Program Contact:
Glenda Mostek, Marketing Specialist
Phone: (303) 869-9173
E-mail: glenda.mostek@state.co.us

FFY2012 Specialty Crop Block Grant

Final Report

Agreement #12-25-B-1449

December 28, 2015

Table of Contents

Projects in bold were Final Reports and were accepted previously; non-bold projects have changed.

*These projects were performed in 2015 with re-allocated money that was not used by other projects within the confines of the FFY2012 Specialty Crop Block Grant.

Final Report: Analyzing Hops Varieties for High Altitude Production and Alternative Marketing Schemes
Partner Organization: Fort Lewis College, Durango, Colorado

Project Summary

This project planted and scientifically evaluated eleven varieties of hops at the Old Fort at Hesperus (7600' elevation) in response to the growing trend of "going local." It collected and summarized growth, viability, nutrient, production and quality measures. Potential producers and consumers participated in three hands-on field days during the season, two traditional winter workshops and two open house networking and marketing opportunities. All information from these educational opportunities is available at local extension offices, the Old Fort location, website (www.tinyurl.com/oldforthops) and chronicled on Facebook page (www.facebook.com/oldfortathesperus).

Preliminary surveys found eight commercial breweries and brew pubs within a 70 mile radius of Hesperus that support the purchase of local hops. However, their needs currently far exceed the region's ability to produce and appropriately deliver the product in a pelletized form. This project developed alternative markets that can utilize fresh whole cone and dried hops in small quantities that home and craft brewers pay significantly more for, and smaller producers can supply. It is this opportunity that can make small acreage hops yards economically viable in Southwest Colorado's high altitude environment.

Project Purpose

The Old Fort at Hesperus is located on 6,300 acres approximately 17 miles southwest of the main campus of Fort Lewis College in Durango. Its vision is to maintain an interdisciplinary field station for education, research, and community partnerships in sustainable agriculture, cultural, natural and physical resources. The site has served as a meeting place for the agricultural community since the early 1920s when it was an educational institution (Fort Lewis College) and continued as a Colorado State University Agricultural Experiment Station from 1956 until June, 2010 when Fort Lewis College returned to manage the site. The Old Fort is located at 7600' in elevation and has the land and water resources available to establish a high altitude hops yard. Additionally, the newly renovated historic library will be available to host field days and winter workshops on site.

In 2011, there were 29,787 acres of hops production in Idaho, Oregon and Washington and only 120 acres in Colorado (National Hop Report, pp1). Due to the recent trend of "going local" more hops users are looking to procure their hops from within the state. Potential growers in the Four Corners region are also taking notice of this increased interest and have been contacting the Colorado State University (CSU) Extension offices in La Plata and Montezuma counties to find out more information about the varieties that grow well in their region (Parmenter and Hooten, personal communication). Establishing a hops yard requires significant investment in trellising (upwards of $10,000/acre), irrigation and time (two to three years). Therefore identifying hops that grow in a dry, high altitude environment is critical to a grower's success in the region. This project planted eleven different varieties of hops at the Old Fort at Hesperus to collect growth, viability, production and quality measures. It offered three hands-on field days during the project and two in-depth winter workshops to educate potential producers and share the results from the

trial. All information from these educational opportunities was made available on site in Hesperus, on the Old Fort website (www.tinyurl.com/oldforthops) and through Facebook (www.facebook.com/oldfortathesperus).

The Four Corners region is fortunate to have eight commercial breweries and brew pubs within a 70 mile radius of Hesperus, CO. They purchased over $550,000 of pelletized hops in 2011 at an average price of $8.00/pound (Amber Beye, 2012 survey). Dr. Kevin Lombard, New Mexico State University researcher at the Agriculture Science Center in Farmington, NM began a small hops trial in 2008 with plant material from USDA-ARS hops germ-plasm center in Corvallis Oregon. He believes the barrier to local production is not only identifying varieties that perform well but also how to market the un-pelletized hops. According to Dr. Lombard, the local brewers will only use fresh hops once a year because it clogs their equipment. Three Rivers Brewery in Farmington retrofitted special equipment to utilize fresh hops produced at the Agriculture Science Center but other breweries have not followed suit. While the large brewers support the purchase of local hops, their needs currently far exceed the region's ability to produce and appropriately deliver the product in a pelletized form. Given this information, this project researched and developed alternative markets to utilize fresh or dried hops in small quantities. In doing the research for this project, we surveyed both commercial and home brewers to find out the amount of hops used annually, prices paid, sources, preferred varieties and forms. These surveys were repeated at the end of the project to measure impact. This preliminary research indicated that home brewers are paying between $12 and $64/lb and are very interested in using locally produced hops. These consumers also utilize fresh whole-cone and dried hops varieties that smaller producers could supply. These higher prices could allow small acreage growers to have lower infrastructure investments (half-acre versus full-acre) with similar returns.

There have been three documented variety trials within the state since 2002 funded by a CSU SCBG: Desert Weyre grower grant (2002-03), CSU Horticulture Research Center in Fort Collins (2004-2009) and Western Colorado Research Center in Hotchkiss (Dr. Ron Godin). The focus of these trials was primarily identifying varieties that could over winter in Colorado. This project would utilize the information from these trials to identify initial varieties. However, the Old Fort Lewis at Hesperus sits at 7,600' along the La Plata River while the highest previous trial was at 5800' in Hotchkiss. Dr. Ron Godin recently presented information at the CSU Extension Hops Growing workshop indicating that alpha levels of hops grown at altitude tend to be higher. Alpha acids provide bitterness while beta acids provide flavor needed for craft beers. Ali Hamm's research at the Horticulture Research Center found that the production of aroma varieties is on the decline due to bitter varieties' better brewing efficiency. Due to this decrease in production, breweries are willing to pay more for the aroma varieties as they are still in significant use with craft breweries. This trial included both bitter (Chinook, Nugget, Magnum, Columbus, Northern Brewer, Horizon, Olympic) and aroma (Cascade, Centennial, Glacier, Sterling, Mount Hood and Williamette) varieties. Trials conducted at the Ag Science Center and Hotchkiss indicate that European varieties do not grow well in this region. Therefore, they will not be included in our trial.

This project planted eleven varieties obtained from Summit Plant Labs since they offer certified disease free hops plants. The hops plugs have a height above the root ball that is approximately 4-10 inches, and a root mass that is 1 1/4" x 1 1/2" x 2 inches. First year hops transplanted mid-

May in the field typically grow to heights of 10-20' if trellised (http://www.plantlabs.com). Purchasing this type of plant material increased the amount of growth and production data in Year 1. Since not all varieties were available from Summit Plant Labs, rhizomes were purchased from other certified sources and took longer to begin significant production. Because of the financial investment needed for infrastructure, it is critical to establish yards free from diseases that can significantly lower quality and yields, requiring the plants to be replaced within a few years. The project plan called for three reps (four plants per replicate) of each variety to be established in a randomized split plot design with 3.5 feet between plants and 10-12' alleys between rows. Fort Lewis College provided the drip irrigation system and a 15' trellis using 2 3/8" steel and three rows of high tensile wire. Plants were established in May of Year 1. Once plants were tall enough to train, hemp string was strung from the bottom of the trellis to the top in a "V" pattern to train the hops on and allow them to climb. Six bines per plant were trained, clockwise, up the twine, with three bines per string. A hands-on field day was hosted in Year 2 to allow potential growers to learn about this process.

In mid-June, the plan called for a petiole sample to be taken from each replicate and analyzed for N, Zn, and B levels that are critical for cone production. Depending upon results, foliar fertilizer was applied if needed. Additionally, foliar measurements using a hand-held Minolta SPAD meter were used to determine if Fe chlorosis is present. The SPAD 502 chlorophyll meter non-destructively measures light transmittance of the leaf in the red and infrared wavelengths at 650 and 940 nm, respectively yielding a numerical output that indicates leaf greenness. The SPAD meters, provided by Fort Lewis College, offer a less expensive and more rapid alternative to estimating chlorophyll content.

Growth and maturity data were collected for each replicate once plants were established. Yearly data included date of emergence, density/spread after Year 1, date of cone set, and long term survivability (dead/alive). Temperature data sensors (www.embeddeddatasystems.com) were placed in the hops yard to record daily minimum and maximum values year round. These data may relate to long term survivability and production at high altitudes. Each replicate was harvested by hand and dried using a commercial drying oven provided by Fort Lewis College. The cone weights for each replicate were recorded in both fresh and dry states. A sample of each replicate had an alpha, beta, and oil analysis performed each year. This data was shared at workshops and posted on the website.

The project team worked with commercial and home brewers in the region to create alternative marketing opportunities by inviting them to field days and workshops to interact with interested producers. We hosted an Open House for these potential consumers in Year 2 and 3 so they could tour the hops yard, evaluate product samples and meet potential growers. These efforts should help expand the use of fresh and un-pelletized locally produced hops.

Three hands-on field days were offered during the growing seasons on trellising, evaluating nutrient needs, and harvesting. Winter workshops in year 2 and 3 provided more in-depth knowledge on establishing hop yards, soil and nutrient considerations, trellis alternatives, post-harvest handling and marketing alternatives. The project team utilized the expertise of Dr. Ron Godin who is experienced in hosting in-depth hops workshop and continues to assist the hops industry by researching small scale harvesters and alternative ways to effectively pelletize hops.

The Project Director worked with Ron when he was at the Western Colorado Research Center and he contributed rhizomes for our initial trial in 2008.

Project Approach

Activities Performed

Met with key personnel

The project team of Beth LaShell, Kevin Lombard, Ron Godin and Amber Bye met several times per year. We also included Jason Thomas (NMSU employee) in our meetings because he has been coordinating the hops trial with Kevin for the past few years. Because of the distance between us, we met in person four times, had three conference calls and numerous email threads. The team worked together to determine hops varieties, lay out the hops yard site, review trellis plans, discuss field day agendas, host field days, plan Spring workshops, review nutrient results, make nutrient recommendations and present at the Spring workshops.

Dr. Kevin Lombard received a grant from New Mexico to host a workshop in 2012 to bring hop growers and brewers together, and set up some hops trials in New Mexico. To enhance the project that was funded through the CO Specialty Crop program, we worked with Kevin to duplicate the variety trial in both Farmington, NM and Las Cruces, NM. This allowed us to compare the effect of altitude on production and acid levels, as well as maximize the dollars we received in this isolated region.

In 2014, Beth LaShell gave a presentation at the New Mexico Organic Farming Conference on growing hops. Dr. Lombard and Godin both attended the presentation and were on hand to answer questions.

I have worked with a lot of different project teams and this one is the best one I've ever worked with. We have a common vision for what needs to be done to advance hops production in the Southwest and we truly enjoy working together. Additionally, we share the work load on big projects and so it makes working together very enjoyable.

Designed and Distributed Marketing Materials
A project website was established at www.tinyurl.com/oldforthops. It houses educational information and allows participants to register for events. We used www.jotform.com to register

for the free events and Fort Lewis College MarketPlace (www.tinyurl.com/oldfortmarketplace) to allow participants to register and pay online for our Winter Workshop.

Program Assistant Amber did a great job publicizing the project and encouraging local media to highlight our field days, workshops and results. Several articles appeared in the Durango Herald and Cortez Journal and a video was produced by Durango TV in 2015. Links to the individual articles and video can be found in the Additional Information section of this report.

Flyers were developed to advertise Field Days, Winter Workshops, Tastings and Tapping Parties. They were distributed using the Project Team's distribution lists, extension personnel, and home brewers clubs. They were also sent to local media as public service announcements. Because the project team was from a wide geographic region, we were able to draw participants from an area extending from the Front Range to Grand Junction and as far south as Las Cruces, NM.

Updates on the project and announcements of upcoming events are also posted on the Old Fort at Hesperus Facebook page (https://www.facebook.com/oldfortathesperus).

Developed Hops Yard (trellis, irrigation, plant layout)
Our initial design was to have three replicates with four plants per replicate in a split plot. At one of our first meetings, Ron Godin suggested that we increase the replicates to four so that we would be sure to have three to analyze. He also suggested that we add a guard plant on each end of the variety replicate to decrease cross fertilization. Therefore, we modified the project to have four replicates with six plants per replicate including a guard plant on each side. This increased the number of plants needed for each variety from 12 to 24. In order to fit this design into the yard, we decreased the spacing between the plants to three feet. This change also affected the per plant amount of money that was available to purchase plants and do analyses.

Trellis Construction. Since we already had one row of established hops, four additional rows (one for each replicate) were created by tilling a 150' strip into existing vegetation running North-South. The rows are approximately 12' apart. Because of the potential for weed pressure, a 5' wide strip was tilled in each row so weed barrier could be laid. Rocks were removed and the soil was leveled. Because of the rocky soil, it was decided that metal poles (2 3/8 inch drill stem) would be used rather than wooden poles.

For the trellis, a row of four metal sleeves were placed approximately 50' apart over two of the rows. Metal sleeves were pounded using a hydraulic pounder to allow the much longer 16' pieces of 2 3/8" drill stem to be slid safely into place. Once the poles were leveled to the same height, they were welded in place. Two 4' earth anchors were placed on each corner of the trellis to assist with supporting weight.

Each pole had a cap welded on the top to secure the 5/32" heavy cable that ran perpendicular to them. Four' earth anchors were used to secure these cables on both the east and west sides of the trellis. A second lighter weight (1/8") cable was installed parallel to the rows. Two cables were placed above each row so that the hops can be trellised in a V-pattern to increase light to the base of the plant and increase production. They were attached to the heavier cable using cable clamps.

During construction of the trellis, Amber took pictures and created a document that was distributed at the Field Day including resources for establishing a hops yard trellis along with detailed instructions. Another useful web resource included Simple Earth Hops: (http://www.simpleearthhops.com/p/hop-trellis-parts-list.html). We made the powerpoint slides available in print format at the our field days and spring workshops.

Bed Preparation. Soil samples were taken from each row and sent to Servi-Tech Labs for analyses. All of the rows had similar results with pH (6.3 to 7) and organic matter (4.2%). Because of the low soil nitrogen levels and the high requirements for hops, nutrient management was challenging. In addition to the typical analyses for P,K and Zn, we also recorded baseline levels for boron, sulfur, calcium, magnesium, sodium, iron, manganese and copper. Of these, Sulfur was the only mineral that was low.

We placed 3' wide weed barrier in the center of each 150' row using landscape fabric staples every foot. Once the fabric was laid, a modified weed burner was used to burn 6 inch holes every three feet. The burner was modified by placing a six inch coffee can on the end of the device.

2014 North End

2014 South End

A drip irrigation system was installed using 3/4" black poly to provide each hole with a 2 gph emitter. During installation, we learned that you need to turn the water on while installing the emitters because the black poly moves considerably when the cold water is turned on. In Years 1 and 2, we watered the plants about 30 minutes per week. However in Year 2, we saw a marked difference in the plant growth between the North and South ends of the yard. After ruling out light differences and soil nutrients, we determined that is could be water. Because the summer of 2014 was extremely dry and the hops plants were growing rapidly, their water requirements were much higher.

In 2015, we installed a water meter on the system and gauged the water not on time but gallons/plant delivered. For example, in July we delivered 1200 gallons of water three times a week. The total amount of watered delivered to the ¼ acre hops yard was 44,151 gallons during the season. Additionally, we had an extremely wet spring and early summer where we received 8.64 inches of rain between April 15 and July 15. During this time, we did not need to water the hops very much. The combination of extra rain and the increased irrigation resulted in no

2015 North End

difference in the North and South regions of the hops yard. In the arid West, water usage is definitely an area that merits further research and documentation.

Because of significant deer damage in Year 2, a wire fence was constructed around the hops yard to serve as a successful deterrent.

Obtained and Planted Disease Free Rhizomes

As described in the original proposal, it was important to obtain disease-free rhizomes when establishing the yard at the Old Fort. More hops yards are experiencing a decline in production around year five that can be attributed to apple mosaic virus. It is very expensive to replace the hops every five years and there is even some preliminary research that indicates the virus stays in the soil. Therefore, we decided to purchase our stock from Summit Labs because their sterile techniques and clean rootstock ensure that none of their hop products carry any hop fungal diseases, including Hop Powdery Mildew, Verticillium Wilt, and Downy Mildew. Additionally, all hop tissue cultures at Summit Plant Labs have tested negative for the following diseases: Hop Stunt Viroid, Apple Mosaic Virus, Hop Latent Virus, Hop Mosaic Virus, American Hop Latent Virus, and Arabis Mosaic Virus (Source: http://www.plantlabs.com/clean-stocks/hop-field-transplants/hop-diseases/ accessed on 11/2/15).

We learned that Summit Labs does not grow all of their advertised varieties each year. It is primarily based upon pre-orders and perceived demand. Therefore, we had to adjust the trial varieties based on availability. We were able to obtain nine varieties from Summit Labs and two from Simple Earth Hops in Wisconsin. Because we ordered 1,000 plantlets from Summit, they were only $3.00 each while the rhizomes obtained from Wisconsin were over $8.00 each. Since there was such a large price break, we teamed with Dr. Lombard on his project and put together an order for 1,000 plantlets which saved us a considerable amount of money. To meet this minimum, we ordered 30 plantlets of nine different varieties including Vanguard, Teamaker, Chinook, Cascade, Centennial, Crystal, CTZ, Nugget and Williamette for our project in addition to 60 plantlets of these varieties for replicate trials in Farmington, NM and Las Cruces, NM. NMSU paid for the plantlets in the New Mexico trials.

While researching disease free availability, we learned that many of the plant sources do not currently test their material. Therefore, we were hesitant to purchase untested rhizomes. The Galena and Mt Hood varieties from Simple Earth Hops were available in small quantities, so we didn't have enough to completely plant all of the replicates. We divided the eight rhizomes (4 Mt Hood, 4 Galena) we received to propagate a few extra for the trials. Fortunately, they have done well and as this project continues past 2015, we will be digging from our existing rhizomes to complete the replicates.

Initially, we considered sourcing our plant material from the hops yard in Farmington, NM because they obtained their plants from USDA. However, USDA could not guarantee they were disease free either. As a result, Dr. Lombard used some of his consulting fees to test all the plants in his hops yard along with the original plants we had prior to this new variety trial. We were very fortunate that he did this testing as all of the old varieties at the Old Fort along with many of the ones from USDA germ plasm tested positive. The only 100% negative tests came from the Summit Lab plant materials. Below is the summary of the paper he published as a result of this study:

> **HOPS VIRUS TESTING: SIGNIFICANCE AND IMPLICATIONS FOR ESTABLISHING HOP PRODUCTION IN NEW MEXICO AND SOUTHWEST COLORADO**
>
> **Research Report 788**
> Kevin A. Lombard, Beth LaShell, Franklin J. Thomas, Jason French, and Todd Bates
> **Summary**
> Some agricultural producers in New Mexico and southwestern Colorado view hops (*Humulus lupulus* and *H. lupulus* var. *neomexicanus*), used in bittering and flavoring beer, as a potential specialty crop for local craft brewing needs. Regional trials in northwestern New Mexico and southwestern Colorado indicate adaptability of some cultivars to a high-altitude, high-desert climate, where diurnal temperature swings are extreme and soil pH can exceed 8. There have been reports, however, of viruses infecting rhizomes commonly used to establish hop yards, and this prompted an examination of potential plant infection by viruses in research plots located at the New Mexico State University Agricultural Science Center at Farmington (NMSU-ASC Farmington) and Ft. Lewis College Old Fort at Hesperus, CO, experimental farms. In 2014, hop rhizomes collected from research plots were tested for the presence of *Apple mosaic virus* (ApMV), *American hop latent virus* (AHLV), *Strawberry latent ringspot virus* (SLRSV), *Tobacco necrosis virus* (TNV), and *Arabis mosaic virus* (ArMV). In one study established in 2008 at the NMSU-ASC Farmington with non-certified virus-free material, 50% of 'Cascade' entries tested positive for ApMV and 17% were co-infected with ApMV and AHLV. *Strawberry latent ringspot virus*, *Tobacco necrosis virus*, and *Arabis mosaic virus* were absent in tested rhizomes. Certified virus-free and *H. lupulus* var. *neomexicanus* entries were free of the five viruses we tested for. Establishing hop yards in New Mexico and Colorado with certified virus-free rhizomes or plantlets is critical to avoid the risk of reduced yields and viral transmission into unaffected hop plantings.

Plant rhizomes

We placed our order with Summit Labs in January and expected them in May but they did not arrive until mid-June. On June 19, we planted 210 plantlets and 18 propagated plants. The plantlets were much larger than we anticipated but in very good shape. The temperatures were close to 90 degrees with no clouds or moisture so we were very concerned about how the plants would take the extreme heat when transplanted. The holes were pre-irrigated before planting and kept very wet for a couple of weeks. Hops are tough! Even the plants where the foot long bines dried up survived. We did use six extra plants to ensure that each hole had at least one hops plantlet. Initially we covered the newly planted hops with agribon fabric thinking that it would

protect them from the direct sunlight. After two days, we removed all of the fabric because the hops were getting too hot under the fabric.
Since planting, we have done a survivability survey each spring and fall. As of spring 2015, we had a 91% survivability rate (208/228) and plan to fill in the missing spots with rhizomes in spring 2016. Because of the varying number of plants in each replicate and variety, a production per plant was calculated to fairly compare them.

Train Bines

Because the plantlets were planted late in 2013, we did not train any of the hops in Year 1. In Year 2, most of the hops emerged by April 7, 2014 and were ready for training by the middle of May. Because of our trellis design, two coir lines were hung above each of the plants. They were tied to a single bent rebar stake so the coir was in a v-shape. Three bines were trained in a clockwise direction around each of the coir lines and all other bines were removed. With the assistance of the program assistant, several student interns and other volunteers, all of the bines were trained by mid-June. In Year 3, the hops emerged even earlier because of the warm spring. We used the same training procedure but had everything trained by May 25. After training and pruning, Amber continued to remove the bines that insisted upon growing back.

Host Field Days

We hosted four hands-on workshops over the course of the project at the Old Fort. We included topics that were of interest to potential growers and/or brewers. In our original proposal, we included incentives for home brewers to attend the field days but found out that most of them are intrigued with how hops are grown but are not as interested in learning how to do it. For each field day, we developed a flyer for advertising that was distributed through list serves, public service announcements in the local papers and Facebook.

Field Day 1- October 1, 2013. Topics included establishing a hops yard, importance of obtaining disease free plant sources, how to take a soil sample and interpret the results. 23 people attended the Open House. The event began with a tour of the hops yard where we showed the components of trellis construction. They could also see how the varieties were randomly planted within the four replicates. There were two larger scale growers present who shared how their trellis was different and the lessons they learned while building it.

Leaves were collected for a demonstration of how a SPAD meter gives different readings based on the color of the leaf. We explained that we would be using the SPAD meter to collect data and try to correlate it to nutrient levels.

After the tour, Kevin led a discussion on the importance of disease free stock as well as a demonstration of how to take a soil sample. Several soil sample results from hops yards were distributed showing the different soil types in the region.
Lastly, we held an open round table discussion about what topics should be included in the winter workshop. Surveys indicated that attendees found the information very useful and are concerned about harvesting and marketing issues that will arise with small scale production.

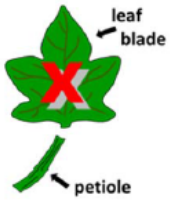
Field Day 2- June 21, 2014. As a hands-on activity, we measured all of the heights, collected SPAD meter readings, discussed training bines and clipped petioles on a sample half of the plants for the nutrient testing. There were producers, potential producers, home brewers, student interns and staff in attendance (12 people). Other potential producers are very interested in the varieties that do well at altitude so they stop by periodically.

Field Day 3- August 24, 2014. Our second hands-on workshop for 2014 was held when we harvested and picked all of the hops. We reviewed harvest readiness indicators with participants, explained the process for keeping the varieties and replicates separate. We had 15 people attend this workshop and they included student interns, restaurant owners, home brewers and potential producers. They assisted with harvest, picking, weighing and bagging of fresh hops.

Field Day 4- July 28, 2015. For 2015, we hosted a field day along with the Old Fort at Hesperus Open House. The entire project team was in attendance from 1 until 6 p.m. In addition to answering questions on the hops varieties and trellis system, petiole samples were collected for a late season test of nutrient levels.

Monitor Nutrient Levels of Plants
Hops are known to require a large amount of Nitrogen (150-250 pounds per acre) especially during cone development. So, in addition to soil testing, we monitored the nutrient levels of the growing hops by taking petiole samples for lab testing, recorded corresponding SPAD meter readings and applied foliar spray when needed.

Take Petiole Samples and Send to Lab for Testing.



We contacted Servi-Tech labs to obtain the proper procedure for petiole testing of hops plants. They provided us with draft documents outlining the proper procedure. Since petiole testing is not a common procedure for most labs, we worked with their technicians to collect and obtain appropriate samples. Samples should be taken approximately 5-6' above the ground and they recommend you collect 20-30 petioles (stems without leaves). However, they need 40 grams of dry weight in order to run samples so more petioles are needed if they are small. Once collected, the petioles should be placed in non-bleached paper bags and dried as soon as possible before shipping. Petioles should not be put in the refrigerator or stored in plastic bags.
In 2014, we collected 60-70 petioles per replicate but because of the large variances in the growth of our hops, the final weights of the samples varied greatly. We also were not

able to start collecting at 5-6' because some of the bines were not that big. By combining all of the replicates, we were able to have enough material to run the petiole tests on 9 of the 11 varieties (Mt Hood and Galena were not included).

In 2015, our plants were much more uniform in size (due to increased and more even watering). However, since we knew that they needed 40 grams of dry weight, we collected petioles based on weight (400 grams wet weight) and not numbers. We collected petiole samples on June 22nd after applying three foliar spray treatments. Additionally, we collected petiole samples at the Field Day on July 28th once the plants had begun to produce cones.

Through the process of developing a procedure, Servi-tech lab personnel were very patient and helpful. We hope that our experience will help them develop better documents for petiole collection and analysis.

Use SPAD Meter to Obtain Chlorophyll Values

We used two SPAD 502- Plus meters to collect readings on the same day that we collected petioles (June 21, 2014, June 22, 2015, July 28, 2015). Participants were able to use the meters at the 2014 Field Day and the 2015 Open House event. They assisted us by using the SPAD meter to collect readings from 30 leaves per replicate before they were placed in the bag for petiole samples. Once collected, the meter returned an average of the 30 leaves that was recorded for later use.

Once we received the petiole analyses, we compared the SPAD averages to the Nitrogen values. In 2014, the Crystal variety had the highest SPAD average and also the highest, but still deficient, Nitrogen value as well. The Teamaker variety had the second highest SPAD average and the lowest Nitrogen value. This variety was selected for its medicinal properties and has returned additional out of the ordinary values for brewing hops (i.e.: 0 % Alpha Acids).

In 2015, the relationship between SPAD readings and Nitrogen levels continued to be inversely proportionate on many varieties. All of the SPAD readings decreased for the 11 varieties tested while our Nitrogen levels nearly tripled. We believe that because we increased early Nitrogen levels, there was more plant growth (petioles) produced but since we were still deficient, the average SPAD readings did not increase. Unfortunately, there is no other data available correlating SPAD readings with any nutrients in hops so we'll continue to collect data to determine how the SPAD readings are related to nutrient levels. Once our Nitrogen levels are adequate, we should see the correct correlation.

Apply Foliar Spray if Necessary

The requirements for hops growth is best explained in the Nitrogen Uptake and Utilization by Pacific Northwest Crops publication by Dan M. Sullivan, John M. Hart and Neil W. Christensen

that was published in 1999 and reviewed in 2013. It is available for viewing at https://catalog.extension.oregonstate.edu/pnw513. Below is an excerpt explaining hops utilization of Nitrogen through the season;

Hops

Biomass. Hops exhibit the same initial slow Phase I growth through the first half of June as do grass seed crops during the winter months. Spring growth produces long shoots with little leaf area. This growth depends primarily on rootstock reserves. Only 10 percent of total biomass is accumulated through mid-June. Phase II growth from mid-June until the latter part of July is linear and rapid. Maximum biomass accumulation occurs by the end of July.

N uptake. Nitrogen uptake and biomass accumulation occur at similar rates. Only 10 percent of total uptake is accumulated through mid-June. The 30-day period from mid-June to mid-July is the period of rapid uptake. The N uptake rate is 3 to 4 lb/a/day near the end of June. By the end of July, the crop has accumulated 80 to 150 lb N/a in the trained biomass.

Management. Apply nitrogen fertilizer by early June to mid-June so it will be available during the period of rapid uptake. A single N application in April was as effective as split applications in western Oregon trials. Consider yield levels when determining N fertilizer rate. Cones contain 5 to 6 lb N/bale or one-third to one-half the total amount of N harvested in the biomass. Most yards are harvested by removing vines, leaves, and cones. After the cones are removed from the vines, the leaves and stems generally are returned to the yards. Leaves and stems contain approximately 40 lb N/t of dry material. Reduce N fertilizer inputs where hop vine residues are applied. N status can be assessed by tissue testing. Collect hop petioles when hops are between three-fourths of the way to the wire and just reaching the wire. This amount of growth generally occurs by mid-June in the Willamette Valley. Choose petioles from mature leaves on the main vine, 5 to 6 feet from the ground. Have the petioles analyzed for nitrate-N. Small-scale N rate experiments and large-scale field demonstrations have shown no yield increase if additional fertilizer is applied when petioles contain more than 4,000 ppm.

Regional research at NMSU Ag Science Center indicates that hops need 200-250 lbs. of Nitrogen per acre. Initially, we applied compost to our soil and side dressed the plants in year one with compost that was 56% organic matter and 1.22% Nitrogen. Results from Year 2 (2014) petiole sampling revealed that our plants were starving for Nitrogen when compared to the data provided by Servi-Tech labs:

Stage of Growth:	**Low/Marginal; ppm NO3-N**	**Sufficient; ppm NO3-N**
Early Vegetative	8-10,000	10-15,000
Mid-Growth	12.5-15,000	15-20,000
Early Flowering	17.5-20,000	20-25,000

Our values ranged from 270 ppm to 3270 ppm with two of the varieties (Mount Hood and Galena) not producing enough petioles to constitute a sample. We immediately prepared a foliar spray using GreenGanic liquid fertilizer (8-7-7) that provided 3 lbs. N per acre and applied it three times in ten days (July 19 – 28). Since foliar spraying can be 10 times more efficient than soil application, we saw an incredible response of growth and production.

Dr. Ron Godin was not surprised with these values even though the plants were green and appeared to be healthy. They just weren't growing very rapidly. He called it "silent starvation" because by the time we might see the yellowing chlorosis, it would be too late. As a project collaborator, he had recommended that we do the petiole samples to test for minerals and nutrients. Of the minerals we were most concerned about (B, Mg and Zn), Boron levels were well within the recommended range but both Mg and Zn were low. Interestingly, our phosphorus and potassium levels were almost double the standard value. The biggest variation for the different varieties came from the Mn and Fe values.

Old Fort at Hesperus Hops Variety Trial

Petiole Test Results

	Number of Plants	Ave SPAD**	Nitrate	P	K	CA	MG	S	ZN	FE	MN	CU	B	NA	Phosphate
Variety			mg/kg	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg
Cascade															
2104	21	35.9	470	0.62	4.99	1.39	0.39	0.1	22	41	32	6	30	0.01	4690
2015		31.1	3370	0.57	5.05	1.05	0.27	0.17	28	78	38	10	28	0.01	2900
Centennial															
2104	23	35.2	1610	0.53	4.3	1.49	0.32	0.11	18	62	35	5	31	0.01	3320
2015		30.1	3730	0.61	6.05	0.98	0.24	0.15	22	51	27	8	25	0.01	3750
Chinook															
2104	21	30.4	580	0.56	4.95	1.27	0.21	0.1	16	40	51	5	28	0.01	4230
2015		28.9	2020	0.65	5.96	1.06	0.23	0.15	20	40	33	8	23	0.01	4330
Crystal															
2104	19	40.8	3270	0.43	5.86	1.42	0.3	0.08	23	42	70	5	29	0.01	3150
2015		31.8	6180	0.6	7.18	0.95	0.27	0.13	29	43	54	8	23	0.013	3990
CTZ															
2104	17	32.7	800	0.51	4.38	1.26	0.23	0.11	18	43	37	5	28	0.01	3240
2015		27.3	1760	0.56	5.24	0.93	0.21	0.14	20	44	28	7	23	0.01	3130
Nugget															
2104	18	34.9	2100	0.44	5	1.52	0.26	0.09	20	46	51	6	33	0.01	2810
2015		24.7	5200	0.6	5.98	1.45	0.24	0.18	64	132	64	12	26	0.093	3060
Teamaker															
2104	20	41.3	270	0.75	5.18	1.27	0.46	0.1	27	66	26	5	31	0.01	4760
2015		32.6	3370	0.63	6.43	1.16	0.27	0.14	29	66	39	7	26	0.022	3680
Vanguard															
2104	24	34.7	1790	0.65	5.51	1.17	0.29	0.12	21	65	33	5	27	0.01	5000
2015		26.7	4680	0.64	6.66	0.86	0.29	0.14	19	37	32	6	23	0.01	4270
WI Hops-Galena															
2104	8	36.7	NA	0.6	5.47	1.49	0.27	0.14	34	94	77	5	31	0.01	NA
2015		29.9	1530	0.54	5.48	0.86	0.2	0.15	27	53	35	8	22	0.015	3410
WI- Mt Hood															
2104	4	39.2	NA	0.75	5.24	1.36	0.38	0.09	32	66	87	5	40	0.01	NA
2015		33.4	2150	0.7	5.4	0.87	0.28	0.17	34	84	50	16	27	0.012	4200
Williamette															
2104	22	33.0	840	0.5	5.59	0.9	0.21	0.11	15	47	36	4	26	0.01	3350
2015		28.6	2170	0.68	6.3	0.61	0.22	0.14	17	38	23	5	22	0.01	4210
		SPAD	**Nitrate**	**P**	**K**	**CA**	**MG**	**S**	**ZN**	**FE**	**MN**	**CU**	**B**	**NA**	**Phosphate**
Industry Standard-Sufficient Levels ***		NA	15000	0.42	2.75	2	0.95	0.4	62	100	62	10	35		
Variety Averages															
2014		35.9	1303.3	0.58	5.13	1.32	0.30	0.10	22.36	55.64	48.64	5.09	30.36	0.01	3839
2015		29.6	3287.3	0.62	5.98	0.98	0.25	0.15	28.09	60.55	38.45	8.64	24.36	0.02	3721

****The SPAD meter is a hand-held device used for the rapid, accurate and non-destructive measurement of leaf chlorophyll concentrations.**

***** Industry averages obtained from Servi-Tech Laboratories**

Because of these somewhat concerning values in 2014, New Mexico State University developed a Nutrient Management recommendation for our region utilizing a fertigation pump on our drip line. Since we were in the middle of a variety trial, we decided to continue with the foliar spaying until the initial trial ended. As we continue the trial into 2016, we plan to install the pump to administer more nitrogen.

We began noticing a difference in the growth of plants in early June, 2014. The plants on the South end of the yard were significantly larger than the same varieties on the North end. We divided each replicate into three quadrants and pulled soil samples from each of them. We tested for Nitrogen and Phosphorus. Initial results showed there was no significant difference between the soil types with a range of 3 to 5 ppm N and 76 to 133 ppm of P. Secondly, we tested the compost that we had used in fall 2013 to see how much N we were adding. While the organic matter was 56%, the % Nitrogen was only 1.22. This test also provided us with secondary nutrients (P, S, K, Ca, Mg and NA) and macronutrients (Zn, Fe, Mn, Cu, B).

We also utilized Fort Lewis College Environmental Health professor, Dr. Phil Shuler's expertise and lab to test the yard for heavy metals (Arsenic, Lead, Chromium and Copper) as a precaution. None of the values were out of character for this region, so we concluded that water was our primary limiting factor in 2014.

In 2015, we applied the same foliar spray three times (June 9, June 20/27 and July 1). Petioles were collected on June 22nd. Our average Nitrogen levels for petioles nearly tripled with a range of 1530 to 6180 mg/kg. While we made significant progress, we are still well below the 15,000 mg/kg sufficient levels recommended by Servi-Tech. In fact when we did a second set of petiole samples on July 28th, our nitrogen levels had fallen to near zero. Most likely, the cones developed between the two collection dates and used up all of the nitrogen.

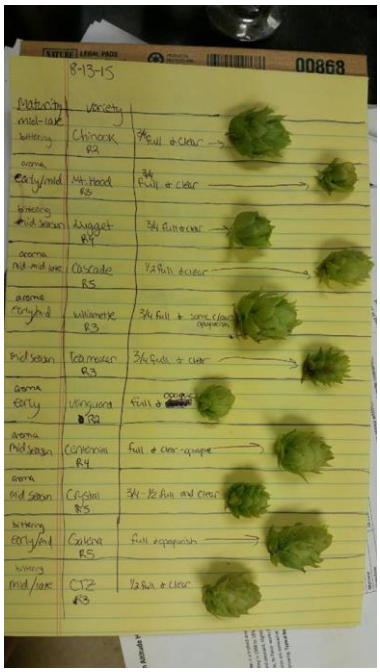
The Petiole samples indicated that we were also low on Zinc and Boron so an additional foliar spray was done on July 29/31st that included these minerals along with additional Nitrogen. Zinc sulfate and Borax (10% Boron) were added to the Greenganic mixture. The Zinc Sulfate was very difficult to dissolve for the foliar spraying. Even after soaking it in warm water, the screen filters on the sprayer were still removed for application. While there is a strong interest in growing organic hops, the amount of Nitrogen needed by the plants makes this difficult. Compost alone cannot supply the Nitrogen needed by

hops and the use of organic foliar sprays may not be cost efficient. We will continue to explore this conundrum in 2016.

Harvest Hops and Collect Production Data

2014. We recorded burring dates which began on July 15th and did variety sampling to determine which ones were ready for harvest. Jason Thomas from NMSU visited our yard several times and provided us with a map along with his comments on harvest readiness. He trained Amber and me on using lupulin color and smell to determine readiness. We noticed that even within a replicate, there was a lot of variation on harvest readiness. For example by our harvest date, some of the cones had started to open up and were past ideal harvest condition. Originally, we were going to try and harvest each replicate as it became ready but the amount of labor that would be necessary was too much. Therefore, we harvested everything on August 24th.

Our harvest began at 9 a.m. in the yard with 15 people assisting with cutting down the bines or picking the hops directly. We prepared brown paper bags (both lunch size and grocery size) with variety, replicate and plant number. If the plant was less than six feet tall, we harvested the cones directly into the bags. Taller plants were cut down, marked with flagging tape (variety, rep, plant number) and transported to our equipment shop. All plants were harvested by 11:30 a.m. Once transported to the shop, we set up tables and screens for volunteers to remove cones and place them in the bags. We finished removing all cones by 4 p.m. so it took 105 hours to harvest our cones.



Weights of wet cones were recorded for each replicate. We had significant differences between replicates and noticed a marked difference between North and South end of the trellis. For example, CTZ was our heaviest producer at 5930 total grams but the replicates were 160, 20, 3300 and 2450 grams for replicates 1 through 4, respectively. Replicates 1 & 2 of the CTZs were on the Northern half of the yard so they were affected by the uneven watering. Because of the lower production numbers, many replicates were combined for analyses.

2015. The first burring date was recorded as July 7th so our harvest was ahead of schedule. To more accurately determine harvest readiness, Amber collected cones and examined the lupulins under a microscope to more accurately evaluate them. Additionally, she used dehydrators to dry the cones to 0% moisture to determine their starting moisture values. Amber began collecting cones on August 11th and recording her observations.

She determined that the Chinooks and Mt Hood's lupulins were full and clear and should be harvested on August 16th. This early harvest also gave us the opportunity to try out our new drying system and monitoring protocol (see drying hops below).

Since all of the hops bines were much larger this year, they were all removed from the yard after being marked with variety and replicate. Every plant in the yard produced some cones in 2015. Once harvested, they were taken to the covered shop and placed on tables and screens for harvesting. Cones were harvested by hand and placed in paper bags by replicate. Total wet harvest weights were recorded prior to loading the hops in to the drier. Varieties were separated into different draws and replicate were separated on the trays.

The additional nine varieties were harvested on August 25th when it was determined they were ready. The same harvesting and drying procedure was followed. Total harvest time for 2015 was 119 man hours.

As you can see from the Production Data table, all varieties increased their weights in 2015. Vanguard and Williamette had the largest yield increases with a 496% and 354%, respectively. Because of this increase, we were able to provide Carvers Brewery with 1814 grams of fresh Chinook cones and we had 160% more dry hops to distribute to brewers after the samples were sent in for analyses.

For the two years of data, our highest production/plant was consistently CTZ (349 g and 343 g, respectively) with Cascade, Chinook, Crystal and Nugget all performing above average. Our poorest performers were Centennial, Mt Hood, Teamaker and Williamette. The Vanguard and Galena varieties showed a marked improvement in 2015 and need additional evaluation to determine if they are adaptable to high altitude.

Production Data for 2014-2015 Harvest
(All weights in grams unless otherwise stated)

Variety	Year	Total Production	Production/ plant*	Total Dry Weight
Cascade				
	2014	**2920.0**	**139.0**	**981.0**
	2015	**4916.0**	**234.1**	**1851.0**
Centennial				
	2014	**640.0**	**27.8**	**185.0**
	2015	**913.1**	**39.7**	**328.0**
Chinook				
	2014	**2960.0**	**141.0**	**1005.0**
	2015	**5086.9**	**242.7**	**1500.0**
Crystal				
	2014	**3280.0**	**172.6**	**962.0**
	2015	**4988.5**	**262.6**	**1385.0**
CTZ				
	2014	**5930.0**	**348.8**	**1923.0**
	2015	**7558.0**	**343.5**	**2596.0**
Nugget				
	2014	**4390.0**	**243.9**	**1400.0**
	2015	**6775.0**	**282.3**	**2048.0**
Teamaker				
	2014	**1470.0**	**73.5**	**471.0**
	2015	**1931.0**	**96.6**	**1090.0**
Vanguard				
	2014	**470.0**	**19.6**	**181.0**
	2015	**2330.0**	**97.1**	**589.0**
Galena				
	2014	**690.0**	**86.3**	**190.0**
	2015	**1290.0**	**161.3**	**340.0**

Mt. Hood				
	2014	**0.0**	**0.0**	**0.0**
	2015	**110.0**	**27.5**	**30.8**
Williamette				
	2014	**432.0**	**19.6**	**215.0**
	2015	**1528.0**	**69.5**	**648.0**
Averages	**2014**	**2107.5**	**115.6**	**683.0**
	2015	**3403.2**	**168.8**	**1127.8**
Averages (pounds)	**2014**	**51.1**	**2.8**	**16.5**
	2015	**82.5**	**4.1**	**18.9**
***Due to the various number of plants per replicate and variety, production per plant was calculated to fairly compare varieties.**				

Send Samples Out for Alpha, Beta and Oil Analysis
After drying the samples, we sent 225 grams of material to Alpha Analytics for testing.

2014. We tested ten of the eleven varieties (Mt Hood didn't produce any cones) and were able to test two replicate combinations for Nugget and CTZ. For the eight remaining varieties, harvested product from all replicates were combined for testing.

The test values were received in approximately a week after they were shipped. Our values for % alpha acids and % beta acids were slightly higher than expected but definitely in line with the type of hops (aroma, bittering, high beta). We also received a complete oil analyses for each of the samples which we shared with other producers at the Winter Workshop. Our Teamaker variety (0% Alpha) surprised the lab and they called because they thought their equipment was broken! As a medicinal hops with high Beta Acids, it has been very popular with a local herbalist who made tinctures, salves and pillows with it.

2015. Our staggered harvest allowed the hops to be in more ideal harvest condition. Since our production weights were much greater, we were able to have at least two replicates to test on seven of the varieties. Nugget analyses on all four reps showed a range of alpha acids from 12.5 – 14.8 with very little difference in beta acids. Cascade and CTZ both had three replicates tested with Cascade's results being very similar while CTZ shoed a range of 14.8 to 17.9 on alpha acids and no difference on beta acids. Crystal, Chinook, Vanguard and Williamette each had two replicates individually tested. This left Centennial, Mt Hood, Galena and Teamaker with only one combined test because of lower production numbers.

Old Fort Values for Alpha Acids, Beta Acids, HSI and Oil % (2014-15)

Variety	Year	Alpha Acids	Beta Acids	Hops Storage Index	Oil%
Cascade					
	2014	8.6	6.4	0.222	1.33
	2015	10.9	6.1	0.199	0.55
Centennial					
	2014	10.4	4.4	0.238	1.79
	2015	11.7	4.3	0.206	1.73
Chinook					
	2014	12.2	4.3	0.236	1.50
	2015	11.2	3.7	0.215	2.20
Crystal					
	2014	7.7	6.5	0.222	1.04
	2015	6.9	6.8	0.188	0.59
CTZ					
	2014	17.2	7.0	0.227	2.57
	2015	16.5	6.8	0.208	1.49
Nugget					
	2014	13.3	5.6	0.231	1.00
	2015	13.8	5.2	0.208	0.67
Teamaker					
	2014	0.0	14.6	0.171	0.85
	2015	0.1	9.6	0.135	0.33
Vanguard					
	2014	4.9	7.8	0.222	0.80
	2015	7.1	10.0	0.197	0.79
Galena					
	2014	12.7	9.3	0.215	1.32
	2015	13.0	10.4	0.189	0.56
Mt. Hood					
	2014	NA	NA	NA	NA
	2015	6.3	6.7	0.203	0.57
Williamette					
	2014	6.0	4.3	0.241	1.32
	2015	7.5	4.0	0.217	1.26
Averages	2014	9.3	7.0	0.223	1.35
	2015	9.5	6.7	0.197	0.98

Top Bittering (high alpha acids) Hops Varieties (based on two-year average)

1. CTZ
2. Nugget
3. Galena
4. Chinook
5. Centennial

Top Aroma (lower alpha acids and higher oils) Hops Varieties (based on two year average)

1. Chinook
2. Centennial
3. Williamette
4. CTZ (highest Oil% but also high alpha acids)

Top Beta Acid Hops Varieties (based on two year average)

1. Teamaker
2. Galena
3. Vanguard

Each year we also submitted test samples from New Mexico State University's hop yard in Farmington, NM to compare the same varieties but at a much lower altitude. We saw that both the alpha and beta acids were significantly higher than those found in Farmington yard. It is difficult to compare production values since we have different nutrient management schemes at the two yards.

Comparison of Old Fort and Farmington Yards- Alpha, Beta, HSI and Oil %

Variety	Year	Old Fort Alpha Acids	Old Fort Beta Acids	Old Fort Hops Storage Index	Old Fort Oil%	NM Alpha Acids	NM Beta Acids	NM H S I	NM Oil%
Cascade									
	2014	8.6	6.4	0.222	1.33	7.3	5.7	0.217	0.40
	2015	10.9	6.1	0.199	0.55	8.0	8.3	0.189	2.21
Centennial									
	2014	10.4	4.4	0.238	1.79	7.4	2.9	0.253	0.65
	2015	11.7	4.3	0.206	1.73				
Chinook									
	2014	12.2	4.3	0.236	1.50	12.4	3.5	0.236	0.73
	2015	11.2	3.7	0.215	2.20	13.4	3.8	0.219	1.67
Crystal									
	2014	7.7	6.5	0.222	1.04	4.9	5.6	0.215	0.66
	2015	6.9	6.8	0.188	0.59	4.9	7.0	0.178	1.00
CTZ									
	2014	17.2	7.0	0.227	2.57	13.7	4.8	0.231	0.55
	2015	16.5	6.8	0.208	1.49	17.7	6.1	0.221	2.66
Nugget									
	2014	13.3	5.6	0.231	1.00	13.8	4.1	0.245	1.22
	2015	13.8	5.2	0.208	0.67	13.8	4.5	0.221	0.91
Teamaker									
	2014	0.0	14.6	0.171	0.85	0.0	11.8	0.179	0.35
	2015	0.1	9.6	0.135	0.33				
Vanguard									
	2014	4.9	7.8	0.222	0.80	4.1	5.4	0.226	0.17
	2015	7.1	10.0	0.197	0.79	5.6	6.2	0.182	0.53
Williamette									
	2014	6.0	4.3	0.241	1.32	3.7	2.3	0.271	0.32
	2015	7.5	4.0	0.217	1.26				

Collect Dry Weight Data

2014. Once harvested and weighed, the hops were placed in a drying oven at New Mexico Ag Science Center in Farmington, NM within 24 hours. They were dried to approximately 32 percent moisture prior to vacuum sealing. Dried hops were placed in a cooler until ready for shipping. Dry weight values from each variety are shown on the previous table.

2015. We utilized our new drying oven designed and built by Jason Franklin (NMSU researcher) that had eight large drawers on a metal frame. There are two box fans built into the top of the unit that pulls air up through the hops. Once the hops are loaded onto the trays, the unit is wrapped in tarps and the fans are turned on.

To determine the appropriate moisture, we utilized the Online Calculator for Drying Hops resource at http://sroc.cfans.umn.edu/People/Faculty/VinceFritz/Hops/HopDrying/index.htm

In order to dry the hops to our goal of 15 percent moisture we first had to determine the moisture coming out of the field. Once all of the hops were harvested from a replicate, a sample was taken to determine its moisture content. The sample was placed in a cloth lingerie bag and weighed before being placed in a commercial dehydrator. The sample was weighed every hour until it reached 0 percent moisture as there was no more change in weight. At the same time, we placed a similar sample bag in the drying oven. Using the online calculator, it returned the

end weight of the bag in the drier for the target moisture level. The average drying time for the hops to reach 10 percent moisture was 24 hours.

The combination of the new drier and the online calculator for drying hops gave us a much more consistently dried product.

Create and Distribute Marketing Samples and Surveys to Brewers
In 2013 we did not produce any cones so we didn't begin to distribute marketing samples and surveys to brewers until 2014.

Once analysis was completed, Amber shared the results with several local brewers and the home brew clubs. One of the goals for this project is to increase the use of local hops in our rapidly growing brewing industry. There is definitely some good interest in using fresh or whole cone hops in special craft brews.

During both our 2014-15 harvests, we were contacted by Taos Mesa Brewery who was interested in purchasing 30 pounds of fresh hops. They had attended the Winter Workshop and are interested in supporting regional hop production, Since most of our research hops were already spoken for, we had him contact Paul Black at Pine River Hops. In 2015, Steamworks (local Durango Brewery) also contacted us about purchasing 70 pounds of fresh hops. He also was able to get the hops he needed from Pine River Hops.

Amber has been an excellent promoter for our variety trial. She attends the home brewers' monthly meetings to give them an update on our progress and invites them to events. She attended the San Juan Brewfest the day before our harvest and talked with Jeff at Carvers Brewery, Kris at Steamworks, and Randy at Riff Raff.

In 2014, she made numerous contacts with local brewers including the following:

- Met with Linda at Ubru to talk about hops for homebrewers. Was told that if we could pre-measure to 4 ounces and have analysis homebrewers would be more likely to use it.
- Met with Dewayne, owner of Mancos Brewing Company. Said he would be interested in trying any of our hops.
- Met with Jeff, head brewer at Carvers and discussed use of hops and tapping party.
- Met with Randy and Jason, owners and head brewers at Riff Raff Brewery and dropped off hops. Talked about naming it after Old Fort Lewis and the survey to fill out.

- Brewed 4 different beers in 5 gallon batches from our Crystal, Chinook, Cascade and Nugget varieties with Jeff and Cody at Carvers.
- Took hops and surveys to Dewayne at Mancos Brewery.

We used several different surveys to gather information from craft brewers, home brewers and consumers of beer made from our hops. Here are links to the surveys that Amber created and distributed:

- Survey for brewers: https://www.surveymonkey.com/s/PB3LD7V
- Survey for Carvers drinkers: https://www.surveymonkey.com/s/J5V8B57
- Survey for Riff Raff drinkers: https://www.surveymonkey.com/s/QKXFZZ8
- Survey for Mancos drinkers: https://www.surveymonkey.com/s/Q853QYT

Amber worked with local brewers to create events that not only promoted our project but also the beers made from local dried hops. The first event was at Carvers Brewing Company on December 5th when they hosted a Tapping Party for the four different beers they created using the same recipe from Crystal, Chinook, Cascade and Nugget. Attendees could order a flight and try them all. Over 100 people attended and Carvers sold $605.25 in beer including 32 taster flights, 24 single taster glasses, 27 pints and 2 draws (10 oz.). Mancos Brewery made a red IPA from our hops (Crystal, Chinook, Cascade and Nugget) and tapped the keg on December 12. He reported that it was very good and people came out just to try it and wants to work with us again next year. Riff Raff also created a brew using citrus, black pepper and licorice along with our hops. According to surveys, tasters found it intriguing and enjoyed it.

In 2015, Carvers used fresh Chinook hops to create an Old Fort Pale Ale for a September 9th tapping party. The 5 gallons of ale was gone in a couple hours as people stopped by for dinner and a beer. We were very pleased with the amount of people who stopped by just to try the Old Fort Pale Ale.

Amber distributed 18.9 pounds of dried hops to commercial and home brewers this Fall after we received the analyses. The brews have not been tapped yet but I'm sure they will be great.

Plan, Schedule and Promote Winter Workshops

The project team of Beth LaShell, Kevin Lombard, Ron Godin and Amber Bye planned both of the winter workshops and once again included Jason Thomas (NMSU employee) in our meetings because he has been coordinating the hops trial with Kevin for the past few years. Because of the distance between us, we met in person once, had conference calls and used email extensively.

Each year, we hosted the workshop at Fort Lewis College in early March. In 2014, we focused on the areas of general hops knowledge, trellis construction, marketing issues related to whole cones, the importance of disease free rhizomes and an overview of the Old Fort Hops trial. In 2015, we focused on interpreting hops analyses, brewer's perspective, harvesting issues including small scale alternatives for picking and drying.

Presentations are archived on www.tinyurl.com/oldforthops under announcements. Or they can be directly accessed through this link:
https://www.fortlewis.edu/oldfort/CurrentProjects/HopsVarietyTrial/HopsResources.aspx

The 2014 What's Hop'n winter workshop was held on Saturday, March 22, 2014 from 9 a.m. until 5 p.m. in the Student Union building on Fort Lewis College's campus. The event was advertised with posters, brochures, email list serves, website information and PSAs. The program included continental breakfast, lunch and beer samples. Pre-registration was $22 per person and $27 at the door. Thirty one people pre-registered and we had seven walk-ins. Participants included academics, growers, home brewers, brewery owners and potential growers. They traveled from New Mexico and Arizona to attend the workshop. Our diverse program included:

Dr. Ron Godin—The Science of Hops

Dr. Godin had shoulder surgery and was unable to travel to Durango so we used Google Hangouts to bring him to the workshop. It worked really well and allowed us to keep our program intact. Dr. Godin received the highest rating from the participants (4.96/5).

Paul Black and John Lyle— Producer's Trellis Designs

Paul and John are both local growers who designed and built their own trellis systems that are very different. The attendees really appreciated the information and pictures provided by the presenters. Their evaluation ratings were 4.4 and 4.24/5 rating, respectively. Some growers appreciated the small-scale perspective and others did not.

Dr. Kevin Lombard—4-Corners Production Realities (4.16/5 rating) and Equipment Options for Small-Scale Growers (3.8/5 rating)

Dr. Lombard highlighted his recent visit to the Northwest hops growing region. He provided us with photos of trellis systems, picking operations, drying, pelleting and storage schemes. We discussed the challenges with converting large scale equipment to our small acreage situations.

Beth LaShell & Amber Beye—Old Fort at Hesperus Variety Trial (4/5 rating)

Our primary focus was to show the group the progression of the Variety Trial at the Old Fort. We covered site selection, soil analyses, trellis construction, variety selection and the importance of disease free root stock. Participants found the presentation useful but would like to have more data on each of the varieties.

Jason Thomas—Testing Rhizomes for Viruses

Jason covered the process for collecting rhizomes for the disease testing that would be done at NMSU. He also described the different diseases that could potentially affect hops production and how they should be dealt with. Because virus transmission is not understood in many of the diseases, particularly apple mosaic virus, we had a good discussion about all of the different theories.

Three Rivers Brewery—Using Whole Cones in Brewing

The former head brewer at Three Rivers Brewery in Farmington began working with Dr. Lombard and Jason Thomas to develop a way to use whole cones in the brewing process. He shared his steel mesh bag that holds the cones while they are in the brew tank. This keeps them from clogging the equipment. Since the brewer was unable to attend, Jason provided pictures of how the brewery uses whole cone hops as well as a transcript of an interview.

Animas Alers– Beer 101 demonstration

For those of us that are not brewers, the Animas Alers demonstration was very educational and for the many brewers in the audience, it was a lot of fun. The group set up a top tier beer stand in the ballroom of the Student Union and brewed an extra IPA using a kit from Ubru, a local homebrew shop in Farmington, New Mexico.

We broke the program periodically to allow them to give us an update on their progress. They also allowed the audience to taste the brew at various stages. Additionally, one of their members provided us with a pony keg of red IPA that he had brewed for us to enjoy with lunch.

The 2015 What's Hop'n winter workshop was held on Saturday, March 21, 2015 at Fort Lewis College Student Union. Advanced registration was $25 and $30 at the door. Because we used the FLC Marketplace website, most of our participants registered ahead of time. We had 50 people attend the workshop and 33 of those folks were new to the workshop. We had people from the Front Range and as far south as Las Cruces, NM. Our program included:

Dr. Ron Godin - Interpreting a Hops Analyses for both brewers and growers (4.74/5)

Ron is always a popular speaker because of his extensive experience with growing hops and educating potential producers. This was a technical presentation that received great ratings

Cody Looman– Carvers Brewing Company - Brewer's Perspective I - (4.04/5)

Cody gave a nice overview of how Carver's utilizes local hops along with some of the challenges. He discussed the brewing process for the December, 2014 Tapping Party that was hosted at Carvers.

Riff Raff Brewery; Pagosa Springs, CO - Brewer's Perspective II - (4.39/5)

Randy Schnose gave a passionate and animated presentation on the importance of local hops especially in the tourist economy that we see in both Durango and Pagosa Springs. He also provided a sixth barrel of beer to be served at lunch.

Paul Black – Pine River Hops - Picking Hops with a modified apple sorter - (4.52/5)

Following a short video, the group went outside to see the modified apple sorter that Paul had brought to the workshop on a trailer. In addition to being a nice break in the program, people really appreciated being able to see the equipment and ask questions.

Jason Franklin -Small Scale Dryer Demonstration

Since Jason was delivering our small scale dryer, he described to the participants how it was built and can be used to dry hops.

Dr. Ron Godin - Mechanics of a Wolf Picker - (4.36/5)

Ron gave a short presentation on how the popular Wolf Picker works. It was a great comparison to the modified apple sorter we had seen over lunch.

Aaron Melin– Front Range Hops- Pelletizing Hops - (4.26/5)

Because not all local brewers can utilize fresh hops in their brewing process, we invited Aaron to talk about his business of pelletizing hops. In addition to explaining the process, he also explained how growers in the 4-Corners region could benefit from working with Front Range Hops.

Dr. Anna Marija Helt, Clinical Herbalist and Aromatherapist - Alternative Uses of Hops -(4.0/5)

Dr. Helt's presentation was very well received as she passed around hops pillows, allowed people to taste tinctures and explained the science behind the herbal properties of hops.

Beth LaShell and Dr. Kevin Lombard - Old Fort/NMSU Variety Trial Updates - (4.1/5)

An update of the Old Fort variety trial was presented along with handouts on production and analyses results. Dr. Lombard talked about the need for regional cooperation especially for equipment as well as the continued need for hops research and education in the 4-Corners region.

Summarize Yearly Data

In the summer of 2013, we established eleven varieties of hops in four replicates. Because of the importance of disease-free stock, nine varieties (Cascade, Centennial, Chinook, CTZ, Crystal, Nugget, Teamaker, Vanguard, Willamette), were obtained from Summit Labs in Fort Collins, CO and two were obtained from a WI breeder (Mt Hood and Galena). Varieties were selected based on their availability from these sources.

Our varieties were categorized as follows:
Aroma Type: Cascade, Centennial, Crystal, Vanguard, Willamette, Mt Hood
Bittering Type (high alpha acid): Chinook, CTZ, Nugget, Galena
High Beta: Teamaker

Because our disease-free plantlets arrived late (June 18), our varieties did not produce any cones in 2013. We recorded survival rates of the 228 plantlets in the Fall, 2013, Spring, 2014 and Fall, 2014. We had a 95.6% survival rate from planting to Fall observation and a 97% winter survival rate of those plants. From spring to Fall, 2014, 98% of the plants survived leaving us with a 93% survival rate of those we planted (208/228).

Since the inception of this project, the importance of disease free rhizomes has greatly increased. As part of our consultation partnership with New Mexico State University personnel, we provided samples from our hops yard for their study. All of varieties established in 2009 from an untested yard in Paonia had at least one virus. They also tested the plantlets we received from Summit Labs and they were all clean. Dr. Lombard completed an excellent peer-reviewed publication (link available in Additional Information section) entitled, "Hops virus testing: Significance and implications for establishing hop production in New Mexico and Southwest Colorado."

Production data collected and summarized in this report include emergence data, burring dates, harvest readiness, wet cone weights, dry cone weights, production per plant. Analyses data included alpha acids, beta acids, hops storage index, and % oil. More extensive oil analysis is available upon request for each of the varieties tested.

Significant contributions and role of project partners in the project:

Beth LaShell- As project director, I coordinated project team work on hops yard infrastructure, variety selection and meaningful production data collection. Coordinating the use of Fort Lewis College equipment and employees to establish the rows and build the framework for the trellis occurred in fall 2012 and we made changes and upgrades to the trellis each year. In addition to accounting activities, hosting team meetings and publicizing the project, I update the website, Facebook and resource listing.

Once the team identified dates and topics for the Winter Workshops, I coordinated speakers, made catering arrangements, created resources for handouts and registered people for the event. In February, 2014, I made a presentation at the New Mexico Organic Farming conference on the project. It sparked a lot of interest in hops and we hope to have an entire track on hops production in the near future.

Amber Beye – As program assistant for the hops project, Amber was responsible for on site development of the hops yard, planting and caring for rhizomes, maintaining irrigation system, and recording data. She assisted with developing information documents on hops varieties and hops yard establishment. She has contributed several facts sheets for Field Days and continues to promote the project to home brewers. Once we had cones to harvest, Amber met with local brewers to get them to try our hops. Because of her effort, Carvers Brewing started 4 batches

(Crystal, Chinook, Cascade and Nugget) of 5-gallons each in 2014 and did a wet hop brew in 2015. Additionally, she has provided sample product to Mancos Brewery, Riff Raff and several home brewers to promote whole cone hops brewing. Her efforts to market a different type of hops has been successful and we appreciate all of her hard work.

Dr. Kevin Lombard – As a horticulturalist with personal research experience involving hops, Kevin has been a key member of the project team. In addition to attending all of our project meetings, he included a colleague Jason Thomas to help with the project. Kevin and Jason assisted us with determining harvest readiness, drying cones and interacting with Alpha Analytics. They also assisted with field days, Winter Workshops and designed a nutrient management plan for our yard.

In 2014, we utilized their small-scale drying oven and they monitored the drying of our hops. In 2015, they built us a similar unit so we would not have to transport freshly harvested hops to Farmington.

One of their most important contributions was the completion of a peer-reviewed article entitled, "Hops virus testing: Significance and implications for establishing hop production in New Mexico and Southwest Colorado.".

Dr. Ron Godin, Colorado State University Extension, Tri River Area Agronomist
Ron continues to help producers develop high altitude hops yards in the region so we are fortunate to have him on our project team. In addition to attending meetings, he has served as a technical consultant on many of our questions related to hops yard construction, varieties and nutrient management. He received the highest evaluations at our Winter Workshops and provided the participants with a sounding board for many kinds of questions related to hops production. He has been an invaluable partner in this successful project.

Goals and Outcomes Achieved

Desired Outcome	Performance Measure	Benchmark	Target		
			2013	2014	2015
To increase the number of hops varieties being appropriately evaluated at high altitudes.	The number of hops varieties being evaluated at the Old Fort.	Currently there are none.	13	13	13

The hops yard was established at the Old Fort with 11 varieties of disease free hops in four replicates of 6 plants each including two guard plants. In 2014, we investigated sources of disease free rhizomes to increase the number of varieties and replace some of the missing Mt Hood and Galena plants. We found very few yards that could provide clean plants and since Summit Labs has increased the minimum number of plants to 1,000, we remained at 11 varieties. In 2014 and 2015, we collected growth, survivability data on all varieties. Additionally we used petiole sampling to analyze the levels of Nitrogen, Zinc and Boron and used a SPAD meter to evaluate chlorophyll levels prior to burring. During harvest, wet and dry weights for each replicate were recorded. After harvest, we submitted from one to four replicates of each variety to Alpha Analytics for alpha, beta and oil analyses.

Desired Outcome	Performance Measure	Benchmark	Target		
			2013	2014	2015
To increase potential growers knowledge of hops production practices.	The number of attendees at Field Days and determination of whether Field Days helped increase the attendee's knowledge of hops production.	0	20 growers to attend the Field Days and for a majority to indicate via survey that the Field Days helped enhance their hops production knowledge.	30 growers to attend the Field Days and for a majority to indicate via survey that the Field Days helped enhance their hops production knowledge.	30 growers to attend the Field Days and for a majority to indicate via survey that the Field Days helped enhance their hops production knowledge.

Over the course of this project, we hosted 4 field days featuring hands-on activities. The first field day was held in October, 2013 and focused on soil sampling, trellis construction and SPAD meter usage. Twenty-three people attended and 12 completed surveys indicating that the program enhanced their hops knowledge. In 2014, we held two field days with 27 total people attending and 20 completing surveys. One was held on Saturday, June 21, 2014 (summer

solstice) and was attended by twelve people. Attendees assisted with collecting petiole samples, operated the SPAD meter and measured the height of the hops. The other one was held on August 24, 2014 and was attended by 15 people. Attendees assisted with harvesting, picking and sorting hops. In 2015, we hosted a field day in conjunction with our Old Fort open house. The hops were burring at the time and we also collected petioles for a late season analyses. Because it was part of a bigger event, we attracted over 50 participants including a lot of new people who had not seen the yard before. Unfortunately, because of the varied audience at the larger Open House, we did not utilize surveys effectively.

Desired Outcome	**Performance Measure**	**Benchmark**	**Target**		
			2013	**2014**	**2015**
To increase the number of commercial hop yards in the Four Corners region.	The number of commercial hop yards in the Four Corners Region.	2	2	2	4

The most successful hops yard in the 4C region is Pine River Hops in Bayfield. They have 1.5 acres and 1600 plants. Paul Black has shared many of his lessons learned at our field days and workshops. Many of our participants had or installed small yards (5-50 plants) that were used to create a home brew or craft brew. These smaller growers have been contacting us about getting disease-free rhizomes from our yard. We hope to be able to provide this plant material beginning in 2016. There are two other larger yards (Ignacio and Cahone) that are in the start-up phase as this project ends. This project also attracted potential growers from the Front Range and Grand Junction area. One of our attendees at the Winter Workshop was working on a 10 acre hop yard this summer. We are looking forward to hearing about their progress at our 2016 workshop.

Desired Outcome	**Performance Measure**	**Benchmark**	**Target**		
			2013	**2014**	**2015**
To further enhance practical knowledge of potential growers during Winter Workshops.	The number of potential hops growers attending the Winter Workshop and determination of whether the Winter Workshop helped increase the attendee's practical knowledge of hops.	0	0	40 growers to attend the Winter Workshop and for a majority to indicate via survey that the Winter Workshop helped enhance their practical knowledge of hops.	50 growers to attend the Winter Workshop and for a majority to indicate via survey that the Winter Workshop helped enhance their practical knowledge of hops.

The first Winter Workshop was held on Saturday, March 22, 2014 with 38 people in attendance including growers, home brewers, commercial brewers, potential growers and even a mobile canning business owner. Attendees were from Durango, Cortez, Dolores, Bayfield, Pagosa Springs, Farmington (NM) and Taos (NM).

The second Workshop was held Saturday, March 21, 2015 with 50 people in attendance including growers, home brewers, commercial brewers, potential growers and several support business owners. Attendees were from Durango, Cortez, Bayfield, Pagosa Springs, Boulder, Fort Collins, Farmington, NM, and Las Cruces, NM.

These workshops were definitely the highlight of the year because we got to share our results and enthusiasm about hops production with a wide variety of folks. Surveys from participants (25 and 29, respectively) indicated that we enhanced their practical knowledge by providing lectures and hands-on activities.

Desired Outcome	**Performance Measure**	**Benchmark**	**Target**		
			2013	**2014**	**2015**
To identify potential buyers for locally produced hops.	The number of craft and home brewers attending the Open House in years 2 and 3.	0	0	20	20

The Program Assistant for the project promoted locally produced hops to both home and craft brewers in the region. Many of them attended our Field Days, Winter Workshops, Tappings and ultimately used hops from our project. We had 18 brewers participate in 2014 and 2015 with six strong relationships being developed with craft brewers in the region including Carvers, Riff Raff, Taos, Steamworks, Mancos Brewery and UBrew (home brew store).

Additional relationships have been developed with Pine River Hops and The Bottom Shelf in Bayfield and Golden Eagle Brewery in Silverton. Both of these breweries only want pelletized hops which should be available in December, 2015.

Desired Outcome	**Performance Measure**	**Benchmark**	**Target**		
			2013	**2014**	**2015**
To increase the amount of locally purchased hops by local brewers.	The number of local brewers using local hops and the amount of locally produced hops purchased by local brewers as determined by survey of local brewers.	0	0	0	5 local brewers using local hops and are purchasing at least 500 lbs. of hops in total.

When this project began, our surveys indicated no local hops being used in the craft industry and only home-grown hops being utilized by home brewers. Initial surveys showed a wide range of prices ($5-30) for the hops. This was primarily due to the confusion of pelletized versus fresh cone hops. Since we do not have access to a local pelletizer, all of the hops distributed from this project were whole cone. In 2015, craft brewers were willing to pay$14/lb for dried whole cone hops. Home brewers indicated $32/lb for small quantities. At the end of this project there were 5 craft brewers, one home-brew store and at least five home brewers utilizing local hops.

Our goal of 500# of hops being purchased locally was not met by end of project. Approximately 240# of wet whole cone hops was marketed locally in 2015 from the Old Fort and Pine River Hops for $7/lb. Additionally, Pine River Hops sold an additional 20# of dried whole cone hops ($12/lb) while the Old Fort distributed 18 pounds to home and craft breweries. Because of marketing issues, Pine River Hops sent their remaining harvest (500#) to Front Range Hops for pelletization. They have several local brewers interested in the pelletized product at $14/lb. If they are able to sell all of their product, it will show the importance of having a pelletizer in the region to assist with marketing.

Beneficiaries

Beneficiaries of our project, "Analyzing Hops Varieties for High Altitude Production and Alternative Marketing Schemes" include a wide variety of interested parties. We certainly reached potential growers as expected and utilized the established grower's expertise to build some great long term relationships. Our second Winter Workshop had 33 new participants with some of them traveling over six hours to attend. I also believe that at least two local land owners benefited because they decided that hops production was too much of a financial investment and too labor intensive. Otherwise, they may have spent $20-30,000 to establish a yard that they couldn't manage and harvest.

Because of our research on the importance of disease free rhizomes, potential growers should financially benefit by not having to replace diseased plants every five years. A representative from Summit Plant Labs attended our Winter Workshop and was able to see the enthusiasm for hops production in 4C region.

Initially, we saw the local breweries as potential customers for our product but they have become a much larger part of this project. Their willingness to try whole cone hops in both wet and dry form has been amazing. They also have helped us promote the project and really want us to succeed.

Lessons Learned

We learned that hops production is much more complicated than most people think. The design and construction of the yard and trellis could be the first stumbling block. Fortunately, we had access to the necessary equipment and expertise to get the trellis built in a reasonable amount of time and have the ability to update it as needed. Some of the small farmers who are exploring hops production may not have these resources.

Locating verified disease-free rhizomes continues to be challenging but it is so important to long-term financial viability. We spent time researching hops varieties that had been tried in other high altitude areas so we felt good about our choices. Locating these choices took some time and Summit Labs was instrumental in getting our yard established. Honestly, the planting and establishment of the hops plants was the easiest part of the project. They are a really tough plant and have survived extreme heat when planted, cold winter temperatures (-24) and both drought and floods with great results.

Our primary challenge has been nutrient management, particularly Nitrogen with some issues with Zinc and Boron. Hops really are a heavy feeder and that is going to make organic production of hops extremely difficult in the Rocky Mountain soils. Nutrient issues were exacerbated by uneven watering in 2014 most likely caused by a slight grade in the yard from North to South.

As our production levels increase, we are learning more about the labor and equipment requirements associated with large scale production. While hand picking hops is a necessity for our hops yard, it is certainly time consuming. With eleven varieties planted within a 150' row, using a mechanical harvester would be challenging. However, as our production levels increase with appropriate nutrient management, utilizing a mechanized picker is definitely something we'll be exploring. Other equipment that needs to be developed for small to mid-size yards include wagon/trailers/lifts that allow you to safely and efficiently access the top of the trellis along with larger driers. We believe that developing an equipment cooperative that would serve producers throughout the 4C region is the next logical step.

Contact Person

Beth LaShell, Coordinator
Old Fort at Hesperus
970-385-4574
lashell_b@fortlewis.edu

Additional Information

Old Fort at Hesperus website:
(https://www.fortlewis.edu/oldfort/CurrentProjects/HopsVarietyTrial.aspx or www.tinyurl.com/oldforthops)
Facebook page: www.facebook.com/oldfortathesperus
HomeBrewing News: http://homebrewingnews.com/articles/fort-lewis-hops-project
Program Assistant Website: https://amerbeye85.wordpress.com/2013/03/28/the-old-fort-lewis-hop-variety-trial/

Newspaper Articles:
7/11/13- Time to Hop to It
http://www.durangoherald.com/article/20130711/NEWS01/130719883/Time-to-hop-to-it--

10/12/13- Braving the Cold to learn more about what makes hops tick
http://www.durangoherald.com/article/20131012/NEWS01/131019821/0/defaultnewsajax/Braving-the-cold-to-learn-more-about-what-makes-hops-tick-
8/8/14- Hops Harvest in Cortez Journal
http://www.cortezjournal.com/article/20140828/NEWS01/140829831/-1/News01/Hops-harvest-
11/17/14- Local hops research expands to local breweries
http://www.cortezjournal.com/article/20141117/NEWS01/141119857/-1/News01/Hop-research-expands-to-area-breweries-
11/29/14- Get a Taste of local hops research
http://m.durangoherald.com/article/20141119/NEWS06/141119490/0/Services/Get-a-taste-of-local-hop-research-

Promotional and Educational Material

What's Hop'n- July, 2012: http://farmingtonsc.nmsu.edu/documents/hops-flier-2013rev2.pdf

What's Hop'n – July, 2012 Program Summary http://aces.nmsu.edu/hch/hopsresearch.html

7/8/13- NMSU Hops Variety Trial to Expand to Higher Elevations
http://newscenter.nmsu.edu/Articles/view/9563/nmsu-hops-variety-trial-expanded-include-higher-elevations

2014 New Mexico Organic Farming Conference- Hops Handout
https://www.fortlewis.edu/Portals/178/NMOFC_Hops_Handout.pdf

2015 What's Hop'n Winter Workshop Brochure
https://www.fortlewis.edu/Portals/178/HopsWinterWorkshopBrochure2015.pdf

Hops Virus Testing- Significance and Implications for Establishing Hop Production in New Mexico and Southwest Colorado- Research Report
http://aces.nmsu.edu/pubs/research/horticulture/RR788/welcome.html

8/14/15- Durango TV- Researchers Hop to It http://www.durangotv.com/video-detail.php?ID=513

Online Calculator for Drying Hops
http://sroc.cfans.umn.edu/People/Faculty/VinceFritz/Hops/HopDrying/index.htm

Pine River Hops YouTube Video
https://www.youtube.com/watch?v=KdpAPsDuzC4&feature=youtu.be

USDA Hops Variety Descriptions http://www.freshops.com/hops/usda-named-hop-variety-descriptions

TITLE: **Colorado Pavilion at the 2013 Fresh Summit Expo Final Report**

PROJECT SUMMARY:

The Colorado Pavilion at the PMA Fresh Summit Expo is an efficient and effective way to help the state's produce growers enhance their market competitiveness, and meet with current customers with an opportunity to expand their sales. The Colorado Department of Agriculture's (CDA) Colorado Pavilion has been an exhibitor at the show since 2008, and this year's show in New Orleans, LA is a continuation of efforts from previous years that were also grant funded. This year, the CDA made attempts to increase the variety of producers as well as updated the design of the Pavilion. There was an organic produce distributor, and a sweet corn operation, that were new among others. Also, the main difference from this year from previous years, was the display design (please see pictures within the Goals Section). The updated design brought positive responses from attendees and Colorado exhibitors alike; Colorado had a greater presence at the show than in all previous years.

The purpose of attending PMA is for Colorado producer's to have a platform to showcase their product in the largest fresh produce show in the country. Having the Colorado Pavilion, a larger, centralized spot for all Colorado companies allows the companies more exposure and ability to promote all produce and specialty crops grown in Colorado.

PROJECT APPROACH:

- Work for the project began in December 2012, with the review of the survey results from the Exhibitors that attended the show in 2012. These results showed that the majority of the Exhibitors requested a new design of the Pavilion with an "open format" and meeting room space.
- March 2013, the State of Colorado began a new logo change and development for the entire state, its departments and the companies that grow, produce, sell, etc… within the State. The CDA planned to use the new logo and "slogan" within the Pavilion design. Work began with BrandWerks Group to design the Pavilion within the budget allocated.
- In July and August 2013, with the help of Global Exhibiting Services (GES) the on-site design/set builders and BrandWorks the Pavilion design and artwork was finalized and sent to GES for approval and deposit was sent.
- September 2013, the CDA confirmed exhibitors which included: Colorado Potato Administrative Committee, Expo LLC, Colorado Certified Potato Growers Association, Northern Feed and Bean Company, Aspen Produce, Farm Fresh Direct, Mountain Valley Produce, Rocky Ford Growers Association, Growers Organic and Ringer and Sons, and kept them up to date on PMA show deadlines, badge information, etc.. Each of this exhibitors maintain their own exhibit space during the show, are dedicated Colorado companies that participate actively to meet PMA deadlines, purchase and coordinate shipping and travel plans, and aid in customer service to attendees at the show.
- October 2013, CDA staff and exhibitors attended PMA Fresh Summit Expo in New Orleans, LA. Attendees often commented, "Is this the first time Colorado has had a

Pavilion?" or "What a great and open display!" These comments meant we had achieved our goal of a greater presence and open display.

- November 2013, each Exhibitor was sent a survey from Survey Monkey (an online survey company), where they were asked questions about the level of customer service provided by the CDA, how well they liked the design of the Pavilion, number of new and current contacts made and if there was an increase in qualified buyers made during the Expo.

GOALS AND OUTCOMES ACHIEVED:

As stated within the project proposal, the main goals for the 2013 Colorado Pavilion were to increase the number of Colorado associations and staff participating in the Pavilion, increase the number of private companies, to generate sales of Colorado produce and to increase the number of contacts made with current and potential buyers. Below is an outline of expected results for each goal versus the actual results found from the emailed Exhibitor Survey:

1. Increase the number of Colorado Associations and staff participating with the Pavilion: Target goals were at least 4 associations with 10 staff to participate. For the 2013 PMA Show, there were 3 associations with 8 staff participants.
2. Increase the number of private companies: Target goal was at least 6 companies with 28 staff. Actual number of private companies that attended was 8 companies with 29 staff participates (there were 9 private companies, but one cancelled the day before the show).
3. Amount of sales generated of Colorado produce. Target sales goal of $1.0 million. Actual number could not adequately be measured. Of the 8 exhibitor responses, most answered with an "n/a" or "unknown".
4. Increase contacts made with current and potential buyers. Target goals were 50 current and 60 new contacts made at the 2013 PMA Fresh Summit. 91 – 104 current contacts and 45 – 60 new business contacts were created at the show.

It would appear from the information gathered within the exhibitor survey, that there new contacts were created (45-60), affirmation that there was an increase in private companies (6 in 2011, 8 in 2013) exhibiting within the pavilion thus showcasing the variety of specialty crops grown, as well as an increased interest from Colorado companies.

BENEFICIARIES:

The Colorado Pavilion targeted assisting two core groups, the produce commodity associations and the individual produce shippers/growers. This year, 3 potato operations, 1 bean grower, 2 potato associations, 1 organic produce distributor, 1 corn grower, and 1 cantaloupe association/grower benefited directly from the CDA Pavilion project. Economic benefits of this activity included the garnering of new international and domestic customers. These participating companies report making contact with existing and new buyers this year and many exhibitors

mentioned that their current customers expect their attendance at the show, and see it as a necessary business interaction.

There was not an increase in attending associations for this year, but those that were at the show stated that they were able educate attendees on Colorado produce, and give valuable information out about commodity suppliers and producers.

Also, although the direct beneficiaries are the exhibitors, the presence of the Colorado Pavilion does benefit Colorado Produce companies and the Specialty Crop industry as a whole. With the over 20,000 attendees walking past and through the Pavilion, looking up at the massive 16 feet Colorado scenery and producer photos, it brought attention to the Colorado producers as whole and increased interest within the produce industry.

LEASONS LEARNED:

A few unexpected issues occurred during this project. Coordinating the exhibitors for booth attendance is always a difficult task, but after this year, the CDA will implement a stricter procedure to fill the booth space; a deposit or upfront booth space payment and contract signed to receive the booth space within the Colorado Pavilion will need to occur to guarantee space. Also, the CDA will rethink the booth structure. Although meeting space is needed and an added benefit for the exhibitors, the size and location within the pavilion may change depending on amount of exhibitors and location of show; after each show the exhibitors are asked to complete a survey that will provide the CDA with information on sales generated from the show, the amount of meeting space needed for next year and other follow up questions to help the CDA Pavilion stay successful for Colorado companies.

CONTACT PERSON:

Casey Palmer
Marketing Specialist
(303)239-4123
Casey.palmer@state.co.us

TITLE: Colorado Proud Fruit & Vegetable Television Advertising Final Report

PROJECT SUMMARY:

Since its inception by the Colorado Department of Agriculture in 1999, *Colorado Proud* has served as the state's primary program to promote food and agricultural products that are grown, raised or processed in Colorado. The program is a great fit with the Colorado consumer's desire to buy local products. Surveys, as recently as September 2013, have found that more than 90 percent of Colorado consumers would be more likely to buy food that was produced in Colorado than outside of the state.

The appeal for local products also lies with restaurants, chefs and retailers. A National Restaurant Association survey conducted in October 2013 found that 81 percent of chefs surveyed believe local produce is one of the "hot" new trends for restaurants. Chefs are looking to buy local products to incorporate into their menus because they know that consumers want to experience local flavors when dining. At the retail level, increasingly higher percentages of their advertising expenditures are being directed toward the promotion of locally grown and processed products.

The purpose of this project was to continue to educate consumers, retailers, and restaurants about the wide range and availability of Colorado specialty crops, resulting in increased purchasing of locally grown products.

This year's project complemented previous years' work by strengthening the Colorado Proud message as it pertains to produce. An additional survey question was added to determine Colorado Proud's effectiveness in promoting Colorado produce specifically. As a baseline we found that 66% of respondents would purchase more Colorado produce if it was labeled with the Colorado Proud logo.

PROJECT APPROACH:

Specialty Crop funds provided the resources for the Colorado Department of Agriculture to implement a television advertising campaign during the summer of 2013 aimed at encouraging consumers to "Choose Colorado" and emphasizing Colorado's fresh fruits and vegetables. SCBGP funds were only used for the television advertising that promoted specialty crops. A total of four 15 second television ads were produced and aired in 2013. Three featured only specialty crops including lettuce, sweet corn, onions, cantaloupe, potatoes and peaches. Additional non-SCBGP funding was used to promote other products that are part of the *Colorado Proud* program.

The Colorado Department of Agriculture contributed $75,000 in cash to the campaign to promote non-specialty crop products. In addition, the partner television station contributed $205,242 worth of in-kind services including bonus air time and production services to promote the non-specialty crop portion of the advertising campaign and to create the one non-specialty

crop ad. Specialty Crop funds accounted for 26% of the total project budget, but received 70% of the airtime.

GOALS AND OUTCOMES ACHIEVED

Colorado Proud developed and executed a television advertising campaign featuring Colorado specialty crops from July through September 2013. A total of four 15 second television ads were produced and aired in 2013. Three featured only specialty crops including lettuce, sweet corn, onions, cantaloupe, potatoes and peaches. Colorado Proud aired 2,041 fifteen second ads, which reached 99.9% of households an average of 20 times and 99.75 of adults, 25-54 an average of 9 times. The campaign resulted in 31.8 million household impressions and 15.3 million adult impressions.

Desired Outcome	Performance Measure	Benchmark	Target	Actual
To increase consumer awareness of the *Colorado Proud* logo.	Consumer awareness of the Colorado Proud logo as measured through annual survey.	76% reported awareness at year end 2011	80%	78%
To increase the percent of consumers reporting purchases of Colorado products.	Percent of consumers reporting purchases of Colorado products as measured through annual survey.	84% reported purchasing of Colorado products at year end 2011	87%	85%
To increase the number of companies licensed at year-end to participate in the *Colorado Proud* program.	Number of companies licensed to participate in the Colorado Proud program as determined by member listing.	1,700 Colorado Proud members at year end 2011	1,900	2,004 (as of 9/30/13)
To increase the consumer's connection of Colorado produce and Colorado Proud.	Percent of consumers reporting desire to purchase Colorado produce with the Colorado Proud logo.	N/A	N/A	66%*

* This measure was not included in the original application, but was added to develop a baseline for future years. This measure will help determine the specific consumer correlation between Colorado Proud and Colorado produce.

The margin of error for the survey was estimated at approximately 4%, so although the actual results are slightly below the target, we still consider the campaign a success. All results continue to be above the benchmarks reported in 2011.

BENEFICIARIES:

The television advertising campaign resulted in nearly 32 million household impressions, which benefited the more than 200 Colorado Proud members that are specialty crop producers and the nearly 400 members that operate restaurants, retail stores, schools and farmers markets selling Colorado specialty crops. (No SCBGP dollars were used to promote non-SCBGP products.) Overall, the program benefited all Colorado produce growers as consumers were encouraged to buy Colorado produce when shopping.

LESSONS LEARNED:

Colorado Proud is close to reaching market saturation. With approximately 80% of Colorado consumers aware of the Colorado Proud logo, future project work should focus on maintaining awareness. Future promotions should continue to encourage consumers to look for the label and "Choose Colorado" when shopping and dining.

We added a question to our annual survey to determine what effect the Colorado Proud logo has on consumer decisions to purchase Colorado produce. This tracking mechanism will help us better determine Colorado Proud's effectiveness when it comes to solely promoting Colorado specialty crops.

CONTACT PERSON:

Wendy White
Marketing Specialist
Colorado Department of Agriculture
303-239-4119
Wendy.White@state.co.us

ADDITIONAL INFORMATION:

The three 15 second television ads featuring Colorado specialty crops are available online at http://www.youtube.com/coloradoagriculture. They are entitled "Colorado Proud Choose Colorado Television Ad"

TITLE: Don't Just Stand There, Plant Something Promotion Final Report

PROJECT SUMMARY:

This Project was being done in collaboration with the Arizona Nursery Association's Plant Something Program. Colorado is one of several state nursery associations currently participating in what is anticipated to be a national promotion of nursery and greenhouse plant material to the general public.

To help with the market and economic condition of the Colorado green industry this project was designed to promote and educate the consumer on the many benefits plants have. This project will inform the consumer on the proper use, placement, environmental, health and aesthetic benefits of plants resulting in their realization of the increased value of their residential and commercial properties as well as the market stabilization of the Colorado green industry.

The need for increased marketing is vital as the markets and economic conditions continue to improve. This project is a broad based marketing effort, designed to reach the broadest public audience across geographical and generational ranges to positively impact the sale for retail and wholesale markets through print, radio, public events and internet promotion.

PROJECT APPROACH:

An independent contractor was retained to create the marketing pieces for both the print ads and the television ads. The contractor also over-saw the creation of an additional website directed solely to the public and the plant something campaign.

Marketing pieces were made available to the association membership for marketing in their individual locations as well as advertising on the plant something website and by the television advertising sale.

The advertising was placed in the Colorado Gardener Magazine, for the April, May, June and July issues, with a circulation of over 38,000 readers. You can find Colorado Gardener along the Front Range from Colorado Springs to Fort Collins & Greeley at garden centers, garden shops, nurseries, public gardens, cooperative extension offices, independent bookstores & hardware stores, libraries, farmers markets, King Soopers stores in the Metro area and Larimer County, other locations in Evergreen, Crawford, Bailey, Durango, Cortez, Clifton, Grand Junction, Vail, Pueblo, Cheyenne, WY, and Santa Fe, NM.

Colorado Community Media published an ad in 23 local community newspapers for the April 4, 11, 18 & 25th, 2013 issues with a current circulation to over 205,335 readers. The community newspaper locations include Arvada, Castle Rock, Centennial, Elbert County, Englewood, Golden, Highlands Ranch, Lakewood, Littleton, Lone Tree, Northglenn, Parker, Teller County, Thornton, Tri-Lakes, Westminster, and Wheat Ridge.

Television advertising was obtained through Comcast Statewide and Rocky Mountain PBS Statewide and ran on seven different stations in Denver and Fort Collins. In Colorado Springs it ran on two different stations and on one station in Grand Junction, for 808 spots during the months of May through August 2013 with 541 bonus spots for the same time frame. The television advertising gave us a total of 1,359 statewide spots.

GOALS AND OUTCOMES ACHIEVED:

A website www.plantsomethingco.org was developed specifically directed to the general public to encourage and educate them on the benefits of landscape plants. The website has given the consumer an avenue to find the answers they need from the experts in the industry.

A television and advertising media buy were obtained that put the plant something marketing campaign in front of the general public in a myriad of ways.

- To increase the amount of plant sales at independent member retail locations over prior year sales by 3% for those participating in plant something and an increase of 2% for those not participating in plant something.–Weather has a major impact on our industry, when the members typically would have been in full swing in April, we were still receiving snow. The impact continues to be seen, with the members still very busy in November, when they typically would not be as busy. Sales in the grant were based on seven participants, at this time we were only able to obtain sales for six of those participants, the combined sales for those six participants for the months of April and May 2013 compared to the combined sales for the same time period for 2012 is down 1%.

- To increase the number of retail locations participating in Plant Something. – We were unable to increase the number of participants in plant something because the members were focused on making up lost revenue in the spring and reduced sales because of the drought. We have seen the same amount of participants wanting to continue the project in the next calendar year and are working on ways to increase that participation moving forward. We have implemented our federally held trademark, Grown'N Colorado® for annuals that are produced in Colorado and will be combining it with the Plant Something project to further strengthen the program.

- To increase the awareness of how to successfully garden. In addition an increase in web traffic due to the campaign advertising by 6%. - For the period of April through August 2013 we had a total of 1,509 people visit the www.plantsomethingco.org website with a total number of pages viewed of 2,262; with a returning visit percentage of 15.65%, with an average visit duration of 1:25. Because the site was new in 2013, we ask that these numbers become our initial benchmark.

Beneficiaries:
The public benefited by access to the plant something website www.plantsomethingco.org which gave the consumer the ability to find retail members in their areas, and to gather information quickly and easily directly from professionals on how to garden successfully, featured plants, monthly tips, dealing with the fires in Colorado Springs, the state wide draught, Emerald Ash Borer and events at retail member locations.

Lessons learned:
The program is new and with members focused on sales and weather we were unable to increase the number of companies participating in plant something as we originally thought.

Those that are participating in this program are using it in addition to their own marketing and as a tool to draw people into their locations.

The marketing pieces for the members i.e. signs and plant stakes don't seem to be as usable to the members as initially thought. We are talking to the participants to see what types of marketing materials would be more beneficial to them.

Unfortunately, Colorado faced a drought this year and due to that drought our members' sales were impacted, as well as the ability for this program to really have the opportunity to have an impact.

Contact person:
Sharon R. Harris
303-758-6672
sharris@coloradonga.org

Final Report: Enhancing the Growth of the Lavender Industry of Western Colorado by Evaluating and Promoting the Quality of Essential Oil produced by Western Colorado Growers for Marketing Purposes
Partner Organization: Lavender Association of Western Colorado

Project Summary

English lavender (*Lavandula angustifolia*) and the hybrid lavandin *(L. x intermedia*) cultivars have been successfully grown and harvested in western Colorado for 10 or more years. While the worldwide market for the essential oil of lavender is substantial no research has been conducted in Colorado to determine the yield or quality of oil of the various cultivars available for production in Colorado. This project was designed to answer the question of which cultivars produce the largest quantity and highest quality oil. This information will be used to further develop Colorado's lavender industry, educate Western Slope lavender growers and promote Colorado's high-altitude essential oil. Oil is being produced in increasing quantity as more farms come on line. It is important to know the quality of Colorado's high altitude lavender and to know which cultivars are producing the best lavender for the market. It is difficult for the producers to market their products until they have this information.

Project purpose

The purpose of the project was to determine the quality of essential oils of lavender (*Lavandula* spp.) grown at high altitude western Colorado farms. Ascertaining the quality of lavender oil being produced in Western Colorado is particularly timely as the lavender plants and the lavender industry in Western Colorado is reaching maturity.

Travis and Honora harvesting lavender

The essential oil of lavender is in high demand for culinary and aromatherapy uses. This steam-distilled oil is used in value-added products such as perfume, lotions, creams, lip gloss, bath oils, and other high priced items. Essential oil of lavender also is used in pesticide formulations, teas, and many other products and thus is in high demand. The oil and its hydrosols (flower water) are increasingly being used in the expanding field of aromatherapy. Much of the U.S. demand is supplied by imported product from France, Russia, Australia, New Zealand, Columbia and other countries. This project enhanced Colorado's lavender products in an effort to fill the demand currently provided by other countries and helped create Colorado job opportunities in the production and marketing of buds, essential oil, and value-added products.

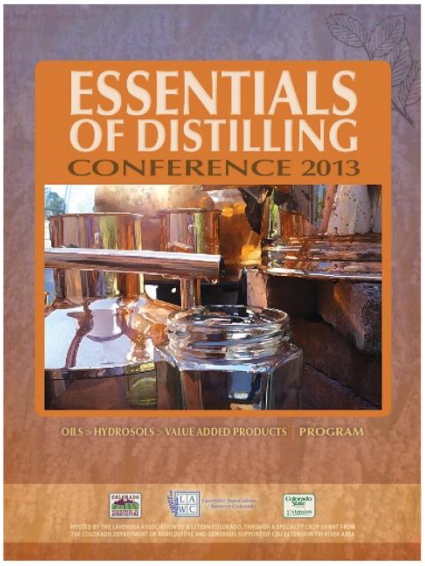
Austin packing the charge with lavender

This project determined the chemical composition of nine cultivars of lavender grown in western Colorado. While the cultivar is the single biggest factor in determining oil composition, flower head maturity at harvest and altitude also are important factors. The content of linalool and linalyl acetate are two of the volatile components that directly affect the price of the oil. While high altitude lavender is said to be of higher quality than lavender grown at lower altitudes, there was no data to support this claim in Colorado.

Essential oils from lavender grown in Colorado were compared to the ISO standard to see how our important components stacked up globally. It was found that very few cultivars (from any location) compare to the international standard and ours was no better or worse than the rest of the lavenders studied in the US. Only the L. angustifolia 'Maillette' grown in Colorado met the standards.

The data generated by this project determined which of the nine cultivars produces the greatest quantity and the highest quality of oil. This information will be used to select cultivars for Colorado and enhance marketing efforts of Colorado's lavender industry. It also assisted in establishing that high altitude Colorado essential oil is of the superior quality that we anticipated it to be.

The Lavender Association of Western Colorado, led by Dr. Curtis Swift and his team of research assistants, Travis Bondurant and Honora Carr, spent the summer of 2013 harvesting, distilling and analyzing the results of the GC/MS reports generated on 11 cultivars of English lavender (*Lavandula angustifolia)* and lavandins (*L. x intermedia*). We also planned and hosted a two day conference to share our results. A more detailed description of our activities follows in the Work Plan.



Project activities:

Plan workshops and inform members of 3 upcoming workshops on distilling techniques, essential lavender oil quality components and uses for lavender oil and its hydrosol. Instead of three workshops, we planned and hosted a two day conference which was attended by over 70 people from all across the United States and Canada.

7 cultivars harvested and dried. Eleven cultivars of lavender and lavandin were harvested and distilled during the summer of 2013. Nine cultivars were harvested from the

main lavender research farm Green Acres U-Pick in Palisade, Colorado. One cultivar 'Maillette' was harvested from Sage Creations Organic Farm in Palisade, Colorado. One cultivar 'Royal Velvet' was harvested from A Pinch of Lavender farm in Palisade, Colorado. Floral stems from each cultivar were harvested in sufficient quantity to provide seven liters of material. The decision was made to use fresh lavender flowers and stems per the ISO standards.

Collection of flower bundles from 2 additional cultivars not in research trial. The additional cultivars L. angustifolia 'Maillette,' 'Betty Blue,' 'Royal Velvet' from A Pinch of Lavender farm and 'Buena Vista' were included in the research.

Data collected on dried flower stems from each block and yield data statistically analyzed using MSTAT-C statistical program Michigan State University. Floral stems of nine cultivars of Lavandula were harvested in 2012. The stems were separated by cultivar, plot number and replication for statistical analysis.

Harvesting was accomplished on the following dates, June 13, 15, 18, 28, 22, 23, 26, and 29, and July 9, 10, and 11. Floral stems were harvested with scissors based on their stage of development thus the reason for the extended harvest season. Bundles were held together with rubber bands and hung in the garage of Bob and Elaine Korver out of direct sun until they were dry. Bundles were stripped of the floral stems by hand and screened through several sizes of sieves to remove extraneous material. Buds were weighed on an Ohaus Scout gram scale and weights recorded. The data was entered into MSTAT-C, a microcomputer statistical program developed by Michigan State University.

Means were run using MSTAT-C to determine percentage of winter survival and average yield of cleaned buds (calyces) per plant. The results are as follows:

Cultivar	Plant Survival (percentage)	Average yield per plant (grams)
L. angustifolia		
'Betty's Blue'	97	7.9
'Folgate'	74	17.3
'Royal Purple'	33	14.8
'Royal Velvet'	86	16.1
'Twickle Purple'	100	27.8
L. x intermedia		
'Fat Spike'	86	38.0
'Impress Purple'	47	26.2
'True Grosso'	87	31.4
'Super'	60	19.9

L. angustifolia:
Based on the above data it is easy to select the highest yielding cultivars for Colorado lavender farms. Only one *L. angustifolia* achieved 100% winter survival; 'Twickle Purple'. 'Twickle Purple' was also the highest yielding angustifolia cultivar with each plant producing 27.8 grams

of buds. That is slightly less than one ounce. Based on the average production per plant, a grower is capable of producing 69,500 grams or 2455.8 ounces (153 lbs) of bud from an acre (2500) of this cultivar. 'Betty's Blue' was the low yielder of the cultivars examined and was also found to be very hard to clean due to the sticky trichomes on the buds.

The number of bundles per plant was fairly consistent however the length of floral stems varied greatly.

Growers wishing to increase the harvest of buds will need to improve winter survival by mulching and providing winter water if soil moisture proves inadequate.

L. x intermedia

The yield of buds from these hybrid cultivars was greatest for 'Fat Spike' and 'True Grosso' at 38.0 and 31.4 grams respectively. 'Impress Purple' and 'Super' production was less with 'Twickle Purple', an angustifolia, exceeding their yields.

Winter survival was a problem for all the hybrids examined ranging from 47 to 87 percent. Winter protection is recommended for lavender growers in western Colorado.

Dr. Curtis Swift distilling lavender oil

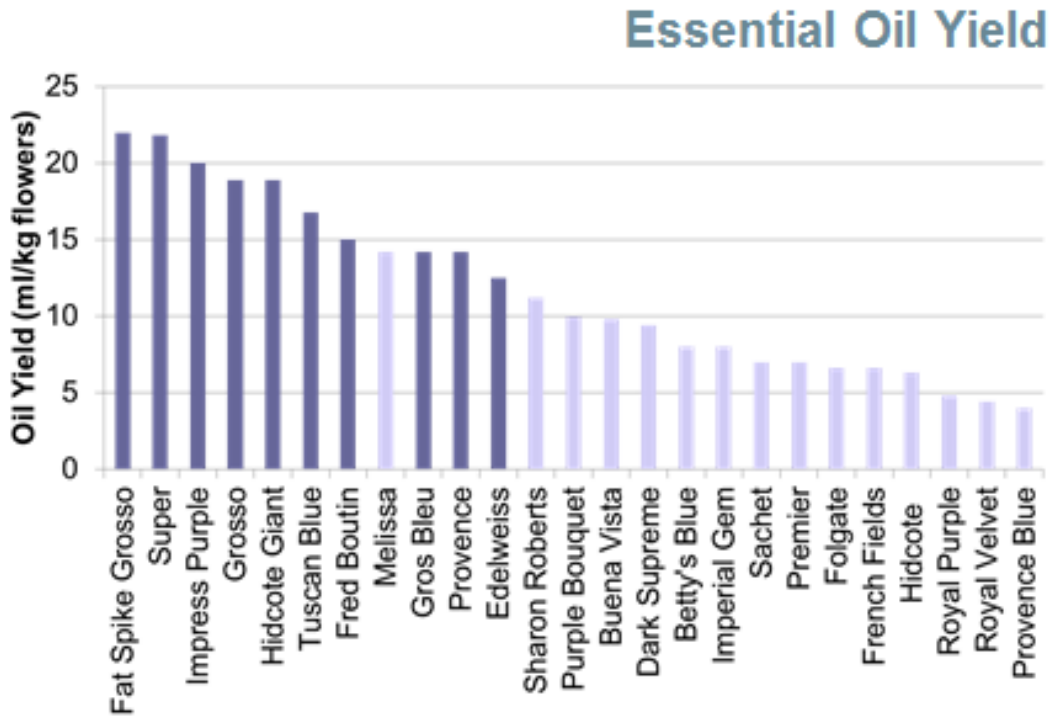
Flower bundles distilled. In July of 2013, the floral stems of 11 cultivars of Lavandula *angustifolia* and *L. x intermedia* were distilled and evaluated by Gas Chromatography and Mass Spectrometry to determine the content of their constituents. The results were compared with the International Standards for Lavender (*Lavandula angustifolia*) and Lavandin (*L. x intermedia* 'Grosso').

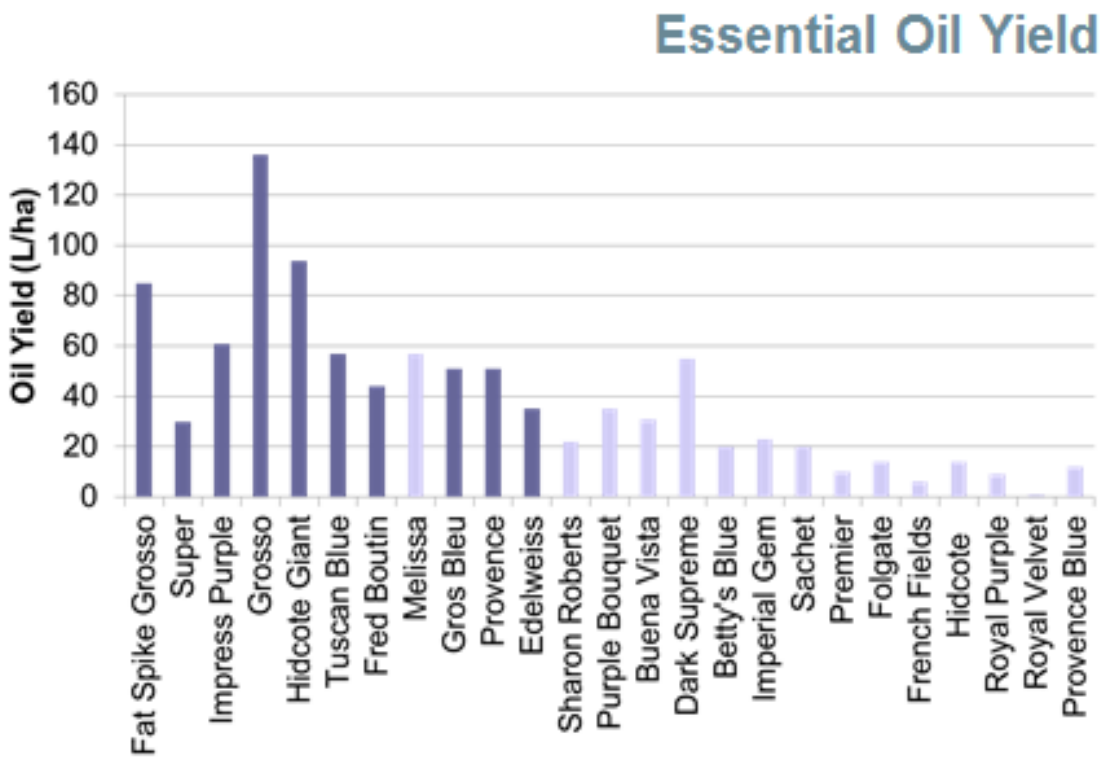
Data of quantity of essential oil produced by each variety and compared to dried flower yield. Most commercial lavender plantations are established for essential oil production with Lavandin producing the bulk of these essences. *L. angustifolia* cultivars typically yield up to 15 pounds of essential oil per acre while Lavandin can produce up to 67 pounds of essential oil per acre. (Barstow and Gardner, 2002). Foster (1992) provides more detail indicating *L. angustifolia* produces 300 to 1800 pounds of buds (calyces) per acre and when distilled result in from 12 to 15 pounds of essential oil. Bud production of Lavandin cultivars range from 3500 – 4500 pounds and 53 to 67 pounds per acre. At a wholesale price of $30 per pound for Lavender and $20 per pound for Lavandin oil, it is critical to select the highest yielding cultivars. Oil yield is highly veritable (Rabotyagov and Akimov, 1987) with new cultivars reported to produce 30% more flowers and 15 to 20% per more oil (MacTavish and Harris, 2002).

Bud production from the cultivars examined in this study ranged from 7.9 to 27.8 grams per plant for *L. angustifolia* and 26.2 to 38 grams per plant for Lavandin. Based on 2500 plants per acre, the yield of buds in pounds would range from 43.5 to 153.22 for 'Betty's Blue' and 'Twickle Purple' *L. angustifolia*, and 144.4 to 209. 43 for 'Impress Purple' and 'Fat Spike' lavandins respectively.

Dr. Sean Westerfeld, Ginseng and Medicinal Herbs Specialist, Ministry of Agriculture and Food, Ontario, Canada conducted a detailed study of the essential oil yield of *L. angustifolia* (light blue) and Lavandins (dark blue). The following was reported at the 2013 US Lavender Growers Association Conference.

References:
Barstow, C. and Gardener, Z. 2002. A market Analysis for Value-Added Opportunities in Lavender and Specialty Herbs. Massachusetts Department of Agricultural Resources.
Directorate Plant Production, 2009. Lavender Production, Department of Agriculture, Forestry and Fisheries, Republic of South Africa, Pretoria
MacTavish, H., Harris, D. 2002, An economic study of essential oil production in the UK. ADAS Consulting Ltd., Government Industry Forum for Non-food Crops.





Essential oil evaluated by GC/MC (gas chromatography/ mass spectrometry). Dr. Swift created a spreadsheet comparing the GC/MS analysis of each cultivar of lavender and lavandin. See results in Appendix.

Conduct distilling workshop. Our "Essentials of Distilling" conference was held on Saturday and Sunday, October 26 and 27, 2013 at the Mesa County Fairgrounds in Grand Junction, Colorado. Our conference featured expert speakers from our local area as well as eastern Colorado and Washington State. They covered topics on the uses and qualities of essential oils and hydrosols of lavenders and lavandins. We also had over ten growers, including Bob Lane of Dayspring Farm in Olathe, display and demonstrate the many different styles and sizes of distillation equipment, from the small tabletop copper alembic distiller to the large 50 gallon stainless steel distiller mounted on a trailer.

Bob Lane demonstrating his distiller

Dr. Swift talking to the conference crowd

Our conference program showing speakers and topics.

SATURDAY : OCTOBER 26





TIME	LOCATION	PRESENTER	TALK/ACTIVITY
8:00 am	*Inside/Outside*		**Registration and Distiller set up**
8:45 - 9:00	*Inside*	**Kathy Kimbrough**	**Opening Remarks**
9:00 - 10:00	*Inside*	**Janet Scavarda**	**Understanding Essential Oils** What it is, what it does, how it is used, and how to market it. Simple yet comprehensive information.
10:00 - 10:45	*Outside*	**Bob Lane/Curtis Swift**	**Start the Distillers!** **Q & A with Bob and Curtis**
10:45 - Noon	*Inside*	**Janet Scavarda**	**Adventures with Molecules** Get to know and love your Gas Chromatogram.
Noon - 1:00	*Inside/Outside*		**Lunch and work with distillers**
1:00 - 3:00	*Inside*	**Ann Harmon** **Cindy Jones**	**Using Hydrosols as a Value Added Product** Hands on workshops using freshly distilled hydrosols.
3:00 - 3:15	*Inside/Outside*		**Break**
3:15 - 5:00	*Outside*	**Bob Lane**	**Best Practices in Lavender distillation** Harvesting – Expected yields – Cleaning your distiller – Overwintering – Variations on stills and how they impact the process and product – Distilling plants other than lavender – Distiller equipment sources.

PRESENTERS

Ann Harmon
Distiller, Certified Organic farmer, Hydrosol Researcher/ Educator. Morning Myst Botanicals, Northport, WA.

Cindy Jones, PhD
Herb grower, educator, formulator. Sagescript Institute, LLC; and Colorado Aromatics, Longmont, CO.

Bob Lane
Lavender farmer and distiller. Dayspring Farm, Olathe CO.

SUNDAY : OCTOBER 27





TIME	LOCATION	PRESENTER	TALK/ACTIVITY
8:00 am	*Outside*		**Distiller set up**
8:45 - 9:00	*Inside*	**Curtis Swift**	**Specialty Crop Grant Report**
9:00 - 10:00	*Inside*	**Ann Harmon**	**Hydrosol IS the Product** Learn the difference between distilling for oils and hydrosols.
10:00 - 10:45	*Outside*	**Bob Lane/Curtis Swift**	**Start the Distillers!** **Q & A with Bob and Curtis**
10:45 - Noon	*Inside*	**Janet Scavarda**	**If I'm Stressed Out, Don't Tell Me!** Thought provoking, life changing information. You won't want to miss this one!
Noon - 1:00	*Inside/Outside*		**Lunch and work with distillers**
1:00 - 2:00	*Inside*	**Janet Scavarda**	**Medicine, You Say?** A guide to producing extraordinary medicinal quality lavender essential oil and hydrosol, from distillation and handling to bottling and marketing.
2:00 - 3:30	*Inside*	**Cindy Jones**	**Making Safe Cosmetics with Hydrosols** Learn how to make fresh & healthy cosmetics the right way with hydrosols.
3:30 - 5:00	*Outside*	**Bob Lane**	**Finish distilling/Q&A/Wrap Up** **Optional - Self guided tour of lavender farms** *(see map)*

Janet Scavarda, DC
Certified Aroma-therapist
Grand Junction, CO.

Curtis Swift, PhD
Lavender farmer and researcher. High Altitude Lavender®, Grand Junction, CO.

Kathy Kimbrough
Advanced Master Gardener. LAWC president for 4 years. Garden Scentsations, Grand Junction, CO.

Conduct workshop on lavender oil's quality attributes. Janet Scavarda's presentation titled "Understanding Essential Oils," covering lavender oil qualities was included in the two day conference.

Conduct workshop on uses for lavender oil and its hydrosol. Janet Scavarda's presentations titled "Medicine You Say?" and "If I'm Stressed out, Don't Tell Me" covered the uses of lavender essential oils and hydrosols were included in two day conference.

Reports detailing yield of flower bundles and yield and quality of essential oil for each of the 9 cultivars completed. The average number of flower bundles for *L. angustifolia* was 6 and for *L. x intermedia* was 9. The length of stems and number of buds per stem varied but was not recorded. Keep in mind this was the second year after planting and would increase each year until maximum production was achieved. The same would be true for essential oil.

Janet Scavarda addressing a full house at conference

Reports posted on the Internet. The Lavender Association of Western Colorado has updated and improved their website. (www.coloradolavender.org) There is now a separate page dedicated to showcase and highlight all of the lavender research that has been done to date and will be done in the future for our members and the public. This report will be posted on our website as soon as possible and will be available not only to LAWC members but the general public and lavender growers around the world.

Goals and Outcomes Achieved:

Goal 1 **Desired Outcome**	**Performance Measure**	**Benchmark**	**Target**
To identify lavender cultivars with superior quality attributes.	Determination of quality aspects of 9 lavender cultivars grown in Western Colorado.	No analysis of quality aspects for these cultivars currently exists.	Complete analysis of the 9 lavender cultivars and quantify superior quality attributes.

Planned Activities:	**Actual Accomplishments:**
9 cultivars harvested and dried - June and July 2013	42 sets – Flower bundles harvested from 7 cultivars in CSU research trial plots at proper time for maximum oil components July 2013
Collection of flower bundles from 2 additional cultivars not in research trial	Flower bundles collected for distillation July 2013
Data collected on dried flower stems from each block	Data collected and recorded in 2012

Yield data statistically analyzed using MSTAT-C statistical program Michigan State University - Sept 2013	Analysis of flower buds completed January 2014
Flower bundles distilled September 2013	Distillation process completed July 2013
Data of quantity of essential oil produced by each variety and compared to dried flower yield – Oct. 2012	Data on oil and hydrosol collected and compared to weight of flower bundles completed January 2014
Essential oil evaluated by GC/MC – Sept – Oct 2013	Essential oil samples submitted to CSU for gas chromatography/mass spectrometry analysis, analysis completed August 2013

Goal 2 **Desired Outcome**	**Performance Measure**	**Benchmark**	**Target**
To disseminate research results identifying the lavender cultivars with superior quality attributes.	Educate growers on the quality traits of the 9 lavender cultivars	No analysis of the quality aspects for these cultivars currently exists.	Create 2 factsheets to be made available to growers and upload information to the association's website.

Planned Activities:	**Actual Accomplishments:**
Reports completed in Dec. 2013; will cover yield of flower bundles and yield and quality of essential oil for each of the 9 cultivars examined	GC/MS results compared with industry standards and reports completed October 2013
Reports posted on the Internet - Dec 2013	GC-MS analysis data and reports were distributed to LAWC members and Essentials of Distilling conference attendees in October 2013. Final report will be posted on LAWC website and authors' websites and social media outlets.

Final results of this research have been posted on the LAWC website. The research results have been downloaded 1,502 times since November 2014.

Goal 3 **Desired Outcome**	**Performance Measure**	**Benchmark**	**Target**
To enhance lavender grower knowledge of distillation techniques.	Conduct workshop on best practices of distilling fine quality lavender oil for growers.	No benchmark data currently exists.	30 growers to participate in the workshop and for a majority to indicate, via a post-workshop survey, that the workshop helped enhance their knowledge of distillation techniques.

Grant manager Kimbrough intended to create a survey and have it included in the binder along with other seminar handouts but unfortunately, this document was overlooked and not created or included in the seminar binder.

Goal 4 Desired Outcome	**Performance Measure**	**Benchmark**	**Target**
To enhance lavender grower knowledge of the high quality attributes of lavender oil and uses of lavender oil and hydrosol including ISO standards.	Conduct 2 workshops on uses of lavender products for growers and the components of high quality lavender oil.	No benchmark data currently exists.	60 growers to participate in the workshops (30 at each) and for a majority to indicate, via a post-workshop survey, that the workshop helped enhance their knowledge of the high quality attributes of lavender oil and uses of lavender oil and hydrosol including ISO standards.

Our approach to achieving Goals 3 and 4 changed due to the increased number of lavender growers wanting to attend our workshops. Rather than holding three separate workshops, we combined the topics into a 2 day conference which includes education on best practices of distilling and a thorough understanding of essential oils, hydrosols and their uses. We targeted 50 attendees from the region, and had over 70 attendees from all over the United States and Canada with one participant from France. The post-workshop survey was not sent out.

Beneficiaries:

The beneficiaries of this project far exceeded our original goals. We hoped the reports and analysis would help our local lavender growers expand their operations by using this information to create higher quality products and market their products to a larger audience. Because of the advertisement of our specialty crop grant and the overwhelming interest from lavender growers across the country, we were able to reach a much wider audience. Instead of 30 to 40 local lavender growers, closer to 100-150 lavender growers from across the country have been impacted by our research and findings on lavender essential oils and hydrosols. These findings will have an impact on the entire U.S. lavender industry when our final report is published. Our report will help lavender growers better understand how to distill for essential oils and hydrosols, how to use the beneficial properties of essential oils and hydrosols and how to compete globally in the essential oils market by creating higher quality products.

Lessons Learned:

Essential oils from lavender grown in Colorado were compared to the ISO standard to see how our important components stacked up globally. It was found that very few cultivars (from any location) compare to the international standard and ours was no better or worse than the rest of the lavenders studied in the US. Only the L. angustifolia 'Maillette' grown in Colorado met the standards.

Several things changed since the grant was awarded to the Lavender Association of Western Colorado. Dr. Curtis Swift, our lead researcher, was employed by CSU Extension when we

submitted the grant to the Colorado Department of Agriculture. He donated his time to the grant based on his current salary. Dr. Swift decided to retire from CSU Extension in August of 2012. He has continued to work on our grant as the lead researcher but his in-kind donation of his salary had to be re-worked. CSU solved this problem by agreeing to pay him directly for the hours he estimated so his in-kind donation is still intact for the grant.

Another challenge was the size and scope of the workshops. When this grant was initially approved, it was thought that holding three separate workshops to inform members on distilling techniques, lavender essential oil quality components and uses for lavender oil and its hydrosols would be the best way to educate our members. Because of widespread interest from lavender growers around the country, it was determined that holding a two day conference would better serve our members as well as other lavender growers. Planning this conference was much more involved than the original workshops as it required a larger facility, hiring speakers from out of the area as well as our local experts, and coordinating the demonstrations of several different distillers. Our members pitched in and volunteered in every aspect of the conference. From displaying and demonstrating their own distillers with their own dried plant materials and propane, to putting the conference binders together, advertising on social media outlets, car-pooling with out of state attendees from the downtown hotels, etc.

Thank you,

Kathy Kimbrough
Grant Manager
Lavender Association of Western Colorado
(970) 255-1312
kkimbro49@yahoo.com

(Appendix) Additional Information:

- EO Grant Budget and Expenses
- GC-MS analysis of *L. angustifolia* compared to Fresh Standards ISO
- GC-MS analysis of *L. x intermedia*
- Report on Evaluation of the Quality of Essential Oils

Angustifolia comparison to French (Maillette) ISO Standards

	Maillette (SCOF)	Folgate	Royal Velvet	Royal Velvet (Nielsen)	Twickle Purple	Royal Purple	Betty's Blue	ISO Std France	ISO Std Other	New York Standards
cis-B-ocimene	0.24	0.19	0.23	0.2	0.09	0.26	nd	0 - 2.5	1.0 - 10.0	
myrcene	0.42	0.35	0.65	0.22	0.18	0.47	0.58	*	*	
limonene	0.23	0.66	0.85	0.19	0.31	0.88	1.04	0 - .3	0 - 1.0	
trans-B-ocimene	0.59	1.02	0.94	1.45	0.95	0.03	1.94	0 - 2.0	.5 - 6.0	
1,8-cineole	0.11	0.45	3.26	1.75	0.44	3.36	1.05	0 - .5	0 - 1.0	t-9
linalool	42.65	17.23	40.78	51.45	24.11	26.55	11.38	30 - 45	20 - 43	24-49
lavandulol	nd	nd	0.96	nd	nd	nd	nd	0 - .5	0 - 3.0	
hexyl butyrate	0.58	0.72	0.96	0.93	0.8	0.8	0.63	*	*	
camphor	0.71	0.29	0.38	0.23	0.38	0.38	0.22	0 - 1.2	0 - 1.5	t-6
terpinen-4-ol	0.21	9.14	3.73	6.79	1.64	6.43	0.17	0 - 1.5	0 - 8.0	
borneol	2.64	1.33	1.68	0.65	1.44	1.38	1.19	*	*	
a-terpineol	0.94	0.3	0.32	0.09	0.29	0.29	0.31	.5- 1.5	0 - 2.0	
linalyl acetate	35.7	41.56	27.71	24.24	51.71	39.59	53.53	33-46	25 - 47	11-55
lavendulyl acetate	0.58	6.66	1.28	0.72	4.3	2.94	9.02	0 - 1.3	0 - 8.0	
B-Phellandrene	*	*	*	*	*	*	*	0 - .2	0 - 1.0	
3 - Octanone	*	*	*	*	*	*	*	1 - 2.5	0 - 3.0	
	85.6	79.9	83.73	88.91	86.64	83.36	81.06	0	0	

*** = not tested**

ND = not detected

New York Standards

L x intermedia GC analysis

	Impress Purple	Provence	Fat Spike	True Grosso	Super	ISO
			Grosso			Standards
cis-B-ocimene	0.63	1	0.55	0.48	0.36	.5 - 1.50
myrcene	1.63	2.48	1.07	0.89	0.93	.3 - 1.0
limonene	1.88	1.8	0.79	0.81	1.26	.5 -1.50
trans-B-ocimene	1.05	nd	nd	0.04	0.84	0 - 1.00
1,8-cineole	14.57	24.82	10.12	9.95	6.29	4.0 - 8.04
linalool	43.13	27.79	24.05	25.68	29.14	24 - 37
lavandulol	0.75	nd	0.69	0.74	nd	.2 - 1.00
hexyl butyrate	nd	0.93	nd	nd	0.61	.3 - .50
camphor	7.43	5	8.02	8.53	2.69	6.0 - 8.5
terpinen-4-ol	0.44	5.06	2.31	2.23	0.18	1.5 - 5.01
borneol	10.69	12.7	1.73	2.3	5.85	1.5 - 3.51
a-terpineol	1.06	1.77	0.82	0.83	0.53	.3 - 1.30
linalyl acetate	4.76	2.28	33.49	31.67	38.33	25 - 38
lavendulyl acetate	0.48	0.42	4.12	4.1	2.3	1.5 - 3.51
B-Phellandrene	*	*	*	*	*	*
3-Octanone	*	*	*	*	*	*

*** = not tested for the ISO**
ND = not detected

Red = higher
Blue = lower

Evaluation of the Quality of Essential Oils of Lavender (*Lavandula angustifolia*) and Lavandin (*L. x intermedia*) grown and distilled at high altitudes of Western Colorado, U.S.A.

C.E. Swift[1], G. Dooley[2], and K. Kimbrough[3]

Abstract:

In the summer of 2013, the floral stems of 11 cultivars of Lavender (*Lavandula angustifolia*) and Lavandin (*L. x intermedia* 'Grosso') were distilled and evaluated by Gas Chromatography and Mass Spectrometry (GC-MS) to determine the concentration of their constituents. The results established base-line data of the essential oils of some *Lavandula* cultivars grown and distilled in western Colorado. The CG-MS of these essential oils are compared with international and other accepted standards. Two of the cultivars evaluated were obtained from locations other than at the Korver research site in Palisade, Colorado.

Introduction:

English lavender (*Lavandula angustifolia*) and the hybrid lavandin (*L. x intermedia*) cultivars have been successfully grown and harvested in western Colorado for 10 or more years. While the worldwide market for the essential oil of lavender is substantial no research has been conducted in Colorado to determine the yield or quality of oil of the various cultivars available for production in Colorado. This project was designed to answer the question of which cultivars produce the largest quantity and the highest quality oil.

The essential oil composition of *Lavandula* is known to be affected by species and variety and growing conditions such as latitude and altitude, fertilization, pesticide use (Topalov, 1989), and harvest time (Zheljazkov et al., 2012). While the chemical composition of the oil is largely determined by the genetics of the cultivar, oil quality can also be influenced by all stages of the production system (McGimpsey et al. 1999).

It has been reported high-altitude wild growing plants contain more esters than lavender grown at lower altitudes. The temperature of steam production is lower at higher elevation resulting in the hydrolysis of linalyl esters happening at a much slower rate creating higher quality oil. (http://www.nature-helps.com/agora/lavender.htm)

[1] C.E. Swift, Ph.D., Swift Horticultural Enterprises, LLC.;
[2] G. Dooley, Ph.D., Assistant Professor, Director of Analytical Services, , Center for Environmental Medicine, Colorado State University
[3] Kimbrough, K., Garden Scentsations; Past President, Lavender Association of Western Colorado

During steam distillation molecular rearrangements, hydrolysis of double bonds and de-esterification of ester to alcohols and carboxylic acids can result. This changes the levels of linalool and linalyl acetate the key determinants of the fragrance of the oil. Linalool provides the sweetness and linalyl acetate provides the refreshing odor attributed to this oil. The final odor of the oil, the linalool to linalyl acetate ratio, was reported to be dependent on the length of distillation utilized.

Essential oil of this genus is produced in both the flower heads and foliage in specialized structures known as glandular trichomes or oil glands (Demissie et al., 2012). The largest quantity of oil is found in the calyces. The calyces (calyx – singular) consist of the sepals modified into vase-like structures from which the corolla (flower) protrudes. The calyces are typically called 'buds'.

Materials and Methods:

A randomized complete block design of 10 cultivars (Table 1) of *Lavandula* spp. were planted in May, 2011 in a furrow-irrigated field on property owned by Bob and Elaine Korver, 3601 G Rd., Palisade, Colorado. Each cultivar was planted six times in blocks of 10 plants each. Border plants were placed on the end of each of the eight rows in the trial. Maintenance provided by the Korver's, Swift, and Colorado State University non-student hourly personnel included irrigation, shearing and shaping, and weed control. Nitrogen fertilizer was applied at the rate of 1 pound per 1000 square foot area once each year after the time of the first bloom period.

In the summer of 2013 floral stems of nine of the ten cultivars evaluated were harvested from the Korver site. Floral stems of 'Royal Velvet' sample #2 were provided by LeAnn Nielsen, Nielsen Vineyard, Palisade, CO for distillation.

- *Lavandula angustifolia*
  - 'Folgate'
  - 'Twickle Purple'
  - 'Royal Purple'
  - 'Royal Velvet' (2 samples)
  - 'Buena Vista'

- *Lavandula x intermedia*
  - 'Impress Purple'
  - 'True Grosso'
  - 'Fat Spike Grosso'
  - 'Super'

McGimpsey et al. recommend the drying of floral bundles prior to distillation. ISO 3515 Oil of lavender (Lavandula angustifolia Mill.) and ISO 8902 Oil of Lavandin Grosso (Lavandula angustifolia Mill. X Lavandula latifolia Medik. French type, however specify the essential oil will be produced by "steam distillation of the recently cut flowering tops." Fresh floral stems were used in this trial. Neither the stage of floral development nor the times for preheating or

extraction are given in the ISO standards. The composition of the still, copper or stainless steel is likewise not specified.

Zheljaskov et al. (2012) reported harvest time had a significant effect on essential oil yields, concentration of linalool, and yields of linalool and linalyl acetate. To limit the effect of differing harvest time (floral development) the western Colorado research project used the stages of floral development specified by McGimpsey et al. from 4 and 6 as the time to harvest and distill the various cultivars (Table 1). To meet these requirements floral stems of each cultivar were individually selected for harvest.

Table 1: Maturity Scale

Stage of Maturity	Description of Floral Development
4	Several flowers open, some beginning to wither
5	Approximately equal quantities of withered flowers and buds; some open flowers
6	Few buds left, some open flowers, but mostly withered flowers

McGimpsey, J.A. and Porter, N.G. 1999. Lavender: a growers' guide for commercial production. Pages 61-62.

Floral heads were harvested on the dates noted in Table 2 based on the above floral characteristics. This necessitated several harvest dates for ‘Fat Spike’, ‘Impress Purple’, ‘Royal Velvet’, ‘Super’, and ‘True Grosso’. ‘Betty’s Blue’, ‘Folgate’, ‘Provence’, and ‘Twickle Purple’ had more uniform floral development and floral stems from these cultivars were harvested on the same day.

Table 2: Harvest and Distillation Dates

Cultivar	Harvest and Distillation Date (s) 2013								
	6/17	6/22	6/24	6/27	6/29	7/01	7/02	7/03	7/05
‘Betty’s Blue		x							
‘Fat Spike’					x		x		
‘Folgate’	x								
‘Impress Purple’						x	x		
‘Provence									x
‘Royal Velvet’			x	x					
‘Super’						x		x	
‘True Grosso’	x				x				
‘Twickle Purple’				x					
‘Maillette’ *									

‘Maillette’ was provided by Sage Creations, Palisade Colorado.

Wesolowska, et al reported the time of distillation of *L. angustifolia* has an effect on the content and composition of the essential oils. They found a maximum essential oil percentage of 2% was obtained after two hours of distillation and the highest concentration of linalool as well as linalyl

acetate was found after one hour of distillation. The lowest concentration of the linalyl acetate was observed after 40 minutes of distillation. The minimum amount of essential oil (1%) was obtained after 40 minutes of distillation.

According to Pittman nearly 75% of the total oil yield comes in the first 25 minutes of distillation to give a commercial grade lavender oil. If other molecules are desired in the hydrosol it takes another 50 to 80 minutes of distillation. Statistical analysis of the results showed significant differences between the main constituents of the lavender oil and distillation time.

Note: The sample of 'Maillette' included in this study was steam distilled for ninety minutes using a stainless steel still. The preheating time was not reported.

Guidelines provided by Denny indicate the preheating stage of the distillation process should be no more than five minutes to prevent breakdown of linalyl acetate to linalool as this would result in a reduction in quality. The duration of the extraction is recommended to be between 25 and 30 minutes. The decision was made to follow Denny's guidelines.

Distillation was accomplished on the same day of harvest using an eight gallon stainless steel essential oil still from Mile High Distilling, Denver, Colorado. Approximate 2 gallons (7 L) of fresh floral stems (buds and stems) were firmly pressed into the section of the still designed to hold the plant material. To ensure proper movement of steam through the plant material (the charge) consisting of stems and flowers were compacted into the charge container. Three gallons of Palisade town water was added to the pot and brought to a vigorous boil before affixing the 'charge' to the still. The pot was refilled as needed. The condenser was supplied with cold water and the condensate was collected in one–liter separatory funnels purchased from NovaTech International. Condensate was generated from the condenser within five minutes of putting each charge on the still. The condensate from the condenser was adjusted to generate a steady stream of liquid by regulating steam production and the temperature of the condenser. A propane burner was used to generate steam in the pot.

When the separatory funnel filled with hydrosol and essential oil, the petcock on the bottom of the separatory funnel was opened and the hydrosol drained off. The essential oil was collected in sterile pint size canning jars. Each container was identified by cultivar name and date of distillation.

The essential oils were placed in the freezer to dewater the samples. The water in the sample froze and the water-free essential oil poured off in another sterile canning jars. Sterile pipettes were used to transfer the e.o. into five-millimeter amber glass bottles with hard plastic caps and chemical resistant liners.

Each collection of amber bottles were identified and placed in a refrigerator until all samples were processed and ready for shipment to the analytical laboratory for testing.

The e.o. samples were mailed on August 9, 2013 to Dr. Gregory Dooley, Assistant Professor, Director of Analytical Services, Center for Environmental Medicine, Dept. of Environmental and

Radiological Health Sciences, at Colorado State University, Fort Collins, CO. for analysis. Essential oil of 'Maillette', provided by Sage Creations Organic Farm was included in this mailing.

The following specifics on the characterization of Lavender Oils by GC-MS were provided by Dr. Dooley.

Sample Preparation

1. In a 13 ml conical vial, add 150 mg of desiccated magnesium sulfate to 1ml of lavender oil and vortex
2. Cap vial and allow lavender oil to sit at room temperature for 2 hours with intermittent vortexing (every 30 mins)
3. Centrifuge sample at 1500 rpm for 5 mins
4. Dilute 100ul of lavender oil supernant to 1 ml with acetone in a GC autosampler vial for GC-MS analysis

GC Conditions

Column: Restek Rxi624Sil MS 30m x 0.25mm x 1.4 um
Carrier Gas: Helium
Inlet Temp: 2500^{o}C
Flow Rate: 1ml/min
Oven Program: 60^{o}C for 6mins to 310^{o}C at 10^{o}C/min (31min run time)
Injection Volume: 2ul via autosampler
Split Ratio: 200:1

Mass Spectrometer Conditions

MS: EI+ Full Scan from 40-200 m/z
Source Temp: 220^{o}C
Transfer Line Temp: 280^{o}C
Electron Energy: 70eV

Data Analysis

Peaks were identified by comparison of MS spectra to the NIST MS spectra database. Identifications were considered valid with NIST algorithm Match Scores greater than 800 (out of 100) and Match Probabilities greater than 60%. Each peak in the chromatogram was integrated and % of total area calculated for each peak.

Statistical analysis of the oils was not accomplished due to lack of adequate quantities of oil and funds available for analysis. Ideally each plot of ten plants should have been distilled and analyzed separately. The amount of floral matter available from each plot was limited and had to be combined to fill the charge to the appropriate level. Denny indicates the height of charge is critical to avoid reflux and the hydrolysis and de-esterification of the desired components.

For the CG-MS results see Appendix.

Discussion:

The internationally recognized standards 3515 and 8902 provide a benchmark with which to compare oils from new production areas. These standards are often referred to in the world trade.

The International Standards 3515 for *Lavandula angustifolia* refer specifically to oils of lavender produced in France, Bulgaria, the Russian Federation, Australia, and other unnamed locations. 'Maillette' is the only named cultivar included in this ISO for which a specific listing of components are given. Spontaneous (wild-growing or seeded plants) and unnamed cultivars of other countries is also listed with a breakdown of e.o. components.

There are two sets of standards for American growers. The official international standards described above and what American companies are purchasing. The latter are based on what is arriving at the Port of New York (Tucker, 2001).

The purpose of this research was to compare Lavandula cultivar essential oil to the international standards and to develop a base line for cultivars grown in western Colorado. Wesolowska reported all of the oil samples they studied contained less linalyl acetate and cis-β-ocimene than the range specified in ISO Standard 3515. Their samples also contained higher levels of α-terpineol than called for in the specifications. Sean Westerveld, Ginseng and Medicinal Herbs Specialist, Ministry of Agriculture and Food, Ontario, Canada, evaluated the essential oil of 31 cultivars of *Lavandula* and none matched the ISO standards (personal communique). Tucker, 2001, reported the only cultivars that compared favorably with 'Maillette' were 'Munstead' (syn. 'Compacta'), 'Irene Doyle', and 'Twickel Purple'. With the exception of 'Maillette' in the Colorado trials the other cultivars did not meet the requirements of the ISO standards.

This publication was supported by the Specialty Crop Block Grant Program at the U.S. Department of Agriculture in cooperation with the Colorado Department of Agriculture. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA or CDA.

References:

Denny, E.F.K. 2001. Field Distillation for Herbaceous Oils. Denny, McKenzie Associates, Tasmania, Australia.

Demissie, Z.A., Cella, M.A., Sarker, L. S., Thompson, T.J., Rheault, M.R., and Mahmoud, S.S. 2012. Cloning, functional characterization and genomic organization of 1,8-cineole synthases from Lavandula. Plant Mol. Biol 79:393-411.

ISO 3515. Oil of Lavender (*Lavandula angustifolia* Mill.) 2002-04-15.

ISO 89802. Oil of Lavandin Grosso (*Lavandula angustifolia* Mill. X *Lavandula latifolia* Medik.), French type. 2009-04-01.

Pittman, V. 2004. Aromatherapy: a practical approach. Nelson Thornes 2004.

McGimpsey, J.A., and Porter, N.G. 1999. Lavender a growers' guide for commercial production. Crop and Food Research Mana Kai, Rangahau. New Zealand.

Topalov, V.D. 1962. Lavender. Essential Oil Crops and Medicinal Plants. 15.HR.G. Danov Press, Plovdiv, Bulfaria pp. 153-183.

Tucker, A.O. 2001. Standards for lavender, lavandin and spike: commercial oils and cultivars. Lavender Bag 15:11-14.

Wesolowska, A, Jadczak, D., Grzeszczuk, M. 2010. Influence of distillation time on the content and composition of essential oil isolated from lavender (*Lavandula angustifolia* Mill.). Herba Polonica, 56 (3): 24 – 36.

Zheljazkov, V.D., Astatkie, T. and Hristov, A. N. 2012. Lavender and hyssop productivity, oil content, and bioactivity as a function of harvest time and drying. Industrial Crops and Products 36: 222-228.

Final Report: Fast Track Development of 21st Century, Slow-darkening Pinto Bean Varieties to Enhance Colorado Global Competitiveness
Partner Organization: Colorado State University, Fort Collins, CO

Project Summary

Colorado pinto beans are prized because they have a bright cream background color. However, in 2015, North Dakota released a new pinto variety that possess a novel gene, termed "slow darkening" (SD), which conditions bright cream pinto color, and reduces discoloration in storage. Because this new variety will likely not be adapted to Colorado growing conditions or possess the needed resistance to rust and other pathogens, there was a need to develop SD varieties for Colorado. The goal of this project was to speed up the development of pinto bean varieties that possess the SD trait with disease resistance, upright architecture, and high yield potential. The Dry Bean Breeding Project at Colorado State University initiated crosses in 2012 to incorporate the SD trait into breeding lines; however, funding resources available at the time would require 6 to 7 additional years to complete. Funds from SCBGP allowed the project to complete the development of two SD varieties by 2015, thus allowing the Colorado bean industry to remain competitive in both the U.S. and global markets. A conservative impact would equate to an increase in crop value between $1.6 and $3.2 million annually and prevent the erosion of competitiveness for the Colorado bean industry.

The Colorado dry bean industry continues to lose local production of pinto beans due to high prices for competing crops such as corn and wheat. This loss is exacerbated by lower production costs for dry edible beans in the northern Great Plains Region and Minnesota. However, Colorado pinto beans are still considered the highest quality produced in the U.S. and often command a premium price. The introduction of SD varieties to the northern Great Plains will surely further erode the competitiveness of the pinto bean industry in Colorado. The goal of this project was to place the development of pinto bean varieties with the slow darkening trait on a "Fast Track" to allow Colorado bean producers to compete with other U.S. markets.

Beans with the slow darkening trait compared to conventional pinto bean lines are shown in Figure 1.

The varieties developed by this project also possess desirable agronomic and disease resistance traits required for commercial production in Colorado, and minimize the dependence on pesticides. Agronomic traits focused on pinto bean lines with excellent seed characteristics such as size, shape and color and the SD trait. The SD trait will allow the beans to withstand storage conditions that normally cause seed discoloration from environmental conditions (e.g., variation in temperature and moisture) and enjoy a longer marketing period. This trait will give Colorado producers the same competitive edge that other production regions in the U.S. will enjoy to allow us to compete with them for high quality pinto beans that do not discolor in storage. In the absence of varieties with the SD trait adapted to Colorado, Colorado's status as the premier producer of high quality pinto beans is in jeopardy.

The specific goal of this proposal was to release two slow darkening pinto bean varieties to Colorado dry bean producers in late 2015. The varieties possess the slow darkening trait

Figure 1. Top lines - all non-slow darkening, bottom lines - all slow darkening after exposure to UV light for 24 hours.

combined with desirable agronomic traits to allow them to be competitive in the national and global dry bean market.

Funds received from the SCBGP complemented those received from other Colorado sources including the Colorado State University Agricultural Experiment Station, Colorado Dry Bean Administrative Committee and Colorado Seed Growers Association, to allow us to initiate "Fast Track" breeding efforts to combine the SD trait into promising 21st century pinto bean lines. The SCBGP funds allowed the project to complete final stages of variety development for two varieties of slow darkening pinto beans by fall 2015.

These funds accomplished this, in part, by utilizing seed increases in winter nurseries in New Zealand to advance final materials more quickly to release and distribute seed sooner to seed producers. The varieties will ensure that Colorado growers and industry have access to SD pinto bean varieties that possess upright growth characteristics for direct harvest, disease resistance to reduce the dependence on pesticides, early maturity to allow timely harvest for crop rotation to winter cereal crops, and high yield potential.

Project Approach

Research Sites

The research was conducted using Colorado State University Research Stations at Fort Collins (ARDEC) and Fruita (Western Colorado Research Center), CSU greenhouse facilities at Fort Collins, and a winter nursery in New Zealand. The Dry Bean Breeding Project (DBBP) had access to all resources to complete stated goals and objectives.

Project Timeline

Activities were initiated prior to this grant in 2011 and completed in fall 2015. Specific activities by year are shown below.

2011
Summer/Field activities:
Parental material was used for crossing to incorporate the slow darkening trait (gene) into breeding populations to combine upright architecture, rust resistance, *Bean common mosaic virus* (BCMV) resistance, and desirable commercially accepted agronomic traits were selected for crossing.

Fall/ Greenhouse activities:
We made eight single crosses between slow darkening pinto breeding lines previously developed by the DBBP at CSU and three commercially acceptable pinto varieties, including Croissant, Long's Peak and Stampede, all of which possess resistance to foliar rust, BCMV, and have upright plant architecture. Fifty F_1 seeds from 12 single crosses were produced.

2012
Spring/Greenhouse:
The F_1 seed was sown in the greenhouse during spring to produce F_2 seed. The F_2 seed produced for each hybrid population was harvested in bulk for planting during summer 2012. Each F_1 plant produced approximately 30 seeds for a total F_2 hybrid population size of 1500 F_2 plants to plant in the field during summer 2012.

Summer/Field:
F_2 seeds from each hybrid population were planted in progeny blocks. Each block had a minimum of 1500 plants (some >3000 plants) and each block was maintained separately to maintain pedigree identity. In September, we made 200 single plant selections based on desirable agronomic traits in each of the four best hybrid populations.

Fall/Greenhouse:
One seed from each of the 200 selected F_2 plants (4 populations X 200 = 800 total plants) was planted in the greenhouse to produce F_3 plants. During the fall, one leaf from each of the F_3 plants was inoculated with a pathogenic strain of common bacterial blight and one leaf inoculated with foliar rust to screen for resistance to these pathogens. Most plants were resistant to rust, but most were moderately or highly susceptible to common blight. Only resistant or moderately resistant plants were saved. One or two seeds from each selected plant were saved to make up a total of 200 plants in the next generation (F_5).

2013
Spring/Greenhouse:
One or two seeds from each of the resistant or moderately resistant F_3 plants were planted in the greenhouse to produce F_4 plants in the greenhouse. The seed produced on the F_4 plants was used for field evaluation/selection during the summer 2013. To ensure that the slow darkening allele was fixed in the selected plants, we screened seed from every plant using the UV light method to

determine if they were homozygous recessive for the *sd* allele (*sdsd*), therefore phenotypically stable for the slow darkening trait. All non-slow darkening lines will be either homozygous dominante (*SdSd*) or heterozygous for the allele (*Sd sd*). Figure 1 shows the results of the UV screening technique. Only homozygous lines were advanced for field evaluation and testing.

Summer/Field:

For each of the four hybrid populations we selected the best 150 F_5 lines based on seed quality, rust and common blight reaction, and other agronomic traits. The greenhouse seed was divided into two equal portions. Half of the seeds from each $F_{4:5}$ line was planted at Fort Collins for phenotypic selection and half was planted in Fruita, CO for clean seed increase and subsequent shipment to New Zealand for winter increase of selected F_5 families. The seed for shipment to New Zealand had to be grown in Fruita, CO because that is a bacterial pathogens free environment and enables us to obtain a phytosanitary permit to ship seed to New Zealand for seed increase, which could not occur for Ft. Collins grown seed. By growing each F_5 family in Fort Collins, we were able to select the best 50 lines for adaptation to Colorado growing conditions and further select for agronomic traits such as plant architecture, disease resistance, maturity and seed quality. All lines were again screened for slow darkening phenotype using the UV method to ensure they are homozygous and pure for the trait. We produced approximately 1 lb. of Fruita grown seed that was sent to New Zealand for seed increase to produce ~ 10 lbs. of seed for replicated plot testing and further increase for the summer of 2014.

2014

Seed from 50 lines harvested from the Fruita increase were shipped to New Zealand in late November, 2013 for winter increase. I visited the NZ increase plots to rogue off-types and take notes on the lines. After taking notes on morphological and seed trait, I discovered that some lines had a seed trait known as "Fish Mouth" where the seed coat ruptures and exposes the cotyledons. It allowed me to discard at least ten lines for Fish mouth, poor growth habit, low yield and other traits necessary for a commercial cultivar. I was able to reduce number of lines to about 40 for harvest and shipment back to Colorado for summer 2014 testing.

Summer Field Nurseries:

The seed grown from in NZ was split in two portions. One portion (~ 4 lbs.) was used for yield testing and phenotypic evaluation (disease resistance, architecture, maturity, etc) at Fort Collins, Lucerne, CO and Yuma, CO. The remaining seed (~4 lbs.) was planted in Fruita for clean seed increase at Fruita, CO. We field tested the 40 lines that we identified in NZ at Lucerne, Yuma, and Fort Collins, CO during 2014. Based on field performance and seed quality we selected the best 6 lines for further increase for pure seed to send back to New Zealand during winter 2014-15. The winter 2014-15 increase was used to produce Breeder Seed and seed for testing in field trials in 2015.

Problems encountered: Because there was some outcrossing that occurred in the seed increase program that allowed some normal darkening seed in the NZ seed increase, we had to expose the seed from the 6 lines we sent to NZ using UV light to identify and select only slow darkening seed. We were able to hand pick 4-5 lbs. of seed to send back to NZ for further increase for Breeder Seed. I again visited the plots in NZ during winter to reduce the number of lines sent

back to us to 5 lines. These lines were planted at Fruita for the production and release of Foundation seed of two varieties for release in the fall/winter 2015-16.

Winter Field Nursery/ New Zealand: 2014-15
We increased the seed of the six selected lines to ~60 lbs of Breeder Seed used for planting Foundation seed during summer 2015 in Fruita, CO. The New Zealand seed will be inspected in New Zealand and considered as Breeder Seed.

2015
Field: Fort Collins, Colorado:
We used the New Zealand seed to plant replicated trials at Fort Collins and sent to the Cooperative Dry Bean Nursery and grown at 10 locations in the US to demonstrate improved slow darkening pinto varieties to growers, and publish the results for promotion of newly released varieties in *Colorado Bean News* and elsewhere.

Field:
Fruita, CO Foundation Seed Increase:
We planted five Breeder Seed lines from seed produced in NZ for Foundation seed increase at Fruita, CO in early June, 2015. Each of the five seed lots were planted to ~ 1 acre and produced approximately 1500 lbs. of Foundation seed. Based on field testing of the four lines in eastern Colorado and in the CDBN, we selected the best two lines, COSD35 and COSD7, from the five increases for release to seed producers in fall 2015. To date we have harvested and cleaned the seed and are ready to determine the best way to release them to seed producers. Our experience with this project has demonstrated the need for field isolation during the seed increase, and precise handling needed to prevent outcrossing during seed production. Outcrossing causes the resultant seed to segregate for slow versus regular darkening and appear as a mixture in the commercial seed product. This effect is known in the industry as "salt and pepper" as the seed ages or is canned and is a serious concern for the industry. To prevent outcrossing during seed and commercial production, fields must be isolated from all other bean fields. Given this problem, we feel that the release of the two lines must be done on an exclusive basis to growers and commercial producers that have strict standards and understand the need to maintain genetic purity. To do this, we plan to release the lines only to knowledgeable grower/seed processors through an exclusive release.

Goals and Outcomes Achieved

Our objective for this project was to release two slow darkening pinto bean cultivars to dry bean producers in Colorado and the U.S. in late 2015. With the production of Foundation seed in summer 2015 for release to growers, we have completed this objective. Performance data from the Cooperative Dry Bean Nursery is not available at this date for all 10 locations, however, performance of the two slow darkening lines COSD 35 and COSD 7 are shown for two locations (CO and WA) (Tables follow). Both COSD 35 and COSD 7 possess upright growth habit, resistance to rust and bean common mosaic virus, and have high yield potential. The Foundation seed for the two varieties produced in 2015 will be made available to appropriate company or agency to produce Registered and Certified seed for commercial production for summer 2016.

Table 1. Performance of dry bean lines at Othello WA, 2015.				
Cooperative Dry Bean Trial, Othello WA				
	Harvest maturity	Lodging	Seed weight	Yield
Entry	days	1 to 9	g 100 seeds	kgha
PT9-5-6	102.3	3.7	39.5	5475
Eldorado	114.0	5.3	47.7	5047
23ST-27	99.3	6.2	42.7	4893
UIP-35	105.0	7.5	37.6	4764
UIP-46	107.0	5.2	46.3	4623
ISB-1173-1	91.0	5.5	49.1	4578
Fathom	111.7	3.3	24.5	4552
Centennial	107.7	4.2	41.9	4540
UIP-40	110.3	3.8	37.8	4512
SF103-8	109.3	6.3	39.7	4437
Othello	101.0	8.0	44.0	4363
COSD-35	110.3	6.3	39.1	4353
COSD-44	102.3	5.7	40.9	3829
ISB-2884-4	110.7	5.7	24.5	3753
ISB-96-3156	95.0	2.5	25.6	3680
COSD-7	100.0	4.5	40.3	3629
COSD-3	97.0	6.3	35.7	3616
COSD-25	100.3	5.8	37.9	2745
Mean	104.1	5.3	38.6	4299
CV	2.1	18.1	3.1	7.3
LSD 0.05	3.4	1.4	2.1	498

Performance of dry bean lines in the Cooperative Dry Bean Nursery at Fort Collins, CO in 2015.					
2015 CDBN Fort Collins, CO					
Entry	**Seed Yield**	**Seed Weight**	**Days to**	**Days to**	**Rust‡**
PT9-5-6	3714	35.0	47	87	1
Powderhorn GN	3689	36.1	46	83	2
UIP-35	3609	33.1	47	84	1
COSD 7	3255	38.5	44	82	3
COSD 44	3222	38.3	43	83	2
Gypsy Rose	3183	28.6	47	88	5,6
COSD 35	3148	36.3	43	84	3
UIP-40	3102	30.9	50	89	1
Inferno	3074	54.2	43	89	3
COSD 25	3006	40.2	43	75	3
Centennial	3003	40.4	44	82	2
COSD 3	2822	36.2	42	78	3
Zenith black	2750	20.7	49	87	5,6
Desert Song	2732	34.8	45	80	5,6,seg?
Dynasty	2717	54.5	44	81	3
Alpena navy	2654	18.6	49	85	3
ISB13-796	2628	35.1	48	83	5,6
Majesty	2483	62.7	45	85	3
Yeti	2439	52.3	44	87	1
Rosie	2433	49.4	44	84	2
ISB96-3156	2408	24.5	42	78	2
UIP-46	2334	37.2	47	86	5,6
Fathom	2320	20.7	46	85	5,6
UCD 0908	2197	49.7	47	92	3
SF103-8	2087	32.3	43	83	5,6
UCD 0701	2038	59.1	43	85	3
ISB2884-4	1963	19.7	50	84	5,6
Talon	1882	49.5	42	80	1
Mist	1878	18.8	48	87	5,6
ISB1259-60	1831	34.1	42	76	5,6
Snowdon WK	1747	56.6	40	80	3
CELRK	1723	54.4	40	80	3
Eldorado pinto	1605	34.2	47	89	5,6
ISB1173-1	1535	33.9	43	83	5,6
Othello	1467	31.0	40	74	5,6
23ST-27	1338	32.9	46	84	5,6
ISB1231-1	1212	33.1	43	82	5,6
Mean	2564	36.7	45	84	
LSD (0.05)	449	2.0	2		
CV (%)	12.6	3.7	3		
‡ Bean Rust reaction to local endemic Colorado races: 1=no symptoms, 2 necrotic flecks, 3=small pustule, 4, 5, or 6=susceptible.					
Plots planted 6/15/2014, Undercut with Pickett One-Step 9/18, threshed with Hege 9/23					

Beneficiaries

Pinto beans are the most important and largest class of dry beans produced and consumed in the U.S. and represent a major export market for the bean industry. Colorado currently ranks between 5th and 7th nationally in total dry bean production and second in pinto bean production. There are over 300 people involved in dry bean production in Colorado including farmers, handlers or landlords of farmers who raise dry beans. In Colorado, dry edible bean farm gate value based on production and processing is between $20.5 million in 2005 and $68 million in 1990 (National Ag Statistics Service). Furthermore, the western region of Colorado has a thriving certified pinto bean seed industry that produces and markets $500,000 to $2,000,000 seed annually. New competitive varieties could double or more the capacity of the seed industry alone. The development of slow-darkening pinto bean varieties will also allow Colorado to remain competitive in both the U.S. and international markets, and maintain their status as the producer of the highest quality pinto beans in the U.S. The varieties developed from this project will provide growers and the bean community a variety with unique seed quality and the desired agronomic and disease resistant traits to fit the evolving 21st Century bean production practices. New high quality varieties will ensure the economic viability of the bean industry and keep Colorado beans competitive with those under development in other dry bean regions of the U.S. Given that the dry bean industry is a multimillion dollar industry, a conservative impact of 5 to 10% would equate to an increase in crop value between $1.6 and $3.2 million annually and prevent the erosion of competitiveness for the Colorado bean industry.

Lessons Learned

The most important lesson from this research project is that partnerships with government (CDA, CSU), private grower organizations (Colorado Seed Growers Association) and stakeholders (Colorado Dry Bean Administrative Board) can result in success and provide stakeholders with tangible goods that enhance their economic viability. The "Fast Track" approach to developing two novel pinto bean varieties would not have been possible without Specialty Crops funding from USDA/AMS government or participation by the Colorado Department of Agriculture. It would also not be possible without the use of the winter nurseries in New Zealand in 2013 and 2014 to increase seed supplies and advance through the inbreeding process. This project should be one example of success for the Specialty Crops Block Grant Program in the U.S.

Contact Person

Dr. Mark Brick
Department of Soil and Crop Sciences
Colorado State University
970-491-6551
Mark.brick@colostate.edu

Project Title: A Systems Approach to Improving the Safety of Cantaloupes
Project Partner: Colorado State University, Fort Collins, CO

Project Summary

This project addressed the need for solutions aimed at increasing the safety of cantaloupes. Cantaloupes have been the vehicle responsible for multiple foodborne illness outbreaks and the cause of consequential damage to the melon industry. Cantaloupes possess inherent advantages for the growth of microorganisms, such as a large complex surface, ability to hold heat, neutral pH, and soil contact; therefore, researchers focus on understanding factors related to cantaloupe which protect and foster the growth of bacteria and the practices from field to table that influence this relationship. Evidence is accumulating to quantify the impacts of various factors but research is also revealing confounding elements which affect the surface ecology. We now know more about the problem but progress towards mitigation has been limited.

While the issues of preventing and removing contamination continue to be addressed, the major outbreaks associated with cantaloupe in 2011 and 2012 prompted actions on the part of Colorado growers to form an association with obligatory production protocols, FDA to implement packing shed inspections, and organizations, including the Colorado Fruit and Vegetable Growers Association and CSU Extension, to provide educational opportunities to growers related to good agricultural practices and food safety. Although the challenges of microbial contamination have not diminished, the food safety climate has improved.

Our approach to improving the safety of cantaloupe was to be systematic but the system changed over the last few years. As new situations emerged, with the formation of supportive grower associations, adoption of farm and packing shed safety protocols, and advancements in information-sharing technology, needs and opportunities for education and guidance materials changed. Outreach education has changed in recent years to include more computer-based information via websites and social media platforms. These factors impacted the original goals of the project including methods of gathering input and providing food safety training and information. A central focus was on gathering baseline information regarding microbial profiles and treatment interventions during processing and by consumers to better understand contamination dynamics. Field and packing shed samples were collected and analyzed with the aim of helping guide post-harvest handling and washing protocols (Chandler et al. 2014) and home washing experiments were conducted (Coleman et al. 2015; Thompson et al. 2014) but results varied.

Gaining familiarity with food safety issues can be key in instilling producer confidence to identify and mitigate on-farm contamination risks. In addition, producers need to plan for the costs of employing food safety plans to maintain financially viable operations. To better assess the local situation, a 19-question food safety cost survey was conducted in Colorado and the curriculum for a full day workshop was developed, delivered, and evaluated by a team of agriculture professionals and Extension specialists and agents.

This project was built on previous work of the team, which has been strongly anchored in improving the safety of agricultural products. Farm-to-Table Food Safety for Colorado Produce

Crops: A web-based approach for promoting Good Agriculture and Handling Practices, funded in 2010 by the Colorado Department of Agriculture through a Specialty Crop Block Grant, generated three webinars still available online and a series of ten produce fact sheets (Wall 2011).

One principal feature of the current project which helped in establishing a stronger network among food safety and public health professionals in Colorado was the development of the CSU Center for Food Safety and Prevention of Foodborne Disease. The first major activity of the Center was to host a *Listeria* Summit in December of 2011 which was followed with a Cantaloupe Symposium in 2013. The Center became an integral part of the Colorado Department of Public Health and the Environment's Integrated Center of Excellence in Food Safety (CoE), designated by the Centers for Disease Control and Prevention in 2012. The two Centers share a common website, housed at Colorado School of Public Health: COFoodSafety.org. The Center provides agricultural production expertise via an interactive website (wiki), *FSI – Food Source Information* (fsi.colostate.edu) to assist public health professionals across the U.S. in their ability to respond to outbreak events.

This tool was developed as a direct result of the 2011 *Listeria* outbreak and serves as a platform for food safety and production information for agricultural commodities. Posted articles were written by public health professionals and Colorado State University faculty and graduate students and reviewed by experts in food production.

The subject of the first wiki article was cantaloupe production. Yearly web traffic to the website from November 1, 2014 to November 1, 2015 included over 19,000 sessions by more than 17,000 users. Twenty-three graduate students who were enrolled in FTEC 574, Current Issues in Food Safety, contributed as writers and reviewers of wiki articles, and researchers from three other states have contributed articles as well.

This informational tool has received accolades at the national level from public health professionals at CDC and FDA, a state-wide innovation in technology award, and it provides important learning and translational experiences for students. Content is intended as a tool for those in the field conducting epidemiological investigations who need basic information on production practices and offers the potential to reduce the impact of foodborne illness outbreaks.

The farm to table approach is also an integral part of the CSU Farm to Table website (http://farmtotable.colostate.edu/), which provides food safety information to all food system stakeholders, including farmers and gardeners (Bunning et al. 2014). On the website, growers have access to GAP (good agricultural practices) webinars and information for creating a farm food safety plan. From November 1, 2014 to November 1, 2015, there were over 36,500 page views by 26,098 unique visitors.

Previous work also included a survey of consumer cantaloupe handling practices in collaboration with researchers at the Centers for Disease Control and Prevention (Scanlan et al. 2013), testing of consumer washing practices (Thompson et al. 2014), and a review of scientific literature related to cantaloupe production, outbreaks, and washing technologies (He 2015). A curriculum

for one-day food safety workshops was developed, delivered, and evaluated by a team from CSU Extension for growers in different regions of the state (Bunning et al. 2015).
A Western Regional Food Safety Center, centered at Oregon State University, has recently been funded by USDA/NIFA and CSU will serve as the lead for the six-state Mountain Region in this Center focused on providing food safety training for produce growers and food producers. The Center for Food Safety and experience with food safety and agricultural production developed over the last three years helped position CSU to play an important role in this endeavor.

Project Approach

Commercial cantaloupe harvested in Colorado and sold to consumers is generally exposed to a washing treatment soon after harvest. FDA recommends all produce, including cantaloupe, be washed again in the home environment near the time of consumption. Our approach included examining the microbial status of cantaloupe during processing, both before and after washing, and after a treatment intervention of chlorine dioxide as well as before and after various consumer washing techniques.

Samples were collected during melon harvest and processing from a farm operation with a processing shed in Rocky Ford, Colorado in 2013 and 2014. One hundred cantaloupe melons were collected prior to washing and 100 were collected after washing and ten additional cantaloupe were collected from final product stored in a cold room. After being individually bagged in whirlpak bags, the melons were placed in plastic crates with ice, sealed, and transported to the microbiology lab in the Department of Animal Sciences at the University of Wyoming for testing.

In addition, water was sampled from well water, faucets, spraying nozzles, and drains. Environmental samples were collected from 23 sites on processing equipment, with two adjacent areas sampled for *Listeria* selective enrichment and *Salmonella* selective enrichment, as well as for total aerobic plate counts (TAC) and fecal coliform plate counts (FCC). Swabs were placed in individual whirlpak bags, labeled, placed in sealed plastic bags, and covered with ice for transport to the lab for testing.

Microbial testing of samples from the farm and packing shed collected in Year 1 revealed TAC were statistically higher for cantaloupes that had been washed compared to those not washed and FCC were statistically lower on washed cantaloupe compared to unwashed cantaloupe. In Year 2 there was no reduction in fecal coliforms or total aerobic counts after washing. While total aerobic counts were similar between years, fecal coliform counts were much higher, in the 10^6/ml range, in Year 2. *Listeria* was not detected in samples collected in Year 1 or Year 2. In Year 1 17 samples tested positive for *Salmonella* but in Year 2 *Salmonella* was only detected after enrichment and none of the 2014 samples were positive via RT-PCR.

To gather information about farm food safety practices, a 19-question survey was distributed to produce growers (n = 52), including melon growers. Survey results indicated no correlation ($p > 0.05$) between operation size and having a plan; 40% of growers with 10 to 100 acre farms were operating without a functional and complete food safety plan. Larger-scale growers (>100 acres; $500,000 sales) reported lowest total costs per acre for food safety practices; smallest scale

growers had the highest per acre costs for food safety. The survey confirmed great diversity among produce growers in terms of farm specifics and food safety preparedness although this varied by region.

Only 17% of participants reported keeping records of on-farm food safety costs. A six-month post workshop survey was also distributed and 67% of participants reported making changes to their food safety plans within the previous six months. It appears produce growers are unequally prepared to adapt current food safety practices to the new Food Safety Modernization Act regulatory environment. Survey findings helped guide the development and planning for three regional one-day workshops which were divided into seven sessions: On-Farm Food Safety Planning, Food Safety Landscape, Worker Health and Hygiene, Irrigation Water Management, Harvest and Post-harvest Operations, Traceability and Recall, and Preparing for Audits. Seventy-nine per cent of workshop attendees reported an increase in their confidence about on-farm food safety, rated as 'considerably' or 'to a great extent,' while 44% indicated they intended to start developing a food safety plan for their farm. Participant quotes indicate increases in confidence: *"Managing food safety practices seems to be less threatening than in 2013 or 2012. Probably due to a better understanding of what is expected."*

Social media and interactive websites have become effective channels for public health professionals to communicate health information, including information disseminated from Land Grant Universities through Extension networks. To access the current use and future potential of social media by outreach professionals, a 67-item survey of CSU Extension personnel was developed and distributed to agents across the state (Peth 2013). Results (n = 69) indicated 64% use social media for professional purposes and most respondents agreed that social media can improve job effectiveness and productivity.

Goals and Outcomes Achieved

Assess equipment sampling as a way to evaluate the efficacy of cleaning and sanitation in packing shed.

One principle project goal was to examine data from environmental sampling of the packing shed surfaces, including equipment, to assess the efficacy of cleaning and sanitation. This goal was addressed by duplicate sampling of 23 sites in Year 1 and Year 2. However, results indicated washing had no impact on bacterial counts between equipment upstream or downstream of the wash process.

Evaluate novel wash water disinfection strategies to reduce the extent of cross contamination during cantaloupe washing.

The goal to evaluate novel wash water disinfection strategies, specifically incorporating chlorine dioxide as an intervention step via the processing line, had mixed results. This goal was completed by sampling and testing cantaloupe (n = 400) before and after treatment in two consecutive years. Fecal coliform counts in the first year were lower post-treatment however total aerobic counts were higher. Results also varied by year, with fecal coliform counts being much higher in the second year for no obvious reason.

Conduct needs assessment with cantaloupe producers.
Assess motivators and barriers to implementation of food safety practices among growers/producers.

Two original goals, to conduct a needs assessment of cantaloupe producers and to assess motivators and barriers to implementation of food safety practices among growers, were combined and expanded to include growers of all types of produce because of the small number producers, particularly melon producers. To assess current food safety practices and associated costs, a 19-question survey (n=52) was distributed.

Create dedicated webpages for growers with best practices for safe cantaloupe production and handling.
To develop GAPs/GHPs webinars for melon growers specifically focused on minimizing growth of L. monocytognes during growing, processing and transporting to market.

The results of the previous goal, the needs assessment and grower interviews, were used to help address the goal to provide food safety education opportunities to growers. Face-to-face workshops were determined to be more desired by growers than on-line modules. A seven-part curriculum addressing the food safety needs of local produce growers was delivered in three workshops (n = 49 from 13 Colorado counties). A six-month post workshop survey of participants was also conducted.

The release of information and implementation of FSMA-associated regulations has been understandably slow due to the need for stakeholder input and time to create an appropriate curriculum to provide educational training. In 2012 when this proposal was written we had no way of knowing that a nation-wide curriculum would be developed but as this became known, CSU participated in committees, calls, and webinars – in fact hosting a webinar, Food Safety Modernization Act: Proposed Rule for Produce Safety Overview and Q & A Session with FDA officials on October 28, 2013 in collaboration with the Produce Safety Alliance. As mentioned, CSU will help in coordinating the upcoming training sessions across six mountain states.

In addition, CSU is working with the Colorado Fruit and Vegetable Association to develop online materials in 2016 for growers to update farm food safety plans to be FSMA-compliant.

Outreach programs and materials targeted to older consumers regarding nutritional benefits and safe handling of melons and other fresh produce.

To fulfill the goal to provide research-based information to consumers, washing methods were evaluated. Results indicated running water and heated water were more effective than washing methods which included aids such as vegetable brushes or soap. This is counter to current recommendations and needs further research. Multiple outreach materials were developed to encourage safe handling of produce by consumers. These included produce information handouts, Facebook posts (farmtotable.colostate.edu), and Pinterest posts.

For the purpose of sharing agricultural and safe handling information, cantaloupe production information was developed, reviewed, and made accessible on the Colorado Food Source Information interactive website. In addition, print media including refrigerator magnets, coasters, and postcards conveying safe cantaloupe handling practices were developed and targeted to higher risk audiences. Information targeted to growers is maintained in the *Grow* section of CSU Farm to Table website.

Develop on-line modules for shippers, retailers and farmers' market vendors focused on best practices for cold chain management, transportation, retail melon storage and display, food service handling and point of purchase signage on safe handling of whole melons.

An information sheet was developed to provide guidance related to cooling produce post-harvest, Precooling Colorado Crops, http://farmtotable.colostate.edu/grow-files/precooling-crops.pdf, and presentation materials were developed (Friedman 2013). Information was presented at a Cantaloupe Symposium at Colorado State University and posted on-line.

Goals not achieved

To evaluate naturally available compounds that suppress the survival and growth of foodborne pathogens in soil.
To evaluate the potential for internalization of bacterial pathogens during washing.
Collaboration with researchers in other states was originally planned for these goals but that did not turn out to be possible, partly due to variability in funding among states and partly due to the Principle Investigator leaving Colorado.

Beneficiaries

This project provided information and outreach materials which are beneficial for current and future produce growers in Colorado and the Rocky Mountain Region. Valuable data was added to the growing library of research in the area of produce safety. In addition, the researchers associated with this project provided numerous graduate students with experiential learning opportunities which generated expertise that, in several instances, is being used directly in their current employment positions. The body of information and knowledge created by this project will help the researchers and the students/public they engage as we collectively move toward a better understanding of produce production issues and the improvement of handling practices.

Lessons Learned

There is still more to learn about cantaloupe. As stated in the project summary, evidence is accumulating to quantify the impacts of various factors but research is also revealing confounding elements which affect the surface ecology. We now know more about the problem but progress towards mitigation has been limited.

A systematic approach has to be dynamic because that is an inherent characteristic of a complex system.

With a complicated challenge such as improving produce safety, it truly takes an active team, from a variety of disciplines, working together on common goals to make progress. With any multi-year project, transitions can be expected but this project experienced an especially high number of changes among the investigators/research team and also changes in the original plans to collaborate with researchers from other states.

Since 2013, two members of our team retired from CSU and three team members moved out of the state, including the Principle Investigator, Lawrence Goodridge. On positive notes, Dr. Goodridge accepted an endowed chair position at McGill University in Canada, two of the researchers involved in both years of microbial testing accepted tenure track positions at Land Grant Universities, and a third is now an APHIS Fellow with the USDA/APHIS National Wildlife Research Center.

In addition, the Animal Sciences building, the intended site for the microbiological testing, was extensively remodeled in 2013/2014 and lab work associated with this project had to be relocated to laboratories at the University of Wyoming with the CSU Foothills Campus.

Being the lone representative for this project at CSU, and coordinating the microbiological work across two states as a non-microbiologist, was challenging to say the least. In terms of lessons learned, it would have been beneficial for the entire team to meet in 2013 to revisit our goals since the proposal was written the previous year and to reevaluate our ability to accomplish the goals and changes in the needs of the melon industry.

Contact person

Marisa Bunning, PhD
Associate Professor and Food Safety Extension Specialist
Adjunct Associate Professor, Colorado School of Public Health
Colorado State University
Fort Collins, CO 80523-1571
Telephone: 970-491-7180
marisa.bunning@colostate.edu

Additional Information - Associated publications

Bunning, M., Sullins, M., Zander, A., Follman, R. Wells, J., Smith Wolsey, P., Wall, G., Vanderpool, T. 2015. Tools for Improving On-farm Food Safety Workshops and Survey of Food Safety Costs. International Association of Food Protection. Portland, OR, July 24-27, 2015. Abstract # P1-141.

Bunning, M., Schroeder, M., Shackelton, E., Peth, J. 2014. Integrating Food safety in a Farm-to-Table Approach. Consumer Food Education Conference, Arlington, VA, December 4-5, 2014.
Chandler, J., Perez-Mendez, A., Coleman, S., Manley, W., Danyluk, M., Bunning, M., Goodridge, L., Bisha, B. 2014. Control of the Microbial Quality of Cantaloupes via Employment of a Processing Line Incorporating Chlorine Dioxide as an Intervention Step. International Association of Food Protection. Indianapolis, IN, August 3-6, 2014. Abstract #P1-108.

Coleman, S., Kessler, H., He, X., Avens, J., Chandler, J., Bisha, B., Goodridge, L. 2015. Evaluation of Consumer Washing Techniques to Reduce Natural Microbiota on the Surface of Whole Cantaloupes. International Association of Food Protection. Portland, OR, July 24-27, 2015. Abstract #P3-199.
Colorado Cantaloupe, CSU Extension, available from: http://farmtotable.colostate.edu/docs/cantaloupefactsheet.pdf
Friedman, R. 2013. Recommended Best Practices for Precooling, Storage, and Transport of Fresh Produce for Colorado Farmers. Master's Thesis, Department of Food Science and Human Nutrition. Colorado State University.

Keeping Food Safe: Cantaloupe, available from: http://farmtotable.colostate.edu/docs/cantaloupecard.pdf

He, X. 2015. Cantaloupe Melon Production, Nutrition, Outbreaks, and Washing Technologies: A Comprehensive Review. Master's Thesis. Department of Food Science and Human Nutrition. Colorado State University.

Peth, J. 2013. Social Media in CSU Extension: Current Use & Perceptions Among Personnel. Colorado School of Public Health Master in Public Health Capstone Project.

Scanlan, R., Bunning, M., Kendall, P. 2013. Cantaloupe Handling Practices Among Consumers at Higher Risk for Listeriosis. Annual Meeting of the Institute of Food Technologists, July 13-16, Chicago, IL Abstract No. 304-07.

Thompson, B., Goodridge, L., Bisha, B., Bunning, M. 2013. Cantaloupe Handling Practices Among Consumers at Higher Risk for Listeriosis. Annual Meeting of the Institute of Food Technologists, July 13-16, Chicago, IL Abstract No. 304-07.

Wall, Gretchen. 2011. Farm-to-Table Food Safety for Colorado Produce Crops: A web-based approach for promoting Good Agricultural and Handling Practices. Master's Thesis, Department of Food Science and Human Nutrition. Colorado State University.

Final Report: Plant Select® Multi-Media Marketing Projects for Horticultural Plants
Prepared by Executive Director Pat Hayward
Partner Organization: Plant Select®

Project Summary

Plant Select® enhanced existing marketing efforts by increasing the connection between tech-savvy consumers and plants selected and developed especially for Colorado gardens and landscapes through the Plant Select® program, by engaging mobile device users with:

- a mobile-friendly website
- QR coding on plant tags
- video library for both mobile and standard users.

Project Purpose

Plant Select® is a nonprofit Colorado corporation. It is a collaboration of Colorado State University, Denver Botanic Gardens, and the Colorado green industry to seek out and distribute the best plants for western landscapes and gardens.

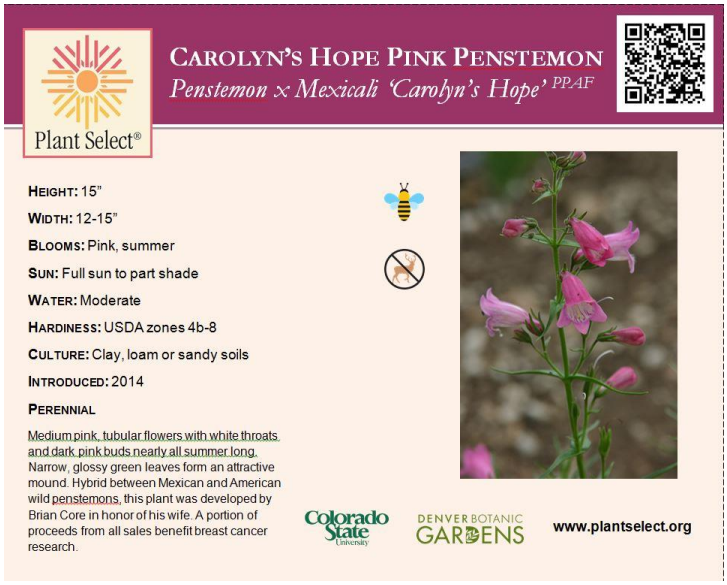
Marketing to mobile device users is increasingly becoming more important as smartphone and tablet ownership increases. QR codes and mobile websites are employed for marketing by a variety of industries and businesses including restaurants, electronics stores, print publications, and more. Although not as common in the horticulture industry, many national growers and plant introduction programs have begun to employ a mix of web-friendly strategies in engage a broad range of tech-savvy consumers. The goal was to enhance the mobile user experience, offer instant product information, and inspire consumers to purchase plants from member Colorado growers and retailers.

Project Activities

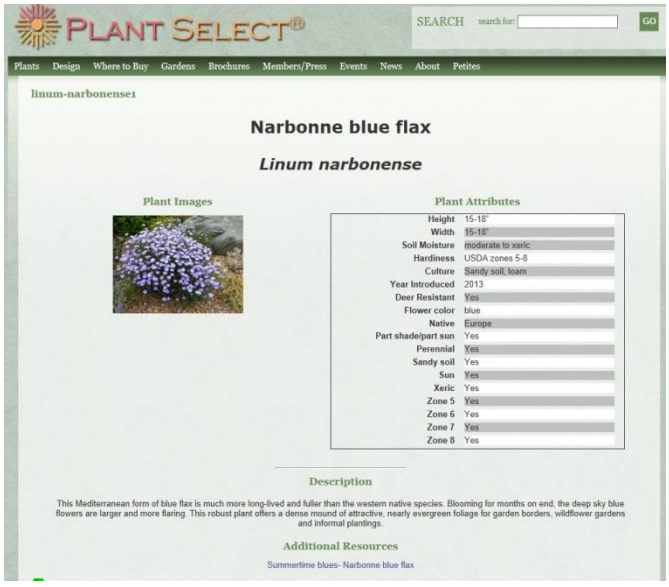
1) Mobile-responsive coding was developed for selected sections of www.plantselect.org making the existing site easily accessed by users of mobile devices, including tablets and smart phones. Completed May 7, 2013.

2) QR codes for individual plants were created. Completed April, 2013.

QR codes were created in partnership with Master Tag. These QR codes are used on tags as well as on display cards designed for use at garden centers and demonstration gardens.

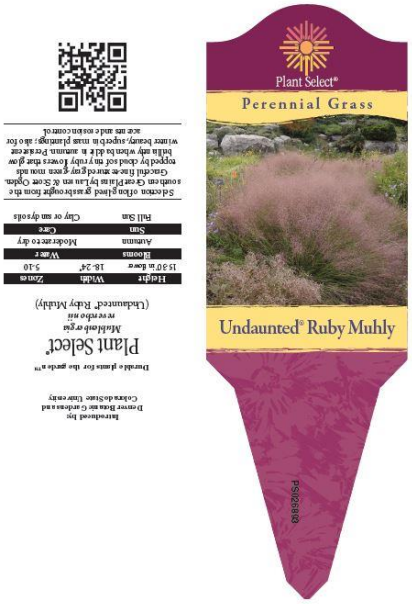


2b) Web pages for QR landing were created. Completed April, 2013- this was part of creating the QR codes – individual plants have their own pages.



16 of the top 25 keyword on our site searches are for individual plants, so it's apparent that people are looking to learn about specific plants. This validated the need for individual plant codes and pages.

2c) 110 plant tags with QR codes were designed and produced. Completed April, 2013.



These tags are available through Master Tag to licensed growers and are the officially sanctioned program tags.

3) Video library creation. A total of 14 new videos were created on a variety of horticultural topics working with two videographers (Scott Dressel-Martin and Chris Colton). Raw footage was shot over 5 days, and shoots were conducted at Laporte Avenue Nursery and Colorado State University (Fort Collins), Denver Botanic Gardens, the Gardens at Kendrick Lake (Lakewood) and Little Valley Wholesale Nursery (Brighton). All videos were uploaded to YouTube.com then embedded into our site at http://plantselect.org/videos/. As each video was published, tweets and Facebook posts were sent out to announce them.

Goals & Outcomes Achieved

1. Increase mobile device use and decrease bounce rate of mobile device visitors.

Goal	Benchmark	Target	Performance Measure	Actual
Increase mobile device user visitors	991 visitors	+50%	1487 visitors	33,017 new users
Decrease bounce rate of mobile device visitors	43%	-20%	34% bounce rate	60-70%

We easily met our goals of increasing mobile device use (see breakdown below) for several reasons, most particularly because mobile use overall has skyrocketed just in the 2 ½ year since

this grant was applied for. We did NOT reach our goal of decreasing bounce rate. This is likely due to a variety of reasons, including slow speed of site (we are upgrading our entire site this winter through an FY13 SCBG), growing impatience of users, and the fact that some of the content of the site is not geared to "fast answers."

Device Category	Date Range	Sessions	New Users	Bounce Rate
Desktop	May 7, 2013 – October 29, 2014	115,109	71%	55.5%
Tablet	May 7, 2013 – October 29, 2014	25,786	15%	60.7%
Mobile	May 7, 2013 – October 29, 2014	20,952	14%	73%

2. **QR codes** and associated pages were developed and implemented on tags and web.

Goal	Benchmark	Target	Performance Measure
Create 110 QR codes for plant tags	0 QR plant codes	110 tags with associated web pages	Completion of tags, web pages.

3. Videos were produced and uploaded to the Plant Select® and YouTube websites and announced as soon as they were loaded. YouTube analytics as of 10/30/14 show a total of 4904 views for the 14 videos created through the grant cycle. Please note, the last four were just posted within the week prior to this report.

Goal	Benchmark	Target	Performance Measure	Actual
Create video library	0 videos	14 videos (adjusted from 15 on 2/7/14)	2250 video views total (average 150 views per video)	14 videos, 4904 views (average 350 views per video)

Video name	Link	views
Plant Select overview	http://plantselect.org/2012/10/what-is-plant-select/	1094
Rock Gardening	http://plantselect.org/2014/02/rock-gardening-with-kirk-fieseler/	381
Gardening with Hypertufa Troughs	http://plantselect.org/2014/02/trough-gardening-with-kirk-fieseler/	491
South African ice plants	http://plantselect.org/2014/02/south-african-ice-plants-with-panayoti-kelaidis/	955
Early summer perennials	http://plantselect.org/2014/02/early-summer-perennials-with-sonya-anderson/	386
Carolyn's Hope penstemon	http://plantselect.org/2014/02/carolyns-hope/	527
Groundcovers	http://plantselect.org/2014/02/water-wise-groundcovers-with-mike-kintgen/	431
Master Gardener training: Groundcovers	http://plantselect.org/2014/05/groundcovers-with-pat-hayward/	268
Master Gardener training: Grasses, Vines, Trees, & Shrubs	http://plantselect.org/2014/05/grasses-vines-shrubs-trees/	388
Master Gardener training: Perennials	http://plantselect.org/2014/05/perennials-with-pat-hayward/	252
Building a Garden	http://plantselect.org/2014/10/garden-building-for-western-plants-with-greg-foreman/	44
Shrubs & trees	http://plantselect.org/2014/10/plant-select-shrubs-trees-with-jim-klett/	30
Ornamental grasses	http://plantselect.org/2014/10/plant-select-ornamental-grasses-with-dan-johnson/	16
Pollinators	http://plantselect.org/2014/10/pollinators-and-plant-select-plants-with-sonya-anderson/	12
Total		**4904**

We did not reach the goal of 15 videos and this expected outcome was noted in the request for extension dated February 7, 2014 approved by the Colorado Department of Agriculture. In that letter we revised our goal to 14 videos. Lining up talent, videographers, weather and garden conditions for shoots turned out to be challenging. The biggest challenge was the amount of time it took to conduct edits on each video. Captions had to be corrected, background images supplied, and overall editing of the "story" took an amazing amount of time as well.

Beneficiaries

As noted in our proposal, the entire Colorado nursery & greenhouse industry should benefit through education of consumers leading to increased sales at the wholesale and retail level. In particular, the 22 Plant Select® grower members, 2 mail-order members, 7 (now 21) landscape professional members and the 53 (now 65) retail members will especially benefit. All members were notified of projects and encouraged to utilize the QR codes, tags and videos produced through this grant.

Grower name	**Location**
Botany Lane Greenhouse	Denver, CO 802296
Britton Nursery, Inc.	Colorado Springs, CO 80923
Center Greenhouse	Denver, CO 80229
Chelsea Nursery	Clifton, CO 81520
Country Lane Wholesale Nursery Inc.	Franktown, CO 80116
Fort Collins Wholesale Nursery	Fort Collins, CO 80524
Gatehouse Gardens, LLC	Greenwood Village, CO 80121
Gulley Greenhouse, Inc.	Fort Collins, CO 80526
Harding Nursery	Colorado Springs, CO 80915
Kiyota's Greenhouse	Fort Lupton, CO 80621
Laporte Avenue Nursery	Fort Collins, CO 80521
Little Valley Wholesale Nursery	Brighton, CO 80601
Loveland Garden Center	Loveland, CO 80537
Nick's Garden Center	Aurora, CO 80014
Palisade Greenhouse, Inc.	Palisade, CO 81526
Paulino Gardens	Denver, CO 80216
Perennial Favorites	Rye, CO 81069
Sunscapes	Pueblo, CO 81004
Timberline Gardens, Inc.	Arvada, CO 80002
Valley Grown Nursery	Grand Junction, CO 81505
Weakland Greenhouses	Fort Lupton, CO 80621
Welby Gardens	Denver, CO 80229

Landscape Professional name	**Location**
Arcadia Design Group	Centennial, CO 80112
Colorado Vista Landscape Design, Inc.	Windsor, CO 80528
Garden Thyme, Inc.	Fort Collins, CO 80524
Gardenz	Lakewood, CO 80214
Green Touch, Inc.	Centennial, CO 80122
Taylored Gardens	Denver, CO 80222
The Horticulture Consultant	Fort Collins, CO 80524

Mail-order seller name	Location
Laporte Avenue Nursery	Fort Collins, CO 80521
Sunscapes Rare Plant Nursery	Pueblo, CO 81004

Retail seller name	Location
Alpha Nursery & Garden Center	Cascade, ID 83611
Bath Garden Center & Nursery	Fort Collins, CO 80525
Bonsai Nursery, Inc.	Englewood, CO 80110
Bookcliff Gardens	Grand Junction, CO 81506
Botanical Concepts Garden Center	Durango, CO 81302
Brady's Garden & Spa Center	Canon City, CO 81212
Chelsea Nursery	Clifton, CO 81520
City Floral Garden Center	Denver, CO 80220
Cliffrose Gardens	Cortez, CO 81321
Country Fair Garden Center	Denver, CO 80229
Country Fair Garden Center at Westwoods	Arvada, CO 80007
Creek Side Gardens	Littleton, CO 80123
Durango Nursery & Supply	Durango, CO 81303
Eagle Crest Nursery	El Jebel, CO 81623
Eaton Grove Nursery	Eaton, CO 80615
Echter's Garden Center	Arvada, CO 80002
Edwards Flowerland	Fort Morgan, CO 80701
Flower Bin, The	Longmont, CO 80501
Fort Collins Nursery	Fort Collins, CO 80524
Fossil Creek Nursery	Fort Collins, CO 80525
Front Range Gardens	Broomfield, CO 80021
Gill Plant Co.	Worland, WY 82401
Good Earth Garden Center	Colorado Springs, CO 80905
Gulley Greenhouse, Inc.	Fort Collins, CO 80526
Harding Nursery Retail	Colorado Springs, CO 80915
Harlequin's Gardens	Boulder, CO 80301
Harmony Gardens	Fort Collins, CO 80528
Highlands Garden Center & Nursery	Centennial, CO 80122
J&L Garden Center & Landscaping Co.	Bountiful, UT 84010
Jared's Nursery & Garden Center	Littleton, CO 80127
Jordan's Floral Gardens	Fort Collins, CO 80521
Loveland Garden Center	Loveland, CO 80537
McGuckin Hardware	Boulder, CO 80302
Meadow Acres Greenhouse & Nursery	Evansville, WY 82636

Millcreek Gardens	Salt Lake City, UT 84106
Mountain Gardens Nursery	Tijeras, NM 87059
Native Roots Garden Center	Durango, CO 81303
Nick's Garden Center, Inc.	Aurora, CO 80014
Paulino Gardens	Denver, CO 80216
Perennial Favorites	Rye, CO 81069
Pine Lane Nursery Inc.	Parker, CO 80134
Pope Farms Produce & Garden Center	Greeley, CO 80634
Rick's Garden Center	Colorado Springs, CO 80904
South Routt Nursery LLC	Phippsburg, CO 80469
Tagawa Gardens	Centennial, CO 80016
Timberline Gardens Retail	Arvada, CO 80002
Tizer Lake Garden & Arboretum	Jefferson, MT 59638
Urban Roots	Denver, CO 80204
Valley Grown Nursery	Grand Junction, CO 81505
Welby Garden Center	Denver, CO 80229
Wilmore Nurseries	Littleton, CO 80122
The Windsor Gardener	Windsor, CO 80550
Wright's Nursery, Inc.	Arvada, CO 80004
Wyoming Plant Company	Casper, WY 82604

Lessons learned

1. When we first set out to create a mobile-friendly site, it appeared it was going to take some detailed coding and training. In the end, partly because we use Wordpress to host our site, it was rather simple to create "responsive" pages that adapt the size and ratio of pages and content to the user's device. This saved a great amount of time and money, and makes all updates seamless rather than having to manage two separate sites when updates were needed.
2. Mobile device users seem to want "instant gratification." Our site is now mobile-friendly but much of the content does not lend itself to smart phone use. The "where to buy" page is quite mobile-friendly, so the hope is that users will use it to find places to buy plants. The video page is also quite user-friendly and lends itself very well to mobile device use.
3. Video production is tedious and time consuming. The original thought was to create simple videos of gardens and plants, but in reality viewers are interested in learning from videos such as these which require much more editing and captioning to identify individual plants by name. Note: we did NOT use all the funds for this portion and that is actually due to the fact that we received a substantial non-profit discount from the firms we contracted with.

Contact Person

Pat Hayward, Executive Director, 970-481-3429, Director@plantselect.org

Final Report: Marketing, Research and Technical Support for Colorado's Small Acreage, Socially Disadvantaged and Beginning Specialty Crop Producers – FFY 2012
Partner Organization: Colorado State University

Project Summary

Rosalyn Barminski telling the crowd about growing cyanobacteria in shallow ponds at a 2013 Field Day.

Colorado State University (CSU) provided marketing, research and technical support to Colorado's small acreage, socially disadvantaged and beginning specialty crop producers. Through continued support for a Specialty Crops Coordinator, as part of CSU's broader Specialty Crops Program, producers benefited from continued research conducted by CSU addressing needs of specialty and small farm producers, including cultivar and season extension, as well as having access to technical support and grant funds for on-farm research and demonstration marketing projects. Research at the CSU Horticulture Field Research Center (HFRC) under the guidance of the Interim Specialty Crops Coordinator included high tunnel production of vegetable crops (for the purpose of season extension), production and use of cyanobacteria in crop fertilization, organic vegetable seed production research, research and demonstration on the use of alfalfa and various cover crops as an organic approach to insect pest management and evaluation of plastic mulches for weed control. Part of the grant funds were used for a research and marketing grants program targeted to small acreage, socially disadvantaged and beginning specialty crop producers – Grower Research and Education Grants (GREG).

Project Purpose

The overall purpose of the project was to effectively develop local food systems by supporting producers with on-farm research, allowing them to supplement and/or build on research conducted by CSU, and providing producers with access to technical support and other resources available across CSU's state-wide academic, research and extension networks.

This project was timely and important because developing local food systems has become increasingly prevalent across the United States, and particularly so in Colorado.

One of the major goals of the project was to continue to drive innovation among Colorado's specialty crop producers with ongoing partial SCBGP funding of the Specialty Crops Coordinator position within CSU's Specialty Crops Program. This full-time faculty position was established under the FY09 SCBGP and is also partially funded by CSU. The Coordinator is central to addressing the needs of Colorado's specialty crop producers and creating synergies within CSU to help realize the substantial potential for specialty crops across Colorado. The Specialty Crops Coordinator conducts and facilitates research in specialty crop production and utilization, including the application of organic methods, especially for organic and small farm producers.

The focus is on solving problems with current crops and on the identification and development of new specialty crop opportunities. The operating costs for cultivar and variety trials research conducted by the Coordinator are funded by CSU. Primary emphasis will continue to be on vegetable and small fruit crops because of the state's need in this area, and especially because such producers are relatively underserved by other current research programs.

This project also was timely and important because it provided underserved producers with access to research programs that focused on vegetable and small fruit crops. Another major goal of the project was to deliver research results to producers through demonstrations, field days, workshops, written and electronic communications and farm visits.

SCBGP funds from this grant continued to be used to implement a research and marketing grants program targeted to small acreage, socially disadvantaged and beginning specialty crop producers. Grants were awarded on a competitive basis for purposes of conducting on-farm production and enterprise feasibility studies, and research to complement prior and ongoing research conducted by CSU. Grants could also be awarded for the development and implementation of direct marketing and farm-to-market demonstration projects. It was expected that producers seeking these grants would work in cooperation with CSU research and extension experts to develop project proposals. Similarly, grant proposals could be developed by CSU research and extension experts to work with targeted producers to advance cultivar and varietal research and/or demonstration marketing projects.

This project built on specialty crop research and grant programs that have been part of prior CDA SCBGP applications. More specifically, specialty crop funds allocated to Colorado in 2001 as part of a supplemental agriculture appropriations bill were targeted to a grower grants program in cooperation with CSU. More recently, though, cultivar trials projects were included in the FY06 and FY07 SCBG and FY08 SCBG-Farm Bill programs (which included a project establishing the Specialty Crops Coordinator). The coordinator position was continued in the FY09, FY10, FY11 and FY12. SCBG programs included small acreage, beginning farmer and socially disadvantaged producer grants.

Project Activities

Develop grant program guidelines and application; announce the grant program; finalize results from previous years' research; post research results to website; and initiate planning for research.

Grant program guidelines and application were updated from previous years. A call for proposals was announced in early 2013 for the Specialty Crops Grower Research and Education Grants (GREG) program with a targeted audience of small farmers, beginning farmers, and socially disadvantaged farmers.

Planning for 2013 research was initiated by interim staff and other CSU staff. Continuing research by CSU under the guidance of the interim Specialty Crops Coordinator/interim staff included high tunnel production of vegetable crops (for the purpose of season extension), production and use of cyanobacteria in crop fertilization, organic vegetable seed production research, research and demonstration on the use of alfalfa and various cover crops as an organic approach to insect pest management and evaluation of plastic mulches for weed control.

Alfalfa was part of the study for reasons other than its production as a crop per se. It was included as part of the array of production techniques needed to profitably produce a wide variety of vegetables (specialty crops), especially with organic/sustainable approaches. It is important to optimize numerous production variables (irrigation, cover crops, green manures, et al.) in this regard. Specific specialty crops that benefited from the study of the use of alfalfa as a cover crop/green manure were lettuce, broccoli, kale, cucumbers, and tomatoes.

Results from previous years' GREG grants were posted on the website as they became available - http://hortla.agsci.colostate.edu/research-programs/specialty-crops/greg/.

Due to the loss of the Specialty Crops Coordinator in 2012, research on the high tunnels and plastic mulches was not completed until 2014. Analysis originally planned for 2012 and 2013 were not completed until 2014 due to the lack of a Specialty Crops Coordinator. Analysis and reports are currently being completed by the new CSU Specialty Crop Coordinator, Leila Graves. Results will be available in February 2015.

Provide technical and management support for grant program and manage research plan – 2nd quarter 2013

In early 2013 a panel of CSU faculty reviewers awarded five GREGs.

The committee reviews the application question(s) that asks the sub-grantee to describe how the project solely enhances specialty crops. The committee uses an evaluation form approved by the CDA's Specialty Crop Program that asks each committee member to gauge/rank how each project will increase/enhance specialty crops. If the project did not appear to solely enhance specialty crops, it would rank

GREG Grant: Currently there is a minimal amount of locally-produced vegetable seed available to gardeners and farmers in Colorado. Through this project, Dan and Jamie Hobbs aim to help small farmers and socially disadvantaged farmers to diversify their operations through production and sale of high quality vegetable, herb, and flower seeds.

poorly among the committee and ultimately would not be chosen to be funded.

The CSU Ag Business Center developed agreements for the grantees.

Grantees for 2013 included:

> "Farm Direct organic seed: market development, product development, and training for women seed farmers in Southeast Colorado": Hobbs Family Farm. Award was $14,000
>
> "The Be Local Incubator Farm": City of Fort Collins/Spring Creek Gardens Award was $11,000.
>
> "The Fountain Creek dry bean project": Pikes Peak Community Foundation/Venetucci Farm - Susan Gordon. Award was $9,500.
>
> "Harvest plan: a Delta-based regional commercial kitchen and food processing facility or value added products distribution site": Deana Sheriff/Volunteers of America. Award was $8,500. This grantee was unable to work within the requirements of the grant program and the grant was never initiated and no funds were disbursed.
>
> "Cultivation of edible mushrooms in arid environments by developing a cost effective growing environment for year round production": Kathryn Johnson/Royal McBee. Award was $7,000.

These projects are complete, have spent all designated funds, and have filed reports on their activities. Report available at: http://hortla.agsci.colostate.edu/research-programs/specialty-crops/greg/.

Specialty crop projects supported by GREG program grants are monitored through: 1. the involvement of the Technical Advisor, and 2. site visits made by the CSU SCPGP Coordinator. Because of the loss of the CSU SCPGP Coordinator in 2012, Sara Kammlade, CSU graduate assistant in the Horticulture department, made annual farm visits to SCP GREG recipients in 2013, as well as to GREG recipients from previous years.

The site visits are particularly important in assuring that all projects not only are focused on the agreed upon objectives, but also that all USDA program guidelines are followed. For example, certain projects, while clearly designed to enhance specialty crop production in Colorado, may have approaches, titles, etc., that might raise questions in this regard. The site visits help confirm that these and other projects are focused solely on Specialty Crops per se. SCP Coordinator visits to the

GREG grant: Cultivation of edible mushrooms in arid environments by developing a cost effective growing environment for year-round production.

sites also provide assurance about appropriateness of expenditures and project management that accounting information may not provide

The loss of the specialty crops coordinator in 2012 resulted in the formation of a search committee in early 2013. During the last quarter of 2013, two candidates were interviewed. One was selected but wanted her spouse to also secure a faculty position at CSU, which was offered. However, the candidate ended up declining the position. A second search was conducted and two candidates were interviewed in the second quarter of 2014. However, neither of the candidates was selected. During the search process, the duties of the Coordinator were divided up between various Horticulture Department staff. In July 2014, an interim assistant professor of specialty crops was hired: Leila Graves, PhD. – Horticulture.

Technical advice and assistance was provided to growers and grant recipients throughout late 2012 and in 2013 by interim coordinators and graduate assistants. CSU SCP fields a steady stream of telephone and e-mail requests for specific information about specialty crop production and marketing.

Provide technical and management support for grant program; conduct Field Day event; and manage research plan – 3rd Quarter 2013

Technical advice and assistance continued to be provided to growers and grant recipients throughout the third quarter of 2013 by interim coordinators and graduate assistants. CSU SCP fields a steady stream of telephone and e-mail requests for specific information about specialty crop production and marketing.

A field day was held in August 2013 for over 30 farmers and others interested in cyanobacterial bio-fertilizer.

Research activities on high tunnel production of vegetable crops (for the purpose of season extension), production and use of cyanobacteria in crop fertilization, organic vegetable seed production research, research and demonstration on the use of alfalfa and various cover crops as an organic approach to insect pest management and evaluation of plastic mulches for weed control continued at the CSU Horticulture Farm.

Review final reports for previous year's grant projects; develop evaluation report of grant program; finalize results from research; post research to CSU Specialty Crop Program website.

Final reports from previous years' grants were received and evaluated and posted to the website. Due to the lack of the Specialty Crops Coordinator, research results from research conducted at CSU Horticulture Farm have not yet been posted, but will be in early 2015, by the Interim Coordinator.

Goals and Outcomes

1. **Desired Outcome**: To facilitate specialty crop production innovation as well as direct marketing opportunities among small acreage, socially disadvantaged and beginning specialty crops producers.

   Performance measure: The number of on-farm research, demonstration and marketing project grants awarded to small acreage, socially disadvantaged and beginning specialty crop producers.

   Baseline: From 2002 thru 2006 CSU awarded 60 grants to specialty crop producers. From 2010 to the beginning of 2012 seventeen small acreage, socially disadvantaged and beginning specialty farmers were awarded Grower Research and Education (GREG) grants.

   The Goal for 2012: Identify and award 5 to 6 recipients for SCP GREGs. Provide technical assistance required to make grower projects successful. Facilitate outreach efforts by grant recipients as their projects results become available.

   Outcome: This goal was met. Five grants were awarded in 2012 on a competitive basis for purposes of conducting on-farm production and enterprise feasibility studies, and research to complement prior and ongoing research conducted by CSU. Unfortunately, one of these recipients was unable to meet the requirements of the grant program and the grant was never initiated.

2. **Desired Goal**: To provide information to Colorado specialty crop producers about the results and recommendations from CSU's research programs relating to specialty crops

   Performance Measure: For results and recommendations to be presented to producers through Agriculture Experiment Station Bulletins, Cooperative Extension Fact Sheets, E-extension webinars and at Field Day events and conferences targeting specialty crop producers, as well as made available online

   Baseline: In 2011, CSU SCP's Field Day event drew more than 100 attendees. Project results were presented to more than 200 producers at the Colorado Agriculture Big & Small Conference and results were posted to CSU's Specialty Crop Program 2011, CSU SCP's Field Day event drew more than 100 attendees. Project results were presented to more than 200 producers at the Colorado Agriculture Big & Small Conference and results were posted to CSU's Specialty Crop Program.

   The Goal for 2012: Produce 6 print publications, 4 webinar presentations, and present findings at 3 conferences and continue to maintain strong attendance at Field Day Presentations.

Outcome:

The goal for **print publications** was reached with 6 print publications. Print publications included:

Interactive effect of nitrogen rate and fungicide or compost tea application on tuber yield and quality of two potato cultivars. Crop Research. 46: 169-173.

Making better decisions – 2013 dry bean variety performance trials. CSU Agricultural Experiment Station Technical Bulletin. 13-5.

Air injection of drip irrigation water improves potato performance in the field. Abstract, Potato Association of America.

Onion ipmPIPE: A coordinated effort to improve the management of onion thrips and Iris yellow spot virus for onion growers and their industry. 2014. APS Plant Health Progress. 15: 172-183.

Onion Health Management and Production. In: CSU IPM Center Report.

Teaching STEM through agriculture: Implementation of an edible plant curriculum in an elementary school. In press in Journal of Agricultural Education.

The goal of 4 **webinar presentations** was not reached. However, during this reporting period, the program web presence included:

Fruit bud cold hardiness, western Colorado. 2013-2014. webdoc.agsci.colostate.edu/aes/wcrc/techbulletins/fruit bud coldhardiness2013-2014.pdf.

http://potatoes.colostate.edu

And an updated CSU Specialty Crops program website: http://hortla.agsci.colostate.edu/research-programs/specialty-crops

The goal of **presenting research at 3 conferences** was reached. The following are conferences where research from this project was presented:

Agriculture Big and Small Conference, February 13-14, 2013. “Managing specialty crop yields on small plots”.

American Society for Horticultural Sciences Conference, July 22-25, 2013. “Evaporative and transpirational water losses from three nursery container types”.

Potato Association of America Conference, July 28- August, 2013. “The role of lipoxygenase in powdery scab disease resistance in potato tubers”.

Southern Colorado Agriculture Conference, February 4-6, 2014. “Timing nitrogen fertilizer application for early and medium maturity potatoes”.

Western Colorado Horticultural Society Conference, January 15-16, 2014. “Alternative peach rootstocks for western Colorado”.

A Field Day was held in August 2013 that was attended by about 30 producers and other interested parties.

Dr. Frank Stonaker presented “High tunnel environmental management” and “Managing crop yields on small plots” at the Colorado Agriculture Big and Small conference in February, 2013.

The resignation of Dr. Frank Stonaker as the CSU Specialty Crops Specialist and faculty member presented a substantive challenge to the productivity, profile, and momentum of the program. However, this challenge has been effectively met, and the program sustained, through the following actions:

Interim assignments were made to minimize any potential loss of program momentum. Dr. Steve Wallner (Professor and Head, Department of Horticulture & LA) served as Interim Coordinator. Research Assistants reporting to Wallner took responsibility for key program elements, including: monitoring the progress and outcomes of Grower Research and Education Grant recipients (Sara Kammlade); and managing Specialty Crops research projects already underway at the HFRC/RMSOF (Gary Gross, Natalie Yoder, Chris Engel, Jeff Popko).

Commitment to replace Dr. Frank Stonaker. Leaders of Colorado State University and the Colorado Department of Agriculture agreed to continue the partnership that has made the program possible. The foundation for this is the shared commitment to fund the replacement Specialty Crops Coordinator faculty position.

A search committee was formed in early 2013. During the last quarter of 2013 two candidates were interviewed. One was selected but wanted her spouse to also secure a faculty position at CSU, which was offered. However, the candidate ended up declining the position. A second search was conducted and two candidates were interviewed in the second quarter of 2014. However, neither of the candidates was selected. During the search process, the duties of the Coordinator were divided up between various Horticulture Department staff. In July 2014, an interim assistant professor of specialty crops was hired: Leila Graves, PhD. – Horticulture.

3. **Desired Goal:** To position CSU as a credible source of information and research relating to specialty crops.

Performance Measure: Percent increase in the number of annual visitors to CSU's Specialty Crops Program website.

Baseline: 29,090 hits to website were recorded for 2011.

Outcome: 29,090 hits to website were recorded for 2011. Results for 2012 are unavailable because the website was moved and hits were not counted. This problem has been remedied and hits are currently being counted.

Data and information continued to be added to the website, including webinars and publications. http://hortla.agsci.colostate.edu/research-programs/specialty-crops/.

4. **Desired Goal:** To facilitate the development of emerging specialty crop grower and marketing associations**.**

   Performance Measure: Develop strong relationships with emerging specialty crop grower associations and facilitate their development

   Baseline: Participate in initial discussion of organization formation with two specialty crop grower groups

   Outcome: Rocky Ford Growers Association (www.rockyfordgrowersassociation.com) has been formed. This group was organized primarily to protect and enhance the market identity and overall viability of the melon industry in the Arkansas Valley of Colorado.

   The Colorado Fruit and Vegetable Growers Association has been formed, a board elected, developed by-laws and a mission statement, have legal status as a 501(c) (6), have developed a web site and social media site, have hired an administrator, launched a membership drive, and developed branding and marketing materials.

Beneficiaries

Beneficiaries of the CSU Specialty Crops Program activities include the GREG recipients; new, small or socially disadvantaged operators that have far fewer resources and support than many of their larger, well established competitors. This group of producers needs to be especially creative and innovative in order to find profitable and sustainable paths. Just as importantly, it needs to have technical expertise available, founded on applied research that is appropriate for their scale and regional uniqueness.

Beneficiaries also include those students and guests attending outreach functions of the GREG recipients. Remotely, web browsers search for and find useful information provided by the GREG participants and by the CSU SCP. Through this overall approach, the number of beneficiaries quickly multiplies into the thousands.

GREG grant recipients receiving funding from this grant year numbered five. Hundreds of producers attended the conferences where results were presented. Thirty producers and other interested parties attended the 2013 field day. The website was recreated late in 2013 so website hits were only 67, but for 2014 numbered 2902. The CSU Specialty Crops Program - Grower Research and Education Grants Facebook page has 86 followers.

Lessons Learned

Research conducted by CSU addressing needs of specialty and small farm producers included high tunnel production of vegetable crops (for the purpose of season extension) and evaluation of plastic mulches for weed control.

A heavy grade of plastic mulch is recommended due to the frequency and severity of hail occurrences. All crops in the field were destroyed and had to be replanted in 2011, 2012, 2013, and 2014. This makes it impossible to collect data. Additional investments in hail protection in the form of floating row covers, hail netting and expansion of high tunnel production is recommended.

Due to the loss of the Specialty Crops Coordinator, research was not coordinated or documented sufficiently in 2012. This is a challenge for the person who eventually steps into the role as Coordinator or Interim Coordinator. The current Interim Coordinator is working to document the intervening years of research and results.

The loss of the Specialty Crops coordinator in 2012, subsequent search with the candidate ultimately refusing the position, and a second, failed search have led to a lack of consistency in the program. Because a Coordinator was not present, focusing on the goals and outcomes, some goals and outcomes were not reached. A new, dedicated interim Coordinator is now in place. A new candidate search will interview candidates for a full-time Coordinator in early 2015. This program should continue at CSU with renewed vigor in the future.

Contact person:

Leila Graves
1173 Campus Delivery
Colorado State University
Fort Collins CO, 80523
(970)491-2029T
Gravesleila35@gmail.com

Additional information:

Natalie Yoder describing her hoop house experiments on kale where she is comparing cyanobacterial bio-fertilizer to other organic fertilizers. This research took place at the CSU Horticulture Field Research Center (HFRC).

GREG grant: Fountain Creek Dry Bean Project.

Final Report: Expanding Colorado Seed Potato Exports to Canada
Partner Organization: Not applicable. This project was implemented by the Colorado Department of Agriculture.

Project Summary

The Colorado Department of Agriculture, with assistance from the Colorado Certified Potato Growers Association (CCPGA), hosted two groups of Canadian seed potato buyers on July 5-8 and July 12-15, 2015. While in Colorado, the groups visited Colorado seed potato farms, the Colorado State University (CSU) San Luis Valley Research Station and local packing and shipping facilities. The Canadian buyers were informed about all the benefits of the various potato cultivars grown in Colorado and exposed to new potato varieties.

Project Purpose

The objectives for these missions were to inform Canadian growers about the benefits of the various potato cultivars grown in Colorado, expose Canadian buyers to new potato varieties, establish relationships between Canadian growers and Colorado seed potato growers and promote sales for Colorado Certified Seed Potatoes.

Due to new potato viruses such as PVYn and nearly four years of drought, Colorado Certified Seed Potato Growers are looking to the Canada market in order to diversify customers, expand sales, increase income and pursue a growing market.

Seed potatoes from Colorado were sold to Canada for the first time in 2013 by one grower. There are now more Canadian growers interested in Colorado Certified Seed cultivars, particularly the varieties Rio Grande, Canela and Colorado Rose. With such interest, the relationships created during these missions were aimed to develop future orders for Colorado seed varieties, and result in royalties from seed potatoes.

These missions continued and extended the work done on an initial visit to Canada by Colorado seed potato growers in 2014. The first trip resulted in relationships with sales brokers in two different Canadian provinces. These two brokers arranged the two groups of growers and buyers that visited Colorado.

Project Activities

Plan and organize 2 inbound missions from Canada to the San Luis Valley in July 2015

The Colorado Department of Agriculture (CDA) along with the Colorado Certified Seed Potatoes Growers Association (CCPGA) arranged and organized for two groups from Canada, one from New Brunswick and the other from Prince Edward Island and Quebec, to come to Colorado to visit with Colorado producers and learn about Colorado Certified Seed potatoes. A total of 12 participants came from Canada to Colorado.

Execute 2 inbound missions from Canada to the San Luis Valley in July 2015

The trade missions brought prospective seed potato buyers to the San Luis Valley (seed potato growing area of Colorado) to see the Colorado Certified Seed potato system. This included visits to the Colorado State University Research Station where potato varieties are developed, visits to test fields, a meeting with USDA and CDA inspectors who reviewed their protocols for export certification, and visits with actual seed potato growers to review their own farm operations, storage, certification protocols and general farm practices to produce certified seed potatoes. They also saw farms that use the various seed generations and spoke with Colorado growers who use Colorado Certified Seed potatoes. They had the opportunity to meet one-on-one with Colorado Certified Seed potato growers to discuss importing seed from their farms to Canada.

The first mission took place July 5-8, 2015 with a group of eight participants from New Brunswick, Canada. While in Colorado, the group visited six farms around the San Luis Valley as well as the CSU San Luis Valley Research Station to learn about new varieties and production opportunities.

The second mission took place July 12-15, 2015 with a group of four buyers from Prince Edward Island and Quebec, Canada. The group visited six farms around Colorado as well as the CSU San Luis Valley Research Station to learn about new varieties and productions opportunities.

This project did not benefit products other than specialty crops.

Goals and Outcomes

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Educate Canadian potato growers about Colorado seed potatoes	Number of Canadians participating in inbound trade missions	0	10	12

The first inbound mission included eight buyers from New Brunswick, Canada. The second inbound consisted of four buyers from Prince Edward Island and Quebec, Canada. A total of 12 buyers participated in the inbound missions to Colorado.

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Establish relationships between Colorado seed potato growers and Canadian Buyers	Number of meetings between individual seed growers and seed buyers	1	25	72

The 12 buyers from Canada each met with six Colorado Certified Seed producers in Colorado.

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Expose Canadian buyers to new potato varieties	Number of new varieties introduced to Canadians	3	7	20

While the buyers visited six different Colorado facilities, farms and the CSU Research Station they were exposed to 20 new potato seed varieties.

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Increase intent of Canadian buyers to purchase Colorado seed potatoes	Number of Canadian buyers who indicate they are "moderately" or "strongly" interested or "will definitely purchase" Colorado seed potatoes	1	8	12

As a result of the first mission, four Canadian buyers have already purchased Colorado Seed potatoes for the 2016 growing season. The remaining four are "strongly" interested in purchasing Colorado seed potatoes.

As a result of the second mission, four Canadian buyers are "strongly" interested in purchasing Colorado Seed potatoes. After seeing all the different varieties of potatoes in Colorado, one buyer is strongly interested in purchasing commercial specialty potatoes from Colorado.

Beneficiaries

The primary beneficiaries of these trade missions are the 36 family farms (at least 200 people) involved in the Colorado Certified Potato Growers Association. By expanding the seed potato market the Colorado Certified Seed potato producers are able to expand exports, increase income, and diversify sales customers.

Other stakeholders include the Colorado Department of Agriculture, the Colorado Certified Potato Growers Association and the Colorado State University Research Station.

Lessons Learned

Colorado seed potatoes are becoming increasingly more popular in areas around Canada due to the different growing conditions, the demand for variety and the interest in disease resistant seed. Many viruses, issues and concerns are not the same in Canada and therefore have different results than seed varieties from Colorado.

Hosting the two missions in Colorado during the growing season in July was ideal. The buyers were able to see seed tubers as well as the plant characteristics.

Contact Person

John Addison, Marketing Specialist
Colorado Department of Agriculture
303-869-9180
John.Addison@state.co.us

Additional Information

Canadian buyers touring Colorado seed plots and fields.

Colorado seed potato producers presenting their seed fields to the Canadian buyers.

Final Report: Farm to Fork Television Advertising
Partner Organization: Not applicable. This project was implemented by the Colorado Department of Agriculture.

Project Summary

Previous television advertising efforts to promote Colorado produce through the Colorado Proud program have focused on the Denver Metro market. Southern Colorado, serviced through stations in Colorado Springs, offered an opportunity to educate a new market about Colorado fruits and vegetables. Colorado Proud partnered with Fox21 in Colorado Springs to promote Colorado produce through the "Farm to Fork" television advertising campaign.

Project Approach

The purpose of this project is to encourage consumers to buy and eat Colorado grown produce. Fox21 established Farm to Fork in 2013 to educate southern Colorado on the health benefits and economic impact of buying local produce and eating fresh. Through a series of local news stories, promotional spots and :15 and :30 second commercials, Farm to Fork highlights the process of what it takes to get food from the fields to the tables of southern Colorado consumers. The program showcases fruit and vegetable growers in southern Colorado and encourages consumers to buy specific produce items (i.e. Rocky Ford Cantaloupe, Pueblo Chilies). Thirteen southern Colorado farms were featured in the Farm to Fork campaign in 2015.

In addition to paid and bonus television ads, Fox21 featured Colorado produce in on-air cooking segments each Tuesday morning newscast during August, Colorado Proud Month. On-air cooking demos showcased produce information and recipes courtesy of the Rocky Ford Growers Association, Garden of the Gods Gourmet and Her Story Café.

The budget of $15,000.00 for television ads was matched by $24,525.00 of in-kind services including ad production, survey, online presence, and bonus ads.

Goals and Outcomes Achieved

As part of the Farm to Fork campaign, Fox21 contracted with Marshall Marketing to conduct a survey in the Colorado Springs/Pueblo market. The telephone/online survey completed 600 interviews with consumers. Consumers were asked if they purchase more Colorado produce if it's labeled with the Colorado Proud logo. This measure determines the specific consumer correlation between Colorado Proud and the purchase of Colorado produce.

Goal	Performance Measure	Baseline	Actual 2014	Target 2015	Actual 2015
Increase the number of people purchasing Colorado produce labeled with the Colorado Proud logo.	Percent of people indicating purchase of more Colorado produce if labeled with Colorado Proud logo.	66%	71%	75%	67%

The July-September 2015 television advertising campaign resulted in 835 :15, :30 and :45 second commercials promoting Colorado produce using the Colorado Proud logo. In addition,

each participating farm aired its own ads and Colorado Proud was tagged in those as well. The promotional/matching spots totaled an additional 1,492 ads.

A Farm To Fork web page was designed on the www.fox21news.com website where consumers found links to participating farms and Colorado Proud as well as recipes from the cooking segments and the archived news stories from the Farm To Fork segments.

The campaign reached 73.7% of the households in the southern Colorado market 9.3 times and 64.7% of adults 25-54 in the market 6.5 times for a total of 2,565,425 household impressions and 2,485,193 adult impressions. These results are nearly double the original proposed outcomes.

Beneficiaries

This project benefited southern Colorado produce growers as well as consumers. Consumers benefited from the project by learning about the variety of produce available to them and understanding how to locate and buy Colorado grown produce.

The project directly benefited the 13 produce growers that actively participated in the Farm to Fork campaign, and the more than 30 produce growers in a 12 county region (Baca, Bent, Crowley, Custer, El Paso, Fremont, Huerfano, Kiowa, Las Animas, Otero, Pueblo, Teller) of southern Colorado. Other beneficiaries included produce organizations such as the Colorado Potato Administrative Committee, Rocky Ford Growers Association and the Colorado Fruit & Vegetable Growers Association.

Lessons Learned

Although the numeric goal was not achieved (statistically, with margin of error, remaining flat from the 2014 result of 71%), this project was an absolute success. The Farm to Fork television campaign effectively educated southern Colorado consumers about selecting, buying and preparing local produce.

Survey results did lead us to look at the semantics of survey questions. We currently ask “Do you purchase more Colorado produce if it’s labeled with the Colorado Proud logo?” Our goal with this question is to not determine if consumers purchase “more” quantity of produce, but rather if they are “more likely” to select produce with the Colorado Proud logo. We may slightly adjust this question in future surveys to make it clearer to consumers.

Contact Person

Wendy White, Marketing Specialist
Colorado Department of Agriculture
303-869-9174
Wendy.White@state.co.us

Additional Information

- Farm to Fork TV Ad #1
- Farm to Fork TV Ad #2
- Farm to Fork TV Ad #3
- Farm to Fork section of Fox21 website

Final Report: Market Research and Sourcing New Markets for Colorado Dry Beans, Potatoes, Onions, Chiles and Carrots
Partner Organization: Not applicable. This project was implemented by the Colorado Department of Agriculture.

Project Summary

One of the factors limiting profitability for specialty crop farmers and discouraging greater planted acres in Colorado is limited markets. Mexico is one of the largest export markets for Colorado and the need for market intelligence and export education is critical in order to help Colorado producers increase sales and exports. Colorado currently exports various specialty crops into Mexico but only to a limited number of buyers. With the market intelligence gathered through this project, Colorado producers will have more contacts and a better understanding about selling their product in Mexico.

Project Purpose

This project was intended to increase Colorado specialty crop sales by providing market intelligence and diversifying client base for producers and handlers of Colorado specialty crops, specifically dry beans, potatoes, onions, chiles and carrots.

Mexico is currently Colorado's largest customer for dry beans. Before the market intelligence report provided by this project, growers and dealers did not have a comprehensive list of bean buyers in their biggest export market, Mexico. The intelligence that was gathered about Mexico will have a direct impact on Colorado growers and dealers by helping gain knowledge to increase sales and relations in Mexico. The Colorado producers now have the opportunity to adjust their sales tactics, create new connections and relationships and potentially increase exports to Mexico.

Mexico already imports Colorado potatoes, but there is potential to increase these exports with the right connections and relationships made between importers and Colorado producers.

There is also real potential for export of other specialty crops to Mexico, such as carrots and onions, and now Colorado farmers and handlers currently have the opportunity to make connections and network with buyers of those products in Mexico.

Project Activities

Assemble a complete list of qualified bean buyers and contacts in Mexico

The Colorado Department of Agriculture (CDA) hired G&G Gestoria en Comercio Exterior S.C., who is CDA's contractor located in Mexico, to compile the list of qualified buyers and organize a market intelligence report on Mexico. In order to create a list of legitimate qualified buyers the report needed to be created by CDA contractor located directly in Mexico. G&G Gestoria was able to gather a list of 115 qualified bean buyers in Mexico to share with Colorado producers. This list was shared via email with Colorado bean dealers, who purchase beans from Colorado producers and market them.

Brief dry bean handlers on contents of qualified buyers list and how to use it, brief handler on current and future crops of dry beans in Mexico

Nora Gonzalez with G&G Gestoria came to Colorado on September 20-27, 2015 to meet with Colorado producers and share the market research and qualified buyers list. Ms. Gonzalez gave a full presentation on her research to a group of Colorado bean handlers and producers in Colorado. Ms. Gonzalez briefed the group on the best way to sell Colorado beans in Mexico, how to contact the buyers from her list and the best ways to increase sales to Mexico. Ms. Gonzalez also had extensive research on the current bean production in Mexico divided out by regions across Mexico. She explained the difference between the regions and provided suggestions on selling product in those different areas. Along with the current market for dry beans Ms. Gonzalez shared a predicted forecast of what the Mexico crops were going to look like in the market for 2015.

Meet with dry bean, onion, potato, carrot and other specialty crop growers in Colorado to educate them on how to do business in Mexico

Nora Gonzalez with G&G Gestoria traveled throughout Colorado for one week to learn about Colorado crops and to brief Colorado producers about Mexico. While in Colorado Ms. Gonzalez visited with onion, carrot, chile, potato, pumpkin and dry bean producers around the state.

The progress of this project was monitored by the CDA project manager. The CDA project manager received the report on dry beans in Mexico and forwarded it on to the Colorado Dry Bean Administrative Committee, dry bean growers and handlers. The CDA project manager participated in the tour of Colorado farms, producers and facilities and ensured that the contractor met with a sufficient number of farmers, companies and grower groups.

This project did not benefit products other than specialty crops.

Goals and Outcomes

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Increase dry bean sales in Mexico market by researching new customers	A comprehensive list of qualified dry bean buyers that will be provided to Colorado bean growers and dealers	0	List distributed to 50 growers and handlers	14 handlers, representing over 50 growers

The list generated by G&G Gestoria consisted of 115 qualified buyers located throughout Mexico. This list, along with the market intelligence report, was distributed to the Colorado Dry Bean Administrative Committee, which posted a request to access the directory on their website for every grower, dealer and handler to see, as well as distributed it to the 14 bean dealers. These 14 bean dealers work with and represent majority of the bean growers in the state. It was decided

that distributing to dealers was the best mechanism since they are the ones actually selling to Mexico, but the report is available to individual farmers as well.

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Increase knowledge of how to market and sell specialty crops to Mexico	Meetings with individual farmers, individual companies, and grower groups	0	20	20

CDA Contractor Nora Gonzalez traveled throughout Colorado for one week and met with five onion producers, four dry bean producers, one carrot producer, seven potato producers, two chile producers, and one mushroom producer. Ms. Gonzalez discussed Mexico with each of the companies to gather intelligence on the Colorado production and gauged interest in exporting to Mexico.

Goal	Performance Measures	Benchmark	Target 2015	Outcome
Increase intention to export crops to Mexico	% of bean handlers and specialty crop producers indicating the project increased their knowledge about exporting to Mexico and their confidence in doing so	0	50% of participants indicate increasing interest in exporting to Mexico	75%

Following the event and tour around Colorado the CDA conducted a survey with the bean producers and handlers who attended the presentation given by the contractor, Ms. Gonzalez. Based on the results of the survey 100% of the bean dealers and handlers believe that the presentation increased their knowledge about exporting to Mexico. However, only 75% of the participants are interested in increasing sales to Mexico.

Beneficiaries

This project directly benefited the Colorado carrot, onion, potato, chile and bean handlers and producers who now have the information and opportunity to diversify and increase their sales to Mexico. The project was supported by farmers who currently grow dry beans as a rotational crop in addition to those growers who are looking at the benefits of having a rotational crop that leaves nitrogen and nutrients in the soil; growers who want to maintain viability, profitability and existing acres of specialty crops such as potatoes, carrots and onions; and the Colorado Department of Agriculture, understanding the value of diverse crops and growth in the export market.

Lessons Learned

When presented the opportunity, Colorado producers are interested in finding new markets to diversify their sales.

By visiting different farms around Colorado, the CDA contractor was able to give useful insight about how those products might perform in the Mexico market and the best way to sell them. The contractor was also able to answer questions and clear up misconceptions about exporting to Mexico that producers may have had.

The harvest season was a perfect time to visit the producers, farms and facilities. The contractor was able to see the finished products, packaging and process of the Colorado producers and advise on how to sell to Mexico.

Visiting the producers and their facilities was beneficial for both the contractor and producers. From the personal visits, CDA and the contractor were able to build personal relationships with growers and talk to the correct sales representatives. Communication through telephone and email are not as personal as visiting the production and expressing interest in their business.

Contact Person

John Addison, Marketing Specialist
Colorado Department of Agriculture
303-869-9180
John.Addison@state.co.us

Additional Information

Onion producer in Colorado showing the freshly harvested crop.

Ms. Gonzalez giving a presentation about dry beans in Mexico to Colorado bean producers and handlers.

Final Report: PlantSomething Colorado Final Report
Project Partner: Colorado Nursery and Greenhouse Association (CNGA)

Project Summary

PlantSomething Colorado was created to combat the lack of involvement in gardening by the younger generation and lack of education on how to successfully garden by many in the general population. Using social media and radio advertising we drove consumers to our public-facing website, plantsomethingco.org for inspiration and education to successful gardening and how to find retail member locations.

Social media and radio ads across the state provided additional awareness of the resources provided on the PlantSomething Colorado website and will benefit any business involved with plants and landscapes. This increased consumer base as well as the knowledge that is provided will increase the sales of plant material.

Project Approach

The public facing website plantsomethingco.org was used to deliver information to consumers and promote local garden centers. In an effort to drive people to the site, we used social media advertising on Facebook, Twitter and Instagram during the months of April to June of 2015. This type of boost advertisement was targeted to consumers that live in specific areas and will be tied to local garden centers in those areas. Paid radio advertising and public service announcements ran during the same season throughout the state of Colorado.

An independent marketing firm, Burns Marketing, was hired, and the focus of their work was engaging consumers and creating interactions with them. A contest was created, along with marketing pieces for the contest participants and the retail locations participating. Burns Marketing also created a social media campaign that included Facebook, Twitter and Instagram, with postings made 2-4 times per day between April and July, in addition to marketing on streaming radio (Pandora). Additional updates were made to the current PlantSomething website to include pages for the contest rules and the find your local retailer and to the home pages.

Goals and Outcomes Achieved

Goal	Performance Measure	Benchmark	Target
			2015
To increase the awareness of how to successfully garden.	Increasing the number of visits to the website and returning visitors as well as increase the number of consumers who participate in a gardening contest	5,491 visits with 82% returning visitors 0 participants in contest (no benchmark as contest is new)	10,000 visits with 84% returning visitors April – 1,500 May – 4,000 June – 2,500 July – 2,000 At the end of the contest, we would like to have approximately 250 picture submissions between Twitter, Facebook and Instagram. Each submission will use the hashtag #plantsomethingco

During the contest the website received 12,690 visits, of which 81% of these visits were new users and 7,597 visits to the participant location page. We did not measure activity in April. Mother's Day (mid-May) is typically the kick off of the gardening season in Colorado, which is why we started measurement in mid-May. Also, the contract for this project with the Colorado Department of Agriculture was executed on May 5.

May 11-31 – 2,073
June – 6,588
July – 2,410
August 3-17 – 3,101

The contest had over 800 photo submissions.

Goal	Performance Measure	Benchmark	Target
			2015
To increase the number of retail locations participating in Plant Something.	The number of participants in the plant Something program will increase	Six retail locations currently sponsoring; 16 participating in program	8 retail locations currently sponsoring; 28 retail location participants

There were 28 participating retail locations this year, up from the 17 we had last year. We had three member companies pay for sponsorships. Marketing pieces were made available to the association membership for marketing in their individual locations, and on their own websites and Facebook pages.

Goal	Performance Measure	Benchmark	Target 2015
To increase the amount of plant sales at independent retail locations.	Increased sales for a specific period of time.	Combined 2014 sales of sixteen: April 2014 - $3,584,991 May 2014- $9,321,661: June 2014 - $6,824,765	April - $55,000 increase; (April numbers will be included if contract is executed in time) May - $100,000, increase June – 75,000 increase

We were not able to get sales from all participating companies, but those we did receive show an increase of $2,097,112.00 over last year. What cannot be measured is the impact to customers that were motivated by the PlantSomething campaign but secured a landscape professional to improve their landscape or purchased plant material from non-member companies. The professional landscapers would have made their purchases at various wholesale locations, the sales of which are not trackable.

Goal	Performance Measure	Benchmark	Target 2015
Increase the number of Facebook likes, Twitter and Instagram Followings	Number of Facebook likes, Instagram and Twitter Followings on PlantSomething Colorado page	Page is currently being developed	250 – Facebook Likes 100 – Twitter followers 100 – Instagram followers

The PlantSomething campaign had 1,213 social media followers, with over 800 photo submissions and 1,011,696 impressions on Pandora. Facebook received 4,490 likes, Twitter received 129 favorites and Instagram received 1,116 favorites.

Beneficiaries

The public, local retail nurseries and garden centers benefited with increased sales and consumer interactions. By driving the public to the PlantSomething website (www.plantsomethingco.org) consumers were able to find local retail members in their areas, and to gather information quickly and easily directly from professionals on how to garden successfully, and learn about featured plants, monthly tips, and events at retail member locations. The contest gave the public another direct means to go to their local retail nursery and garden center, as that was the only way they could enter and participate in the contest.

The wholesalers, both in the state of Colorado and outside of Colorado benefited by the increased number of sales of plant material to their customers, the retail nurseries and garden centers. By increasing the number of new gardeners each year, the sales for both the retail and

wholesale industry should increase as the number of plant materials bought from year to year grows and thus increasing the supply needed.

Lessons Learned

Throughout the 2015 Plant Something Campaign, we were able to identify many things to continue in the future and others that need to be improved on. We had great success with our campaign being run through social media platforms. With over 1,200 followers on the three platforms, we were able to reach a wide audience on a consistent basis. Our original goal was approximately 250 followers total. When paying to boost our posts on Facebook, we were able to reach an average of 11,000 people per boosted post. Our website visits increased by 700% over the previous years, specifically the pages that list the independent retail locations of companies that are participating in the campaign. Of the people that visited the website, 81% were new visitors. We were able to create excitement around gardening with the contest and giveaways we had and in turn had over 600 photographs of people gardening posted on our site. During the 4 weeks that the Pandora radio ads ran, we increased our web visits significantly.

In 2016, we'll focus more on boost posts as we found that our ROI in that area is greater than others, such as Pandora. The plant stakes that we provided were not used in as many photos as we'd hope, so we'll revisit providing those to participants. We also learned a lot about the way Facebook tags posts and the ability of administrators to see the pictures. In 2016, we'll refigure our processes to accommodate the tagging.

Contact Person

Allison Gault
Executive Director
Colorado Nursery and Greenhouse Association
303-758-6672
agault@coloradonga.org

Additional Information - Graphics:

Here are some of the graphics and social media pages that were used during this year's campaign.

PlantSomething Facebook page.

PlantSomething Twitter page.

PlantSomething Instagram page.

Pandora radio spot examples

PlantSomething contest marketing Kit for the retailers. Kit included plant stakes & seed packets.