various studies document the cardiovascular, anti-cancer, immune stimulating, and blood sugar lowering properties of wolfberry polysaccharides. Wolfberry polysaccharides also have a low glycemic index. A study published in the Journal of Ethnopharmacology, found that L. barbarum polysaccharides restored antioxidant values in aged mice. Another study showed that pretreatment with from 5-20 mg of Lycium polysaccharides significantly decreased the frequencies of damaged DNA in mice testicles after being exposed to hydrogen peroxide. With a score of 17.78 mg per gram, Phoenix Tears dried fruit rates high for antioxidant potential. Another positive aspect of the wolfberry polysaccharide content is it's low glycemic index. Though Phoenix Tears dried fruit has a high sugar content in the form of polysaccharides, these sugars are tied up in long chain-sugar protein complex in a way that makes them behave like slowly digested fiber, not high octane sugar.

Another "signature" nutrient of wolfberries is betaine. Betaine is a methyl donor nutrient similar to SAMe, folic acid, and vitamins B6 and B12. Donation of methyl molecules is involved in proper liver function and cell reproduction. Betaine also promotes carnitine formation. Betaine is used to reduce high levels of homocysteine, which is a risk factor in heart disease and stroke. Betaine is effective in lowering blood sugar and treating asthmatic conditions.

Betaine content of Phoenix Tears wolfberries assayed at 2.19 mg/g for fresh fruit, 2.24 mg/g for frozen fruit, 4.61mg/g for dried fruit, and 19.38mg/g for dried leaves. As with the dried leaf ORAC, the 19.38 value is far higher than values found in the literature and indicates that the leaves may be more nutrient loaded than the fruit. Internet searches reveled only a few sources listing betaine content of their products. Three sources listed betaine content for dried Ningxia fruit at .1mg/g, far below the values found for any of the Phoenix Tears products.

Carotenoids in the form of carotene, alpha carotene, zeaxanthin, and lutein were measured in fresh and dried fruit. Results are listed in the table below.

Carotenoids (mcg/g)

Carotenoid	Fresh Fruit	Dried Fruit
Beta Carotene	3.29	
Alpha plus Beta Carotene		12.36
Zeaxanthin		47.28
Lutein	6.71	41.44
Lycopene	0.24	0.99

The above dried fruit values are higher than for spinach, which is commonly used standard source for dietary Carotenoids.

Dr. Donald Daugs served as project principle investigator. He supervised all aspects of the project. The person who was initially engaged to carry out most of the project tasks, as project director, left the state shortly after the project was funded. Consequently much of the work was redistributed to other persons. Jill Davidson took over the business plan and legal requirements of the project, and Tiffany Bergsjo assumed duties for web site production. Both did outstanding jobs. Valynn Kunzler assumed some the duties with regard to plant production, with minor amounts of labor assigned to other individuals. Dr Daugs covered other aspects of the project, which would have been carried out by the intended project director, including all plant growing and testing procedures. Taun Beddes, Cache County Extension Agent, assisted with some editing of the Grower's Guide and Nathan Daugs, Conservationist, Blacksmith Fork Conservation District, carried out the oversight and administrative duties. He not only took care of the paper work details, but also visited the growing sites regularly. He will coauthor a number of articles that will result from this project.

Goals and Outcomes Achieved

DNA testing has clearly established Phoenix Tears wolfberries as Lycium barbarum.

The few tests done on dried leaves suggest a whole new dimension of research. With an ORAC value of 436 micromole TE/gram, a betaine value of 19.38 mg/g, the leaves exceed all fruit product values in these components. The ORAC value is higher than anything found in the literature. Given the centuries long use of wolfberry leaves and roots in China as food and medicine, and the results obtained from our testing, leaf and root testing needs to be expanded. **Market for the root and leaf product may be greater than for the fruit.** As with blueberries the leaves may be more nutrient loaded than the fruit

and the fruit is already excellent. Polysaccharides were only tested on dried fruit. Polysaccharide content of fresh fruit, frozen fruit, and leaves should also be investigated.

A Grower's Guide was authored and incorporated into the Phoenix Tears web site. Refer there for complete viewing (www.phoenixtearsnursery.com). The document is extensive and includes pictures.

Phoenix Tears Nursery, LLC was formed as a result of this project. Without the data on variety identification and nutrient analysis there would have been little reason to proceed. Both the business name: Phoenix Tears Nursery and the web site address of phoenixtearsnursery.com are now reserved and legally registered. Phoenix Tears Nursery is licensed by the State of Utah and has been inspected by Mark Ashcroft, Cache County Extension Agent. He will inspect again the spring of 2010 and issue shipping permits.

Phoenix Tears Nursery, LLC was incorporated late fall 2009. The original intent was to form a grower's cooperative. Due to feedback from potential growers the less formal agreements that are printed below better fit their desires. The original plant source owners will receive a royalty on all plants sold and sellers will receive a percentage of the sales price.

The business plan created as part of the project was instrumental in forming the LLC and facilitating the entire process of establishing a nursery.

Beneficiaries

The nutrient and plant propagation data from this project is of value for any Utah wolfberry grower. This interest extends to all 81entities who purchased Phoenix Tears plants over the past year and to hundreds of phone and email inquires. The web site www.phoenixtearsnursery.com has become a regularly visited Internet site for information on wolfberries. Donald Daugs has emerged as a valuable resource person and receives from one to ten wolfberry related inquiries most days.

The primary economic impact of the project was on Phoenix Tears Nursery, LLC. The business plan resulting from the project facilitated incorporation and moving from deficit status to a small profit in 2010 and a projected very good 2011 season. This also affected the three cooperating plant growers. Without the nutrient data from the project plant sales to national retail garden nurseries would not have been possible. As a result of the marketing plan and the nutrient data Phoenix Tears plants will be featured in six national retail spring 2011 catalogs. These entities are buying plants in lots of 1000.

As a result of the initial results on leaf nutrients another Specialty Crop grant was awarded: Utah Wolfberry Plant Nutrient Data and Information Enhancement. This led to a SARE grant proposal: A Feasibility Study to Determine the Commercial Potential of Lycium barbarum Leaf Production. The prospect of leaf production has a higher profit potential then berry production as the fruit must be harvested by hand and the leaves can be harvested mechanically.

Another outgrowth of the project was the writing of a wolfberry recipe book: *A Superfood Cook's Dream Come True*.

Lessons Learned

The least effective component of the project involved preparing and shipping fresh and frozen fruit for nutrient analysis. In both instances the products arrived at the test site partially liquefied, resulting in poor test results for water-soluble nutrients. It appears the ripe fruit is too fragile to ship in other than a dried state.

The most remarkable aspect of the project was the data on dried leaf material. ORAC and betaine were measured on dried fruit. This was not in the original plan, but was included as there was some literature on use of leaves in China. The scores were incredibly high and have resulted in a whole new endeavor to open a whole new agricultural niche. A first effort in this direction has been the arrangement with a California almond grower wishing to diversify to add 5 acres of wolfberries for leaf production.

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4. Project Title: Wasatch Community Gardens' Youth Gardening Program

Re-submitted as Final Report

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 the entire community.

Wasatch Community Gardens addresses these issues through our Youth Gardening Program. Specialty Crop Block Grant (SCBGP) funding has supported this program previously. Funding in 2010 allowed us to continue the program, revise existing curriculum, create new curriculum, refine the program's goals and objectives, and improve our evaluation process. By continuing our Youth Gardening Program year after year, we are able to develop ongoing relationships with partner agencies, work with the same groups and even some of the same kids for consecutive years, and continue to work with new youth each year.

Project Approach: Our Youth Gardening Program provides the opportunity for low-income children to learn about nutrition and enjoy fresh produce in a positive and fun way. Through hands-on, "feel the soil between your fingers and pick sun-warmed tomatoes from the vine" lessons in the garden, taught by a K-8 certified teacher, youth in our program are empowered with the skills, knowledge, and awareness to make healthy choices for themselves and the environment. They learn new gardening skills, engage in identifying, tasting, and preparing unfamiliar vegetables and fruit, demonstrate an understanding of where their food comes from, learn teamwork and patience, and develop an appreciation for the outdoors. Physical activity is also an important component of the program; many lessons include lively activities that keep youth on the move throughout the garden.

In order to achieve the program's goals, in 2010 Wasatch Community Gardens collaborated with 25 social service agencies, including the Boys and Girls Club, Odyssey House, YMCA, YWCA, Youth City, and Indian Walk-in Center. We also partnered with Salt Lake City School District (SLCSD) for the 2009-10 school year to engage more low-income Salt Lake City youth in garden-based education. Such partnerships help to maximize our impact in the community by leveraging our organizations' respective skills and resources: we provide the gardens and expertise, while our partners provide the youth participants and necessary infrastructure.

Specifically, we engaged low-income youth in experiential garden lessons through four seasonal sessions in our youth gardens. Half of the classes were held at the Grateful Tomato Garden in the Central City neighborhood and the other half at the Fairpark Garden on Salt Lake's west side. Classes were taught by our experienced youth educators in the gardens and in Wasatch Community Gardens' Greenhouse Learning Center, which is located in the Grateful Tomato Garden.

Nearly 1,600 youth participated in our Youth Gardening Program. During the year, youth prepared and tended almost 6,000 square feet of garden beds and harvested several thousand pounds of fresh produce to be eaten during class, shared with their families, and donated to local food pantries. The kids grew and harvested food and tasted and prepared new fruits and vegetables. Lessons encompassed the arts, humanities, history, culinary practices, and science to help each child find a way to connect to the garden and to consume fresh fruits and vegetables.

Goals and Outcomes Achieved: The goal of the project was to empower youth with the skills, awareness, and knowledge to grow and harvest food; taste and prepare new fruits and vegetables; and become stewards of their own health and that of the planet.

The following measurable outcomes were achieved at the end of each 6-10 week Youth Gardening Program session:

a) 90% of participants gained a new gardening skill.

b) 90% of participants identified and tasted three new fruits or vegetables.

c) 90% of participants took home a new fruit or vegetable to share with their families.

One of our major accomplishments in 2010 was to revise our program goals and objectives and create a new evaluation tool that will be implemented with our first session in 2011. The benefits of this new evaluation tool are myriad. We will use it as a way to evaluate and update our curriculum on a consistent basis and ensure that we are running our program in the most efficient and impactful way possible. This tool will also enable us to evaluate the impact of our programs on the youth we work with, obtaining both qualitative and quantitative data to track results.

Beneficiaries: In 2010, the Youth Gardening Program served 1,600 youth. Of the roughly 500 children in our weekly garden classes for whom demographics are tracked, 69% were from households with "extremely low" incomes as defined by Federal guidelines and 19% were from households with "very low" incomes. Only 12% of youth served were from households with "moderate" and above incomes. The youth represent a diverse cross section of Salt Lake City, with a wide variety of ethnic backgrounds.

Lessons Learned:

The most important lesson that we learned during the course of the Youth Gardening Program in 2010 was by making a few tweaks to our youth programming calendar, we could actually bring more youth into the gardens to learn than ever before. Last summer, we took a step back to consider to how many youth we are able to serve in the course of a year, which led us to examine the current structure of our program and consider how we could expose more youth to fresh fruits and vegetables without overtaxing the capacity of our organization. With our current partnership model, we are able to serve a consistent number of youth each year, in all four seasons. However, most agencies that we partner with to bring youth to the gardens are only able to bring the children at certain hours of the day, and with two youth gardens, we are only able to offer a limited number of slots that work for those partner agencies per day. In order to involve more children in youth gardening in 2011, we are going to expand our programming to offer one-time school field trips, and longer format summer camps. Both of these measures will allow us to reach more youth, and also expand the type of education we provide to include short format but high impact garden experiences for school groups, and longer-format, more in depth programming for summer camp attendees. Paired with our core youth programming, we will be able to reach a far broader audience than we could in the past.

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5. Project Title -

Improving Winter Crop Growth Potential and Survivability in High Tunnels

Project Summary and Need:

Much of the work to develop high-tunnel production systems has been carried out in the Eastern (http://plasticulture.cas.psu.edu/H-tunnels.html) and Mid-western U.S. (www.hightunnels.org) where high humidity results in increased pressure from fungal pathogens. Foliar and fruit pathogens are generally not the limiting factor in the high-elevation arid climate of the Intermountain West. However, in high altitude desert climates like Utah, growth is often limited more by extreme day-night temperature fluctuations. This is particularly true in early spring when temperatures can fluctuate by more than 50F (10C). Growth problems from significant temperature variations within the tunnels are very common in the late fall through early spring period when one tries to grow crops when outdoor temperatures are very cold. In Utah, high light levels are common in winter, but short day lengths and low sun angles limit the amount of naturally occurring heat entering the tunnel. Cold night temperatures may be overcome by (1) using row covers or "crop blankets" inside the tunnel, (2) by creating secondary tunnels (fabric or plastic row covers) inside the high tunnels or (3) through modest heat additions like soil and targeted air warming. However, for lower value crops like winter greens, these may not be economical in all situations. In addition, for small fruits like blackberry which are moderately hardy under Utah conditions, one needs to both keep the temperature in the tunnel from getting too low (when extremely cold outside) which can damage the canes, and from getting too warm which can cause buds break too early in the spring.

Therefore, winter impacts on leafy salad greens and blackberry needs further study to develop cost effective production systems. With this information, growers will have additional production options and the detail horticultural and economic information needed to assess if this fits into their present production scheme. These finding can help small intensive fruit and vegetable producers in the intermountain region (CO, ID, NV, WY, UT) of the western US. The potential impact of this project would expand the production of selected crops throughout the winter months when locally grown produce is

not available, and would allow for the production of high value crops not otherwise suited to harsh climate.

High tunnel season-extension technology has been demonstrated at Utah State University and extended to Utah's farmers and ranchers. More information is needed on potential uses of high tunnels during periods of the year when local produce may not be available or where climatic conditions are less conducive to growth. The main reason for growers failing to adopt winter production is that plant growth is slow and productivity levels are low in salad crops like spinach (when too cold) and early bud break in cold sensitive crops like blackberry (if too warm) hinder optimal productivity. Therefore the goals for this project were;

1. Assess growth and yield response of various winter salad greens to environment modification techniques
2. Devise improved survival strategies for overwintering blackberries.
3. Use generated information to draft enterprise and production guides.

Project Approach and Methodology:

Goal #1: Environmental Modification Techniques:

Six crop production systems were tested during the late fall - early winter of 2009-10 when outdoor environmental conditions are cold. Spinach (*Spinacea oleracea*) and Lamb's Lettuce (*Valerianella locusta*) were seeded in the greenhouse in late-September and transplanted in high tunnels (4 plants/ft^2 in early November and grown through to late-December (lower light levels and decreasing outside temperatures). The experiment was repeated in mid-January with plant growth and crop production monitored to mid-March (light levels and temperatures improving). To alter the environment around the plants, we used heating cables to warm the soil and row covers to alter the air temperatures around the leaves. The six growing systems were (see Figure 1);

1) Thermostatically controlled soil heating cables (programmed to heat when soil temperatures dropped below 50F); no row covers (heated control)
2) Soil heating cables plus low plastic tunnels (see Figure 1)
3) Soil heating cables plus floating row covers
4) Unheated soil, no additional covers (unheated control)
5) Unheated soil plus low plastic tunnels
6) Unheated soil plus floating row covers

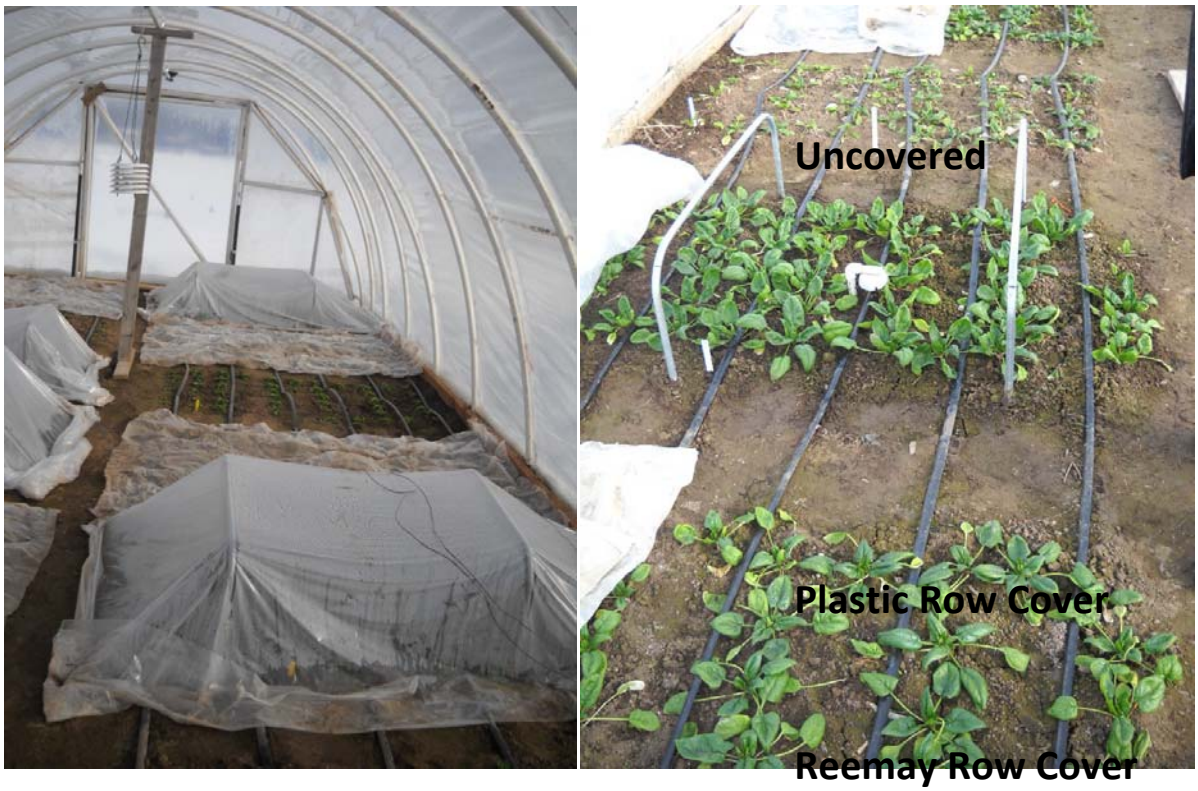

Figure 1. The influence of row covers on spinach grown under plastic, under Reemay or without a row cover (control). Spinach planted on Nov. 3 and the photographs taken on Dec 21, 2009.

Spinach and lambs lettuce were harvested every 10 days (5 harvests) and plant fresh weight, leaf number, and the number of plants harvested recorded. Soil and air temperature at plant level and outside the high tunnels were monitored throughout the study.

Project Results:

The addition of soil heat generally increased the productivity of lamb's lettuce and spinach when compared to not heating the soil during both the fall and spring production periods (Table 1). Row covers (plastic or floating mulch) also increased final yield when compared to the uncovered controls. In general, lambs lettuce yield was greater when grown under low plastic tunnels than when gown under the floating row cover. The level of productivity between the fall and spring planted lambs lettuce were significantly different from each other. Due to the heat cable malfunctions in the fall planted spinach, we were not able to directly compare the fall crop to the spring crop. However, if we just compared the un-heat fall spinach to the spring spinach; yields were not different from each other.

Air temperatures around the plants were significantly influenced by row cover treatment. Figure 2 illustrates the diurnal change in temperature for two very cold days in early February 2010. Outside temperature did not get above 0°C (32°F) during the day with an over-night low of -15°C (5°F). Plants grown without any row cover experienced a low temperature of -8°C (18°F) and then plants were exposed to a high temperature during the day of 25°C (77°F). In contrast, plants grown under the

Reemay or Plastic row covers were subjected to a low night temperature of -1°C (30°F) and warmed up to more than 30°C (86°F) during the day. The differences noted in final plant yield when spinach and lambs lettuce are grown under row covers is due to improved over night low temperatures and higher day temperatures which improves plant photosynthesis and thus plant growth.

Table 1. Yield response of lambs lettuce and spinach to various row covers and soil warming techniques (fall-winter 2009-10).

	Final Yield (lbs./ft2)			
Production Systems	December 2009		March 2010	
Lambs Lettuce	+soil heat	-soil heat	+soil heat	-soil heat
Low Plastic Tunnels	0.073 a	0.072 a	0.055 a	0.040 a
Floating Row Covers	0.048 b	0.033 b	0.037 b	0.024 b
Uncovered Controls	0.035 b	0.027 b	0.018 c	0.013 c
Soil heat vs. no heat	0.052	0.044	0.037	0.026
Spinach				
Low Plastic Tunnels	-@	0.078 a	0.067 a	0.038 a
Floating Row Covers	-	0.064 b	0.059 a	0.025 b
Uncovered Controls	-	0.039 c	0.029 b	0.012 c
Heat vs. no heat	-	0.060	0.052	0.025

@ heat cable malfunction – data not different from non-heated
Values followed by the same letter are not different from each other

Project Outcomes and Achievements:

Goal #1: For winter production in high tunnels, there was a significant improvement in plant yield for both lambs lettuce and spinach due to better temperature management. Overnight temperatures never drop too low and day temperatures get significantly above the minimum temperature (5°C or 40°F) needed for growth for either lambs lettuce or spinach. One question of interest is "how rapidly does plant photosynthesis increase after plants are subjected to repeated cold-hot cycles?" This question is raised because yield levels are still quite low and do not achieve productivity levels that are considered economic. We will be refining the production approaches to try and achieve productivity levels

approaching 0.15 lb/ft2 in our fall/spring 2010-11 plantings. A production level of 0.15 lb/ft^2 (1 kg/m^2) is considered to be the break point for economic sustainability. For the fall planted crops which start production when temperatures outside are more mild, this may be achievable since yields only need to double to get more than 0.15 lb/ft^2. However, other approaches may be needed for plantings occurring in mid-January when night temperatures are quite cold, light levels low, and establishment and early growth of either lambs lettuce or spinach is more adversely affected by these conditions. Differences in the relative growth rate (change in weight per unit time) for the first harvest interval in the fall planting were three times greater that during the same period in the winter planting (data not shown). Plants respond to the better growing environment in the fall and grow faster, thus achieve a higher final weight. One approach improving winter production would be to plant at higher densities which would increase yield per unit area even though it would not change the actual growth rate of the plants. Planting at higher densities would increase production costs since more plants need to be propagated and transplanting labor costs would be higher.

Goal #2: We are beginning the evaluation of the effects of the following overwintering techniques on high tunnel and outdoor grown blackberries (various varieties). The following treatments were imposed on the plants in the late October 2009 and plant growth will be rated in late May 2010 for cane growth (number, length, weight, etc), date of bud break, first flowering and fruiting potential.

1) Plants will be covered or uncovered to assess extra winter protection to the canes.
2) Plants will be left standing upright (on trellis) then either covered or uncovered.
3) Prostrate trellises will be either covered with row cover or left uncovered.

Preliminary findings indicate that fluctuating temperatures in the tunnels results in incomplete dormancy and increased incidence of winter injury. As a result, cane damage is quite substantial and flowering is negatively affected which results in low yields. None of the production techniques tried have been successful and additional protection methods are required before recommendations can be made to Utah growers.

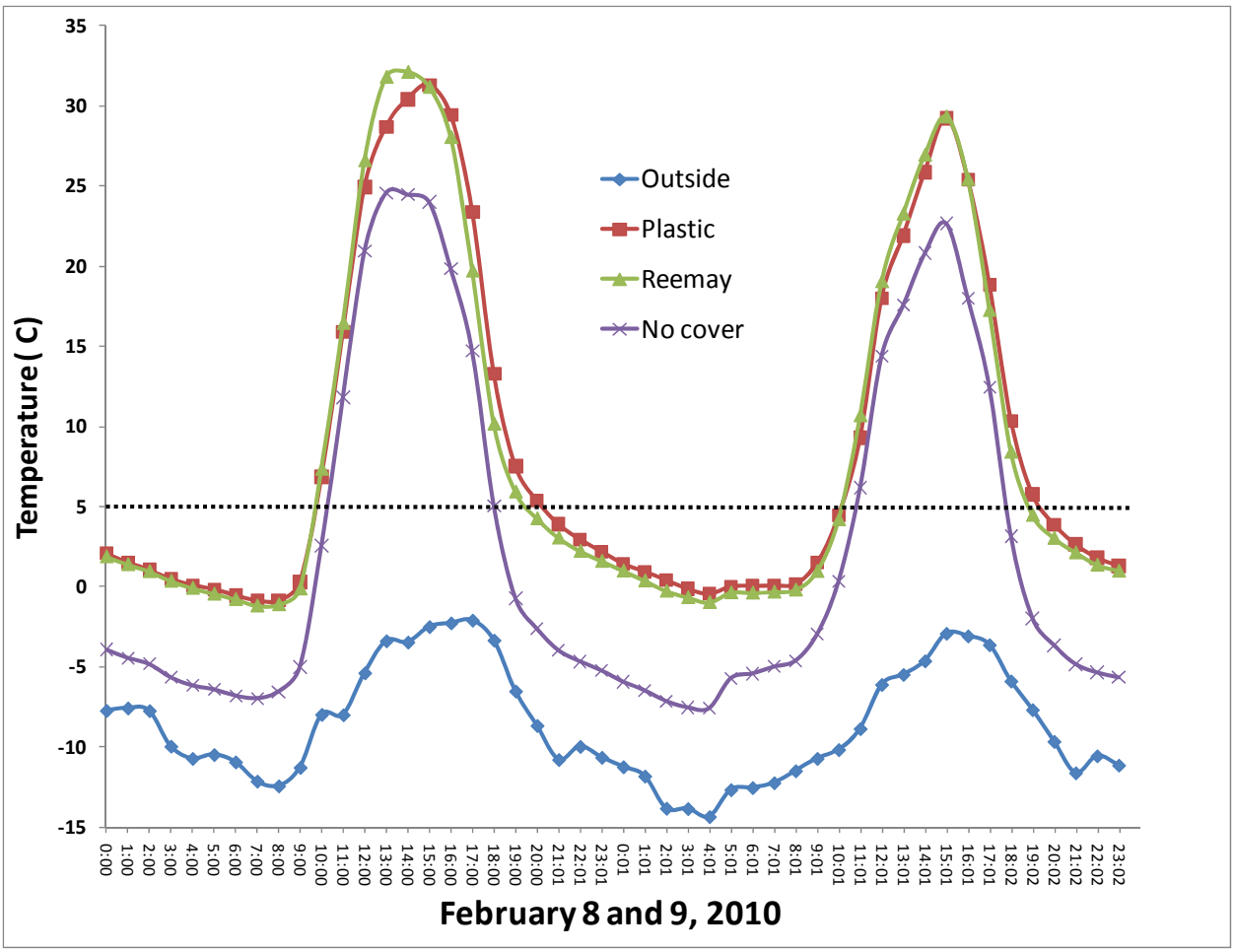

Figure 2. The influenced by different row cover treatments on air temperature (°C) over two days in early February, 2010. Row covers were the no cover control, a floating Reemay cover, or low tunnels covered with plastic inside the high tunnel. Outside air temperature is also shown. The dotted line shows the minimum temperature required for spinach or lambs lettuce growth.

Goal #3: Winter production guidelines are being written outlining plant establishment considerations (seeding or transplanting) and planting dates (fall vs. winter). While the preliminary data has been helpful understanding how plants perform in cold conditions, it should be noted that the systems employed do not generate yields that are yet considered economical. In June of 2010 we hired Ms Taunya Ernst (MS graduate student) who is researching the effects of changes in plant density (4, 9, 36 plants/ft2), comparing direct seeding to transplanting, and exploring if leaf clipping is more economical than selected leaf remove. If these alternative production methods increase yield if would offer a solution to the problem of low productivity. It would also allow the grower to harvest the same plants over a much longer growing period which would save reestablishment costs and the problems associated with slow winter growth. These studies were planted in late-October 2010 and will be grown until mid-March 2011. In

addition, Ms Ernst is exploring how photosynthesis changes as plants are exposed to repeated freezing-thawing cycles. This data may explain more fully the growth responses and highlight plant adaption to variable environments of high tunnels during the fall-winter period.

The publication is being worked on now. Taunya is drafting the factsheet using data from our studies on pak choi, spinach, lettuce, and lamb's lettuce (mache). We are trying to have it submitted to USU extension by April and then it goes out for external review (to other specialists with knowledge of high tunnels).

Once it is approved, we will post it to the USU Extension Web site (http://estension.usu.edu/) in our high tunnel section. We will advertise it in the Berry Growers Newsletter, Vegetable Growers Newsletter which goes out to fruit and vegetable growers throughout the intermountain region. We are gathering email addresses from the region to set up a list which will serve as an additional method of dissemination of the findings from our studies.

Beneficiaries:

Findings from these studies were presented to more than 200 growers, industry and government persons at national and regional meetings in Utah, Nevada, Idaho and California in 2010. These presentations highlighted findings from our studies and provided participants with up-to-date information on production approaches and market opportunities. In addition to more formal presentations, we hosted over 40 growers who came to tour the Utah State University research site in Logan.

Significant Outcomes, Accomplishments and Presentations - 2010

Presentations:

Drost, D and B. Black. 2010. High Tunnels and IPM: How Season Extension Technologies Impact Pests and Diseases. Western IPM Working Group. May 18. Logan, UT.

Drost, D and B. Black. 2010. Hoop House Construction and Season Extension Technologies. Nevada Indian Agriculture and Rural Summit. May 24-26. Fallon, NV.

Hunter, B, **D. Drost**, and B. Black. 2010. Frost Protection for Early High Tunnel Tomatoes. Amer. Soc. Hort Sci., Aug. 2-5; Palm Desert, CA.

Rowley, D, B. Black and **D. Drost**. 2010. High Tunnel Strawberry Systems for High Elevations. Amer. Soc. Hort Sci., Aug. 2-5; Palm Desert, CA.

Hudson, B. and **D. Drost**. 2010. Increasing Winter Salad Greens Yield in High Tunnels. Amer. Soc. Hort Sci., Aug. 2-5; Palm Desert, CA.

Black, B. 2010. High tunnels for high elevation production. 116th Annual Convention of the Idaho State Horticultural Society. Nov. 22-23; Nampa, ID

Publications:Rowley, Daniel, Brent L. Black, **Dan Drost** and Dillon Feuz. 2010. Early Season Extension Using June-Bearing 'Chandler' Strawberry In High Elevation High Tunnels. HortScience 45:1464-1469.

1) Britney Hunter, **Dan Drost** and Brent Black. 2010. High Tunnel Lettuce Production. USU Extension Bulletin.
http://extension.usu.edu/files/publications/publication/Horticulture_HighTunnels_2010-04pr.pdf

2) Brent Black and **Dan Drost**. 2010. Temperature Management in High Tunnels. USU Extension Bulletin.
http://extension.usu.edu/files/publications/publication/Horticulture_HighTunnels_2010-04.pdf

Lesson Learned:

High tunnels can effectively be used for the production of winter greens provided additional protection is used during the coldest periods of the year. Spinach and Lambs Lettuce grown in tunnels produced high yields when covered compared to uncovered. At present the benefits of additional supplemental heat with electric cables does not provide sufficient environmental modification to further increase plant production and thus is not advised. We were unsuccessful in achieving what has been reported to be a level of production that is economic. Other methods of production (higher plant populations, repeated harvesting of existing plants, and direct seeding) are being tested to see if fresh biomass levels of 0.15 lbs/sq ft can be achieved which have been reported to be a level of production deemed economic. These techniques are being used in the winter of 2010 and 2011 and will be reported on later.

A complete re-evaluation of blackberries grown in high tunnels is required to assess better plant protection approaches that ensure better levels of production. At this time, we cannot recommend high tunnel production of blackberry as levels of production are just too low.

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Additional Information and Copies of Publications

See Publication list above

6. Project Title: Evaluation of caneberry varieties for yield, quality and susceptibility to insect caneborers in northern Utah (Final Report)

Diane Alston, Entomologist, Utah State University
Brent Black, Fruit Specialist, Utah State University

Project Summary

Raspberry production is a small, but important agricultural industry in Utah. Value-added berry products, such as Bear Lake raspberry shakes, and jams and syrups sold at market stands contribute to Utah's agri-tourism industries. Raspberries are a high value crop with a short shelf life, making them particularly well suited to local production and consumption. Recently, the northern Utah raspberry industry was devastated by an outbreak of Raspberry Bushy Dwarf Virus (RBDV), a pollen-borne virus that is spread by pollinators. The intense severity of the RBDV outbreak was primarily due to the industry's dependence on the cultivar 'Canby' that is highly susceptible to the virus. New summer- and fall-bearing raspberry cultivars offer adaptability to a wider range of climates, and some exhibit resistance to RBDV and other pests. Few of the newer cultivars have been tested in the Intermountain West. Besides the virus, several species of caneboring insects are key pests to caneberry production. Project results confirm that differences in susceptibility among new raspberry cultivars exists, and could play an important role in development of sustainable pest management strategies that incorporate well-timed and effective insecticide applications and crop management practices to reduce caneborer infestations.

Project Approach

Caneberry Variety Trials

Seventeen summer-bearing raspberry varieties were evaluated in 2010 for winter survival, yield, fruit size, and flavor. For ease of comparison, three year average performance was calculated and a 'letter grade' assigned. Results were presented at the 2010 Kaysville field day on August 17th 2010. Two USU Extension fact sheet on raspberry insects were published and a third fact sheet on recommendations for raspberry varieties to plant in Utah is in progress. The three-year evaluation and letter grades for yields are shown in Table 1. The harvest season for the fall-bearing raspberries was prolonged due to a long mild autumn. Harvests of the 10 cultivars in this trial continued into the 4th week of October before a mild frost rendered the remaining fruit unmarketable. In previous

seasons, earlier frosts have limited total yields of the later fall bearing types. This prolonged season will give a better indication of the fruiting potential for these later fall-bearers. In separate research on fruit production in season extending 'high tunnels', it has become apparent that there is a need for late-fruiting fall-bearing cultivars adapted to Northern Utah.

Table 1. Total fruit yield in pounds of fruit per row foot for summer-bearing raspberries.

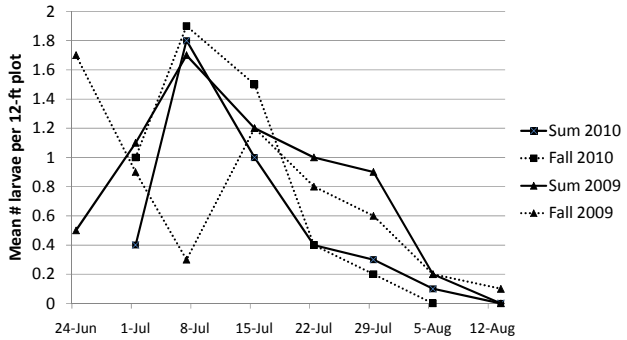
cultivar	2008	2009	2010	Average	z score	grade
		(lbs per row foot)				
Royalty	0.967	1.834	1.679	1.49	1.55	A
C. Bounty	0.571	1.797	1.538	1.30	1.05	A-
Chemainus	0.348	1.919	1.434	1.23	0.87	B+
Georgia	0.760	1.639	1.324	1.24	0.87	B+
Reveille	0.530	1.917	1.305	1.25	0.79	B+
Cowichan	0.465	1.624	1.110	1.07	0.35	B
Canby	0.347	1.546	1.225	1.04	0.32	B-
Saanich	0.275	1.503	1.277	1.02	0.22	B-
C. Delight	0.261	1.495	1.275	1.01	0.16	B-
Mautere	0.292	1.437	1.137	0.96	0.13	B-
Titan	0.275	1.575	0.805	0.88	-0.15	C+
Willamette	0.190	1.140	0.908	0.75	-0.50	C
WDNV2	0.289	1.214	0.456	0.65	-0.69	C-
Tulameen	0.120	1.215	0.845	0.73	-0.73	C-
C. Dawn	0.072	0.969	1.074	0.70	-0.92	C-
Coho	0.028	0.790	0.678	0.50	-1.44	D
Lauren	0.090	0.511	0.276	0.29	-1.88	D-
mean	0.346	1.419	1.079			
st.dev.	0.250	0.398	0.376			

Caneborer Insect Studies

Biology and Phenology

Raspberry horntail infestation was similar among summer- and fall-bearing varieties between 2009 and 2010 (Fig. 1). Horntail larvae were first detected in canes about one week earlier in 2009 (June 24) than in 2010 (July 1). Horntail densities peaked in early July in both years, and then declined through mid August.

Fig. 1. Raspberry Horntail Abundance in Summer- and Fall-Bearing Raspberries
Kaysville, UT – 2009 and 2010



Parasitism of horntail larvae by several species of parasitic wasps ranged from 0 to 100% during 2009 and 2010 (Table 2). Parasitism peaked in late July in both years, and was slightly higher in 2009 than 2010. Parasitism of horntail larvae infesting summer-bearing raspberry canes was higher than for fall-bearing raspberries in both years.

Table 2. Parasitism of horntail larvae in summer- and fall-bearing raspberry canes in 2009 and 2010.

Date	**% parasitism of larvae**			
	Summer varieties		**Fall varieties**	
	2009	**2010**	**2009**	**2010**
June 24	0	-	9.1	-
July 1	-	0	-	25.6
July 8	35.1	25.8	41.7	20.0
July 15	32.1	21.7	25.5	44.1
July 22	-	73.1	-	47.1
July 29	98.4	59.1	100	33.3
August 5	61.5	80.0	25.0	0
August 13	70.0	-	40.0	-

<u>Raspberry Varietal Susceptibility</u>

Table 3 shows mean cumulative number of raspberry horntail larvae per 12-row-ft in 17 summer- and 10 fall-bearing raspberry varieties from late June to mid August, 2009-10, Kaysville, UT. Varieties are ordered from least to most susceptible based on mean infestation levels in the two years.

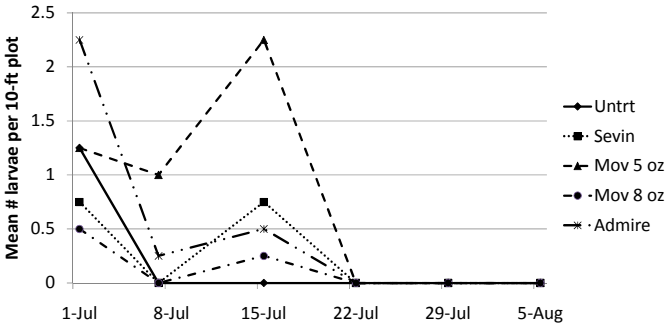
Table 3. Susceptibility of summer- and fall-bearing raspberry varieties to raspberry horntail infestation in 2009 and 2010, Kaysville, UT.

Summer variety	**Mean no. larvae 2009**	**Mean no. larvae 2010**	**Fall variety**	**Mean no. larvae 2009**	**Mean no. larvae 2010**
Royalty	2.8	0.3	Polana	3.0	1.8
Cascade Dawn	1.5	2.0	Caroline	4.8	2.0
Cascade Delight	1.8	2.8	Summit	5.5	3.3
Moutere	3.0	2.0	Heritage	8.3	1.5
Coho	4.8	1.8	Ruby	5.3	4.5
Cowichan	4.3	2.3	Joan J	3.3	7.3
WDNV2	6.3	1.0	Polka	7.5	3.3
Georgia	4.3	4.8	Jaclyn	4.3	6.8
Chemainus	5.5	3.8	Himbo Top	3.0	8.3
Tulameen	5.8	3.8	Anne	5.5	11.3
Titan	5.3	5.3			
Cascade Bounty	6.0	6.8			
Lauren	10.8	2.0			
Canby	8.5	5.8			
Willamette	12.0	4.3			
Reveille	10.3	6.5			
Saanich	7.0	12.3			

<u>Insecticide Control</u>

Plots were set up as a single row in the fall-bearing raspberry variety 'Himbo Top', and were 10 ft long. Five treatments were set up in a randomized complete block design with four replications: 1)Untreated check, 2) Grower Standard, Sevin XLR @ 2 qt per acre, 3) Movento 240SC @ 5 oz per acre + 0.25% v/v Dyne-amic, 4) Movento 240SC @ 8 oz per acre + 0.25% Dyne-amic, and 5) Admire Pro @ 14 oz per acre. Treatments 2-4 were applied to canes and foliage soon after vigorous growth of new canes began and repeated twice. Foliar treatments (Trts 2-4) were applied with a Solo Mistblower backpack sprayer @ 50 gpa. Application dates: May 5 and 20, and June 2. Admire (Trt 5) was applied post-bloom as a soil drench with a directed spray nozzle @ 500 gpa on July 7. Cane infestation peaked at 2.25 larvae per 10-ft plot during July, but then declined to zero in late July and early August. There were differences in infestation levels among dates, but there were no differences among treatments, nor were there treatment X date interactions (Fig. 2). The cool, wet spring conditions delayed the horntail population in 2010 as compared to 2009 (see Biology and Phenology above). Horntail densities were low, and differences among treatments were not discernable.

Fig. 2. Insecticide Control: Raspberry Horntail
'Himbo Top' Fall-Bearing Raspberry: Kaysville, UT - 2010



Statistical Differences:	Date: Jul 1 > Jul 15 > Jul 8 > Jul 22 – Aug 5 Treatment: NS Date X Trt: NS

Outreach Education and Impact Evaluation

Results were presented to approx. 60 growers and home gardeners at the Utah State University Kaysville Research Field Day on August 17, 2010. Project results were also be presented at the Utah Berry Grower Association (UBGA) winter meeting on January 20, 2011. Extension fact sheets completed to date: Raspberry Horntail (http://extension.usu.edu/files/publications/factsheet/raspberry-horntail09.pdf) and Spotted Wing Drosophila (http://extension.usu.edu/files/publications/publication/ENT-140-10d.pdf). A pre-project survey was conducted at the 2010 UBGA winter meeting (10 respondents). Survey results found that the three most popular raspberry varieties are Caroline, Joan J and Polana. A majority of the growers planted new acreage in 2009, and plan to again in 2010 (56% response rate for each). Thirty percent of the respondents had visited the raspberry variety trial at the USU Kaysville research station. Raspberry horntail, spider mites, and grasshoppers were listed as the top three insect pests. The majority of growers use insecticides (67%) and pruning (56%) to manage insect pests, while 33% use ground covers and 11% rely on natural enemies. A follow-up survey will be conducted at the 2012 UBGA winter meeting, and for one to two subsequent years to evaluate changes in adoption of caneberry varieties, satisfaction with varieties, pest incidence in varieties, and satisfaction with pest management techniques. The results of the surveys will be shared with the industry and grower community to help promote adoption of suitable caneberry varieties in northern Utah and improved pest management practices.

Goals and Outcomes Achieved

1. *Increase in acreage of newer raspberry and blackberry varieties planted in northern Utah following outreach education on the advantages and attributes of the varieties to the caneberry industry.* We conducted a post-project survey of berry growers at the Utah Berry Grower Association (UBGA) winter conference on February 23, 2012, and compared the responses to a pre-project survey conducted at the 2010 UBGA conference to assess change in adoption of newer varieties. The primary raspberry cultivars grown from 2010 to 2012 remained similar with 'Caroline' and

'Polana', both fall-bearers, as two of the most popular. 'Cowichan', a summer-bearer, was listed as one of the most important cultivars in 2012. The fall-bearer, 'Joan J', was mentioned as a popular cultivar in 2010, but not 2012. New berry acreage continues to be planted by a majority of berry growers: in 2009, 56% of respondents planted new acreage ('Caroline' was the most common), and in 2011, 63% of respondents planted new acreage ('Polana' and 'Polka' were the most common). Intentions to plant raspberries declined; however, as only 25% of respondents plan to plant new acreage in 2012 ('Autumn Britten' and 'Autumn Bliss' were listed as new cultivars to be planted). In the 2012 survey, fifty percent of growers reported that their caneberry (raspberry and blackberry) acreage had increased in the last three years while 25% said it was the same, and 25% said it had decreased. Results from the post-project survey support the conclusions that raspberry acreage has increased in the state and that greater awareness of new cultivars with resistance to Raspberry Bushy Dwarf Virus (RBDV) via educational opportunities at the UBGA field days and winter conferences contributed to selections of newer cultivars that are well adapted to production in northern Utah.

2. *Improvement in management of caneboring insects resulting in increased yield and quality of caneberry plantings.* Two new Extension fact sheets are completed, and two more fact sheets and a research publication are in progress. Again, comparison of responses from the pre- and post-project grower surveys allowed us to assess changes in insect pest management practices in the caneberry industry. The raspberry horntail and spider mites were listed as the two most problematic caneberry pests in both the 2010 and 2012 surveys (by 38 to 75% of respondents). Grasshoppers were listed as an important pest in 2010 (by 44% of respondents), but not mentioned in 2012. Insecticides and cane pruning were the most common pest management practices in both surveys (used by 63-67% and 25-56% of respondents for insecticides and pruning, respectively). Ground cover management to minimize dust, and thus reduce spider mite infestations, was used by 33% of respondents in 2010, but by only 13% of respondents in 2012. In 2012, 50% of respondents reported that yield loss (quantity and quantity) from pests was <5% while 25% felt that losses were 6-10%, and 13% reported losses of 11-20% of their crop. Growers were not asked about yield loss estimates in 2010. Thirty-eight percent of growers reported that the intensity of pest management practices had increased in the last three years while 25% felt it had stayed the same, and 13% thought it had decreased. When asked if they felt that their knowledge about caneberry pest management had increased in the last three years, 100% of respondents chose "yes" and 88% felt that this had translated to improved pest management on their farms. Sixty-three percent of growers reported that they used IPM practices on their berry farms and none had certified organic farms. Thirteen percent expressed interest in learning more about organic berry practices. We can conclude that this research and outreach project was highly beneficial to training berry growers about pest issues and integrated pest management practices. All growers felt that they had gained new knowledge and most felt that it had a positive impact on improving caneberry pest management on their farms.

Beneficiaries:
The major beneficiaries are the growers and support industry for berry production in the state. Project results have been disseminated to growers, Utah Department of Agriculture and Food inspectors, Natural Resource Conservation Service agronomists, Utah State University Extension agents, agricultural product suppliers, and others. In addition, the information has been disseminated to home gardeners via the USU Extension Master Gardener Program and Extension online websites. 2010-11 face-to-face contacts for the project investigators in extending project information are at least 200 people. In addition, subscriptions to the Utah small fruit IPM advisory is 4,297 and to the Utah Pests News is 3,144 people.

Lessons Learned:
The project is completed and has formed the foundation for continuation of related research in 2011-12. We have provided the raspberry industry with recommendations for most productive and insect resistant raspberry cultivars. We have formed a knowledge base on the most important insect caneborer pest, its biology, phenology, and biological control. Future research and continuation of outreach to the raspberry industry will complete the project goals within the next 1-2 years.

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Additional Information
Publications:
Alston, D., B. Black, and M. Murray. 2009. Raspberry horntail (Hartigia cressonii). Utah State University Extension and Utah Plant Pest Diagnostic Laboratory ENT-132-09 (4 pp.). http://extension.usu.edu/files/publications/factsheet/raspberry-horntail09.pdf.

Davis, R., D. Alston, and C. Vorel. 2010. Spotted wing drosophila. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory ENT-140-10 (4 pp.). http://extension.usu.edu/files/publications/publication/ENT-140-10d.pdf

7. Project Title: Developing a high density tart cherry production system for earlier cropping, improved fruit quality and optimum pest management

Submitted in Final Format

Brent Black, Fruit Specialist, Utah State University, Logan
Thor Lindstrom, Research Technician, Utah State University, Kaysville Research Farm

Project summary: High density orchards provide a number of efficiencies, including: increased yields per acre, improved fruit quality, reduced labor costs, and earlier returns on investment. High density orchards also offer environmental benefits, as the use of fertilizers and crop protectants (fungicides, insecticides) can be more efficiently applied. Tart cherries are Utah's major fruit crop, but cannot be managed in high density orchards using existing technology. The primary objective of this project is to establish an experimental high density orchard where research can be carried out to evaluate rootstocks, tree training and pruning, and canopy-shake harvest technology.

Project approach: An experimental orchard of 'Montmorency' tart cherry was planted at the Kaysville Research Farm in Kaysville, Utah during the 2010 season. Experimental treatments include combinations of three tree training systems, four tree spacings, and four rootstocks. **Tree training systems** include a tall spindle consisting of one central leader with weak fruiting laterals that undergo renewal pruning to remain fruitful; a "bi-baum" or "parallel V" system where two permanent leaders will be established parallel to the row, each with weak fruiting laterals; and a "candelabra" system with four permanent leaders also established parallel to the row. The reasoning behind the multi-leader systems is to spread tree vigor out among leaders and better limit tree growth to the proper size. **In-row spacing** treatments include 1.2, 1.8, 2.4 and 3.0 meters. Previous research with apples, peaches and other tree crops has shown that close tree spacing also has a pronounced dwarfing affect on otherwise vigorous rootstocks. **Rootstocks** (listed from smallest to largest) include Gisela 3®, Gisela 5®, Gisela 6®, and the current industry standard Mahaleb. All of these rootstocks have previously shown adaptation to Utah climate and soils in a wide-spaced NC-140 planting (Lang et al, in review).

The planting is arranged as an incomplete factorial split-split plot design, where the main plot treatments are tree spacing, the sub-plot treatments are rootstock, and the sub-sub plot treatments are training system. This design was used to reduce the likelihood of trees on larger rootstocks causing excessive border effects to neighboring plot. Likewise, the design is an incomplete factorial as not all rootstocks appear in each spacing and training system, and only the spindle system is used at the closest spacing. Gisela 5® is common to all treatments, whereas Mahaleb and Gisela 6® are included only in the wider plant spacings and Gisela 3® is included in the intermediate and close spacings. Each experimental plot is approximately 9 meters long, to allow for mechanical harvesting tests of individual treatment combinations. Tree growth and initial survival was recorded in the fall of 2010 (Table 1).

Goals and outcomes achieved: The experimental orchard has now been established and will be a valuable research resource for the next 10 to 15 years. This was the primary objective of this proposal. The experimental planting was featured at the 2010 Kaysville Fruit and Vegetable Field day on August

17th, and also showcased at the national NC-140 Tree Fruit Rootstock research meeting held in Utah on November 4th and 5th. Three experienced tart cherry growers have agreed to act as an advisory committee in developing and refining training and pruning strategies for this orchard.

Future plans - Plans for 2011 include ongoing maintenance of the planting, continued measurement of plant growth and initial fruit set. Trees will not be cropped in 2011 to encourage further plant establishment, but will be cropped in 2012. Discussions are currently underway with a major equipment manufacturer to arrange for an over-the-row mechanical harvester to be used during the 2012 season to collect data on early yields.

Beneficiaries and lessons learned: While it is too early to draw conclusions from this young planting, it is expected that the results will help to develop new strategies for growing tart cherries. This research orchard will benefit tart cherry producers in Utah, and potentially throughout the United States industry.

Status of Funds: All of the2009-2010 funds for this project have been spent. Major expenses were for the purchase of custom propagated trees ($3,944), supplies and equipment for installation of a sprinkler system ($1,554), establishment of the alleyway cover crops, and labor for planting, irrigating and pruning the orchard ($1,742).

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Table 1. 2010 Montmorency High Density Cherry Trial

Summary of Multi-Leader Trees

Rootstock	2010 Trunk Circ. at Planting (mm)	2010 Tree Survival	2010 Average # of Shoots
Gisela 3	14.5	41/42	1.92
Gisela 5	15.8	71/71	2.18
Mahaleb	12.3	32/42	2.44

8. Project Title - Utah-specific Potassium and Phosphorus Nutrient Management for Tart Cherry Productivity and Quality

PROJECT SUMMARY

Fertilizer management has been purported to improve fruit tree productivity, fruit quality, health benefits of the fruit, and increase the profits for the producer/processor. Much of the research that has been conducted on fruit tree responses to fertilizer application come from the prominent production regions of the country and are very different from Utah climatic and soil conditions.

It has been observed that in high fruit crop load situations (without fertilizer application) soluble solids, titratable acidity, and color tend to decrease, thus reducing fruit quality. Recent work with apples in Utah has shown that supplemental phosphorus (P) and potassium (K) improve fruit quality under high crop load conditions when conventional soil tests would indicate sufficiency. Tart cherry is Utah's primary fruit crop and ranks in the top five tart cherry production regions nationwide. Therefore, it is desirable to investigate the response of tart cherry to P and K management. The objective of the research was to determine the optimum fertilizer rate and formulations to maximize fruit quality.

Different rates and formulations of P and K were applied to replicated single-tree plots of mature tart cherries (*Prunus cerasus* 'Montmorency') in 2009. Fruit and leaf tissue samples from the treatments were compared for P and K content, and fruit quality was evaluated on the basis of soluble solids, titratable acidity and color.

PROJECT APPROACH

Fertilizer applications were made on 18 May 2009 and 2 June 2009, and fruit and leaf tissue samples were collected on 14 July 2009 and 30 July 2009. Leaf tissue samples were analyzed for P and K content and fruit samples were analyzed for P and K content, sugar content, acidity, and color.

In our study, the 16:16:16 N:P:K formulation applied twice during the early growing season (at 16 ounces per tree) showed the most prominent increase in fruit soluble solids, a slight increase in titratable acidity, and a slight increase in the color of the fruit—all of which indicate the potential of P and K fertilizer management to improve crop quality and market value.

In 2010, more complete rate-response and fertilizer formulation trials were set up at two locations in Santaquin, UT (Cherry Hills Farms and South Ridge Farms). Table 1 shows the treatment levels and fertilizer material mixes used in these two experiments.

Table 1. 2010 Tart Cherry Fertility Trial Treatments Details

Rate Response Comparison

Control (Received only the previous applied Nitrogen application of 0.7 lbs. Urea/tree)
16:16:16 0.5 lbs/tree
16:16:16 1 lb/tree
16:16:16 2 lbs./tree

Formulation Response Comparison

16:16:16 (1 lb/tree applied 2 times; May and June, 2010)
Steric P + Steric K + Urea*
Steric P + SOP + Urea*
Steric K + MAP + Urea*
KMag + MAP + Urea*
SOP + MAP + Urea*

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* Materials were combined for a nutrient content ratio equivalent to the 16:16:16 treatment.

Steric P and K (shown as SP and SK in figures 3 and 4) are organic carrier sources of the two nutrients and represent new materials being marketed in Utah. They are expensive materials, but there is some interest in testing claims that they are more effective at delivering these important nutrients compared to traditional mineral solid and liquid fertilizers. The SOP designation is for traditional Potassium Sulfate (or Sulfate of Potash). The KMag material is a mined mineral source called Potassium-Magnesium Sulfate and MAP is the designation for traditional Monoammonium Phosphate solid fertilzer.

GOALS AND OUTCOMES ACHIEVED

The primary goal of the project was to identify the optimum rate and formulation of P and K fertilizer that would improve tart cherry productivity. The screening study in 2009 allowed us to indentify the formulations and bracket the rates of fertilizer application that hold significant promise for further study.
The results from this study were based on single-tree plots and small samples of fruits. In 2010, fruit was tracked through commercial harvest and processing to determine both yield and processing quality. Fruit and leaf tissue samples were also taken through the season to determine the correlation between tissue concentration and fruit yield and quality. From these correlations, a nutrient management program will be developed that will increase yield and fruit quality, while sustaining tree growth and productivity

Based on the data from the 2010 studies, this work will be continued in Santaquin (Cherry Hills and Southridge Farms) and Kaysville (USU Research Station), Utah. The studies are designed to replicate the tests of the effect of multiple rates and different formulations of P and K fertilizers on fruit yield and quality components (acidity, soluble solids and color). Yield data from the rate-response and fertilizer formulation comparisons in presented in figures 1 through 4. Fruit quality data from the 2010 studies is currently still being processed. Plots are in place to continue this research through the 2012 season.

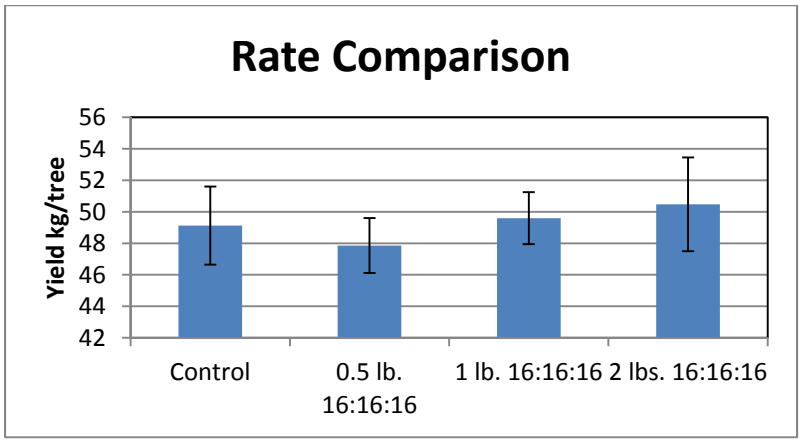

Figure 1. Fertilizer rate yield response at Cherry Hills Farms research plots

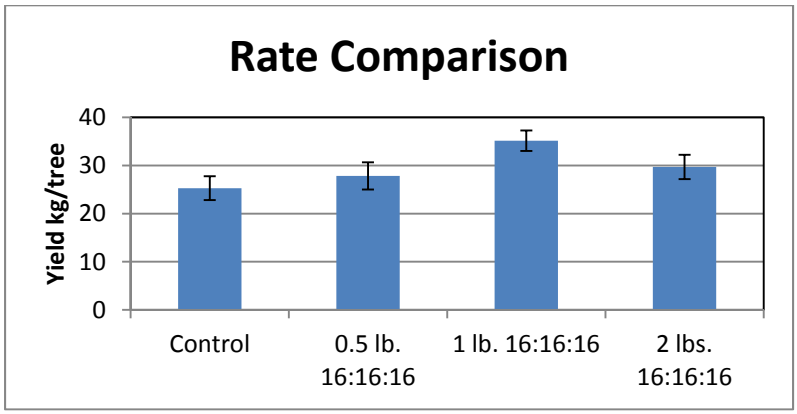

Figure 2. Fertilizer rate yield response at South Ridge Farms research plots

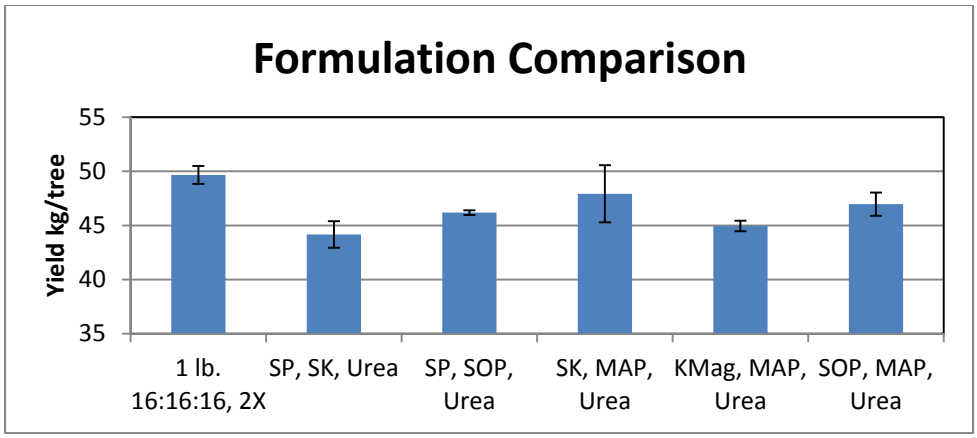

Figure 3. Comparison of the effect of fertilizer formulation on tart cherry yield, Cherry Hills Farms research plots.

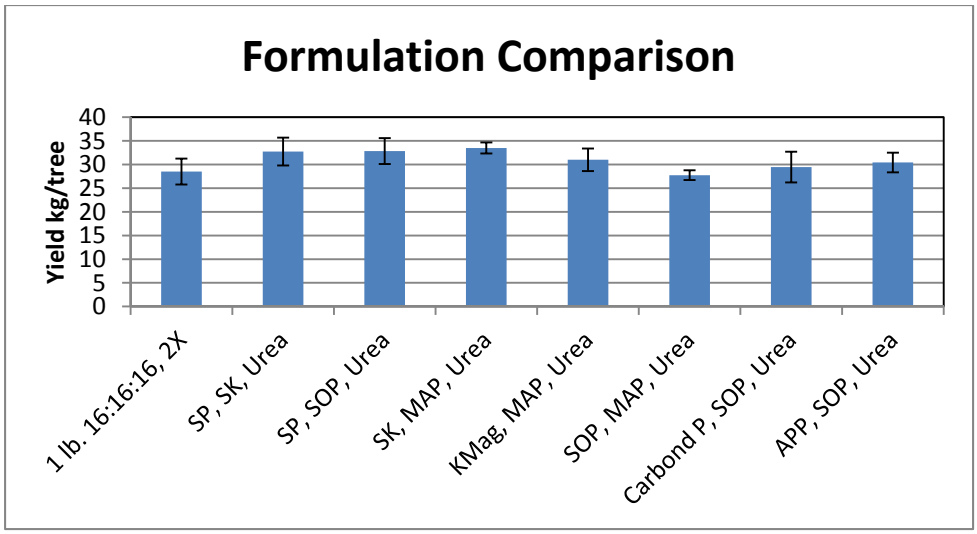

Figure 4. Comparison of the effect of fertilizer formulation on tart cherry yield, South Ridge Farms research plots.

The results show that there is no statistically significant difference between the treatments (either in rate or formulation) at either of the two locations. However, there is a consistent increase in yield with the application of P and K, and there is no advantage in applying any of the more expensive sources over the traditional mineral fertilizer source (16-16-16). This is an important result and provides significant grower decision support information for selecting and fertilizing tart cherry. Continued study and the further replication it allows may help us capture additional error control and allow identification of differences suggested by the consistent trends we see in the data already.

In addition to the research results presented in this report, progress has also been made on the dissemination of up-to-date soil and plant tissue testing interpretation for Utah conditions. A Utah State University Extension document entitled "Get The Most Out of Your Orchard Crops Through Soil and Tissue Fertility Testing" has been through initial review and is under revision. We hope to have this document through the process at the end of spring 2011. A copy of the draft of the document is attached for reference.

BENEFICIARIES

The potential impact of this project cannot be overstated. The current trends indicate that our Utah tree fruit industry, a vital player in the diversification of agriculture within the state and a valuable cash-crop, is facing pressures that could result in rapidly declining production. Urbanization has forced growers into marginal soil and growing environments that require more locally-specific management information. The expense of fertilizer management and other inputs and practices is also tightening margins and increasing grower economic risk.

The commercial tree fruit industry in Utah has a total of 6,644 acres in operation with an estimated utilized product value of $17 million (National Agricultural Statistics Service data for 2007) which accounts for about 11% of crop-related cash receipts in Utah, and is surpassed only by hay and wheat.

Tart cherries are Utah's most important fruit crop with 3,300 producing acres with 2009 production of 34 million pounds valued at $8.16 million (NASS, 2010). Recent increases in fertilizer costs have forced fruit producers to re-examine their fertility practices. In order to remain profitable, orchard managers need help determining the optimum and most cost effective methods and materials for maintaining fertility levels for maintaining high quality fruit.

LESSONS LEARNED

An unintended impact of the research is the focus it has received regarding regional culture and environmental issues. By its nature, the project addresses stewardship by improving the competitiveness of a critically important sector of Utah agriculture, namely the tree fruit industry. Significant interest has be generated in potential project outcomes that will help maintain and enhance profitability and ensure productivity on marginal lands that Utah orchardists are forced into due to local urbanization, thereby enhancing the quality and productivity of soil and water resources.

Local niche marketing (kiosk-type) and agro-tourism are also closely tied with these orchard operations and this project will help ensure the continuance of these regional, rural social benefits as farm incomes and risk are stabilized. Moreover, though the project does not deal directly with with health and safety issues, per se, improved soil nutrient management always carries with it the conjunctive benefit of protecting against fertilizer over-application and the potential for off-site nutrient transport. Off-site nutrient movement can have adverse effects on non-target environments such as the surface and groundwater resources of Utah Lake and its associated alluvial aquifer that surround and underlie this production region, and form the basis for irrigation and municipal water supplies in the Utah County and Salt Lake County areas.

Therefore, though an unintended impact, sustainability issues have begun to emerge as driving forces for continued efforts and will require the broadening of scientific analysis including community development, rural economics and environmental quality monitoring.

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9. Title: Partner with Utah State Horticultural Association to Offer Fire Blight Short Course

Utah State Horticultural Association and Utah State University Extension

Project Summary

The Utah State Horticultural Association (USHA) research advisory committee rated fire blight as the number one concern that limits apple production. In recent years, disease incidence has been increasing with losses of up to 20%. Fire blight is a springtime, bacterial disease that enters the wood via flower and shoot infections, causing localized cankers and sometimes tree death. It is unpredictable and difficult to manage due to spring's variable environmental conditions. And changes in production to high-density orchards and high profit, in-demand cultivars that are more susceptible, increase chances for disease incidence. Utah apple growers represent 264 operations on 1400 acres, and conditions in 2007 and 2009 resulted in severe fire blight infections that caused reduced yield and increased labor costs. Loss of a high density orchard could cost the grower $5,000-10,000 per acre in a single season.

This project offered a fire blight short course to apple growers taught by fire blight specialists in the U.S. Over 50 attendees from Utah and Colorado gained a comprehensive understanding of the disease, the latest techniques in detection, use of forecasting models, and disease management strategies. Audio-recorded presentations were posted to the Utah Pests website, and a DVD will be distributed to interested growers in winter 2011. A fire blight annual management guide was prepared, uploaded to the web, and will be distributed to growers at the 2011 annual grower meeting. And finally, IT programmers at the Utah Climate Center worked to make updates to an online fire blight risk prediction tool.

Project Approach

The fire blight workshop held in Provo, UT, was organized by representatives from the USHA and USU Extension, and was widely advertised. Fifty apple growers from Utah and Colorado gained an improved understanding of the tools necessary to manage fire blight in a unique, non-judgmental environment. Speakers for the one-day workshop included Dr. Ken Johnson, Plant Pathologist at Oregon State University, Tim Smith, Fruit Extension Specialist at Washington State University, and Debbie Breth, Fruit Extension Specialist at Cornell University. Each speaker spoke twice (agenda shown at end). Resistance to streptomycin, the number one antibiotic used in prevention of this disease, exacerbates the fire blight problem in Utah County. Growers learned about ways to improve the effectiveness of the alternative antibiotic, and how to manage existing infections. They also learned about the symptoms and life cycle of fire blight, how infections occur, host tree resistance, orchard design, insect effects, using models, and the best management decisions for the best implementation time.

All talks were audio-recorded in Camtasia and converted to flash video files for web viewing on the Utah Pests website at http://utahpests.usu.edu/ipm/htm/publications/slideshows#fb. (The USHA website has a link to the Utah Pests site.) The recordings have been viewed almost 100 times. USU Extension also created a publication using content from the workshop entitled, "Fire Blight Annual Management Guide." It is available online at http://utahpests.usu.edu/ipm/htm/publications. This publication will be distributed to all growers at the 2011 USHA annual convention in January, as well as to Utah Extension county offices and applicable governmental agencies.

Funding from this project was also used toward an existing online pest activity warning tool called Utah TRAPs (timing resource and alert for pests, http://climate.usurf.usu.edu/pest.php). TRAPs was created through a partnership between USU Extension and the Utah Climate Center. The tool contained a simple fire blight prediction that has now been updated with an improved interface, greater forecasting period, and an increase in the number of geographic locations from 10 to 17. (Soon it will increase to 30.) The model itself (Cougarblight) was radically updated by its creator, Tim Smith (one of the short course speakers) in August 2010. With the funds from this grant, the programmers were able to incorporate those changes in USU's online offering. The "new and improved" interface and model change will be announced to growers at the USHA annual convention in January 2011 as well as to growers statewide through USU Extension's weekly email newsletters.

Prior to the fire blight workshop, we distributed a survey to growers during the 2010 annual Utah State Horticulture Association growers' meeting, and received 20 responses. We then questioned a set of growers in personal communication in fall 2010, and the results are shown below:

Question	2009	2010
% growers with 10-20% loss due to fire blight	31	15
% growers with more than 20% loss	6	1
% that treated with antibiotics	56	44
% that have applied antibiotics after bloom	53	10
% that have used biologicals	12	10
% that prune out fire blight at all times of the year	40	45
% that use Cougarblight model (TRAPs online tool)	21	40

Goals and Outcomes Achieved

1. Growers that attended the workshop or have viewed the content online have a greater confidence in fire blight management. All Utah growers, as well as growers from neighboring states, have access to the fire blight short course contents online and in writing via the publication. Knowledge of the effectiveness of the newest products and management strategies gives growers the tools they need to prevent fire blight infections and suppress existing ones. Changes in behavior are shown in the table above. The most significant change is the number of growers who have stopped applying antibiotics after bloom. These applications are ineffective, and have been costing growers money and contributing to negative impacts. The number of growers that have adopted a year-round pruning regimen increased from 2009-2010, which is also a positive change.

2. Incidence of fire blight in Utah orchards decreased in 2010 from 2009. We cannot say that this change is solely based on the improvements in fire blight management because the conditions this past spring were not optimal for infections. But we will continue to survey apple growers in Utah for fire blight incidence in the years to come to meet a goal of 10% - 25% reduction in fire blight cankers in orchards compared to 2009.

Beneficiaries

This project directly benefits commercial apple growers in the state of Utah (approximately 1400 acres and 264 operations). Growers from neighboring states with similar climates (Colorado, Idaho, Nevada, Wyoming) will also benefit from the online content. A link to the online material was sent to the commercial growers in Colorado by the director of the Western Colorado Research Center. An effective fire blight management program can potentially save an apple grower $5,000-10,000 per acre by preventing tree death and orchard loss. Extension and state government faculty benefit by being able to better serve their clientele, which includes thousands of residential backyard growers. USU Extension has incorporated information from the workshop and TRAPs online tool in its weekly newsletter alerts that reach up to 3000 individuals.

Lessons Learned

- When organizing the short course, we soon realized that some of the top professionals we were hoping could speak were unavailable. Fortunately, the speakers that did attend were willing to present on two separate topics.

- Growers in Colorado value the outreach activities that the Utah State Horticultural Association and USU Extension provide. They would be a good group with which to conduct future collaborative projects. We have already collaborated with faculty at the Western Colorado Research Center in producing a Utah-Colorado Tree Fruit Production Guide.

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Additional Information

FIRE BLIGHT WORKSHOP

USU Extension and Utah State Horticultural Association
February 23, 2010
Provo, UT

Agenda:

8:30 – 9:30: Fire Blight Overview, Tim Smith, Washington State University

9:35 – 10:20: Methods for Detecting Fire Blight, Ken Johnson, Oregon State University

10:30 – 10:45: Break

10:45 – 11:25: Fire Blight Models I - Using Cougarblight, Tim Smith

11:30 – 12:10: Fire Blight Models II – Using Maryblyt; *and*: Status of Fire Blight in New York Debbie Breth, Cornell University

12:10 – 12:50: Lunch (provided in the room)

12:50 – 1:35: Fire blight Management using Biological and Chemical Control, Ken Johnson

1:40 – 2:10: Other Management Alternatives/What to do in an Epidemic, Debbie Breth

2:15 – 3:00 (approx.): Practical Experiences/Testing the Models, Tim Smith and Debbie Breth

Speakers:

Debbie Breth is an Extension specialist in IPM of fruit crops and Team Leader of the Lake Ontario Fruit Program at Cornell University Cooperative Extension.

Dr. Ken Johnson is a plant pathologist at Oregon State University. He has conducted years of research on fire blight that has contributed to the development of integrated disease control strategies.

Tim Smith is an Extension educator on tree fruit at Washington State University. Tim developed Cougarblight, and has worked extensively on fire blight management.

10. Project Title: Determining Incidence of Three Diseases in Utah Stone Fruit Orchards

Utah State Horticultural Association and Utah State University Extension

Project Summary

With increasing varieties of planting stock from sources outside Utah, and changes in orchard designs and operational practices over the last several years, we have seen an increase in symptoms on stone fruits, some of which have not been identified to cause. Speculation has led some growers to apply fungicides that may have been unnecessarily applied, or may have been applied at the wrong timing. There are a few plant diseases of stone fruit trees that are fairly common in many parts of the country, but in Utah, we do not know how prevalent they are because a formal survey had never been conducted before now.

This project surveyed Utah stone fruit orchards for three specific diseases: brown rot (*Monilinia fructicola*), bacterial canker (*Pseudomonas syringae*), and cytospora canker (several *Cytospora* sp.). Brown rot has never been found in Utah, but is a major problem on peaches in some parts of the West including California and parts of Colorado, resulting in significant yield losses due to diseased flowers and fruit. *Pseudomonas* and cytospora cause stem cankers and are challenging to manage, and depend upon proper pruning, plant health maintenance, and prevention of wounds, rather than chemicals.

Cytospora was the most common pathogen found in the survey. Bacterial canker was found in eight samples, and visual inspections and culturing of plant material did not yield any occurrence of *Monilinia* (brown rot). We have received a second year of funding to continue looking for these diseases and identifying symptoms in Utah. Results of this project will help to build the capacity of Utah Extension specialists in diagnosing plant diseases accurately and provide control recommendations, and will enable growers to more effectively implement stone fruit disease IPM programs.

Project Approach

The lead investigator (Marion Murray, USU) received training from Colorado State University in identification techniques for stone fruit pathogens including preparation of specialized media, fungal identification, and incubation techniques. Marion then trained a student assistant to help work on the project (the project team).

The team traveled to a total of 12 stone fruit orchards in Utah and Box Elder counties to survey for diseased tissue at various times of the season. Most of the inspection and collection occurred during spring and early summer, when the pathogens would have been most active. During that time, each orchard was surveyed approximately 8 times, and then they were surveyed 6 additional times over the course of the summer, including harvest. The orchards were surveyed by walking in a random pattern and stopping at every 10th tree to look for: dead flower buds and shoot tips,

recently killed branches, flower blasting and oozing sap, and diseased fruit. Suspect plant material was collected and portions of the tissue were either cultured on sterile growth media or incubated. The collection sites were identified using a GPS transmitter in case a unique pathogen was detected.

Utah county agriculture extension agents were trained on identifying the specific diseases in question in early March at an in-service training workshop, and were asked to provide notification of suspect symptoms. The extension agents did not find evidence of these disease in their counties, nor did they receive any diagnostic samples. We felt that the training they received was still worthwhile as they may receive or find a suspect sample in the future.

The team cultured and identified fungi from 181 samples while an additional 120 isolations did not grow anything on the media. Fungi were identified based on taxonomic keys. For most specimens, a wet mount of spores was prepared by teasing apart colonies with a dissecting needle and transferring to a slide with cover slip. All cultures were observed under a microscope. Out of all identified samples, the most common pathogen was cytospora, which kills bark and cambium, causing gummosis and cankers. Coryneum blight (shothole) was the second most commonly isolated pathogen, and *Pseudomonas syringae* (bacterial canker) was third. *Monilinia*, which causes brown rot, was not found. Results are shown in the table below.

Fungus	**Type**	**Number of Isolations**
Cytospora	Fungal pathogen (cytospora canker)	36
Wilsonomyces carpophilus	Fungal pathogen (coryneum)	17
Pseudomonas syringae	Bacterial pathogen (bacterial canker)	8
Monilinia fructicola	Fungal pathogen (brown rot)	0
Pennicillium	Secondary fungus	14
Alternaria	Secondary fungus	12
Botryosphaeria	Secondary fungus	11
Cladosporium	Secondary fungus	5
Botrytis	Secondary fungus	4
Aspergillus	Secondary fungus	2
Other secondary fungi	contaminants or non-pathogenic fungi	65
Other secondary bacteria	contaminants or non-pathogenic bacteria	7
Abiotic problem	hail, freeze injury	17
Blank cultures	asymptomatic flowers that were tested for latent pathogens	103

This report has been posted onto the Utah Pests website at: utahpests.usu.edu/ipm/htm/publications/research. We have received a second year of funding to continue with this project, and a more comprehensive report will replace this one. In addition, results will be written in article format with pictures, and included in the first Tree Fruit IPM Advisory for each of the 2011 and 2012 seasons, which are emailed to a membership of 3000 fruit growers. We will present results of this first year to growers at the 2011 Utah State Horticultural Association. The Utah Plant Pest Diagnostic Lab staff is now more aware of the fungi and bacteria that commonly occur in Utah stone fruit trees.

Goals and Outcomes Achieved

3. Cultures collected from this survey were donated to the Utah Plant Pest Diagnostic lab, where they can be used to help the lab improve response time to clients concerned with stone fruit diseases. Through the second year of funding, we will look at the number of stone fruit disease samples sent to the lab, response time, and compare this to results in 2010.

4. Utah State University Extension faculty working on this project will use results of this year and next year to develop future integrated pest management strategies for stone fruit diseases through the production of fact sheets and information output in the weekly Tree Fruit IPM advisories. USU Extension is currently writing the 2011 Utah-Colorado Tree Fruit Management Guide and is incorporating results of this project into the publication.

5. Knowing which diseases are established in stone fruit orchards will allow Extension agents and specialists the ability to provide early warnings of potential disease outbreaks so that appropriate control measures may be accurately advised.

6. After the second year of this project, we expect to see improvements in profitability for Utah stone fruit growers due to improved ability to properly identify certain symptoms. Some diseases are managed with cultural controls, such as cankers, while others are managed with chemicals, such as brown rot. For example, growers learned in the weekly tree fruit advisory mailing this summer that the disease, brown rot, has still not been found in Utah, and fungicide applications that had been wrongly applied in 2009 were not applied in 2010. Pesticide applications should only be made when exact confirmation of a particular disease is made.

7. We used a Trimble GPS unit to map locations where samples were collected, and will prepare a final map after the locations from the second year of data are collected. This information will be useful to Extension faculty and agents at Utah State University as well as to the Utah State Horticultural Association. Growers and others will know where the disease is most prevalent and could use the information for treatment, and for establishing new orchards or removing old orchards. Extension faculty and agents will be aware of potential yield reductions associated with these pests, and can quickly consult with the growers on necessary remedial actions.

8. This project provided a training opportunity for a USU student employee majoring in horticulture. The student learned about disease identification, monitoring and sampling techniques, sterile culturing and incubation techniques, photography, and management strategies. The student has since moved on to manage a greenhouse operation. Part of his position will be to diagnose and manage plant pests. The information he learned working on this project will help him greatly in his new career.

Beneficiaries

All commercial operations growing stone fruits in Utah will benefit from this project. Approximately 200 operations grow grown stone fruits on 5,181 acres. Utah is second nationally in tart cherry production, comprising 47% of all Utah grown tree fruits, and 61% of Utah stone fruits (3,150 acres). Peach is the second most commonly planted stone fruit, comprising 1,278 acres (26% of the total stone fruit acreage). Residential backyard growers will also benefit as this group contributes significantly to pesticide applications, and having a greater understanding of fruit tree pests will help them to fine tune applications. The end goal is sustainable, healthy fruit.

Lessons Learned

1. Many pathogenic fungi are difficult to grow in culture, and there is a possibility that symptoms on collected plant material may have been caused by pathogens, but either the pathogen was not active in the plant or we were unable to isolate the fungus. We would not know if we had "missed" a detection without repeating this survey an additional season.

2. Weather patterns affect plants and pathogens. Although this past spring was moist, it was also very cold, too cold for most pathogens to develop or cause infections. Weather conditions change from year to year so it is necessary to search for symptoms and pathogens in more than just one season.

3. Due to Utah's drier climate, symptoms may appear differently than what is recorded in the literature, or may affect only certain plant parts. It is important to collect plant specimens for culturing fungi that may not represent the typical symptoms for that target pathogen.

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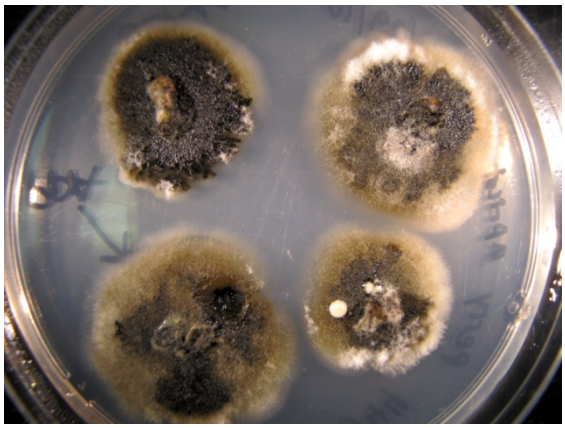
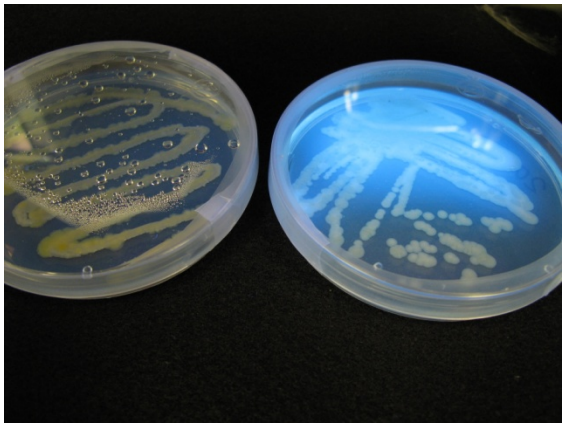
Additional Information

Images of Cultures:

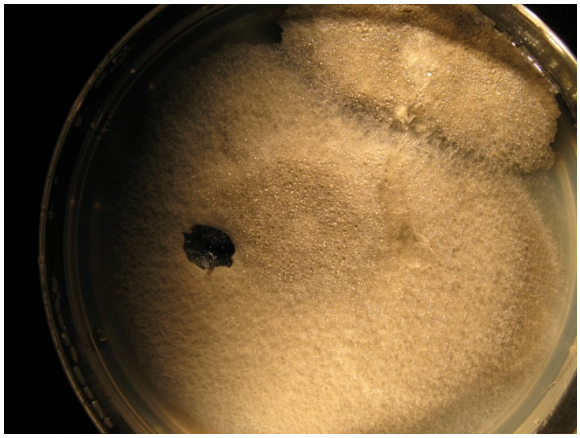


*Wilsonomyces carpophilus (*coryneum*)*

Cytospora culture



Pseudomonas syringae culture fluorescing



Alternaria culture

11. Project Title: Cherry Fruit Fly Control with GF-120 Killing Stations (2009-10)

Diane Alston, Entomologist, Utah State University

Project Summary

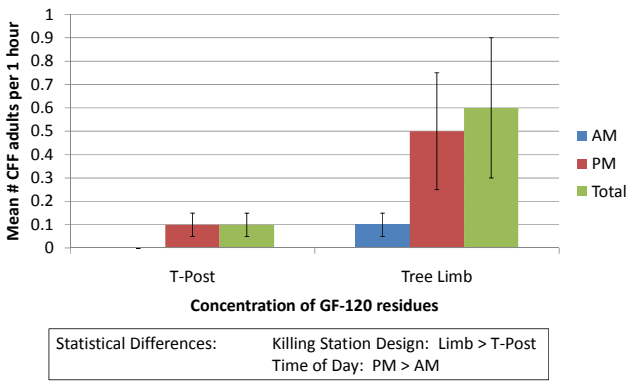
Western cherry fruit fly (CFF) is the key insect pest of cherries in Utah and western North America. A reduced-risk bacterial insecticide, spinosad, formulated with a feeding attractant, GF-120 Naturalyte (Dow AgroSciences), is effective in attracting and killing CFF. GF-120 sprays have proven successful in suppressing CFF populations in Utah cherries; however, the insecticide bait is highly susceptible to ultraviolet (UV) light degradation and is not rainfast. "Killing stations" constructed of inverted plant pot saucers (36 cm outer diameter; 5 cm deep) painted yellow and sprayed with GF-120 protected the insecticide bait from UV and rainfall, and extended the longevity of attraction of cherry fruit flies.

Project Approach

Killing Station Design

The initial killing station design was to mount them on t-posts to aid in fruit fly observations; however, to lower the cost and simplify deployment, mounting killing stations on tree limbs is more practical. Stations were sprayed with 40% GF-120 insecticide bait and the number of CFF landing on each station was observed every 15 min for 1 hr. Station design treatments were replicated eight times on June 16 and 30. Killing stations hung from cherry tree limbs were more attractive to CFF than those mounted on t-posts, and more CFF were attracted to killing stations in the afternoon (2-4 pm) than in the morning (10 am-noon) (Fig. 1).

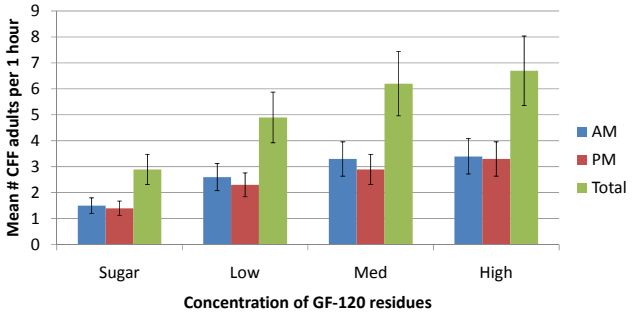
Fig. 1. Effect of **Killing Station Design** on CFF Attraction, Kaysville, UT - 2010



CFF attraction to GF-120 concentrations

The labeled rate of GF-120 dilution ranges from 17-40%. We tested three concentrations: 1) Low, 1 part GF-120: 5 parts water (17% concentration); 2) Medium, 1 part GF-120: 2.5 parts water (29% concentration); and 3) and High, 1 part GF-120: 1.5 parts water (40% concentration). GF-120 concentrations and 20% sugar water were applied to killing stations with a hand-pump sprayer and compared for their attraction of CFF adults. Killing station treatments were replicated 16 times between June 16 and July 14. The number of CFF adults that fed on GF-120 residues and died during a 1 hour period was determined. Killing stations sprayed with GF-120 were more attractive to CFF than those treated with 20% sugar water. There was no difference in attraction among the GF-120 concentrations (low=17%, Med=29%, and high=40%) (Fig. 2). There was no difference in attraction of killing stations in the morning (10 am-noon) or afternoon (1:30-4:00 pm). In this trial, we showed that GF-120 applied at the low concentration of 1:5 (17%) is just as attractive as applications at higher concentrations [1:2.5 (29%) and 1:1.5 (40%)].

Fig. 2. Effect of **GF-120 Concentration** on CFF Attraction, Kaysville, UT - 2010



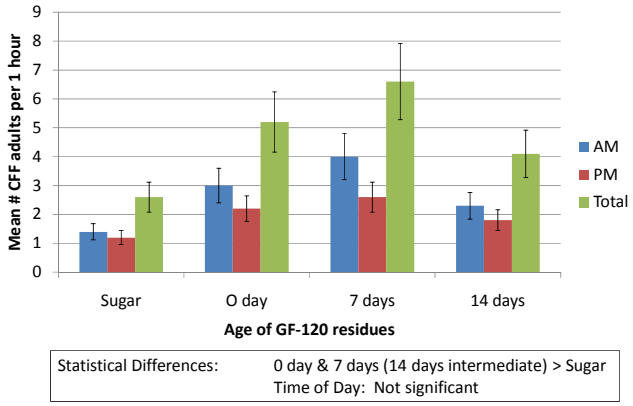
Statistical Differences:	GF-120 Low, Med & High Concen. > Sugar No differences among GF-120 concen. Time of Day: Not significant

CFF attraction to aged GF-120 residues

Freshly applied GF-120 (40% concentration) (0 day) was compared to residues aged 7 and 14 days, and to freshly applied 20% sugar water. Killing station treatments were replicated 20 times between June 17 and July 14. The number of CFF adults that fed on GF-120 residues and died during a 1 hour period was determined. Killing stations sprayed with GF-120 were more attractive to CFF than those treated with 20% sugar water. Residues aged for 7 days were just as attractive as those freshly applied (0 day) (Fig. 3). GF-120 residues that were 14 days old were less attractive than 7-day residues, but not than fresh (0 day) (see that error bars overlap between 0 and 14 day means). We have observed that fresh GF-120 residues can be mildly repellent to CFF. There was no difference in attraction of killing stations in the morning (9:30 am-noon) or afternoon (1:30-3:00 pm). The GF-120 product label recommends reapplication every 7 days, or immediately after a rain event. There was only 0.09 in of rainfall during the trial (0.06 in on June 16 and 0.03 in on July 6). During the trial, maximum air temperatures ranged from

75-95°F, and most days were sunny. In this trial, attraction of GF-120 residues to CFF was extended to 14 days.

Fig. 3. Effect of **GF-120 Residue Age** on CFF Attraction, Kaysville, UT - 2010



Statistical Differences:	0 day & 7 days (14 days intermediate) > Sugar Time of Day: Not significant

Influence of killing station density on fruit infestation

Cherry fruit infestation by CFF was compared for three killing station (KS) densities: 1) Low, 1 KS every 20th tree (9 KS per acre); 2) Medium, 1 KS every 10th tree (18 KS per acre), and 3) High, 1 KS every 6th tree (30 KS per acre). One hundred fruits were randomly selected from 6 trees with KSs within each density plot at the beginning of the trial (July 7), and every week through August 5. Cherries were placed on larval emergence trays, and the number of emerged CFF larvae and pupae determined. KSs sprayed with GF-120 did not completely prevent fruit infestation by CFF, but they did lower fruit infestation levels to no more than 0.3% when deployed at the medium and high densities (18 and 30 KS per acre). KSs show promise as a supplemental control method for CFF in commercial orchards (e.g., place them along borders and in population "hotspots"), or as a stand-alone control method in smaller acreage cherry orchards with low CFF densities. Once placed in an orchard, they are relatively easy to maintain with targeted GF-120 sprays every 1-2 weeks. Sprays can be applied to KSs with a directed nozzle from a hand-pump or electric sprayer mounted on an ATV.

KS density	**# CFF emerged per 100 fruit**				
	July 7 (pre-trial)	**July 14**	**July 21**	**July 28**	**August 5**
Low	2.7	3.2	1.2	2.5	0.5
Med	2.3	0.3	0.3	0	0
High	2.5	0.2	0	0	0

Outreach Education and Impact Evaluation

Preliminary results from trials were shared with growers at the Utah State University Kaysville Research Field Day on August 17, 2010 (approx. 60 contacts). A report was given

at the Utah State Horticultural Association (USHA) Convention on February 1-2, 2011. A second year of funding for this project was awarded. One Extension publication has been completed. A research publication is in preparation and will be completed after including results from the second year of data collection in 2011. A survey of Utah tree fruit producers was conducted by the USU Extension IPM Program in January, 2010. The response rate was 88% (sample size: 382 growers). Survey respondents reported that GF-120 was used on 4 and 356 acres of sweet and tart cherries, respectively, in the 2009 growing season. Thirty-seven growers (14%) categorized their fruit farm as using certified organic practices. A post-project survey of cherry producers will be conducted in 2012 to assess the current usage of GF-120, including use on organic cherry acreage, and grower receptivity to use of killing stations to extend the longevity of the insecticide bait product. Results of the surveys will be shared with the tree fruit industry at meetings.

Goals and Outcomes Achieved

1. An *increase in use of GF-120 Naturalyte, a reduced risk and organically certified attract-and-kill insecticide product, by Utah cherry producers.* An informal survey conducted by the author of 15 cherry producers in 2009 found that GF-120 made up only 20% of current insecticide sprays in conventionally managed orchards, and 50-75% of treatments in organic orchards. A post-project survey of cherry growers was conducted at the Utah State Horticultural Association (USHA) convention in Provo, UT, held January 31 to February 1, 2012. The majority of survey respondents who grow cherries (sweet and tart) have used Naturalyte GF-120 to control cherry fruit fly in the past three years (54%). However, the number of GF-120 applications per orchard per year declined from 2009 to 2011. An average of 4.5 applications of GF-120 per year were applied in 2009, 3.7 applications in 2010, and 1.6 applications in 2011. In contrast, use of other reduced-risk spinosyn products (those in the same chemical class as GF-120) increased from zero to 2.5 applications per year. It appears that there has been a shift to greater use of Delegate (spinetoram), Success, and Entrust (full cover spray formulations of spinosad with the latter being an organically certified formulation) in the past two years that has accompanied a reduction in use of GF-120. The major reason given for this shift was preference for applying a full cover spray formulation of spinosyn that could be mixed in the spray tank with fungicides and other products in lieu of the ATV-mounted sprayer used to apply GF-120. The growers felt that the use of tank mixes reduced the number of trips through the orchard with application equipment, thus saving time and fuel. The cherry acreage reported in the survey represents 43.8% of the total state's cherry acreage of 3,800 acres (2011 Utah Agriculture Statistics); thus the survey results provide a good representation of cherry fruit fly control measures used in the state.

2. *A change in organic cherry production in Utah that is linked, at least in part, to the use of GF-120 Naturalyte.* The 2012 survey results found that GF-120 was used more by organic than conventional cherry growers. The organic cherry acreage reported in the survey (64 acres) was all treated with GF-120 (100% of acreage, an average of 7 sprays per year) and about half of it was treated with Entrust (approx.. 50% of the acreage, an average of 2 sprays per year). In the question and answer session after results from the GF-120 study was presented, organic and conventional growers expressed an interest in using killing stations on the borders of cherry orchards and in fruit fly hotspots to supplement other insecticide applications (including other spinosyns). Organic cherry growers said they would continue to use GF-120 on all of their acreage and use Entrust for supplemental control near harvest when ripe cherries are most vulnerable to attack by cherry fruit fly. Spinosyn is the only group of insecticides with efficacy against cherry fruit fly that is organically certified. Based on research results, the growers felt that the relatively high number of killing stations needed to prevent cherry infestation (30 stations per acre under high cherry fruit fly densities) was prohibitive to their use across large acreages. However, they were interested in using killing stations with GF-120 or other bait insecticides for supplemental control on borders with external fruit fly sources and in other orchard hotspots.

Beneficiaries

The major beneficiaries are the growers and support industry for tree fruit production in the state. Project results have been disseminated to growers, Utah Department of Agriculture and Food inspectors, Natural Resource Conservation Service agronomists, Utah State University Extension agents, agricultural product suppliers, and others. In addition, the information has been disseminated to home gardeners via the USU Extension Master Gardener Program and Extension online websites. 2010-11 face-to-face contacts for the project investigators in extending project information are at least 260 people. In addition, subscriptions to the Utah tree fruit IPM advisory is 4,163 and to the Utah Pests News is 3,144 people.

In 2010 (2011 Utah Agricultural Statistics), Utah produced 3,300 acres of tart and 500 acres of sweet cherries for a total value of utilized production of $12.2 million (Utah Agricultural Statistics 2010). Tart cherry growers have recently planted more acreage because the market for dried cherry products has been expanding. Tart cherry acreage increased by 18% from 2006 to 2009 while sweet cherry acreage remained about the same. Increasing markets for tart cherries are linked to many factors, including health promotions of red fruits with high levels of antioxidants. However, improvements in cherry fruit fly management also play a role in increasing cherry production in the state. For conventionally managed orchards that prefer to rely on insecticide sprays as their

primary fruit fly control tactic, implementation of a lower density of killing stations could help reduce populations in the orchard and provide an effective pest monitoring tool. For organically managed orchards that must rely on spinosad as a primary fruit fly control tactic, an effective density of GF-120 killing stations could provide season-long control of fruit flies. An estimate of the price increase for organic over conventional cherries is 20-30%. If GF-120 killing stations prove to be effective for control of cherry fruit fly at a cost-effective density of deployment (≤ approx. 10-20 killing stations per acre), then killing stations could contribute to an increase of up to $1.9 million of added value for production of organic sweet and tart cherries in Utah.

Lessons Learned:
The project is completed and provided the baseline data for continuation of the research in 2011-12. The yellow killing stations were shown to be effective in protecting the GF-120 insecticide bait from UV radiation and rainfall. Use of killing stations alone did not prevent fruit injury, but reduced it to as low as 0.2%. Supplementation of the killing stations with an organic insecticide spray of spinosad may be adequate to completely prevent fruit injury.

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Additional Information
Publication:
Alston, D. and M. Murray. 2010. Western cherry fruit fly (*Rhagoletis indifferens*). Utah State University Extension and Utah Plant Pest Diagnostic Laboratory ENT-102-06 (6 pp.). http://extension.usu.edu/files/publications/factsheet/western-cherry-fruit-flies06.pdf.

12. Project Title-
Earwig Trapping and Control in Peach Orchards (2009-10)

Diane Alston, Entomologist, Utah State University
Marion Murray, IPM Project Leader, Utah State University

Project Summary
The European earwig is an economically damaging pest of stone fruits, especially peach, nectarine, and apricot. Earwigs chew holes into the ripening fruits and reduce fruit quality, harvestable yield, and economic value. In a pre-project survey of Utah peach growers

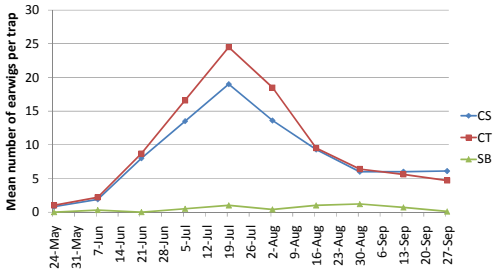
conducted at the Utah State Horticultural Association Convention in January 2010, 68% responded that their peach crop is damaged by earwigs. Insecticides were the most common method for earwig management (used by 61% of peach growers who reported earwig damage in their orchards). Results showed that corrugated cardboard rolls placed on the trunk and scaffold limbs of peach trees were more effective in monitoring earwig populations than sticky trunk traps and beating tray samples. There were two generations of European earwig, and adults from the second summer generation overwintered. A reduced-risk insecticide, spinosad (Success), was just as effective as a broad-spectrum insecticide, carbaryl (Sevin), in reducing earwig densities and protecting fruit from injury.

Project Approach

Evaluation of Earwig Traps

Three trials were conducted in Kaysville, Santaquin and Genola to evaluate the attractiveness of three trap types for earwigs. Strips of corrugated cardboard (flute size "A", Wagner Packaging, Salt Lake City, UT; 4 in wide X 10 in long) rolled up lengthwise and tied onto peach tree trunks (CT) and lower scaffolding limbs (CS) were significantly more attractive to earwigs from late May through September than sticky bands (SB) made by placing a band of duct tape around the trunk (Fig. 1). Duct tape was placed to allow enough space between the trunk and band for earwigs to crawl under the band.

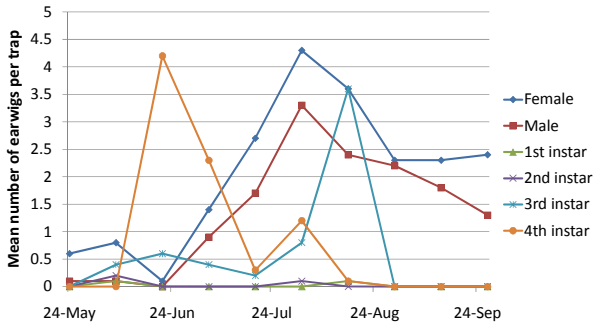
Fig. 1. Efficacy of trap types in attracting earwigs



Earwig Life Stage Phenology

To better understand the biology of earwigs in peach orchards, the phenology of each life stage was monitored with cardboard roll traps. Previous research has shown that adults are the primary overwintering life stage. We found that the traps detected only adult females and males in late May, and by early June, low numbers of nymphal instars 1-4 were detected (Fig. 2). Nymphs were active in peach trees based on trap capture from early June through late August. The most abundant nymphal instars found in traps were the 3rd and 4th instars. The new summer generation of adults was first detected in early July, adult densities peaked in early August, and was the dominant life stage through the termination of trapping in late September.

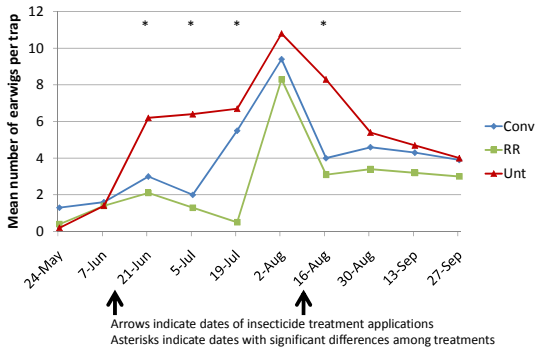
Fig. 2. Earwig life stage phenology based on attraction to traps



Insecticide Efficacy

We compared the efficacy of a conventional insecticide, carbaryl (Sevin XLR @ 3 qt/acre), to a reduced-risk insecticide, spinosad (Success @ 6 oz/acre), and an untreated control for reducing earwig densities. Insecticide treatments were applied on June 14 and August 13. Both insecticides significantly reduced earwig densities below the untreated control (Fig. 3).

Fig. 3. Efficacy of insecticides against earwigs



Peach Fruit Injury

Earwig feeding injury to peach fruits was first detected on August 11. At this time, adults were the primary life stage active in the orchard; therefore, it is likely that adults are the primary fruit-feeding stage. Fruit injury was measured weekly for four weeks through early September. Both the conventional (Sevin) and reduced-risk (Success) insecticide treatments were effective in reducing fruit injury below that of the untreated control (Table 1).

Table 1. Percentage of peach fruits with earwig and cat-facing insect injury.

Insecticide treatment	% injury from earwigs	% injury from cat-facing insects

Conventional (Sevin)	1.0	0.3
Reduced-risk (Success)	1.3	0.3
Untreated	5.8	0.5

Evaluation Metrics and Outreach Education

A pre-project survey of peach growers was conducted at the Utah State Horticultural Association (USHA) Convention on January 21, 2010. Twenty growers responded that they grew peaches. Sixty-eight percent of respondents indicated their peach crop is damaged by earwigs, and 69% of these reported damage in the range of 5-10% of the crop. Of those whose crop is damaged by earwigs, 62% use insecticides (Sevin was the only insecticide product reported) for control while 31% don't use controls, and 8% use cultural practices to reduce injury. A second year of funding to support this project was awarded for 2011. We conducted a second year of trapping and insecticide efficacy trials, and evaluated the contribution of earwigs to predation of green peach aphid. We presented first-year results to fruit growers at the 2011 USHA Convention. The project leaders in collaboration with a PhD graduate student wrote an Extension fact sheet on the European earwig, including information on trapping, optimal control timing and insecticide efficacy. The fact sheet is published on the USU Extension website. We will conduct a follow-up survey of peach growers in winter of 2012 to assess how outreach education on earwig phenology, detection traps, and insecticide efficacy has changed their behavior in managing earwigs. We will obtain information on changes in use of earwig traps (no use reported in pre-project survey), performance of earwig sprays based on improved timing with traps, and changes in insecticide use and fruit injury following implementation of trapping and better timing of insecticide sprays.

Goals and Outcomes Achieved

1. *Greater awareness of earwig population densities in peach orchards through an efficient trapping system and increase in use of earwig monitoring traps.*

In 2010 and 2011 research studies, we determined that cardboard rolls placed on peach tree trunks and lower scaffold limbs were highly effective in attracting earwigs, and were an effective population monitoring tool (Fig. 1). In a survey of peach growers at the 2010 Utah State Horticultural Association (USHA) convention, no growers indicated that they currently used earwig monitoring traps. Trapping results were presented at the January 2011 and 2012 USHA conventions, and at spring and summer informal fruit grower meetings, and in a new fact sheet. A post-project grower survey was conducted at the USHA convention on January 31 to February 1, 2012 to assess the level of grower adoption of earwig monitoring. More survey respondents reported crop damage from earwigs in 2012 than 2010 (88% vs 68%). Forty percent of the respondents reported using traps and orchard scouting to monitor earwigs in 2012 as compared to zero respondents in 2010. These data show a 40% increase in awareness of earwig activity and use of monitoring techniques.

2. *Decrease in injury to peach fruits resulting from optimal timing of effective insecticides for earwig control.*

The efficient cardboard roll traps revealed that adults are the overwintering stage, that nymphs are present from June through August, and that it is the new summer generation of adults whose densities peak in early August that cause the primary fruit-feeding injury (Fig. 2). In addition, we demonstrated that both a reduced-risk and conventional insecticide (Success and Sevin, respectively) were effective in reducing earwig population densities (Fig. 3) and fruit injury (Table 1) as compared to an untreated control. We have educated growers on these results at meetings in 2011 to achieve this goal. Although awareness of earwig injury to fruit increased between pre- and post-project surveys (68% before to 88% after), the most reported crop injury category decreased from 5-10% of fruit with injury reported by 69% of respondents in 2010 to <5% of fruit with injury reported by 47% and 5-10% injury reported by 40% of respondents in the 2012 survey. Growers reported a greater range of methods used to optimally time earwig control in the 2012 survey. Forty percent of growers now monitor earwigs and use fruit ripeness (softness) measurements within the last 2-3 weeks before peach harvest to optimally time treatments for earwig control. In addition, 20% of the post-project respondents reported using orchard ground vegetation and earwig habitat management to reduce earwig densities compared to only 8% in the pre-project survey. It is evident that exposure to education on earwig crop damage and management options has had a positive impact on increasing grower awareness of the problem and promoting integrated pest management practices to improve earwig control.

3. *Increase in use of reduced-risk insecticides for management of earwigs in peach orchards.*

2010 and 2011 research results show that a reduced-risk insecticide, spinosad (Success), is as effective as a conventional insecticide, carbaryl (Sevin) (Fig. 3). In the 2012 post-project survey, 73% of growers who experienced earwig injury in their peach orchards applied insecticides compared to 61% in the 2010 pre-project survey. The insecticide carbaryl (Sevin) was the only insecticide reported to be used for earwig control in 2010. In 2012, 18% of respondents reported using reduced-risk insecticides (insect growth regulators and neonicotinoids) while 55% used Sevin and 18% used a synthetic pyrethroid. Greater awareness and monitoring of earwigs after exposure to education on earwig crop injury and management may have contributed to an increase in earwig control treatments applied in 2012 as compared to 2010. However, an increase of 18% in use of reduced-risk insecticides post-project versus complete reliance on a conventional insecticide pre-project demonstrates a willingness by growers to try insecticides that are less harmful to beneficial insects and the environment.

Beneficiaries

The major beneficiaries are the growers and support industry for tree fruit production in the state. Project results have been disseminated to growers, Utah Department of Agriculture and Food inspectors, Natural Resource Conservation Service agronomists, Utah State University Extension agents, agricultural product suppliers, and others. In addition, the information has been disseminated to home gardeners via the USU Extension Master Gardener Program and Extension online websites. 2010-11 face-to-face contacts for the project investigators in extending project information are at least 260 people. In addition, subscriptions to the Utah tree fruit IPM advisory is 4,163 and to the Utah Pests News is 3,144 people.

Utah's peach production was valued at $5.7 million in 2009 on 1,500 bearing acres (Utah Agricultural Statistics 2010). Peach price was $1,040 per ton for 5,500 tons of utilized product. In the pre-project survey, 61% of respondents reported applying an insecticide for earwig control. This translates to approximately 915 acres being treated for earwig control. Cost for just the insecticide including labor and equipment is estimated at approx. $50 per acre. If one application can be avoided due to better timing based on earwig population monitoring, approx. $46,000 can be saved by the industry. If the amount of harvestable peach product is increased by just 2% due to better earwig control (a conservative estimate based on the data that 68% of pre-project survey respondents reported earwig injury of 5-10%), then approx. $114,000 of greater profits could be realized (5,500 utilized tons × 0.02 ×$1,040 per ton) each year.

Lessons Learned:

The project is completed and has formed the knowledge base for a second project to expand upon what was learned in earwig trapping, phenology, and insecticide control. Growers are now being encouraged to monitor for earwigs with simple cardboard traps to help them determine the optimum time to control earwigs, if needed. Growers have now been made aware of a reduced-risk insecticide alternative for earwig control. Future studies will evaluate more insecticide options.

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13. Developing Marketable Tart Cherry Concentrate

A Proposal from Payson Fruit Growers

Project Summary:

Many areas of the country have available to them Tart Cherries that are either fresh, canned or dried. The need to introduce Tart Cherry Concentrate and its benefits to the public has been seen by growers and producers throughout the United States. Tart Cherry Juice Concentrate is available in some regions throughout the country but not in all areas.

This project has helped Payson Fruit Growers, an agriculture cooperative located in Utah; develop a tart cherry juice concentrate product; educational and marketing materials; and a sales plan for internet and western United States regional sales.

Project Approach:

In order to introduce and market tart cherry concentrate to the target consumers, the marketing and sales plans were developed. This development included the following:

1. Expansion of the Payson Fruit Growers business model to include the sale of Tart Cherry Concentrate.
2. Development of the packaging materials: UPC codes, Bottles, Logo, labels, and shipping containers.
    a. We found that the use of a shrink-on label is best for our project. It accomplished the need for a waterproof label and ease of application. The label designer and fabricator significantly contributed by following our expectations of quality and they made suggestions that resulted in an outstanding label.
3. Development of educational materials such as brochures and signs for distribution to participating stores:
    a. The brochure and artwork designers worked closely with us to provide the desired results.
4. Launch the new product for internet sales and attempt to launch in two health food chains in the Western United States.

Goals and Outcomes Achieved:

Our goals were to develop a healthy cherry product, educate the consumer of the benefits of adding Tart Cherry Concentrate to their daily diet and make the product available in the target region. In order to accomplish these goals the following were accomplished:

1. Within six months of grant approval, the business model, labeling, and legal work were completed. All packaging materials met our expectations and achieved the quality of presentation we sought for.
2. The product was introduced to two established and well know health food stores.
    a. Sprouts: Headquarter in Phoenix, Arizona
    b. Sunflower: Headquarter in Phoenix, Arizona
3. The new bottled product was introduced to the public on our website in January of 2010.

Beneficiaries:

The Beneficiaries of this project are still few. The product is excellent, but as of this date, we have not been given approval from the two health food chains to sell the product in their stores. The actual cost of development has exceeded any profit from the project. We have made the tart cherry concentrate available on the internet and it popularity is starting to pick up. The beneficiaries are those internet customers who are using the concentrate for personal health oriented benefits.

Lessons Learned:

1. Establish business relationships with established food brokers who have contacts and know the current business environment.
2. We now have a better understanding of the target market and the sensitivity of price to the consumer.
3. We realize that more marketing and promotional funds must be available to satisfy large chain stores.
4. Starting up a new private label brand is very difficult and expensive; it sounds easy on paper, but obtaining shelf space if difficult and costly.
5. We may be ahead of our time. As the health benefits of tart cherries become more recognized and accepted, this product will succeed. We need perseverance, patience and money.
6. Positive results: The finished product has very fine visual appeal. Even though the product is stored in a freezer, the labeling remains intact and readable. The bottle size is easily storable in a home refrigerator.
7. An unexpected outcome is that the shrink-on label is easily applied.

Contact Person:

Project oversight will be provided by Chad Rowley, General Manager and other office staff at Payson Fruit Growers. Chad's Telephone number is (801) 465-9242 and his e-mail address is chad13@paysonfruit growers.com.

14. PROJECT TITLE - Propagating Superior Clones of Native Utah Plants for Use in the Landscape Industry

PROJECT SUMMARY:

Many of the water resources in Utah were allocated in wet portions of the long-term drought cycle. These optimistic allocations, coupled with the increased demand by growing populations on a renewable but finite quantity of water have placed Utah in a situation where water is becoming increasingly scarce and valuable. Since landscape irrigation uses more than half of the culinary water in

the state, water efficient landscape design and management is potentially an excellent source of water conservation. One way to be efficient is by using drought tolerant plants.

The demand for trees and shrubs used in such landscapes is currently being met by commercial horticultural nurseries located outside the state, and by reclamation nurseries. There is a potential niche market for exceptional clones of Intermountain west native trees and shrubs that would be more appropriate (and thus more valuable) for landscaping than traditional nursery plants or the genetically diverse trees and shrubs grown for reclamation purposes.

Many of the plants sold for landscaping in Utah come from nurseries outside the state. While some of these plants are drought tolerant, most are not. Currently, plants for use in water conserving landscapes are a minor market especially in the cold desert climate found in most of Utah. One potential source of drought tolerant plants is the native plants already existing in the Intermountain west. Native plants are not a panacea and often have problems such as disease and insect susceptibility and poor adaptation to urban landscapes. But, superior selections that are attractive, functional, and trouble-free could help fill the demand for drought tolerant plants. As such they could be very competitive as a specialty crop in the Intermountain region. For example, the native canyon maple (*Acer grandidentatum*) is a small tree that survives along Utah foothills with no supplemental irrigation.

This project builds on the 2008 Specialty Crops Block Grant Program "Locating and Documenting Clones of Native Plants for the Landscape Industry." Under that project we identified plants with potential for use and landscaping and began establishing them in a nursery environment. The 2008 project was limited to those plants with characteristics that cannot be consistently propagated by seed. This restriction is important because it permits production of superior selections rather than just seedling-run material. The domestication and use of such plants in the nursery trade depends on being successful asexual propagation that permits retention of desirable genetic traits. Critical to this step is determining which means of asexual propagation (grafting, cuttings, layering, or division) will allow us to establish daughter plants in a controlled nursery environment. Once in a nursery environment, additional work can be done to optimize propagation techniques.

The timeliness of this project cannot be overstated. The simple reality is that Utah has a limited (albeit renewable) water resource. As populations grow, landscape water conservation will permit the quality of life that we enjoy while insuring adequate water for agriculture, culinary, and industrial use. The demand for water conservation is already here, but our ability to respond with water conserving plants is limited by their growth rates. Since it can take several years to propagate and produce woody plants for sale, the sooner we begin, the sooner we can start conserving water and benefit local nurserymen.

PROJECT APPROACH:

Since receipt of the grant, the following activities have been accomplished, either as directly supported by the SCBG or through allied support:

- This project is a cooperative effort with the Utah Agricultural Experiment Station and other granting agencies such as the federally funded Drought Management Initiative. In cooperation with these partners the research greenhouse facilities in Logan, Utah have been upgraded to include supplemental lighting, intermittent mist with deionized water, bottom heat, enclosed white polyethylene rooting chamber, temperature sensors, and recorders. Funds from this grant were used only to build the rooting chamber and purchase a portion of the heating mats and those have been used solely for the production of specialty crops and for specialty crop research.

- Facilities at the Utah State University Botanical Center now include a mound layering facility with controlled irrigation and a common garden area for growing on selected plants for observation.

- Facilities at the Greenville Farm in North Logan, Utah include an overwintering structure for containerized plants and common garden areas for growing of selected plants, and demonstration gardens constructed by students to show-case native plant materials.

- Research with bigtooth maple (*Acer grandidentatum*) grafting has shown that optimum chip budding time for domestication of wild plants in a controlled nursery is from mid-July to mid-August in northern Utah. Success rates during that time period have been greater than 90%.

- Research by Melody Richards (a graduate student) with the difficult-to-root bigtooth maple has shown increases in rooting success of 30-85% through the use of hedging, etiolation, and softwood cuttings. Results varied depending on accession.

- Research by Kevin Cope (an undergraduate research fellow) with Utah juniper (*Juniperus osteosperma*) another difficult-to-root plant, examined the role of talc-based rooting hormones, rooting substrate, white polyethylene rooting chambers, bottom heat, periodic misting with deionized water, and juvenile stock plants from Park Valley, Utah in rooting of hardwood cuttings. His results indicated that juvenile cuttings treated with 8000 ppm IBA as a talc-based dip, stuck in a 2:1 perlite:peat rooting substrate, and held in a white polyethylene rooting chamber in a greenhouse environment with mist applied twice daily and bottom heat held at roughly 70F can result in up to 60% rooting after 16 weeks.

- Research on the vegetative propagation of other selected native woody plants through cuttings has proven variable depending on the species (Table 1). We have seen excellent success with selections of *Ericameria*, *Paxistima myrsinites*, and *Ceanothus martinii*. More moderate success has been found with selections of *Cercocarpus intricatus*, *Mahonia fremontii*, *Amelanchier*, and *Ceanothus velutinus* with considerable variability in success depending on accession. Propagation of accessions of *Cercocarpus ledifolius* (a genetic broom from Logan Canyon, Utah) and *Juniperus osteosperma* (mature accessions from Ephraim Canyon and Kanab, Utah) remain problematic with virtually no rooting of cuttings.

- Student involvement in these projects has included Melody Richards (completed an MS degree in 2010), Kevin Cope (undergraduate research fellow in 2010), Richard Anderson (nursery manager at the USU-BC and recent graduate of USU), and several undergraduate research employees.

- Additional research indicates that alcohol-based rooting hormone applications seem to be detrimental to *Amelanchier*, *Juniperus osteosperma*, and to a lesser extent, some selections of

Cercocarpus intricatus. We have also found that *Ceanothus velutinus* retains cutting quality longer with a ROOTCUBE® rooting medium than a perlite:peat soilless medium.

- Publications relevant to this work include:

Cook, S and L.A. Rupp, 2011. Drought Tolerance: A Database of Irrigation Requirements of Woody Landscape Plants of Northern Utah. Utah State University Extension Factsheet. http://extension.usu.edu/files/publications/publication/Horticulture_Drought_2011-01pr.pdf

Cope, K.R. and L.A. Rupp. 2011. Cutting Propagation of *Juniperus osteosperma*. Am. Soc. Hort. Sci. Annual Meeting Abstract #408. Sept 25-28, 2011 Waikoloa, Hawaii.

Richards, M.R. 2010. Selecting and Propagating Clones of Bigtooth Maple (*Acer grandidentatum* Nutt. Master's Thesis. Utah State University. http://digitalcommons.usu.edu

Richards, M.R. and L.A. Rupp. 2011. Propagating Bigtooth Maple. Utah State University Extension Factsheet. http://extension.usu.edu/files/publications/publication/Horticulture_Trees_2011-03pr.pdf

Richards, M.R. and L.A. Rupp. 2011. Propagation of *Acer grandidentatum* by Etiolated Cuttings. Am. Soc. Hort. Sci. Annual Meeting Abstract #174. Sept 25-28, 2011 Waikoloa, Hawaii.

Rupp, L. A., Varga, B. A., Anderson, D. 2011. Selection and Vegetative Propagation of Native Woody Plants for Water-Wise Landscaping. In: Proceedings of the 16th Wildland Shrub Symposium Threats to Shrubland Ecosystem Integrity. May 25-27, 2011, Utah State University, Logan, UT Natural Resources and Environmental Issues. Vol XVII pp. 281-290.

Rupp, L.A. and M.R. Richards. 2010. Selection and vegetative propagation of exceptional native woody plant clones. WERA-1013 Report of the Intermountain Native Plants Cooperative. Vol 2. pp 22-39. http://www.uwyo.edu/wera1013support/docs/2010%20navite%20plants%20report%20-%20final%20draft.pdf

Selection	Source	Control	Hormodin 1	Hormodin 2	2000 ppm IBA as Dip 'N Grow	4000 ppm IBA as Dip 'N Grow
Amelanchier spp	Aberdeen, ID	12%	12%	6%		
Amelanchier spp	Logan Canyon, UT	8%			17%	15%
Ceanothus martinii	Ephraim Canyon, UT	0%		55%	100%	
Ceanothus velutinus	Logan Canyon, UT	11%			17%	50%

Ceanothus velutinus	Logan Canyon, UT		53%	33%		
Ceanothus velutinus	Logan Canyon, UT	0%	0%	0%		
Cercocarpus intricatus #025	Spring Mountain, NV	0%			0%	0%
Cercocarpus intricatus #026	Spring Mountain, NV	15%			28%	52%
Cercocarpus intricatus	Kjelgren home, UT	8%			96%	100%
Cercocarpus intricatus	Wah Wah Mtn, UT		0%	0%		
Cercocarpus ledifolius (broom)	Logan Canyon, UT July 2010	0%	0%	0%	0%	0%
Cercocarpus ledifolius (broom)	Logan Canyon, UT August 2010	0%	0%	0%		
Cercocarpus ledifolius (broom)	Logan Canyon, UT August 2011				0%	0%
Ericameria spp	Raft River Mtn, UT	22%	33%	67%		
Juniperus osteosperma	Ephraim, UT	0%			0%	0%
Juniperus osteosperma	Kane County, UT	0%	0%	0%		
Mahonia fremontii	Wildland Nursery	0%	10%	10%		
Paxistima myrsinites	Teton Pass, ID	100%			100%	100%

Table 1. Preliminary results of rooted cutting experiments conducted during 2010 showing the plant material, source, and percentage of rooted cuttings with treatments using Hormodin 1 (1000 ppm IBA in talc), Hormodin 2 (3000 ppm IBA in talc), and Dip 'N Grow at 2000 or 4000 ppm IBA in an alcohol-based solution.

The most significant results of our research thus far has been to successfully propagate bigtooth maple by cuttings. Previous to this research, propagation by cuttings had been largely unsuccessful. These results provide a model for locating desirable accessions, domesticating them, and then propagating them for use in the nursery industry. This model leads us to conclude that similar results can be found with many other plants, even though some of them are highly recalcitrant in regards to vegetative propagation.

This project could not have been completed without the assistance of the Utah Agricultural Experiment Station and the Utah State University Botanical Center. Their role in providing facilities and support personnel has been invaluable. In addition, we are currently working with J. Frank Schmidt Nursery in Oregon to rapidly develop bigtooth maple trees for evaluation in the landscape before releasing accessions for use by the industry.

GOALS AND OUTCOMES ACHIEVED:

- Rooting requirements of multiple native plants were examined
- Research was done in collaboration with students at the graduate and undergraduate level
- A valid protocol for propagation bigtooth maple was established
- Progress has been made on methods to propagate Utah juniper
- The long-term goals of this project, including increased nursery production and use of drought tolerant plants in landscapes, are still works in progress. As clearly delineated from the beginning of this project, these goals will take years to accomplish. But we are very much on the way and have made measurable progress toward those goals.

Comparison of goals with actual accomplishments:

1. Goal: Identification of 40-50 trees and shrubs for future development.

   Accomplishments:

   To date approximately 75 native plants have been identified and documented for potential development. An additional 40 plants have been recommended, but are not fully documented at this point.

2. Goal: Space for common gardens and other areas will be developed and a living collection of superior specimens of native woody plants established.

   Accomplishments:

   Facilities are available for use at the USU-BC, Greenville Farm, and USU Research Greenhouses. While the collection is still a work in progress, we have demonstration gardens created by students at the Greenville Farm which have used some of our plants; there are new plantings of bigtooth maple for evaluation at Aberdeen, Idaho and North Logan, Kaysville, and Lehi, Utah; we also have plantings associated with a new mound layer propagation facility. A number of plants are also available as nursery stock in containers. Selected plants are being incorporated into gardens at Utah State University and the Utah State University Botanical Center (as well as other gardens) as opportunity

allows. This will make them accessible to the public while minimizing the tremendous cost of garden maintenance.

3. Goal: Publication of an Extension Bulletin on native plant propagation.
Accomplishments:

Students have completed writing assignments on the propagation of native plants, but a final publication has not been completed, largely due to the challenge of moving from student level publications to manuscripts that can be published by Extension. However, a publication has been done on irrigation requirements of woody plants and overall propagation of bigtooth maple.

4. Goal: Rootstocks will be established for grafting plants.
Accomplishments:
Our research has focused much more on cuttings than on grafting and what little grafting we have done has been accomplished with existing plants. We do not have a current orchard of native plant rootstocks. Another aspect of this is that we are very underfunded in regards to being able to maintain such a rootstock planting.

5. Goal: Travel the state of Utah to collect and propagate native plants.
Accomplishments:
Done: This goal has been largely approached through the collection and propagation of cuttings, to that end we have been quite successful in reaching this goal.

6. Goal: A long-term outcome (3-6 years) is the adoption of plant material in the nursery and landscape trades as evidenced by:
- Production of selected plants by Utah nurseries
- Production of selected plants by nurseries outside of Utah
- Specification of selected plants in landscape designs
- Retail and wholesale sales of selected plants for landscaping

Approach:
None of the plants we are currently developing are accessible to the landscape industry, which gives us basically a baseline of zero. As the plants are evaluated and released they will be given a specific cultivar name which will enable us to track progress by their adoption and sales in the industry and by incorporation in landscape architects specifications. Specifically, we will track adoption by monitoring the production and availability of these plants by cooperating, early adaptor nurseries.

7. Goal: Reduction in landscape water use.
Approach:
While the ultimate goal of this research is to reduce landscape water use while maintaining landscape quality, it will be very difficult to measure. State-wide the 1995 baseline of water consumption was 321 gallons per capita per day (gpcd), of this 66% or

213 gpcd is for residential use and an estimated 143 gpcd or 67% of residential use is used for landscaping (UDWR, 2003). Our goal is to reduce the 143 gpcd used for landscaping through the introduction of native landscape plants. However, it is difficult to make any kind of direct measurement of this goal because even the use of even the most drought tolerant of plants will not save water if consumers over-irrigate. Thus, water conservation remains a very complex goal. The availability of water-conserving native plants is a critical tool in the conservation of landscape water and landscape sustainability that cannot be over-emphasized. But, given the multiple programs being developed and implemented by entities such as USU Extension, the Utah Nursery and Landscape Association, the Utah Department of Agriculture and Food through sponsoring nursery research, the Utah Division of Water Resources, and various water conservancy districts, it will be very difficult if not impossible to determine the direct impact of native landscape plants on overall water conservation. We will have to assume that if native plants are being produced in the state and sold to the landscape industry and consumers that the end result will be an increase in water conservation. Overall conservation levels will be tracked through data generated by the Utah Division of Water Resources.

BENEFICIARIES:

Due to the slow growth rate of woody plants, we are still very much in the developmental stage of this project. While we have identified improved plant selections and the means to propagate them, a final stage remains of evaluating their performance in the landscape before releasing them to the landscape industry. Future beneficiaries should include both the nursery and landscape industries as well as the public and other users of landscape plant material.

LESSONS LEARNED:

Lessons we have learned include:

- A further realization of the amount of time it takes to work with woody plants and their propagation.
- The amount of work required to collect plant materials at the proper stage and then appropriately test them for propagation methods.
- The importance that proper identification and marketing of selected plants will play in their adoption and use by the landscape industry. It is one thing to work out the necessary techniques for propagation and another to have them adopted by local nurserymen.
- The amount of time and money required to maintain plant collections is significant, even without any additional research being done.

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ADDITIONAL INFORMATION:

Allied publications:

Croft, A., Rupp, L. A., Kratsch, H. (2011). Landscape Maintenance Water-Efficient Landscaping in the Intermountain West. Utah State University Press.

Millis, E., E. Klotz, T. Stonely, M. Waters, and L. Summers. 2003. Utah's M&I Water Conservation Plan: Investing in the Future. Utah Division of Water Resources. 35 pp.

Rosenberg, D. E., Kopp, K., Kratsch, H., Rupp, L. A., Johnson, P. G., Kjelgren, R. K. (2011). Value Landscape Engineering: Identifying Costs, Water Use, Labor, and Impacts to Support Landscape Choice. Journal of the American Water Resources Association, 47(3), 635–649.

15. Developing Reduced Input Conventional Orchard Floor Management Options for Soil Quality, Weeds, and Efficient Water Use

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 2010 growing season which represents the third year of this long-term project.

The project approach and significant results and accomplishments

Five different combinations of organic and inorganic fertilizers and mulches have been established. These treatments were compared for their effects on fertility, tree growth, weeds, and water use. Separate trials evaluated new organic weed control products and novel cover crops for potential integration in orchards with arid climates and cold winters. This site will be used as a source of information and outreach to local fruit growers. Results from in row fertility treatments on trunk cross sectional area show that use of compost resulted in tree growth equal or better than with NPK. Available soil nutrients were enhanced with use of compost when compared to NPK treatments. Weed control between the compost and NPK treatments was similar. Paper mulch decreased early season weeds compared to the herbicide treatments; however by the end of the season mulch alone was insufficient in controlling weeds. There was no difference in end of season weed control between the mulch + herbicide combination and the non-mulch treatments. The use of paper mulch significantly reduced tree growth, however, indicating paper mulch tied up significant amounts of N making it unavailable for plant uptake. Yield and fruit size was significantly reduced in the compost + mulch treatment compared to the other three treatments. Fruit size was largest in the compost + herbicide treatment.

Acetic acid and scythe both have potential as non-residual non-systemic contact herbicides relative to the glyphosate control. Both the clove oil and lemon oil were relatively ineffective on all weeds accept small annuals, however. Wood chip and paper mulches were the most effective mulch combinations. Straw would be very effective if clean seed free straw could be obtained or a means of sterilizing it determined.

Soil quality and nutrient availability was significantly improved by the use of compost and mulch, however, 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.

Novel alleyway cover crops were established at Kaysville and Tintic to determine the amount of on farm fertility that could be generated within the orchard. At the Tintic site (a young orchard planted in 2008) vetch, alfalfa, and the alfalfa-strawberry clover-white clover mix established faster, produced more biomass and suppressed more weeds than grass. In a mature tart cherry orchard in Kaysville, alfalfa produced the most biomass followed by the alfalfa-strawberry clover-white clover mix. There was no difference in biomass production between black medic and grass while bird's foot trefoil and hairy vetch produced the least biomass in the mature orchard. All the cover crops suppressed weeds equally well with the exception of bird's foot trefoil which contained the most weeds. Nitrogen fixation and water use was positively associated with biomass production. Alfalfa and alfalfa-strawberry clover-white clover mix contributed 179-194 pounds of nitrogen in above ground biomass that was deposited in the tree row as mulch. Those same treatments used the most water while grass used the least. These results

demonstrate that legumes have the potential to produce the majority of the nitrogen needed by mature tart cherry trees, however, there is a corresponding increase in water use.

Goals and outcomes achieved

We have been successful in meeting the third year's goals of this long-term project. Details of our progress under each of our goals is presented below.

Goal A. *Manage weeds and optimize fertility for establishment of organic and reduced input peach production:*

Orchard Establishment: The new organic and reduced input peach orchard was established in April 2008. All treatments were reapplied in the spring of 2009 and 2010 as planned: **1)** conventional herbicide + 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 **5)** compost + spray on paper mulch + organic herbicide.

Soil Nutrients, soil quality and tree growth: Soil nutrient data (nitrate, ammonium, P, K, Ca, Mg + trace elements, pH, electrical conductivity, and texture) were taken at 0-30cm from each plot in May 2010. In addition, soil nitrate and ammonium was measured at 0-30cm in June, July and August. Leaf nutrient data was collected in June and July and trunk diameter, canopy width and height measured at the end of the growing season. Trees were supplied with 90g N per tree in the form of urea or steer manure compost in mid-March. Compost rates were also adjusted up or down relative to this base rate depending on tree growth. Compost N rates were based on analysis of the product and assuming available N of 20% in the first season.

Weed control: weed control was achieved in 2010 with either spray on paper mulch or herbicide applications. Weed densities were determined in the tree row and alley way. 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.

We conducted a third and final year of experiments evaluating mulch and herbicide combinations for most effective weed control in organic plots without hand weeding. Six alternative herbicides **1)** acetic acid 20% **2)** acetic acid 10% **3)** clove oil, **4)** lemon oil, **5)** scythe and **6)** glyphosate control were evaluated alone and in combination with four mulches **1)** straw, **2)** paper, **3)** wood chip, **4)** no mulch.

Goal B. *Optimize water use and soil quality through organic matter inputs, groundcover and mulches:*

Water use: Soil moisture was recorded on a weekly basis starting in June and using capacitance probes installed in the soil.

Soil quality: Soil quality (soil organic matter, pH, electrical conductivity, enzyme activity) measurements were taken at a depth of 0-10cm in June.

Goal C. *Farm generated fertility:*

Different legume combinations were selected to test the possibility of growing fertilizers within the orchard at two locations. Each treatment was evaluated for cover crop and weed biomass three times during the season before mowing. The six treatments were as follows: **1)** black medic, **2)** hairy vetch, **3)** alfalfa, **4)** clover alfalfa mix, **5)** orchard grass, and **6)** birds-foot trefoil in a mature tart cherry orchard at the Kaysville Research Station. An additional four treatments **1)** alfalfa, **2)** clover alfalfa mix, **3)** hairy vetch, and **4)** orchard grass are located in a 2 year old cherry orchard in Tinic Valley, Utah. The treatments were assigned to 6 replicate plots measuring 12 x 15ft, in a randomized complete block design.

Outcomes generated:

Two scientific papers were successfully published from the data collected over the three year establishment phase of this orchard. The first peer reviewed paper titled "Alternative alleyways for tart cherry orchards" was published in the *Journal of the American Pomological Society* **65**:208-217 in December 2011. This paper was awarded first place in the Hedrick Award for best student paper by the American Pomological Society. A second journal article titled "Mulch and organic herbicide combinations for in-row orchard weed suppression" is currently in press at the *International Journal of Fruit Science* and will appear in their December 2011 issue. An Extension bulletin on alternative orchard floor management is currently under review. This bulletin will be disturbed to commercial growers in the 2012 growing season and posted on the USU Extension and Horticulture websites. A chapter on orchard floor management drawing on results generated by this project is also in review and will appear in the 2012 edition of the Utah-Colorado Commercial Tree Fruit Production Guide published by Utah State University Extension and the Western Colorado Research Center, Colorado State University. Eds M. Murray and H. Larson. At least two additional fact sheets on the use of composts, living and non-living mulches, cover crops and alternative herbicides will be generated as our results are consolidated in the next phase of the project.

Beneficiaries

Two undergraduate students were trained in research methods and data collection as a result of this project. The first graduate student on the project Marc Rowley successfully defended his thesis in March 2011.

Field day: A field day was held at the Kaysville experiment station on August 17 2010 to highlight this project. The session included a general introduction to the goals of the project, presentations on water,

weed and arthropod management and sampling techniques and included ample time for growers to look at the plots and ask questions. Approximately 50 growers visited the plots during the day. We also held a grower advisory meeting after the field day to gather input and advice on the progress of the project so far.

Winter meeting: Results from this project were also presented at the Utah State Horticultural Association's winter meeting on February 1st 2011. Approximately 80 growers and industry representatives attended. A second grower advisory meeting on the project was held prior to this winter meeting.

Lessons Learned

Successfully collecting the third 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. This phase of the project represented the establishment phase. We learned that compost can provide sufficient nutrients for establishment of young peach trees provided weed control is good. The potential for loss of yield in organic production is therefor a result of inadequate weed control not lack of nutrients. Compost also improves soil quality and nutrient availability in high pH soils. The cost of compost is greater than NPK however. Further research is needed to quantify the benefits of compost to the system as a whole in order to calculate a true cost benefit ratio. Mulches provide good early season weed control but provide insufficient weed control later in the season without additional use of herbicides. Acetic acid and scythe were the two most effective alternative herbicides for use in combination with mulches.

The cost of mulch and alternative herbicides may prove prohibitive unless a premium can be obtained for the fruit such as in certified organic production. Legumes establish well in both young and mature orchards and some species hold the potential to produce most if not all the nitrogen needed. This saving in terms of fertilizer inputs is balanced by increased irrigation water inputs. The establishment phase of this project has positioned us well for the next phase of the project. The next phase involves the production phase in which we will monitor the effect of alternative orchard floor management treatments on tree growth and health, fruit production, soil quality and pest dynamics. Further research is needed to determine the persistence of legumes in the shaded environment of a mature orchard, and their ability to withstand wheel traffic.

Additional information available (e.g. publications and websites).

Rowley, M.A., B.L. Black, C.V. Ransom, J.R. Reeve, and J.E. Creech. 2011. Alternative alleyways for tart cherry orchards. *Journal of the American Pomological Society* **65**:208-217.

Rowley, M.A., C.V. Ransom, J.R. Reeve, and B.L. Black. 2011. Mulch and organic herbicide combinations for in-row orchard weed suppression. *International Journal of Fruit Science*.11:316-331.

Black, B.L. and Rowley, M. Orchard Floor Management. Utah State University Extension. (in review).

Roper, T., M. Rowley, M. Murray and B. Black. 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. (in review).

Contact person for the project.

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16. Project Title - Quality characteristics and antioxidant activity of six varieties of Utah Red Raspberries (Final Report)

Project Title-

Quality characteristics and antioxidant activity of six varieties of

Utah Red Raspberries

Based on cultivar and methods of storage

PROJECT SUMMARY

Interest in the importance of antioxidants and the specific antioxidants available in fresh fruit has increased exponentially over the past decade, with particular interest in the high amount of anthocyanins in berries. Several studies have been published which evaluate the Oxygen Radical Absorption Capacity (ORAC) of raspberries, but none have specifically examined raspberries grown in Utah. Raspberries grow well in several areas of the state, so it was determined that a compilation of data examining the ORAC of several varieties of Utah raspberries with samples

obtained throughout the season would provide growers and consumers with information about locally produced berries and increase sales and consumer nutrition. This study would also allow a more complete examination of the changes in ORAC during refrigerator or freezer storage than had previously been done.

Interest in antioxidant research made this project timely. Access to the necessary resources made the timing imperative. This project required both access to several varieties of raspberries that were grown in a controlled environment and cooperation with a facility which had the capability of analyzing the berries. A joint relationship between Cornaby's Farm and Dr. Tory Parker, a Food Science professor at Brigham Young University, met this need. Cornaby's Farm contributed the raspberries that were collected from an experimental plot of raspberries in Salem, Utah. Dr. Parker provided access to students to analyze the samples and the equipment at the BYU Food Science laboratories. Dr. Parker also assisted in writing the article and submitting it for publication.

PROJECT APPROACH

Cornaby's Farm developed an experimental plot of six varieties of primocane raspberries with raised beds, underground fertigation, and a trellis system in 2007. Berry varieties included "Autumn Bliss", "Caroline", "Jaclyn", "Joan J", "Polana" and "Polka". The raspberries for this project were collected during the summer and fall of 2009. Approximately 1 cup of each variety was collected every two weeks from August 15, 2009 through October 10, 2009 (five pickings). Each sample was divided into three portions: one for fresh analysis, one for analysis after refrigeration for one week, and one for analysis after freezing for 30 days. ORAC and phenolic analysis was performed on each sample and data were compiled. For specific information about analysis, please refer to the attached article.

The focus during 2010 was statistical analysis of the data and preparation of an article for publication in HortScience. This journal, printed monthly, was selected because it is readily available to interested parties and has stated goals to "apprise horticultural scientists and others interested in horticulture of scientific and industry developments and of significant research, education, or extension findings or methods." (http://hortsci.ashspublications.org/site/misc/about.xhtml). The article was accepted for publication and printed in the February 2011 issue (see attached).

A complete analysis of the data is included in the attached article, but highlights are as follow: There is significant difference between total phenolics and antioxidant capacity (ORAC) between cultivars and over time. During this season, 'Autumn Bliss' had the highest ORAC and phenolic content, while 'Caroline' had the lowest ORAC and phenolic content when fresh. When compared with three different varieties of raspberries purchased at the grocery store, the Utah berries averaged between two and four times as high in ORAC and phenolics. Analysis also indicated that refrigerated berries had a significantly higher total phenolic content than fresh or frozen berries, but this may be due to moisture loss from the method of storage. The ORAC and phenolic content of frozen berries did not vary significantly from either fresh or refrigerated fruit. Interestingly, antioxidant values are higher in berries harvested later in the season (Freeman, Stocks, Eggett, Parker, 2010).

Janet Stocks collected the berries and labeled them appropriately for analysis. Dr. Troy Parker and his student, Brenner L Freeman, prepared the samples, performed the analysis and prepared the bulk of the article for publication, with assistance from Janet Stocks. Dennis L Eggett performed the statistical analysis. A great deal of data was collected during this project that remains to be evaluated and may yet yield conclusions that will assist in furthering knowledge in this area. The funds obtained from the 2010 Specialty Crops program will allow comparison between years and may provide explanations for the conclusions of this project, as well as furthering the body of research on antioxidant capacity of Utah red raspberries.

GOALS AND OUTCOMES ACHIEVED

The goals for this project were to (1) Determine whether there is a difference in antioxidant capacity and phenolics between varieties of raspberries; (2) Identify trends in antioxidant values throughout the season; (3) Compare the antioxidant values for Utah raspberries with those that are grown in California; and (4) See if there is a significant change in antioxidant capacity and phenolics when Utah red raspberries are refrigerated for one week, or frozen for 30 days.

Each of these goals was satisfactorily achieved and a body of knowledge concerning the ORAC and phenolics of Utah red raspberries was collected and summarized. The Specialty Crop Grant we received for 2011 will be used to expand this set of data and allow us to compare data between years.

BENEFICIARIES

The results of this project have been presented in the HortScience Journal and formal presentations have been made for the Utah Berry Growers Association and Utah State Master Gardeners. Informal discussion of this project has been circulated at several Farmers' Markets throughout the state, the Fancy Food Shows in Washington D.C. and San Francisco, California, and on our website. It is our desire to use this data to support the desirability and marketability of Utah Red Raspberries throughout the country and emphasize the nutrition provided by locally grown Utah fruit.

There were about 60 people at Utah State Master Gardeners Association meeting and about 20 at the Utah Berry Growers Association. I will also be presenting this information during a lecture at the Central Utah Gardens in March for about 100 people and at the Utah State Master Preservers State meeting (estimated to be about 100 people). This information has also been distributed at farmers' markets in Spanish Fork, Salt Lake City, and Saint George.

LESSONS LEARNED

One of the challenges of this project was the mass amount of data collected and the numerous correlations that were detected with cursory evaluation. The scope of the project was probably too large to develop completely within two years; each of the goals could have been a project in itself, but we knew we had a relatively short time to access to Cornaby's Farm's experimental

raspberry plot, so we decided to gather all of the data in one year, even though we couldn't completely analyze all of the correlations we found.

We also discovered that we couldn't compare our results with those of other researchers because a standard method of sample preparation has not been established throughout the research community. Since raspberry seeds contain higher antioxidant values than either the pulp or the juice, preparation methods that completely pulverize the entire berry lead to higher values. Most researchers prepared their samples by freezing the berries with nitrogen at the growing site, then shipping them to the research facility where they were processed with high shear before analysis. We tried to mimic the amount of mastication that would occur in when consumers eat raspberries, so we blended the fresh or thawed mixture, leaving some seeds whole or broken. Since we couldn't compare our data with that from other sources we performed analysis using our methodology on berries purchased from the grocery store to obtain comparative measures.

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17. Project Title - Cultural Practices for Fall Raspberry Mechanical Harvesting

SUMMARY: Utah has a robust market for raspberries, both fresh and in products such as jams, jellies, and syrups. Results of a 2009 Specialty Crops Grant showed that high quality fall raspberries can be grown in Central Utah but highlighted that production cost issues must be addressed. Particularly, hand harvesting is expensive and reliable hand harvesting labor is difficult to find for plantings of more than a few acres. Mechanical harvesting is financially attractive, but there is a scarcity of information on cultural practices for machine harvesting fall raspberries. This project builds on cultural practices initiated during the 2009 Specialty Crops Grant project and investigates additional cultural practices required for mechanical harvesting and large scale production.

APPROACH: The project researched four methods of thinning, two methods of pruning, and two trellis configurations for best yield and quality of mechanically harvested fall raspberries. Specifically, using the Caroline variety as the test variety, canes were pruned (cut to the ground) in late fall or spring, trellis configuration was either one support at 30 inches or two supports at 30 inches and 42 inches, and canes were (1) removed to the base of the raised bed, (2) removed outside of the trellis support width, (3) removed to leave canes only on top of the raised bed, (4) thinned within the row leaving the most vigorous six canes per foot. Each of the sixteen permutations was picked with the mechanical harvester and records were kept of raspberry size and total yield.

Cane Pruning Results: No significant differences were detected in the vigor or yield of canes pruned in the late fall (after several frosts) or early spring. Fall cane pruning is preferred because canes can be cut while the ground is either dry or frozen; making it easier for equipment to cut canes at ground level without scalping soft, wet spring soil. Mid-winter cane cutting would be preferable, but late fall was selected because the ground must be free of snow for ground-level cutting and snow fall and persistence cannot be forecasted. There was no evidence that spring cutting increased cane number or cane diameter over late fall cutting. This may not be true for other fall raspberry varieties.

Trellis Results: Caroline cane height is strongly dependent on the timing and amount of nitrogen applied. Nitrogen was applied directly to the roots throughout the period when irrigation water was available using our drip system. A wet spring delayed irrigation water availability and hence fertigation during the critical early weeks of primocane growth, and the canes did not grow as tall as expected. For twine strung on the 42” trellis arm to support the canes in windy conditions, the canes need to be over 52” tall. Many of the canes in the project did not attain this height, making it difficult to draw conclusions on yield. The mechanical harvester was able to pick upright canes more thoroughly than canes drooping near to the ground over the 30” support twine. Another year we would side dress nitrogen in the late winter or early spring to increase cane height and use both support twines.

Thinning Results: The study found that rows with fewer canes per foot produced fewer, but larger berries. This favorable result was offset by higher thinning costs. The rows with no thinning produced the smallest berries, and even though there were more berries, the mechanical harvester missed many berries due to the wide row width. Additionally, after several pickings, the outside canes showed damage from the picker plates. The rows that were trellis-support width and raised-bed-top width showed similar results with average berry size of 4.7 grams (varied during the season). The rows sides were treated with AIM herbicide when the primocanes were about 8 inches high, then string trimmed after regrowth. AIM treatment was expensive. Since multiple trimmings were required, specialized equipment would have been helpful. On rows that were thinned to 6 plants per foot the average berry size was over 5 grams, but average yield (weight) decreased by about 8 percent. In-row thinning was a prohibitively expensive manual operation, justifiable only if premium fresh market pricing can be guaranteed. Caroline growers that direct a majority of their product to the processing market should not thin within the row.

GOALS AND OUTCOMES ACHIEVED: Sixteen experimental rows were managed according to the plan permutations, were mechanically harvested; and the results were tabulated per plan. Rows that were thinned to about 10 inches harvested well and produced the highest yield. The cost for mechanical harvesting is about one-third that of manual harvesting. Preventive maintenance for the harvester is crucial.

BENEFICIARIES: Central Utah raspberry growers that are contemplating mechanical harvesting can benefit from the results of this project. Fall raspberries can be harvested mechanically, thereby reducing harvest costs and increasing harvest predictability.

LESSONS LEARNED: Apply sideband nitrogen in early spring to promote cane height growth. Cut canes in late fall before it snows. Trim canes to about 10-inch row width and maintain throughout the season. Fall raspberries are difficult to pick with a mechanical harvester because the berries grow on the tip of the canes or on very short laterals. Mechanical harvesting requires excellent machine uptime, so preventative maintenance and a skilled mechanic-on-call is essential. Berries may need to be picked daily at the height of their production. Machine harvested berries have a shorter shelf life than hand picked berries.

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18. Project Title: Emery County Early Varieties Trial

Project Summary:

The purpose of the project was to continue the development of a model for a specialty fruit crop industry in Emery County, Utah. In 2007, UDAF granted our organization a Specialty Crops grant for our project on the orchard operated by Michael McCandless. This project was continued with this grant.

The 2007 application focused on soft fruits like peaches, cherries and grapes. While this project is successful and is doing well, it has been determined that the largest demand in this area is for quality apples and pears and on early vegetable crops. We, therefore, replicated the previous application which included acquisition of approximately 60 fruit trees, but we also added a PVC cold frame system to enable the earlier planting and harvest of vegetable crops for sale at the local farmers market and

community celebrations. The information gathered from this project will be distributed with the local farmer's market participants to enhance the overall quality of the local specialty crops market.

In addition to the grant funds, our Grower, Mr. McCandless was able to secure in excess of $2000 in additional donations of product and services for the project and he contributed approximately $1500 in direct funds to the project. This was for upgraded irrigation and upgrades to the High Tunnel Greenhouse.

The results of the project were most promising for the apple and peach variety testing. The High Tunnel project had wind damage that reduced its effectiveness, but still some promising results were achieved.

Finally, compost fertilization appears to be the best form of fertilization in the difficult soil types encountered in this part of Utah.

Project Approach:

A number of different projects were conducted to benefit small growers in the region. Variety testing of Apples, Pears, Peaches and Grapes were undertaken to test their commercial viability. In addition, we tested 2 new peach rootstocks, specifically designed to grow in our heavy clay, alkaline soils.

We also conducted comparative research on traditional fertilization versus Biotical Nutrition and Compost Application.

Finally, we constructed a PVC based High Tunnel Greenhouse to test its ability to extend growing seasons and increase market for the local farmers markets.

Goals and Outcomes Achieved:

To determine the feasibility of small fruit operations in the area, the following goals were set:

- Test and establish “late blooming” but “early-season” fruit varieties to create first-to-market opportunities for apples and pears.
- Develop a supply of early vegetables for the local farmers market using a cold frame system
- Partner with USU Extension to manage alkaline soil problems
- Utilize Colorado River Salinity Forum funding of pressurized irrigation systems
- Partner with Castleland RC&D Council to provide administrative support and monitoring

We succeeded in obtaining significant additional contributions and donations to the project from a wide assortment of entities. Natures Organics, Gene Hawks, USU Extension Emery County, USU Extension Logan, NE Vine Supply and North American Plants. In total we estimate that we have received in excess of $2000 in value of services and products for the project.

Goals and outcomes achieved by our grower, Mr. McCandless are listed below.

1. Peach Variety Testing. North American Plants, a large commercial rootstock propagation company agreed to donate 24 rootstocks to our program. These rootstocks are CADAMAN and ROOTPACK R, both of which have been specifically developed to adapt to high PH, Clay soils like we have here. They sent thee rootstocks over the winter, so we partnered with Utah State University and the local Emery County Extension office to over-winter these at the USU greenhouses in Logan, Utah. These were then potted by USU and were shipped to in June. Roughly half of each variety survived the over-wintering and subsequent transplanting. We have had some struggles with damage from rabbits on the ROOTPACK R varieties, but have added additional protection to these for winter.
2. We are performing variety trials for 3 varieties of apples, two peach varieties and one new pear variety and all were shipped and planted in 2010. We ended up with 10 Braeburn apple, 20 Red Sensation pear, 6 Independence nectarine, 6 Saturn peaches, 20 Gale Gala and 10 Brookfield Galas. All the apples and peaches have begun to leaf out and they look fantastic. All signs are that we will have a high survival rate of these. It appears we will have 100% survival of apples, and about 90% for peaches. The Pears are another story. We immediately found that the Red Sensation Pears were not tolerant of the soil conditions in our orchard. Within a month, more than half had died of salt stress and by fall, we had lost 75%. The five remaining trees look good and seem to be prepared to over-winter. This is probably a combination of rootstock and variety incompatibility with our soil.
3. High Tunnel Greenhouse. Due to the additional funding that UDAF was able to supply to our grant, we have chosen to make the high tunnel more permanent in nature. We installed treated lumber bases and 20 windows to be mounted at the base of the high tunnel to provide better ventilation and permanence. Our concern was that the high tunnel would only last as long as the Sheeting on the outside, and this seemed to be a waste of funds. We also installed large posts and beams to augment the stability of the structure. The structure was complete in mid September and we had planted some pepper and tomato varieties for fall sale. On October 6, we had tornado speed winds come through and tear the project apart. It ripped the cover off and actually broke several 2 x 4 supports inside the structure. We were able to rebuild and absorbed about $150 in additional costs. We did sell peppers from the greenhouse this year

and a few tomatoes. Due to the problems with the winds, we did not keep them alive as late as hoped.

4. Biotical Nutrition. We have been working with Mr. Gene Hawks to test a micro-biotical soil enhancer. In plain English, it is microbes that are added to the soil to enhance fertility. We have placed the microbes on alternating rows of the newly planted trees as well as in the existing orchard. We are then re-applying the microbes on a regular basis, with a specially formulated mineral mixture to strengthen trees. We will be comparing the growth of the trees over the life of the orchard. The microbial trees will be compared to the rest of our trees which will receive a traditional fertilization schedule.
5. Compost Nutrition. We also succeeded in getting Natures Organics to provide a donation of about $500 in compost from their Milford facility. This was placed as a control to compare with the Biotical Nutrition that is mentioned above. We applied the compost to a single row of trees in the new section of the orchard and on alternating rows in the old orchard. We also applied it to 50% of the grape vineyard.
6. USU Extension used our orchard this year for training on pruning during the local Master Gardner training that is held annually. This will be an additional way to keep the partnership with USU.
7. Grape Variety Testing. We included 4 new varieties of grapes and planted them in the new test area as well. These are all clay tolerant, cold weather varieties. We were able to get the company NE Vine Supply to provide discounted pricing due to our project. We were able to get 10 of 12 vines to survive the summer and go into the winter healthy.

Beneficiaries:

The variety testing for apples, peaches and pears is being shared with USU Extension on a monthly basis. This information is then distributed throughout Emery and Carbon counties by Extension. The research on Compost and Biotical Nutrition is also being monitored by Extension and will be shared with local growers as results materialize.

The High Tunnel Green house performed well and provided a nice crop of peppers, however, due to the wind damage we sustained, we did not have as much impact to the local farmers market as hoped. We anticipate planting in early March to get ready for early season crops in 2011.

The research on varieties is also being shared with North American Plants, Van Well Nursery and Willow Drive Nursery.

Lessons Learned:

1. Early apple varieties such as Braeburn and Early Fuji all appear to thrive in our soil conditions and climate.

2. Peach and nectarine varieties tested (Saturn and Independence) also appear to be doing well, but did not outperform earlier tests we have done with Flaming Fury Varieties
3. Red Sensation Pears are NOT a good choice for our soil conditions. We struggled to get a 25% survival rate.
4. Composting on grapes in our soil environment appears to be the best form of fertilization. In comparison to chemical fertilizers and Biotical application, Compost is clearly the best nutrition for grapes in our conditions.
5. 80 mile per hour winds will damage a high tunnel green house. We survived winds up to 50 mph, but the October storm was very damaging to the project.

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19. Project Title: Making Utah Cherries More Competitive

PROJECT SUMMARY

The purpose of the project is to help make Utah tart cherries more competitive against other fruits/berries to lead to increased use of tart cherries as an ingredient in manufactured foods and on restaurant menus. The end result will be an increase in demand for Utah tart cherries and higher returns for producers and processors in the state.

To help strengthen the demand-side program for tart cherries, it's crucial that we first Gain important insights about the product innovation/ingredient decision process to best determine how to sell-in tart cherries as a competitive ingredient

PROJECT APPROACH

First, CMI commissioned a qualitative and quantitative research study conducted by a third party research firm. The study provided a picture of how cherries are currently perceived by key B2B targets (manufacturers and foodservice operators).

- Partnered with BRS Market Research Group to conduct a confidential phone survey among 17 senior ingredient decision makers at food manufacturer and foodservice establishments.

Based on the findings of the research, CMI developed a strategic communications plan to position tart cherries as a competitive ingredient to trade media and the relevant ingredient decision makers at food manufacturers and foodservice operators.

- Leveraged CMI's thought leadership initiative and product innovation research to drive awareness around fruit ingredient decisions and how food companies/commodity boards can use this as a crucial resource to help bring their ingredients to market.

GOALS AND OUTCOMES ACHIEVED

The goal of the ingredient decision research was to uncover information and insights to use as the foundation of a product innovation program aimed at increasing ingredient use of tart cherries. Key learnings, delivered to CMI Task Force and industry leaders, included:

- New product innovation takes place within a Stage Gate process, where R&D executives are involved at key stages. R&D remains the key to which ingredients are used and in what proportions and combinations. It is R&D's job to deliver products that fulfill the promise made in concept statement.
- Food innovators are always on the lookout for emerging "Super Fruits," and health halo and consumer appeal are key consideration priorities.

Building upon the research, CMI was able to leverage findings to help shape communications that would position tart cherries as an appealing, yet highly under-leveraged Super Fruit. The goal of the communications plan is to reach key ingredient decision makers via the publications they read and conferences they attend, specifically by securing 2-3 key placements in top industry publications and 1-2 speaking engagements at priority industry conferences. Specific communications outcomes achieved include:

- Secured speaking opportunity for CMI Chief Marketing Officer Jeff Manning at the **SupplySide West** trade show October, 2010. Manning delivered the research findings on the ingredient decision making process. SSW is one of the largest events for innovative ingredients. Food and beverage marketers and manufacturers attend to find ingredients, suppliers and ideas to create their next best seller.
- Developed presentation for accepted speaking proposal at Research Chefs Association (March 2011) show.

- Secured placements in *Food Product Design* and *Natural Products Insider* of a bylined article authored by CMO recapping the research.
- Secured a video interview for CMO with *Food Product Design* online during Supply Side West, providing the opportunity to further the messaging about the Ingredient Decision Maker study.

Overall, the outcomes achieved give CMI great ammunition to further strengthen the demand-side program for cherries through continued marketing efforts, specifically Utah tart cherries.

BENEFICIARIES

- **Utah growers/processors** – We continue to elevate Utah cherries through our messaging and media outreach, calling out Utah as a key cherry growing state and targeting Utah-based agri-business media. Also, in delivering research results to Utah industry representatives, we're ultimately helping them better position/market Utah cherries for product development.

LESSONS LEARNED

- Premium price can be justified so long as ingredient is overall appealing to consumers
- Participants viewed tart cherries as very high in quality, nutritious and an emerging food ingredient. Many considered cherries underutilized and still not as broadly used as blueberries or strawberries.
- Understanding and identifying the different ingredient decision makers at manufacturers can be very challenging; however targeted communication in specific trade outlets or trade shows put Cherries in the presence of these important and sometimes elusive contacts.

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ADDITIONAL INFORMATION

- Link to release of study findings: http://www.choosecherries.com/Uploads/Documents/8589249912690675808.pdf

- Link to CMO's interview from Supply Side West with *Food Product Design*: http://www.foodproductdesign.com/news/2010/11/align-marketing-with-priorities-to-optimize-outre.aspx
- Article: http://www.foodproductdesign.com/news/2010/10/insights-on-ingredient-selection.aspx
- Article from *Natural Products Insider*: http://www.naturalproductsinsider.com/articles/2010/08/anatomy-of-a-decision.aspx

New Study Offer Insights into Ingredient Decision Process

Cherry Marketing Institute Research Has Implications for All Fruits

LANSING, Mich., June 15, 2010 – The Cherry Marketing Institute (CMI) today announced the findings of a new product innovation and ingredient study. Based on confidential interviews with senior food industry executives, the study helps dissect the product development process and reveals why certain ingredients make it into products that will appear on grocery shelves and restaurant menus.

"The ingredient decision is absolutely critical for food and specifically fruit marketers," said Jeff Manning, Chief Marketing Officer for CMI. "Fruits like tart cherries, blueberries, cranberries and dried plums depend heavily on ingredient use by food manufacturers and food service operators. Yet few study the buyers who make the all important ingredient selections."

The study, managed by Nina Diamond, Ph.D. of the B/R/S Group, involved in-depth phone interviews with senior research and development executives at 17 major food manufacturers and food service operators. "We were greatly encouraged and somewhat surprised by the ranking of factors in the ingredient decision process," said Diamond. "While price and supply are important, consumer appeal is the top priority."

Though specifics vary by organization, several common themes emerged:

- **The Stage-Gate process continues to dominate.** Conceived by new product development researchers decades ago, this approach involves five stages, each associated with a set of activities and deliverables executed by a multifunctional team. Every stage is followed by a review that involves senior management (the "Gates"). The process is designed to maximize the productivity of company resources and minimize the risk of marketplace failure.

- **R&D drives most ingredient decisions.** While the Marketing function provides broad direction and support, and may lead the multifunctional new product management team, R&D remains the key to determining which ingredients are used and in what proportions and combinations. It is R&D's job to deliver products that fulfill the promise made in the product concept statement.
- **"Super Fruits" are alive and well.** Because health and wellness are key consumer concerns, food innovators are aggressively developing new products containing fruit – always on the lookout for emerging "Super Fruits." The appeal of many fruits that have been in favor during the past few years has faded and new, on-trend fruits are being sought.
- **Science is important, but seldom a determining factor.** One reason for this attitude is that hard nutrition claims are under immense scrutiny. More critical is that an ingredient is perceived to be healthy – as well as flavorful – by consumers.
- **Cherries are appealing, but underleveraged.** Study participants viewed tart cherries as great tasting, high in quality, nutritious, and an "emerging" food ingredient. Many considered cherries underutilized relative other fruit ingredients, but on a clear upward trajectory
- **A premium price can be justified if an ingredient helps deliver the concept.** This reflects the industry's consumer focus and the fact that most juices and snacks are blends, containing multiple fruits. The key is to get the taste, color and texture right for the new product concept and the consumer.

"This study has clear implications for anyone producing and marketing food ingredients," said Manning. "The 'Food Future' looks bright for tart cherries, especially as we further broaden their appeal and acceptance."

Funded in part by a grant from the State of Utah, the information and insights from this new research will be used as the foundation of a product innovation program aimed at increasing ingredient use of tart cherries.

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The Cherry Marketing Institute (CMI) is an organization funded by North American tart cherry growers and processors. CMI's mission is to increase the demand for tart cherries through promotion, market expansion, product development and research. For more information on the science supporting the unique health benefits of cherries and for cherry recipes and menu ideas, visit www.choosecherries.com.