Wyoming Department of Agriculture

Specialty Crop Block Grant Program – Farm Bill

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Final Performance Report

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QUALITY INFORMATION FOR EXISTING AND POTENTIAL SPECIALTY CROP PRODUCERS

PROJECT SUMMARY

Data has shown that small acreage landowners (and often larger and even smaller landowners as well) in Wyoming want more user-friendly, practical, climate-appropriate information on a variety of specialty crop issues. Small acreage landowners were (and are) a logical target for specialty crop information as many beginning farmers and ranchers begin on smaller acreages before gaining the experience and capital needed to expand onto larger acreages; and other specialty crop endeavors require limited land so are sustainable on smaller acreages. The overall purpose of this project was to raise awareness of and provide information on specialty crop topics through articles in the popular and well-known medium of the *Barnyards & Backyards* magazine.

Prior to this grant reader response to published articles in Barnyards & Backyards and attendance at small acreage workshops has made it evident that there was also a great hunger in the state for information about pollinators and bee-keeping. Our climatic conditions (severe winters, short seasons, aridity, lack of pollinator forage, etc.) can make bee keeping more challenging than in areas with a more amenable environment. With our pollinator guide we sought to provide potential specialty crop producers with timely information on pollinators, their needs, plants to support them and basic beekeeping considerations in a state with very challenging environmental conditions.

PROJECT APPROACH

Utilizing survey information and expert knowledge we developed topics, recruited authors and ultimately produced articles on topical areas such as the basic information needed to begin production in a variety of vegetable and fruit crops, season extension techniques - which are vital to profitable production at higher altitudes in our state, integrated pest and disease control, weed control, and pollinator support. This is the first SCBGP grant the Backyards and Barnyards received.

Timeline	**Personnel**	**Activities completed**
Created list of topics covered in magazine articles	Personnel from the Small Acreage Issue Team partners (University of Wyoming Extension, conservation districts, WY Dept. of Agriculture, Audubon Rockies, etc.) And other logical partners.	October 2014 (First large input session), team personnel met 3-4 times each year (Fall 2014 – Winter 2016 and brainstormed grant funded Specialty Crop articles,
Created detailed outline of pollinator guide	Small Acreage Issue Team partners (University of Wyoming Extension, conservation districts, WY Dept. of Agriculture, Audubon Rockies, etc.) and other logical partners.	Detailed outline was created at PI meeting on August 13, 2015 in Casper Wyoming. Tweaks occurred to this outline as content was obtained.
Secured authors and partnerships secured for magazine articles and pollinator guide information.	Jennifer Thompson, University of WY Extension	Secured authors for magazine Specialty Crop articles (grant funded and non-funded) periodically from Fall 2014 through Spring 2017. Authors and partnerships were

		secured early (Winter 2015), but due to a dearth of Wyoming specific pollinator information and pictures, areas of controversy in pollinator studies, the research (100+ scientific papers reviewed) and consultation with other experts (such as those at USDA-ARS Logan The Pollinating Insect-biology, Management, Systematics Research lab, WY Natural Diversity Database) the process took much more time than originally anticipated.
Authors submitted rough draft articles and guide sections	Small Acreage Issue Team partners (University of Wyoming Extension, conservation districts, WY Dept. of Agriculture, Audubon Rockies, etc.) and other logical partners.	Magazine articles – (draft articles were submitted the weeks of Jan 1, April 1, July 1, and Oct 1 dependent on the issue the article appeared in) Guide – First rough drafts for some of the sections came in Oct 2015; others were not completed until late 2016.
Detailed editing and review of written pieces	Jennifer Thompson and Steve Miller, University of WY Extension Magazine - In addition to editors above, 7 Small Acreage Issue Team magazine article review committee members and ad hoc experts when needed Pollinator guide – In addition to editors above, cumulatively approx. 8 informal reviewers (not already involved in project) reviewed guide material. Four formal peer reviewers.	Magazine articles – thorough, 3 tiered editing and review took place for all funded and non-funded Specialty Crop articles in each issue from Winter 2014 through Spring 2017. Guide – Sections were edited multiple times as they hit reasonable completeness. This began in later 2015 and ranged by section through later 2016. At least 6 informal peer reviewers reviewed the guide sections, 4 formal peer review reviewers reviewed the final sections (from late 2016 through March 2017). Additional content expert reviewers were engaged to review the additional online only appendices in 2017.

Accompanying photos were obtained	Jennifer Thompson, University of WY Extension	Magazine articles – photos were secured from authors or stock sources for all funded and non-funded Specialty Crop articles in each issue from Winter 2014 through Spring 2017. Guide – A few appropriate pictures existed among authors and we were able to secure more from a variety of sources but we ended up taking several hundred Wyoming specific pictures during the growing seasons of 2015, 2016 and very early 2017 (see photo credits in guide for photo sources).
Publications were laid out and then printed	Tana Stith and Tanya Engel, UW Extension Magazine – Tana Stith laid out the magazine issues. Review and editing on laid out versions of article and printer's proofs were conducted by Steve Miller, Jennifer Thompson and Tana Stith. Guide – Tanya Engel laid out the guide. Review and editing on laid out versions of guide and printer's proofs were conducted by the publication authors, Steve Miller, Jennifer Thompson and Tanya Engel.	Magazine articles – layout (by Tana Stith) for all funded and non-funded Specialty Crop articles in each issue occurred from Winter 2014 through Spring 2017. Three rounds of additional reviews/editing occurred on laid-out versions of each issue of the magazine. Printing and shipping occurred after that process was complete for each issue. Guide – Due to an unusual glut of publications going through our only layout department, personnel cutbacks and various other changes at our institution, layout work on the guide was delayed until Summer 2017. It was completed and several rounds of editing took place before final printing.
Distribution and state-wide promotion	Jennifer Thompson, University of WY Extension. Ms. Thompson arranged logistics of printer bidding, arrangement of payment, communication with project partner organizations, shipping lists, etc. Various other staff at UW carried out	Magazine articles – Shortly after printing magazine issues were shipped out to locations across the state (see map in report). Magazine articles were also promoted through email list serves and at events around the state.

	the printer spec reviews, bidding processes, financial transactions and contributed to maintenance of magazine shipping lists.	Guide – Pollinator guide was printed and shipped in the summer of 2017. Guide was promoted through email list serves, social media, contacts with partner organizations and beekeeping associations, and a press release. Though we used our own project funds to supplement grant funds for printing and shipping of the guide (4,000 copies), few "extra" copies were printed. Demand has been high in the state and only a few copies are left. Due to the publication of the guide several pollinator workshops are being planned out in the state this year.
Surveys occur to measure usage, etc.	Jennifer Thompson, University of WY Extension	Surveys were conducted in 2017 to determine the usefulness of these materials (see data in report). Additional data collection will be taken at workshops scheduled this year.

All articles were printed and distributed in the magazine and pdf files were posted to increase in awareness of specialty crop topics.

The following were magazine articles published on Specialty Crops Topics:

- Unraveling the mysteries of mushrooms
- Rediscover your roots (vegetable root crops)
- Featured landowners: Family lives more sustainably (article features Specialty Crop supported high tunnel and the CSA it makes possible in an EXTREMELY challenging growing environment)
- Wyoming hosts many native pollinators
- Ten Rocky Mountain natives you can grow
- Not your usual garden crop (hops) -
- Are radiant heat retention strategies beneficial to high tunnel production?
- Easy to grow, good for you, taste great – but a little raspberry research will sweeten the success
- Enjoy this nutritional powerhouse's tartness softened by sweet
- Risks of residual herbicides in compost and manure used in gardens
- Voles
- Apple-icious! Use these tried-and-true methods for apple goodness all year long - 3 pages
- Featured landowner: Diversity, adaptability key to bee, beef, vegetable operation - 2 pages of relevant content

Magazine articles published in 2016-2017 on specialty crops topics not funded by grant:

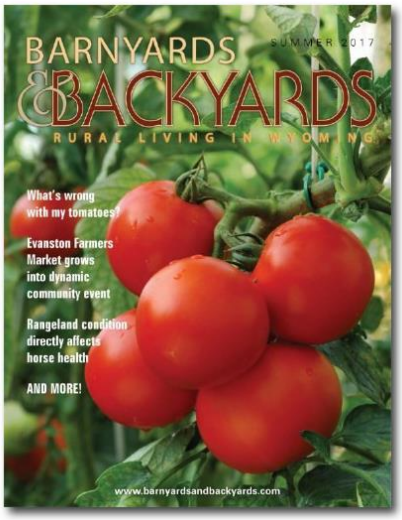
- European paper wasp, a world traveler, finally arrives in Wyoming
- Fruit production do's and don'ts for the backyard or hobby farmer

- Pruning your grapevines –
- Assessing cold damage guides pruning for bountiful vineyard production
- Unpretentious potato quietly goes about feeding the world
- Need more season for growing your vegetables? We can do that
- Apple, pear trees can survive and thrive in Wyoming
- Featured landowner: Passion for growing turns into grand experiment
- Garden pest control may not require heavy artillery
- What's eating my plant?
- Residential lot-turned-small-farm yields prized produce
- The backyard buzz: Wyoming's native bees (pollination)
- No lie! You can grow cherry trees in Wyoming – just be selective
- The science behind crop improvement and new plant development
- Three strawberry types sweeten Wyoming tables
- Lungren Girls' Farm: A-maize-ing fun for the whole family
- Growing healthy soil in the garden

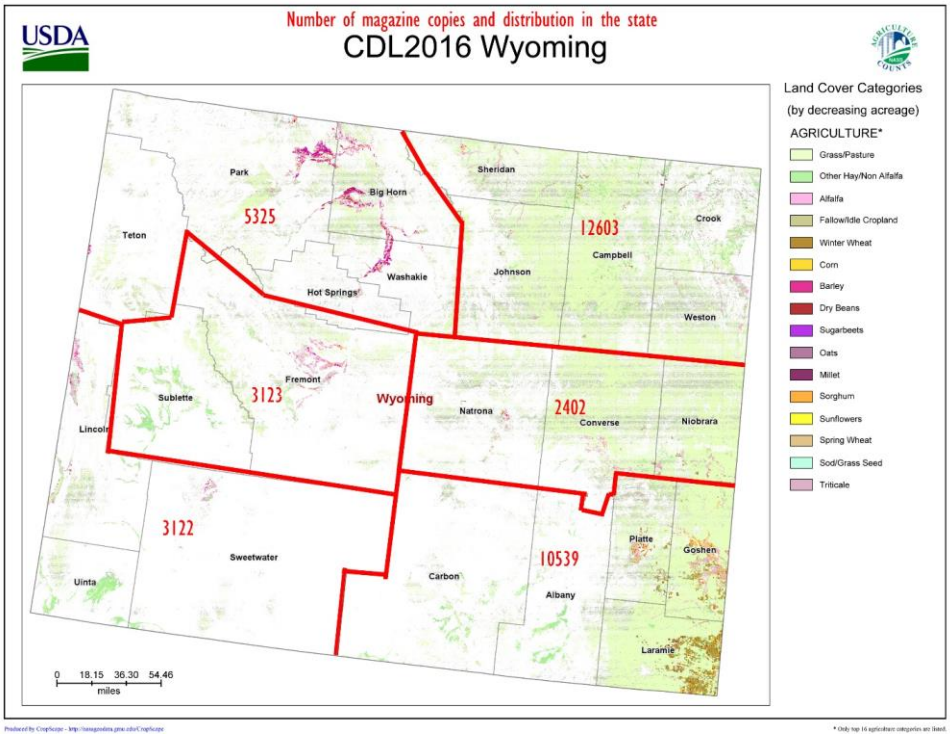
Pollinator guide sections were written using Wyoming-appropriate content, accompanying pictures relevant to our area were taken, and the publication was professionally edited, designed and printed. We created a user-friendly stand-alone publication that provides practical information for those who want to learn more about pollinators (native and introduced), which Wyoming-hardy flowering plants to grow to support them (whether on a farm or ranch or throughout a community in gardens) and the basic considerations for beginning bee-keeping in our climate.

GOALS AND OUTCOMES ACHIEVED

GOAL 1: Increase awareness of specialty crop issues by individuals exposed to the articles.
Performance Measure: Provide practical information for small acreage landowners on a variety of specialty crop issues through Barnyards & Backyards articles. Increase the number of specialty crop articles to twenty-five percent of the content of each issue of the Barnyards & Backyards magazine (winter 2015 issue through the fall 2016 issue). (6-7 pages on specialty crop topics per issue)+
BENCHMARK: There was no benchmark set to include specialty crop articles.
TARGET: We proposed that a total of 13,200 copies would be distributed of which 25% will be related to specialty crops.



We have far exceeded our goal of 13,200 copies of the *Barnyards & Backyards* magazine being distributed, as 23,050 copies were distributed while using grant funds (Winter 2015 through Spring 2016 issues), and additional 17,150 copies were distributed without grant funds (Summer 2016 through Summer 2017). A total of 40,200 copies were produced during the entire grant period. Over the 6 issues produced during the time grant funds were contributing to costs (2015 through spring 2016 issues) 33% of the magazine content was on Specialty Crop subjects. The last of the grant funds allocated for printing and shipping were expended on part of the articles in the spring 2016 issue. The issues from summer 2016 through summer 2017 were produced without Specialty Crop grant funds. $24,337.86 ($6,569.69 on Specialty Crop related article pages – 27% of total pages) was expended on printing and shipping for these issues.



Four issues of the *Barnyards & Backyards* magazine have been published and shipped. We met our goal of 13,200 copies distributed, as 14,866 copies were distributed. 26% of the total page in the 4 issues was on Specialty Crop subjects.

Magazine articles on Specialty Crops Related Topics:

Winter 2015 (3,600 copies printed and distributed)

This issue contained 3 articles with Specialty Crop content. (7.75 pages)

Article titles:

- Unraveling the mysteries of mushrooms - 3 pages
- Rediscover your roots (vegetable root crops) - 3 pages
- Featured landowners: Family lives more sustainably (article features Specialty Crop supported high tunnel and the CSA it makes possible in an EXTREMELY challenging growing environment) – 1.75 pages

Spring 2015 (3,300 copies printed and distributed)

This issue contained 5 articles with Specialty Crop content. (13 pages)

Article titles:

- Wyoming hosts many native pollinators - 3 pages
- Ten Rocky Mountain natives you can grow - 2 pages of pollinator beneficial content
- Not your usual garden crop (hops) - 2 pages
- Are radiant heat retention strategies beneficial to high tunnel production? - 3 pages
- Easy to grow, good for you, taste great – but a little raspberry research will sweeten the success - 3 pages

Summer 2015 (3,874 copies printed and distributed)

This issue contains 2+ articles with Specialty Crop content. (4+ pages)

Article titles:

- Enjoy this nutritional powerhouse's tartness softened by sweet - 3 pages
- Risks of residual herbicides in compost and manure used in gardens - 1 pages
- Voles

Fall 2015 (4,092 copies printed and distributed)
This issue contains 2 articles with Specialty Crop content. (5 pages)

Article titles:

- Apple-icious! Use these tried-and-true methods for apple goodness all year long - 3 pages
- Featured landowner: Diversity, adaptability key to bee, beef, vegetable operation - 2 pages of relevant content

Magazine articles on specialty crops related topics not funded by Backyards and Barnyards grant:

Winter 2016 (4,092 copies printed and distributed)
This issue contains 6 articles with Specialty Crop content. Three were result of other specialty crop projects. (14 pages)

Article titles:

- European paper wasp, a world traveler, finally arrives in Wyoming – 1 page
- Fruit production do's and don'ts for the backyard or hobby farmer – 3 pages
- Pruning your grapevines – 2 pages
- Assessing cold damage guides pruning for bountiful vineyard production – 3 pages
- Unpretentious potato quietly goes about feeding the world – 3 pages
- Need more season for growing your vegetables? We can do that – 2 pages

Spring 2016 (4,092 copies printed and distributed)
This issue contains 4 articles with Specialty Crop content. (12 pages)

Article titles:

- Apple, pear trees can survive and thrive in Wyoming – 3 pages
- Featured landowner: Passion for growing turns into grand experiment – 3 pages
- Garden pest control may not require heavy artillery – 3 pages
- What's eating my plant? – 3 pages

Summer 2016 (4,200 copies printed and distributed)
This issue contains 2+ articles with Specialty Crop content. (6+ pages)

Article titles:

- Residential lot-turned-small-farm yields prized produce – 3 pages
- The backyard buzz: Wyoming's native bees (pollination) – 4 pages
- No lie! You can grow cherry trees in Wyoming – just be selective – 3 pages
- The science behind crop improvement and new plant development – 3 pages

Fall 2016 (4,200 copies printed and distributed)
This issue contains 3 articles with Specialty Crop content. (6 pages)

Article titles:

- Three strawberry types sweeten Wyoming tables – 2 pages
- Lungren Girls' Farm: A-maize-ing fun for the whole family – 1 page
- Growing healthy soil in the garden – 3 pages

Winter 2017 (copies printed and distributed)
This issue contains 3 articles with Specialty Crop content. (8 pages)

Article titles:

- Couple turns eastern Wyoming property into pollinator playground – 3 pages
- Land blossoms under direction of northeastern Wyoming family – 3 pages
- Spinach provides a powerful punch against health villains – 2 pages

Spring 2017 (copies printed and distributed)

This issue contains 3 articles with Specialty Crop content. (10 pages)

Article titles:

- Apply a little agricultural economics to your garden for best results – 3 pages
- Garden cover crops bolster soil nutrients, organic matter – 3 pages
- Family operation cultivates best vegetable growing techniques for short growing seasons – 4 pages

Summer 2017 (copies printed and distributed)

This issue contains 3 articles with Specialty Crop content. (9 pages)

Article titles:

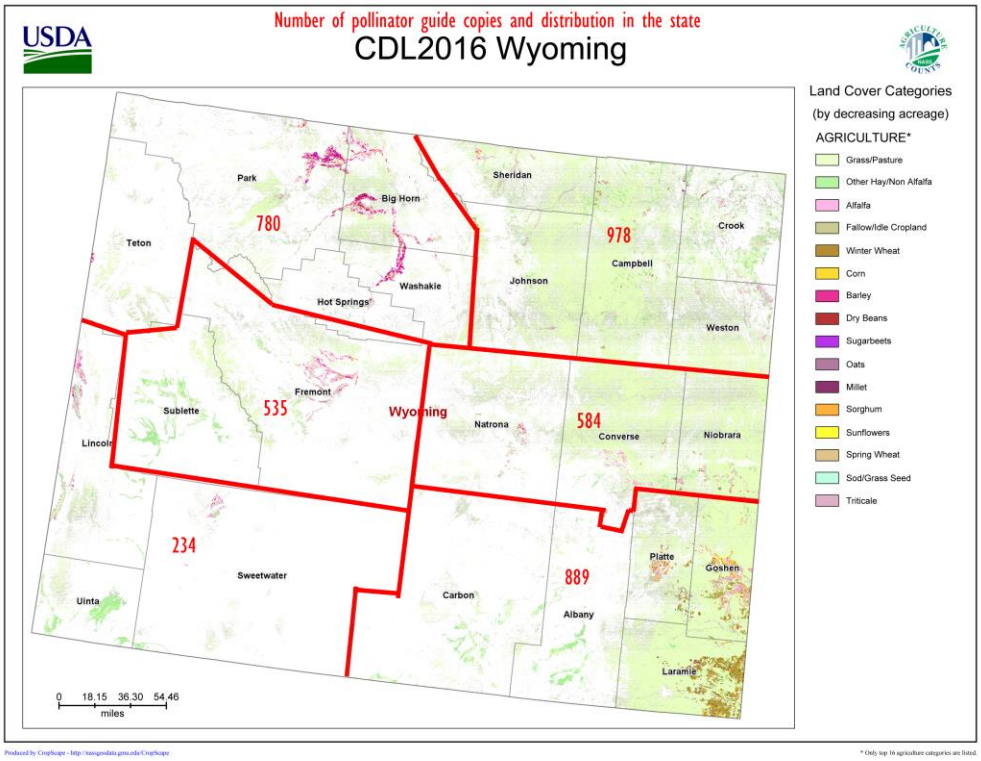
- Evanston Farmers Market grows into dynamic community event drawing from Wyoming and Utah, opening markets for local goods – 3 pages
- What's wrong with my tomatoes? – 3 pages
- Plants with perk – 3 pages

PERFORMANCE MONITORING: We expected a minimum of 25% of the participating organizations to report increased awareness. 95% of responding readers reported that the *Barnyards & Backyards* magazine articles increased their awareness of topics related to growing specialty crops (54% Yes, quite a bit; 41% Yes, some; 5% No).

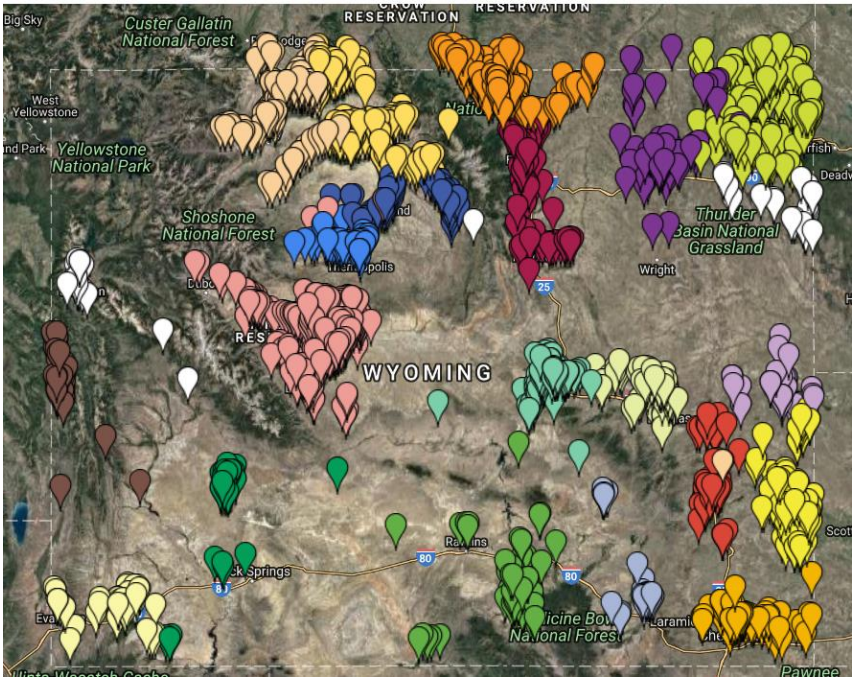
Participating organizations reported that the articles raised their own awareness (76% Yes, quite a bit) and that of their clientele (73% Yes, quite a bit).

GOAL 1: Provide practical information to small acreage landowners on pollinators, which plants to grow to support them and the basic considerations for beginning bee-keeping by creating and distributing a user-friendly stand-alone publication

Performance Measure: We proposed that we would promote guide and track copies shipped to each destination (offices and other locations around the state) to measure use by locality.

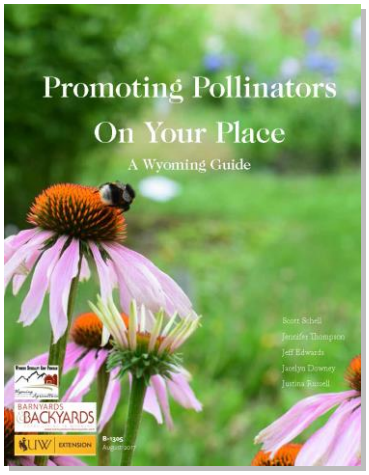


Wyoming Apiary Sites



TARGET: Develop, print and distribute (to UW Extension/Master Gardeners, conservation districts, and other Barnyards & Backyards partner organizations) at least 5,000 copies of the guide.

PERFORMANCE MONITORING: Pollinator guide sections were written using Wyoming-appropriate content, accompanying pictures relevant to our area were taken, and the publication was professionally edited, designed and printed. Due to the length of the publication needed to provide the appropriate information and increased printing and shipping costs 4,000 copies of the pollinator guide were printed and distributed across the state (see map above). Printing and shipping for copies exceeded the monies budgeted out of the grant, so we picked up the balance out of our funds. In addition, supplemental appendices providing more information on climatically appropriate plants to support pollinators, Wyoming-appropriate pollinator seed planting mix creation guidance, and additional images of Wyoming pollinators were created and posted on-line.



An electronic version of this guide can be found at
http://www.uwyo.edu/barnbackyard/resources/pollinators.html

We posted an electronic version on the Barnyards & Backyards site and UW Extension publications site, and encouraged linking from all partner organization sites. We have promoted the guide across the state through email list serves, newspaper press releases, social media and other media. Due to publication delays we will be conducting usage surveys after our next growing season.

BENEFICIARIES

The target audience for the Backyard and Barnyard magazine and the Pollinator Guide was the same. At least 4092 UW Extension educators, Master Gardeners, and Wyoming specialty crop producers were impacted by reading the publications. The number is likely much higher as people often share back copies with friends or neighbors.

LESSONS LEARNED

Due to the dearth of information about pollinators in Wyoming and what appeared to be somewhat biased information common in many popular pollinator informational sources for other parts of the country, we ended up doing extensive research of the pollinator literature (over 100 peer-reviewed scientific papers), and interviewing of other expert state-based sources. This took some time. The injection of resources being expended through federal sources to support pollinator research in this area will likely correct this situation over the long term. The project coordinator also had an unexpectedly hard time convening fellow pollinator guide authors in-person in a timely manner due to their extremely heavy schedules and the travel distances involved in our state. With the improvement of electronic meeting resources over this grant period, in the future she will engage authors electronically if an in-person meeting can't be accomplished in a timely manner. Effective face-to-face conversations (rather than emailing, etc.) are vital to begin a project such as this, especially when determining content to be covered, cataloging informational base sources and identification of gaps in knowledge/content.

CONTACT INFORMATION

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STUDYING GRAPEVINE WATER REQUIREMENT AND IRRIGATION MANAGEMENT STRATEGIES IN WYOMING VINEYARDS

PROJECT SUMMARY

The purpose of the project was to study grapevine water requirement and possible approaches for efficient water utilization, resulting in improved grapevine growth and development, yield and berry quality in Wyoming vineyards. Inadequate water and subsequent drought-related stress continues to be a major issue affecting early establishment and productivity in Wyoming vineyards. Grapevine water requirement varies with age, phenology stages and berry color (red/white). We initiated field experiments to study the effect of geotextile fabric on water requirement, grapevine vegetative and reproductive growth and fruit quality parameters. Landscape fabric was established in grapevine cultivars 'Frontenac' and 'LA Crescent' in a randomized block design that also contained control rows with no fabric cover. Irrigation systems were established to water the fabric treatments and controls. We also installed a Watermark irrigation sensor system to record soil water potential while leaf water potential was recorded using a pressure chamber. Days required for fruit ripening and fruit quality data including fruit TSS, pH and titratable acidity were measured for the landscape fabric and control treatment for both cultivars. We observed a significant increase in the days to ripening and improvement in fruit quality characteristics of treated vines compared to the controls in both cultivars. Additionally, water requirement along with weed growth and proliferation were significantly lower in the fabric treatment compared to the controls. Information on experiments was provided during field days, and field visits organized for growers. The study successfully demonstrates the benefits of using landscape fabric for reducing water requirement, labor costs associated with weeding and improving fruit quality.

PROJECT APPROACH

The study was established to evaluate the influence of geotextile use on cold-hardy wine grape fruit quality characteristics, and was initiated at a cooperating grower's vineyard in Wheatland, WY in 2015. Two varietals commonly grown in WY, *V.* 'Frontenac' a cross between 'Landot' 4511 and Univ. of Minn. *V. riparia* no. 89 (Univ. of Minn, 2017a), and *V.* 'La Crescent', a cross between 'St. Pepin' x 'E.S. 6-8-25' (Univ. of Minn, 2017b), are included in the study. It is presumed that the use of geotextile fabrics in WY vineyards may reduce irrigation requirements through the reduction of evaporative losses, and hasten fruit ripening through microclimate modification by way of reflective heat. Experiments were initiated in 2015 to study the influence of geotextile fabric on cold-hardy grapevine fruit quality in Wyoming vineyards. A test site was established at a grower's vineyard in Wheatland, WY where ten-year-old 'Frontenac' and 'La Crescent' vines trained as a quadrilateral cordon system were offered for experimentation. During the spring of 2015 vines were pruned to convert the training system from a quadrilateral cordon into a high bilateral cordon. Cordon arms on the top wire were pruned to 1 meter in length in either direction of the head, and canes were pruned leaving 24 two-node spurs. Vineyard drip irrigation was fabricated with each treatment assigned to a separate zone for a total of two zones per varietal. Irrigation zones were comprised of 1.9 cm polyethylene tubing manufactured by Landscape Products, Inc. [1] (Tolleson, AZ) run down the length of a row with Rain Bird (Azusa, CA) XB-01 emitters installed proximally to the root flare of each vine. Two treatments were established, a control and the installation of 4.8 oz. woven needle-punch geotextile fabric manufactured by Western Landscape & Geotextile Supply (Denver, CO) under vines. Four out of five rows for each varietal were selected for the study, with border rows excluded from the study. For the 2015 season, all pruning, vine maintenance, and irrigation practices were carried out by the vineyard owner in line with her typical production practices. A "Water Mark" moisture sensor system was installed in the vineyard to record soil water potential and correlate it with leaf water potential measurements that were made. Following 100% veraison, five sets of berry samples were collected from each treatment three times, with the last collection date taking place at harvest

(September 19th, 2015). Samples were collected at random from vines located throughout the treatment replicates in an effort to obtain representative samples. Individual samples consisted of thirty berries picked randomly from the cluster profile. Samples were immediately cooled and transported for analysis. Laboratory analysis of samples was carried out at the University of Wyoming College of Agriculture and Natural Resources (Laramie, WY). Berries from samples were weighed individually, then macerated for chemical analysis. Fruit ^{o}Brix (^{o}B), titratable acidity (TA), and pH were recorded for each sample. Paired t-tests were performed on fruit chemistry data with Minitab 17 (Minitab Inc.; State College, PA) statistical software. This project built on a previous SCBGP study on evaluation and identification of promising grapevine cultivars for diverse edaphic and climatic zones of Wyoming, to overcome obstacles to initial vineyard establishment that would result in increased production and early returns. The objectives were: 1) To identify grapevine cultivars that exhibit rapid growth and establishment in specific soils and locations in WY and 2) study the influence of varying soil and climate on grapevine yield and quality.

GOALS AND OUTCOMES ACHIEVED

GOAL I: To provide information to increase the knowledge of producers on grapevine water requirement at various phenology stages by researching requirements during the growing season.

PERFORMANCE MEASURE 1: Results determined by our research to effectively manage water provided to growers to increase the knowledge of 20-25 grapevine growers on how to schedule irrigation and allocate water based on vine requirements and effective utilization of scarce water resources.

GOAL 2: Provide information to increase the knowledge available to producers by researching the effect of geotextiles/landscape fabrics on growth, maturity time, and yield and berry quality in mature grapevines.

PERFORMANCE MEASURE 2: Grape growers were given information gathered to conserve soil moisture and improve yield/quality using simple measures. Generated information was disseminated at research conferences, field days and master-gardener workshops, and can be utilized by members of the Wyoming Grape and Wine Association and homeowners.

Research Outcomes: The geotextile treatment significantly influenced the amount of water required for irrigation of grapevines. The rows with geotextile treatment were water less frequently compared to the control rows based on leaf water potential observations. Some differences were observed in time required for veraison, juice TSS, pH and titratable acidity between the covered and bare treatments for both 'Frontenac and 'LA Crescent'. Earlier veraison, higher juice pH and lower titratable acidity were observed in the landscape fabric treatment compared to the bare treatment for Frontenac (Figure 2; 3; 4). This is significant considering the fact that major problems in Wyoming grape and wine production include a low juice pH, which is caused by higher titratable acidity and ultimately causes the wine quality to go down. Although we could not see titratable acidity values to those observed in traditional *Vitis vinifera* cultivars, we hope to manipulate these further through irrigation treatments. Frontenac and La Crescent grapevines were propagated in a greenhouse in Sheridan and planted in the field for estimating water requirement of grapevines. Soil tensiometers and a "Water Mark" soil moisture system were installed in the field to study soil moisture levels for scheduling irrigation. A pressure chamber was also purchased to measure mid-day leaf water potential in the bare and landscape fabric treatments. Similar results were observed with respect to berry chemistry under Sheridan conditions. The use of geotextile fabric resulted statistically significant differences between 'Frontenac' treatment and control pH at harvest, and 'La Crescent' ^{o}B at harvest. Additionally, a significantly higher amount of weed control was obtained in the landscape fabric treatment compared to the non-covered rows (Figure 5). Thus, the use of geotextile fabrics in WY vineyards may result in earlier veraison, and improved fruit quality compared to grapevines where no fabric is used. In 2015 and 2016, the test sites experienced heavy rainfall and a late season freeze/snowfall in 2017, which resulted in no irrigation being provided to the vineyards until mid-July. Since the soil was at field capacity for a major duration, we were unable to estimate accurately, water requirement of vines prior to veraison. We observed a reduction in water requirement of vines post veraison in the landscape fabric treatment. It was difficult to accurately estimate the total water requirement due to the rainfall experienced during the growing season. However, we can provide

recommendation on initiating irrigation to vineyards based on soil water potential and their corresponding leaf water potential.

OUTCOME PERFORMANCE MEASURES 1 and 2:

Presentations were made on grape production for updating grape growers and interested homeowners in research activities being carried out for expanding viticulture activities in Wyoming. Talks were presented at the Sheridan county master gardeners in April 2015 (15 people) and the local food production conference in Cheyenne in 2016 (18 people). A grape production workshop was conducted in Powell in May 2015 (30 people) to provide information on the benefits of irrigation management on mitigating cold damage in the vineyard Presentations and visits were carried out at the annual field days in Sheridan (280 people over 3 years) and Powell for years 2015, 2016, 2017 (200 people over 3 years). A presentation was also made at the UW Extension ESCAPE conference (50 people). Information to several growers and homeowners was also provided via phone consultations. Thus stakeholders statewide benefitted from research activities. Beneficiaries of the project included current and prospective grape growers, homeowners and college students

Outcome 2: The resulted were also presented at the fifth international conference of mountain and steep slope viticulture held in Conegliano, Italy. The following publications resulted from the grant project.

Baldwin, M. and Dhekney, S.A. 2017. The grape research program at the University of Wyoming. Proceedings of the 5th International Conference on Steep Slope and Mountain Viticulture, 55-60.

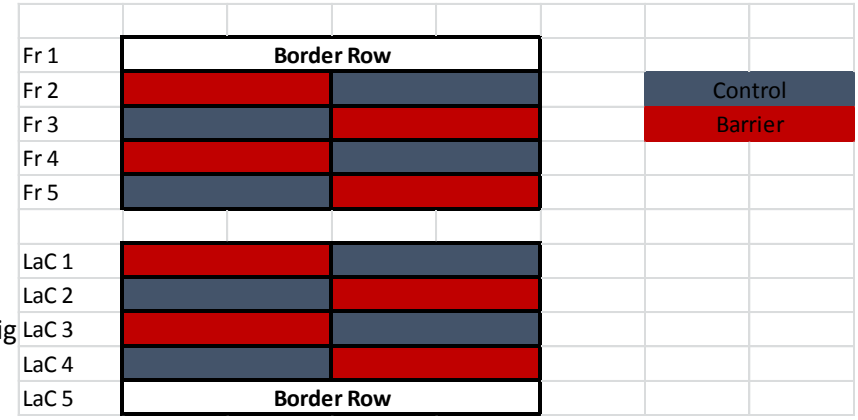
BENEFICIARIES

Presentations were given to 593 individuals in Wyoming and 55-60 internationally. Also (14) prospective growers who requested information for growing grapes were provided information on site selection, soil and water analysis, varietal selection, sources for purchasing grapevines and grapevine management practices. Information was also provided to 9 current grape growers. Information on the benefits of irrigation scheduling on grapevine yield and quality were also presented along with field visits to visitors who were interested in grape production. Based on feedback obtained from prospective growers, we expect to see an increase of 8-10 acres in grape production in Wyoming.

LESSONS LEARNED

Bird foraging at the Wheatland site was a huge problem. To overcome this problem, bird netting was installed over the treatment and control vines. Fungal diseases such as black rot and *Botryospheria* were a problem which was controlled by fungicide sprays. The heavy rains in May and June in most grape growing locations minimized the need for any supplemental irrigation until the end of July. This makes is very difficult to accurately estimate the water requirement of vineyards in Wyoming. This problem was compounded by unseasonal rains in September which minimized water requirement of vines during the process of acclimation.

Figure 1. Plot Layout of the experiment



Fig

Figure 2. A view of the experimental plot in Sheridan.

Figure 3. Effect of landscape fabric treatment on Frontenac TSS/Brix

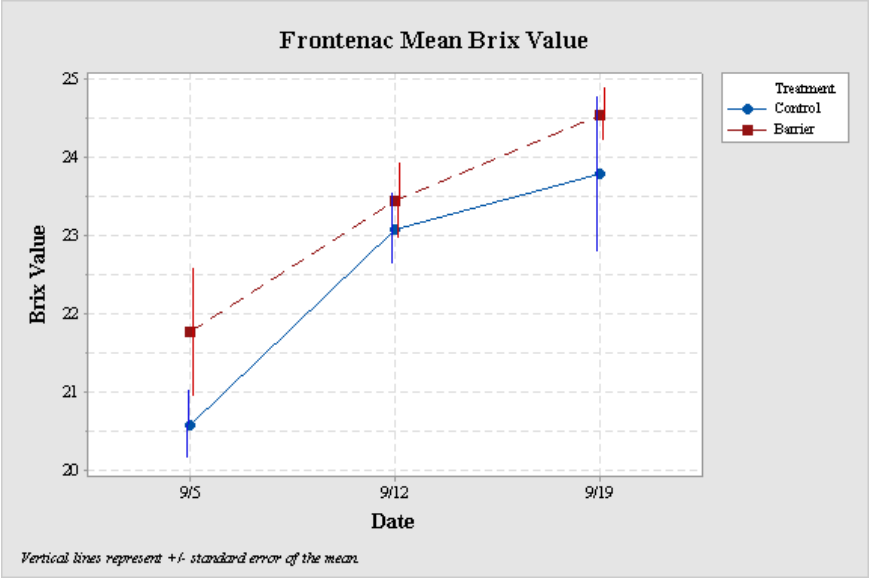


Figure 4. Effect of landscape fabric treatment on Frontenac juice pH

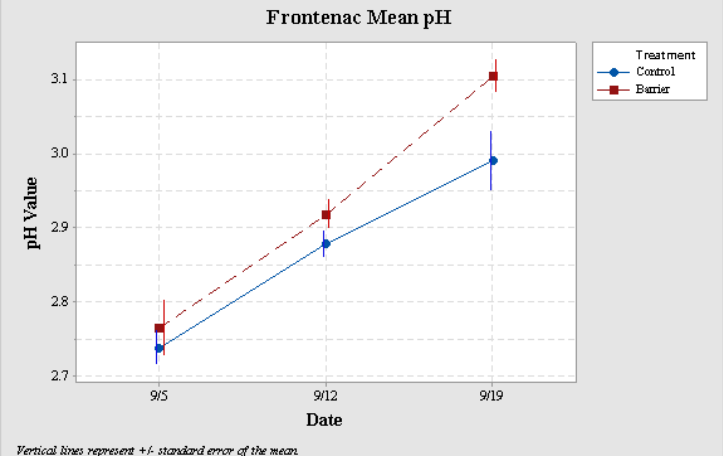
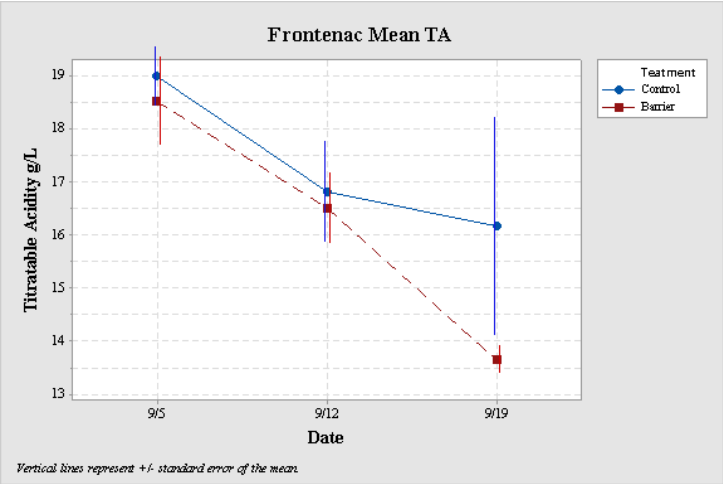


Figure 5. Effect of landscape fabric on Frontenac titratable acidity



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USING DNA TO IDENTIFY HERTAGE AND NOVEL APPLE CULTIVARS

PROJECT SUMMARY

The sweet apple was a critical resource during settlement of the central Rocky Mountain States. Highly adaptable, the apple was a convenient food source of great nutritional value, even when dried, and provided numerous other critical products. The diversity of apple cultivars in Wyoming during these years was quite high. A number of apple varieties were even developed specifically for the cold drought-prone, high elevation climate of Wyoming. Unfortunately, the identification of individual trees in orchards to specific cultivars has been mostly lost. Alarmingly, the last remnants of 19th and early 20th century plantings struggle to survive in isolated nearly forgotten or abandoned orchards. The objective of the study was to use molecular techniques to identify 75-120 year old heirloom and historic apple trees to cultivar, or to establish parentage in novel cultivars, in apple trees from Wyoming. This project expanded and enhanced the first Wyoming Heritage apple project by providing for the first time accurate names of cultivars for trees that had been long forgotten. It is also providing information on the parentage of unknown heritage trees scattered around Wyoming.

PROJECT APPROACH

This project built on a previously funded project with the SCBGP to obtain scions from 100+ year old orchards and trees in Wyoming and graft them onto hardy rootstock. The previously funded project provided inroads into known orchards in the state as well as knowledge of the people who were interested in apple cultivation in Wyoming, i.e. the previous project provided an excellent starting point in order to find samples for DNA analysis. Unfortunately, the previous project was limited by the fact that most trees could not be accurately identified to cultivar. Therefore the logical step was to move to the next step, the current proposed research activity aimed at using DNA to identify the apple cultivars found in the state.

Refined the database of sweet apple producers, orchards (historic and in current production), to include the DNA identification of the hardy and prolific individual trees and cultivars of apples for the state of Wyoming.

Grad student was hired to help with project objectives.

Worked with producers and individual land-owners to obtain leaf samples from notable trees for DNA identification and collected approximately 700 leaf samples by the end of fall 2015 from both trees previously bench grafted and from orchards visited.

Leaf samples were obtained from a total of approximately 1050 trees distributed across 105 orchards or individual trees.

DNA from representative samples was extracted using two different extraction procedures to determine the technique that best approximates the process used to develop the large Germplasm Resources Information Network (GRIN) database of Apple cultivars operated by the USDA Agricultural Research Service.

The GRIN contains 1251 apple genotype accessions in a publicly available database that we used for comparisons identification of our unknown trees. Not all were a match for geotypes found in GRIN.

DNA from 993 field samples, along with the 450 additional comparator reference samples were extracted using commercially available DNA extraction kits.

Conducted four presentations/workshops to promote heritage apples and increase the knowledge of producers and potential producers in Wyoming.

Website was updated. Information on over 200 apples tested or found still living in Wyoming has been compiled into a series of brochures by region (i.e. by city) and made available at the Wyoming Apple Project Website.

GOALS AND OUTCOMES ACHIEVED

GOAL: To increase our knowledge of heritage apple varieties in Wyoming by DNA testing to cultivar or in the case of novel variety to establish their parentage.

PERFORMANCE MEASURE: A database of apple cultivars identified by DNA testing will be established and a list of cultivars that can be recommended for different areas of Wyoming and surrounding states will be developed and distributed. A list of new or novel cultivars found will be made available to anyone interested in further testing of these trees. In addition, in year three of the proposed research we will produce a brochure summarizing the identities and distribution of apple cultivars across Wyoming.

BENCHMARK: No trees have been identified by DNA testing

TARGET: A target of 300 trees from Wyoming to be tested. Currently there are over 60 orchards and remnant orchards and individual trees of note in the Wyoming Apple Project Database, and nearly 800 scions have been collected2) Work with producers and individual land-owners to obtain leaf samples from notable trees for DNA identification.

The proposed project was centered on four objectives. The outcomes achieved for each is provided for each of the four goals below.

Objective 1) Refine the database of sweet apple producers, orchards (historic and in current production), to include the identification of the hardy and prolific individual trees and cultivars of apples for the state of Wyoming. At the beginning of the research, the database included 60 known orchards. During the proposed research activity, and additional 70 orchards or individual trees were identified.

Objective 2) Work with producers and individual land-owners to obtain leaf samples from notable trees for DNA identification.

Leaf samples were obtained from approximately 1050 trees distributed across 105 orchards or individual trees. After culling diseased or otherwise substandard samples the final total for Wyoming trees sampled and genotyped was 993. Because the identifications were based on a comparison of microsatellite loci with known cultivars, many additional samples were also analyzed for direct comparison that was not previously in the USDA GRIN database. These comparator reference samples were from USDA Apple Orchard, Geneva, NY and the Seed Saver Exchange, Decorah, Iowa, and totaled over 450 samples. The sampling in Wyoming during the proposed research activity included locations in Wyoming as follows: Lander (8), Casper (9), Wheatland (5), Sheridan (8) Kaycee (2), Laramie (2), Powell (2), Douglas (8), Lingle (1), Pavilion (4), NE-WY (1), Buffalo (33), Big Horns (5), Cheyenne (3), and Burns (1).

Objective 3) The DNA from leaf samples will be extracted and analyzed using established methodologies already in use in the Miller lab.

DNA from the 993 field samples, along with the 450 additional comparator reference samples was extracted using commercially available DNA extraction kits. Total DNA concentration and quality was calculated in the USDA lab in Fort Collins, CO. Samples were analyzed for microsatellite loci at the USDA, ARS Genomics and Bioinformatics Research Unit, Stoneville, Mississippi. Microsatellite profiles for the 993 Wyoming samples and the 450 comparator reference samples were added to the USDA GRIN apple database. A matrix of microsatellite loci was created and compared to the Wyoming apple samples. A spreadsheet was developed including confirmed, suspected, unknown and uncertain cultivar names. In addition, Principal Coordinates Analysis (PCA) construction and distance-based algorithms (hierarchical clustering and Neighbor Joining) were also used to better understand relationship between cultivars and to potentially identify parentage of unknown and putative novel cultivars. A program known as Network and Cercus was also implemented to cross check these relationships and look specifically at parentage of cultivars found in Wyoming and between known cultivars in the USDA and Seed Savers Exchange data set to obtain clues regarding potential identification of unknown cultivars.

In all, identification of 58% of the Wyoming apple samples was confirmed by direct comparison with comparator genotypes. Thirty cultivars were identified from Wyoming. This means that 42% of the cultivars could not be confirmed through comparison with samples in the USDA GRIN database. This suggests that additional reference samples are needed for comparison. It also may suggest that there are a number of novel cultivars that have arisen in some of the larger orchards in the last 100 years.

Objective 4) Successful identifications entered into the Wyoming Apple Project database, and will be made available to the public via the Wyoming Apple Project website. In addition brochures summarizing the identities and distribution of apple cultivars across Wyoming will be produced.

Successful identifications were made available to the public via the Wyoming Apple Project website. Information on over 200 apples tested or found still living in Wyoming has been compiled into a series of brochures by region (i.e. by city) and made available at the Wyoming Apple Project Website. The history of the apple cultivars (i.e. origin, date, synonyms, characteristics, photos) and a brief history of the local homestead, orchards and nurseries selling these apples are included for each area. A document that summarizes all cultivars (i.e. Apples of Wyoming: Lost and Found) is also available to allow apples enthusiast the ability to observe all 200 apples in a single page. Additionally, photos of 200+ apples have been compiled together to create a Wyoming apple ID photo and illustration booklet for those who may have missed the sampling during 2016-2017. This consists of over 400 drawings and photos of apples collected from the USDA Watercolor drawings and GRIN date base. They can use this data set to narrow down which cultivars they may have. The test phases of the Wyoming Apple Database, including the city brochures can be found at https://jmagby.wixsite.com/mysite

PERFORMANCE MONITORING:

A presentations was made at the Specialty Crops Workshop in Wheatland with 23 people were in attendance. Surveys showed an increase in knowledge between 10% and 50% which reflect the fact this was the second workshop at this location. A grafting workshop was done for 26 people at the Sinks Canyon Center and for 17 people at the Wyoming Farmers Marketing Conference. People attending grafting workshops started out with little to no knowledge of grafting and were able to take the skills learned and successfully graft apple scions to root stock at home which reflects a 90-95% increase in knowledge. A presentation at the Farm to Market seminar for 21 showed an average increase in knowledge of 43%. Approximately half the individuals were very knowledgeable on the topics while for others it was completely new.

BENEFICIARIES

Because there are few sweet apple producers in Wyoming, relatively few individuals in the state are educated on the techniques required for growing and maintaining sweet apple trees. USDA lists 20 active apple orchards. We know of 4 new producer orchards. Inquiries by 5 nonprofits wanting to incorporate small orchards into local community gardens have also been received. Individuals that participated in the sampling of apples during this project were directly impacted by becoming more knowledgeable about different varieties of sweet apples that they have. The 87 people who attended workshops and presentations had an overwhelmingly positive response. No database of producers, varieties, or production of sweet apples existed in Wyoming. Several other states including Montana, Colorado, Nebraska, and New Mexico are interested in our findings. The pamphlets we have produced on the Wyoming Apple Project and the cultivars found at each city/locale where we visited will be very popular and could reach many hundreds of people in years to come. We also believe that the Website will become very popular with people in Wyoming as well as the entire US, especially following completion of grafting and pruning videos, and the numbers viewing the website could reach easily into the thousands. Additional beneficiaries are the 25 scientists/labs around the world that USDA collaborates with regarding apple marker dataset comparisons and about 60 apple collections around the world with respect to apple gene bank conservation issues. There are several labs around the world that are relying on project results being added to data base to help design their genotyping experiments for this next summer.

LESSONS LEARNED

The apple cultivars found in Wyoming mostly follow a fairly predictable chronology of cultivars recommended by the Wyoming Horticultural Society (the forerunner to the Wyoming Extension Service), the cultivars available at regional and later local nurseries, and cold hardy cultivars introduced to the region from Russia. The qualification "mostly" stems from the fact that many other cultivars exist in the state, but as for now cannot be conclusively identified. We do know that there are likely a number of novel cultivars that have arisen in at least some of the larger orchards. Ongoing parentage analysis will help some on this count. However, we do not believe that all of the cultivars that we were unable to identify are novel cultivars. Rather, it is our hypothesis that the diversity of apple cultivars found in older orchards in Wyoming is much higher than the 30 we were able to conclusively identify. It would be beneficial to continue this study with an addition round of sampling including a broadened list of reliable reference samples for comparison from potential or likely sources available at the turn of the century.

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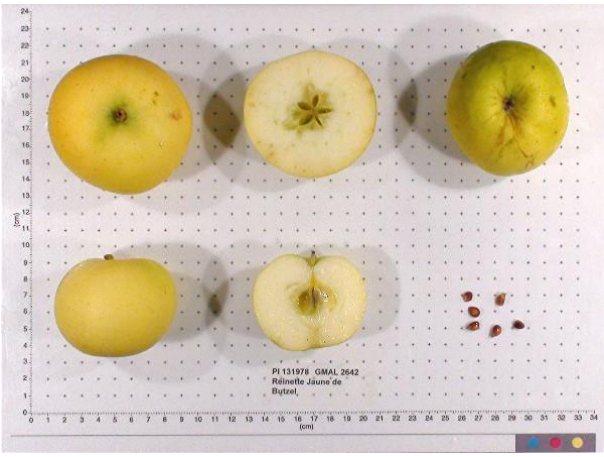


Dying McIntosh apple tree planted in Lingle 1905

RESEARCH AND OUTREACH TO IMPROVE DRY BEAN PRODUCTION AND PROFITABLITIY IN WYOMING

PROJECT SUMMARY

Dry bean (*Phaseolus vulgaris*) is one of the most important specialty row crops in Wyoming. According to the 2014 National Agricultural Statistical Service (NASS), Wyoming produced 44,800 tons of dry edible beans (excluding dry lima beans) on 42,000 acres with a total production of $27 million (USDA-NASS, 2014). Figure 1 shows the trend in total dry bean production in (million $) and dry bean yield in Wyoming from 1919 to 2016. Therefore, the overall goal of the project was to identify cultivars and management practices that may continue to increase dry bean production in Wyoming. Sustainability of dry bean production in the semiarid to arid region of Wyoming is only possible with irrigation (surface or sprinkler), as rainfall does not supply the required amounts of water for growth. However, changing climate conditions with increasing number of extreme events such as drought, flooding, along with water regulation in Wyoming increases pressure on major irrigated cropping systems. In recent years, many Wyoming

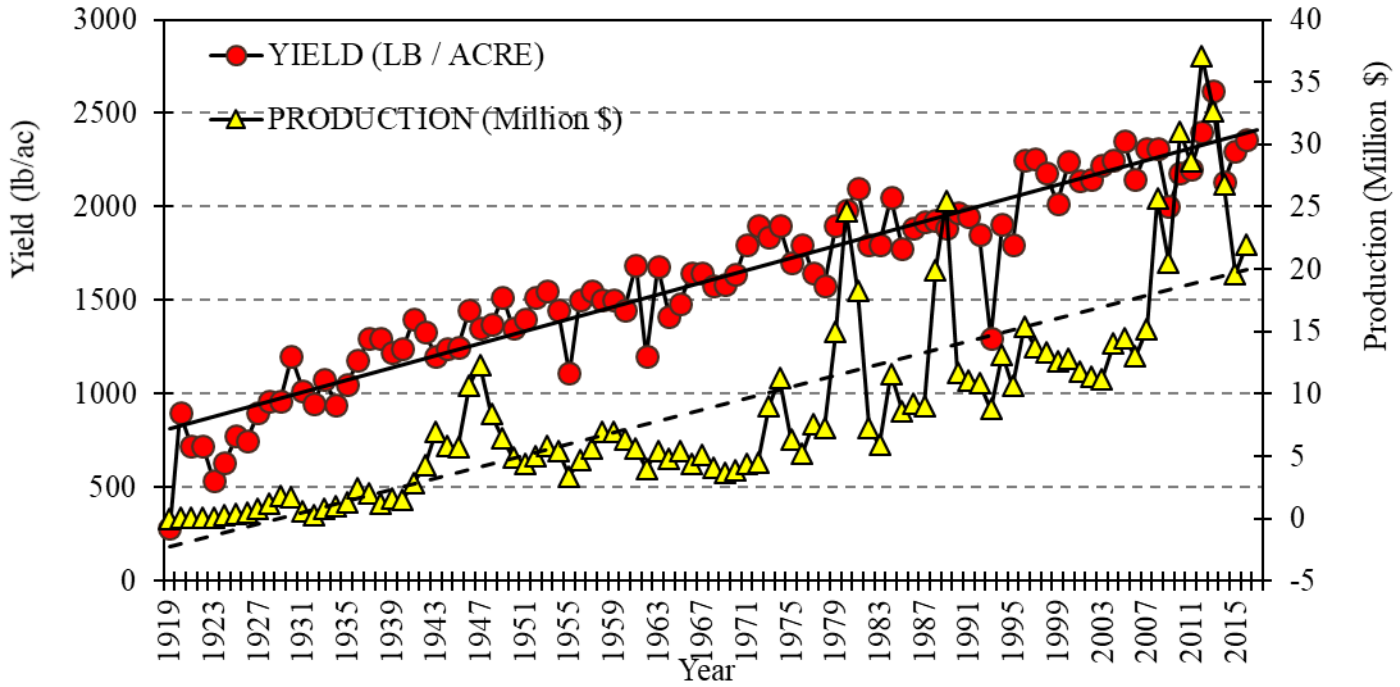


Figure 1. Trends in dry bean yield (lb/ac) and total production (Million $) in Wyoming from 1919 to 2016.

production areas did not receive adequate irrigation water for the complete growing season(s). Producers are not certain that they will have adequate water quantity and quality to grow their bean crops in future years. Thus, profitability for Wyoming dry bean producers will require genotypes with drought tolerance as well as other traits such as earliness. The first objective of this project was aimed (i) to identify dry bean genotypes tolerant to drought; (ii) quantify the relationship between dry bean yield components and tolerance to drought and (iii) investigate the dry bean ecophysiological traits in response to drought.

Dry bean production in Wyoming is relatively expensive compared to other crops due to high labor, equipment, and fuel costs. A typical dry bean grower may use five to nine field operations over each acre of dry beans. Dry bean growers in Wyoming have expressed interest in direct harvest as one way to reduce the cost of dry bean production. One of the primary concerns raised with adopting direct harvest is the potential for harvest losses.

Over the last several years, we have been working with growers and on the SAREC research farm to develop cultural practices to reduce the potential for harvest loss. We have evaluated the impact of previous crop stubble and winter

planted cover crops, and both have increased harvest efficiency compared to direct harvest on tilled soil. The logical next step in this process is to evaluate the impact of different dry bean germplasm (market classes, as well as varieties within a market class) in how they respond to previous crop residue or cover crops. This knowledge will be critical to developing recommendations on best practices for direct dry bean harvest systems for Wyoming.

The next objective of this project was to evaluate the impact of different dry bean germplasm (market classes, as well as varieties within a market class) in how they respond to previous crop residue or cover crops in a direct-harvest dry bean system. The first year of this project (2016) was focused on evaluating dry bean germplasm for the ability to elongate at the 1st and 2nd internodes (height to cotyledon and unifoliolate leaves, respectively). A severe hail storm prevented necessary yield data from being collected in 2016. The second year of the project (2017) was a continuation of 2016, with the following specific objectives: 1) evaluate early-season node elongation for 15 different dry bean cultivars; 2) evaluate whether those node heights related to pod height at maturity; 3) determine the yield trade-offs (if any) from early season node extension; and 4) evaluate the impact of green vegetation on 3 dry bean cultivars that exhibit different early season node elongation patterns.

Tillage practices combined with pre-plant incorporated or pre-emergence herbicides are the foundation for the majority of the weed control program in dry beans. Although these practices are efficient in providing early weed control, species that emerge late in the growing season such as Venice mallow and nightshades (berries) can be difficult to control. Late emerging weeds can interfere with harvest and affect the quality of the harvested bean crop. Therefore, the third objective was to explore alternatives for late season weed control in dry beans.

Soil-borne dry bean diseases such as *Rhizoctonia* and *Fusarium* root rot typically are common issues in dry bean production with disease severity dependent on environmental conditions, variety and cropping history. Growers have had limited options addressing these issues. The fourth objective of the project was to determine if a single in-furrow application of different fungicides at planting is sufficient to protect the dry bean crop until harvest from soil-borne disease.

Understanding what dry bean producers want from the Dry Bean Commission in the near term may be crucial to continued funding through the recently approved check-off. The last phase of this project was to conduct a scientifically valid survey of dry bean producers in Wyoming. The fifth objective was to determine what sorts of research and outreach is needed as well as other activities that would be useful to handlers and growers of dry beans. This project was not built on previously funded specialty crop projects.

PROJECT APPROACH

Objective 1. Identify dry bean genotypes tolerant to drought.

The study was conducted during the 2016 and 2017 growing seasons at University of Wyoming Powell Research and Extension Center (PREC), Powell Wyoming and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), Lingle. A detailed summary for both of the locations follows.

Powell:

The field experiments at PREC, Powell WY (44°45’32”N and 108°45’30”W, at an elevation of 4376 ft. above mean sea level), were conducted in one with traditional sprinkler irrigated field with GPS mounted lateral move overhead sprinkler irrigation system (Valmont Industries, Inc. Valley Nebraska) in 2017 and conventional tilled surface irrigated field in 2016. The long-term average annual precipitation in the area is 153 mm and the long-term average growing season (May 1–September 30) precipitation is 109 mm with significant inter-annual and inter-growing season variation in both magnitude and timing. The soil at the site is Garland Loam with water holding capacity of 0.29 m^3/m^3 field capacity, 0.15 m^3/m^3 permanent wilting point and 0.43 m^3/m^3 saturation point.

Split-plot arrangement with 36 genotypes replicated three times was setup at Powell, WY in both 2016 and 2017 growing season under well-watered and drought treatments. Table 1 represents the different genotypes used in this study. Difference in varieties among the years is due to the availability of certain varieties in a given year. Market classes included black, dark red kidney, flor de mayo, and light red kidney, navy, pink, pinto, and small red. Genotypes composed the 216 subplots. Well-watered treatment in this research represented the conditions in which the crop was irrigated when soil water depletion was approximately 40–45% of the total available water, to avoid any potential water stress impact on crop yield. Irrigation timings were based on the soil water content of well-watered treatment. In 2016, a total of five irrigations were applied for the wet treatment and four irrigations were applied for dry treatment. For the 2017 growing season, a total of 15 irrigations were applied for both well-watered and dry treatments (Table 2).

For 2016 growing season, plots (three rows) were sown on 25 May 2016 at 15 feet long with a 22-inch row spacing at 90,000 seed per acre. Stands were assessed visually (0 = no stand to 10 = full stand with no gaps) on 15 June and canopy temperatures were recorded on 18 July, 12 August, and 16 August (both morning and afternoon). Similar to 2016 growing season, for 2017 growing season plots (three rows) were sown on May 23, 2017 at 15 feet long with 22-inch row spacing at 90,000 seeds per acre and stands were assessed visually on June 14, and June 22. Detailed information on the primary agronomic management practices, including planting, fertilizer, insecticide, herbicide, and pesticide application date, amount, and type for 2016 and 2017 growing season are presented in Table 3.
In addition, extensive data collection was conducted in both 2016 and 2017 dry bean growing season. The volumetric water content was measured in each plot in both surface irrigated field in 2016 and sprinkler irrigated field in 2017 on weekly basis at different soil depths at 1 ft. interval in 2016 and 6-inch interval in 2017 up to 36 inches by using the CPN 503DR Elite hydroprobe moisture gauge (CPN, Inc.). The neutron probe access tubes were installed on the crop row between two dry bean plants in the area that are representative location of average conditions with satisfactory emergent, uniform and healthy plants.

For both growing seasons, leaf area index (LAI), plant height, canopy temperature, stomatal resistance, NDVI and SPAD readings were also collected routinely using LICOR LAI-2200 plant canopy analyzer, telescoping measuring rod, Apogee handheld infrared thermometer, Delta-T model AP4 steady-state porometer, Trimble NDVI meter, and Spectrum SPAD 502 plus chlorophyll meter, respectively. For 2016, canopy temperatures were measured on July 18, August 12 and 16. For 2017 growing season canopy temperatures were recorded on July 12, July 28, August 9, August 16 and August 22 (morning and evening).

At the end of the growing season, 10 ft. center row was hand-harvested for yield analysis. In addition, two plants were hand-harvested separately for yield component analysis which included number of pods, bean weight (average individual weight per seed), and pod wall weight.

Lingle:
The field experiments at SAREC (Lingle) WY (42°8′15″N and 104°20′47″W, at an elevation of 4178 m above mean sea level), were conducted in sprinkler irrigated fields with GPS mounted lateral move overhead sprinkler irrigation system in both 2016 and 2017 growing season. The long-term average annual precipitation in the area is 340 mm and the long-term average growing season (May 1–September 30) precipitation is 222 mm with significant inter-annual and inter-growing season variation in both magnitude and timing. The soil at the site is Haverson and McCook loams, 0 to 3 percent slope with water holding capacity of 0.28 m3/m3 at field capacity and 0.13 m3/m3 at permanent wilting point.

Table 1. List of different cultivars used in 2016 and 2017 growing season for Powell and Lingle, WY Locations.

Powell, WY		Lingle, WY	
2016	2017	2016	2017
Avalanche	0863Per	Avalanche	Avalanche
CELRK	Avalanche	Bill-Z	Centennial
Centennial	CELRK	Centennial	CmRdMx
CO14330-10	Centennial	CO-46348	CO14330-10
CO14790-3	CO-46348	Com. Red Mexican	CO14790-3
CO25069-2	Common Red Mexican	COSD-25	CO25069-2
CO33176-1	COSD-35	COSD-35	CO33176-1
CO33176-15	COSD-7	Croissant	CO33176-15
CO-46348	Coyne	Desert Song	CO46348
CO91216-15	Croissant	Eclipse	CO91216-15
ComRedMx	Desert Song	El Dorado	COSD-35
COSD-35	Dynasty	ISB1231-1	Croissant
Croissant	Eclipse	LaPaz	DesertSong
DesertSong	ISB1259-60	Long’s Peak	Eclipse
Eclipse	ISB96-3156	Monterrey	LaPaz
LaPaz	LaPaz	Othello	LongsPeak
LongsPeak	Lariat	Poncho	Monterrey
MedicineHat	Long’s Peak	Rosie	Othello
Monterrey	Monterrey	T-9905	Poncho
Montrose	ND-307	UI-259	UI-259
ND-307	Othello	UIP-40	UI-537
Othello	Poncho	UIP-46	UIP-35NezPerce
Palomino	PowderHorn	Zorro	UIP-40TwinFalls
Poncho	PT9-5-6		Zenith
Powderhorn	Rio Rojo		Zorro
PT9-5-6	Rosie		
RioRojo	Stampede		
Scout	T-39		
Stampede	T-9905		
Talon	Talon		
UI-259	UCD-0908		
UI-537	UI-259		
UIP-35NezPerce	UI-537		
UIP-40TwinFalls	UIP-35		
Zenith	Yeti		

Zorro	Zenith		

Table 2. Summary of irrigation dates and amounts for each treatment in 2016 and 2017 dry bean growing season for sprinkler and surface irrigation fields at Powell, WY.

2017				2016		
Irrigation Dates	Well-Watered	Dry		Irrigation Dates	Well-Watered	Dry
5/27/2017	0.25	0.25			7/5/2016	8-Jul-16
6/1/2017	0.5	0.5			7/15/2016	22-Jul-16
6/6/2017	0.5	0.5			7/25/2016	5-Aug-16
6/9/2017	0.75	0.75			8/4/2016	19-Aug-16
6/20/2017	0.5	0.5			8/19/2016	
6/29/2017	1	1				
7/6/2017	0.75	0.5				
7/13/2017	1.25	0.8				
7/19/2017	1	0.7				
7/26/2017	1.25	0.8				
8/3/2017	1.25	0.8				
8/11/2017	1.25	0.8				
8/19/2017	1	0.7				
8/25/2017	1	0.7				
9/1/2017	1.25	0.8				

Table 3. Detailed field agronomic management practices, including planting, emergence, harvest dates, herbicide and fertilizer type, amount and application data for 2017 dry bean experimental year under surface and sprinkler irrigation field.

2016	Tillage Management	Planting Date	Emergence Date	Pre-Herbicide Type	Pre-Herbicide application Date	Pre-Herbicide application amount	Fertilizer application dates	Fertlizer type	Fertilizer application amount
Surface Irrigation	Roller Harrow	25-May	June 05-10	Sonolan	22-May	32 oz/ac	22-May	11-52-0	50/30/0
				Eptam		40 oz/ac		46-0-0	
2017									
Sprinkler Irrigation	Roller Harrow	23-May	June 03-08	Sonolan	22-May	32 oz/ac	22-May	11-52-0	50/30/0
				Eptam		40 oz/ac		46-0-0	

For both years, fields were prepared with conventional tillage and land was fertilized with nitrogen (N) and phosphorous (P) according to soil test recommendations. Plots were sown on 26 May 2016 at a rate of 87,000 seed per acre and 6 June 2017 at 90,000 seeds per acre. The study included 23 genotypes in 2016 and 25 genotypes in 2017 planted in four-row plots that were 16 feet long with 30-inch row spacing. Similar to PREC set-up, a split-plot design was used with three replicates which were divided into well-watered or drought (the main plots) for both years. Genotypes composed the 138 subplots in 2016 and 150 subplots in 2017.

For the 2016 growing season, plots were watered to prevent stress until 5 or 6 July when the drought sections received 0.5 inch of water compared to 0.75 inch for the well-watered. On 8 July, the normalized difference vegetation index (NDVI) was measured over the second and third rows of each plot with a RapidScan CS-45 Handheld Crop Sensor and the unit held at a height of one meter above the canopy. The equation for NDVI was (Reflectance at 670 nm – Reflectance 730 nm) / (Reflectance at 670 nm + Reflectance at 730 nm). Plots were watered again on 11 or 12 July with 0.5-inch water for drought sections and 0.75 inch for well-watered sections. On 23 July, canopy temperature was measured in the morning and afternoon on all plots with an Apogee MI-2H0 infrared thermometer with a horizontal field of view. Also on 23 July, stomatal conductance was measured on the third uppermost fully-expanded leaf of three genotypes using a Decagon SC-1 leaf porometer at midday.

For 2017 growing season, three acres of land were dedicated for this specific study and other dry bean studies. Previously, the land hosted wheat in fall 2015 through summer 2016 and was prepared for dry bean by disking, fertilizing with 50 pounds on N per acre and 40 pounds S per acre, subsoiling, and a second disking all in April 2017. Seed of 25 dry bean cultivars varying in maturity and market class were sown on 6 June 2017 in 30-inch rows at a planting depth of 2 inches. Plots (a.k.a. subplots or experimental units) were four rows wide and 16 feet long with a five-foot alley separating plots within the same pass. Outlook (21 oz/a) and Prowl H2O (32 oz/a) were applied pre-emerge on 8 June 2017. Plots were irrigated equally as needed until half of the cultivars developed blooms. At bloom, 10 July 2017, differential irrigations began with drought-stressed plots receiving two-thirds the amount of fully irrigated plots. For all plots, irrigation was terminated on 29 Aug 2017. The experimental design was a randomized complete split-plot design with two irrigation levels (full vs. drought) as the main factor and cultivar as the subplot. Three replicates (blocks) were used and the six main plots were separated in space by 30 feet in the east-west direction and 40 feet in the north-south direction. Weeds were controlled by hand at least weekly throughout July, Aug, and September.

Stand rating was recorded visually on 2 July 2017. Canopy temperatures were on 23 July, 5 Aug, and 23 Aug 2017 using an Apogee MI-2H0 infrared thermometer. Normalized difference vegetation index (NDVI) was recorded on 12 Aug 2017 using a RapidScan CS-45 handheld crop sensor. Plant height was recorded in early September 2017. At maturity (the date which varied for each plot), eight feet from the two center rows of each plot (16 feet total) was harvested and collected for grain yield (after using a Haldrup LT 25 plot thresher). A two-plant sample was collected separately from the area just outside of the two center rows and from that sample, the number of pods and seeds were counted and from those two plants the trait “average number of seed per pod” was calculated.

To further the development of experimental dry bean lines with potential drought tolerance, parental material was chosen from a set public dry bean lines that performed well at Lingle or Powell during the past few years to develop new experimental lines for testing. Accessions from the USDA-ARS *Phaseolus* germplasm collection have also been used as parents. Nineteen lines advanced from crosses involving parents from public dry bean breeding programs in Colorado, Idaho, and Nebraska were grown in Powell, Ft. Collins, and Lingle during the 2017 growing season. These 19 lines were at the F4 stage, planted in unreplicated plots (either one-row or two-row plots depending on location) and a single-plant selection was made from each plot. Lines were screened for rust at Fort Collins. These lines are designated as the LPID series and at Lingle only, plots were harvested for yield under full irrigation and moderate drought stress. Progeny from numerous other crosses (not part of the LPID series), but at an earlier generation (F3), were grown in one row plots and single-plant selections were made from those also. Selections and yield samples are being processed during December 2017 and January 2018 in preparation for planting in June 2018 at Lingle. Yield data is not available at this time (December 2017) but is expected to be available by March 2018. Either the single-plant selections and/or bulk samples from the LPID series will be grown at Lingle in 2018 in replicated plots alongside several drought-tolerant check cultivars.

In a related project, we grew 33 advanced lines from the Dry Bean Drought Nursery (DBDN) at Lingle in 2017. There were two replicates and each line was grown under fully-irrigated and moderate drought conditions (for a total of four plots each). Among the 33 were commercial checks and public entries. Although these 33 DBDN lines are not part of our breeding program, our 2017 observations at Lingle will serve as a guide as to which of the public entries will be used as parents during our spring 2018 greenhouse crossing plan.

Objective 2: Evaluate the impact of different dry bean germplasm (market classes, as well as varieties within a market class) in how they respond to previous crop residue or cover crops in a direct-harvest dry bean system.

Field study at SAREC: For our germplasm screen (objectives 1 through 3), we worked with Dr. Heitholt to measure early-season cotyledon and unifoliolate heights for 15 different dry bean cultivars. Dry bean was planted under sprinkler irrigation at SAREC near Lingle. The study was a split-plot randomized complete block design with 3 replicates; nitrogen application was the whole-plot factor and dry bean cultivar was the split-plot factor. Height from the soil to cotyledon, unifoliolate, and 1st trifoliolate leaves was measured several times throughout the season. Within each plot, 3 consecutive bean plants within the center of the plot were selected at random for measurement. At dry bean maturity, the height of the lowest and second lowest pod was measured in a similar manner by measuring 3 consecutive dry bean plants in each plot. Yield data was then collected.

Planter box study at LREC: Three dry bean cultivars were chosen to investigate elongation in response to cover crop presence under controlled conditions at LREC in Laramie. The cultivars 'COSD-35', 'Othello', and 'ND307' were chosen because they exhibited short, intermediate, and tall unifoliolate and trifoliolate heights, respectively, in previous field studies at SAREC. Beans were planted June 5, at a depth of 1-inch, seeds spaced 1.5-inches apart in 2 offset rows. Planter boxes were 3 inches wide, 7 inches deep, and 48 inches in length, allowing for 32 bean seeds to be planted in each box. After crop emergence, each box was thinned to 16 plants per box. The box was placed between 2 other planter boxes that were either filled with soil or planted with sod. The soil vs sod treatments were used to simulate beans growing without or with a cover crop, respectively, at the time of dry bean emergence. Previous work has shown that presence of a green cover crop at the time of bean emergence can increase the height of the first 2 dry bean internodes, and subsequent pod height. Height from soil level to the unifoliolate leaves was measured 30 days after planting. Chlorophyll content was measured on three leaves on three consecutive plants per box. At the end of the season, dry weight, leaf area, and number of trifoliolate leaves were also collected from each box.

Objective 3. Explore alternatives for late season weed control in dry beans.

In the summer of 2016, two field trials were conducted in farmer's field near Burlington WY. In one field 7 different combinations of PRE and POST emergence herbicides were tested for Venice mallow control. In a second field, 7 combinations of POST emergence herbicides were also tested for Venice mallow control. Treatments at both sites were evaluated for weed control efficacy, crop safety and yields. In addition, treatments were subject to inspections previous to harvest I order to verify if they would qualify for seed certification.

Pinto beans ('Othello') were planted in 22 -inch rows at a rate of 85,000 seeds per acre, on May 28. Soils at the site are a Preatorson gravelly sandy loam (1.1% organic matter, pH 7.8). Trial was furrow irrigated, and water was supplied according to crop needs. Herbicide treatments were applied with a CO2 pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 30 psi with TeeJet® DG8002 nozzles, application dates and weather conditions are detailed in table 1. Experimental plots were 11 feet wide by 30 feet long and arranged in a randomized complete block design with 4 replications. Three weed counts from a 2.7 ft2 area were recorded per plot, before post application, 15 days after treatment (DAT) and before harvest. Dry bean yields were estimated by harvesting a 10 ft. length from the two middle rows of each plot on August 29.

Pinto beans ('La Paz') were planted in 22 -inch rows at a rate of 123,000 seeds per acre, on May 15. Soils at the site are a Sharland gravelly clay loam (1.3% organic matter, pH 8.1). Trial was sprinkler irrigated, and water was supplied according to crop needs. EPTC (3.5 L ha-1) + ethalfluralin (2.3 L ha-1) was broadcast applied PPI to the whole study area. The POST herbicide treatments were applied with a CO2 pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 30 psi with TeeJet® DG8002 nozzles, application dates and weather conditions are detailed in table 1. The field was cultivated in between rows approximately 10 DAT. Experimental plots were 11 feet wide by 30 feet long and arranged in a randomized complete block design with 4 replications. Three weed counts from a 2.7 ft2 area were recorded per plot, before post application, 15 days after treatment (DAT) and before harvest. Dry bean yields were estimated by harvesting a 10 ft. length from the two middle rows of each plot on September 7.

In cooperation with Park County's Extension educator, a short field day was organized to show both trials to the public, and share findings.

A Venice mallow seed germination study was under way in order to better understand the mechanisms of establishment of this weed in the field.

Objective 4. Determine if a single in-furrow application of different fungicides at planting is sufficient to protect the dry bean crop until harvest from soil-borne disease.

Studies were initiated to compare the relative efficacy of fungicides applied in-furrow at planting for management of these soil-borne diseases. Treatments were different between the two years. Therefore, each year will be presented separately.

2016

Field plots were established at the Sustainable Agricultural Research & Extension Center (SAREC) located near Lingle, WY. The elevation of SAREC is 4,165 ft MSL, and the soil type at the plot location was a Mitchell clay loam soil at pH = 7.9. Overhead sprinkler irrigation was applied as needed.

Experimental plot design was a RCBD with 4 replications; plots were 4 rows (30-in row centers) by 20 ft long, with a 5 ft in-row buffer. All treatments were made to and data were collected from the center two rows. Planting date was 2 June, 2016 with variety Centennial. Fertility was 30 lb N + 50 lb P2O5 + 20 lb S on 2 June based on soil tests. Weed control was accomplished with applications of Outlook (21 oz/A) + Prowl (32 oz) on 2 June. Outlook (12 oz) + Raptor (4 oz/A) + Basagran (16 oz/A) applications were made on 22 June.

Plots were inoculated with an isolate mix of Rhizoctonia solani (AG 2.2 IIIB) and Fusarium grown on barley. Inoculum was spread with a cyclone spreader at a rate of 50lb/A and then incorporated. Disease development was slow likely a result of environmental conditions throughout the growing season.

On 2 June plots were planted with the planter press wheels held up, effectively leaving an open furrow. Soon after, fungicide treatments were directly applied to the open furrow. Furrows were closed with foot pressure after treatment. Fungicides were applied with the aid of a CO2 backpack sprayer (Bellspray Inc., Opelousas, LA) in a total volume 800 ml per 200 ft of row at 42 psi (single #8002 flat fan nozzle). The foliar maintenance treatments were not applied because of the hail storm (see below).

Stand counts were conducted on 11 July by counting all plants in the middle two rows of each plot (2 x 20'). Plot vigor (1-10) was rated on 23 June, with 1 = dead plants and 10 representing the best looking plot per replication. On 6 August five plants per plot were pulled randomly from each plot and rated for stem rot incidence due to Rhizoctonia and or Fusarium infection.
Data was analyzed with the Proc GLM procedure in SAS 9.4 (SAS Institute, Cary, NC). Separations of means was tested using Fisher's protected LSD ($P \leq 0.05$).

2017
Field plots were at the Sustainable Agricultural Research & Extension Center (SAREC) located near Lingle, WY. The elevation of SAREC is 4,165 ft MSL, and the soil type at the plot location was a Mitchell clay loam soil at pH = 7.9. Overhead sprinkler irrigation was applied as needed.

Experimental plot design was a RCBD with 4 replications; plots were 4 rows (30-in row centers) by 20 ft long, with a 5 ft in-row buffer. All treatments were made to, and data were collected from, the center two rows. Planting date was 5 June, 2017 with variety Orthello (plant population seeded at 75,000). Fertility was 60 lb P2O5 + 30 lb S on 4 April, 2017 based on soil tests. Weed control was accomplished with pre-emergence applications of Outlook (21 oz/A) + Prowl (32 oz) on 1 June.

Plots were inoculated with an isolate mix of Rhizoctonia solani (AG 2.2 IIIB) grown on barley. Inoculum was spread by hand at a rate of 50lb/A and then lightly incorporated with a field packer. Fusarium was not inoculated since this field location had endemic populations from past cropping history.

On 5 June plots were planted with the planter press wheels held up, effectively leaving an open furrow. Soon after, fungicide treatments were directly applied to the open furrow. Furrows were closed with foot pressure after treatment. Fungicides were applied with the aid of a CO2 backpack sprayer (Bellspray Inc., Opelousas, LA) in a total volume 800 ml per 200 ft of row at 42 psi (single #8002 flat fan nozzle).

Stand counts were conducted on 19 June and 10 July by counting all plants in the middle two rows of each plot (2 x 20'). Additionally, on 19 June plants were observed for phytotoxicity (0-100% affected). Plot vigor (1-10) was rated on 5 July, with 1 representing dead plants and 10 representing the best looking plot per replication. On 19 June and 10 July plots were rated for disease incidence (2 x 20" row). Plants that were dead or showing wilt symptoms were considered diseased. Percent stand decline due to the combined effects of root disease was determined in the plot on 5, 24 July, 24 August and 5 September. An area under the disease progress curve (AUDPC) was computed for stand decline data. The AUDPC is a measure of season-long disease severity for each treatment. Additionally, on 29 August, ten plants per plot were pulled randomly from each plot and rated for stem rot incidence due to Rhizoctonia and/or Fusarium infection.

Plots were harvested on 11 September by hand pulling bean plants in 10 ft of row. After drying, bean plants were threshed in a portable threshing machine and seed yield and quality (100 seed weight) determined.
Data was analyzed with the Proc GLM procedure in SAS 9.4 (SAS Institute, Cary, NC). Separations of means was tested using Fisher's protected LSD ($P \leq 0.05$).

Objective 5. Determine what sorts of research and outreach is needed as well as other activities that would be useful to handlers and growers of dry beans.
A survey administered by North Dakota State University was obtained from the principal investigator. Questions for a Wyoming survey were developed from that survey. The draft survey was shared with the Wyoming Bean Commission

for comments. The final survey (Appendix A) and survey protocol was submitted to the University of Wyoming Institutional Review Board for approval (Appendix B).

A list of dry bean producers was compiled from two different sources with a total of 259 unique producers. A letter requesting producer names and addresses was sent to bean handlers and a search was made of producers of record with the Wyoming Department of Agriculture. A random sample was selected with the intent of having results of +/- 3% at the 95% confidence level. The survey was mailed to 210 producers. Only 32 surveys were completed and returned, much lower than was needed for valid results. This level of response would be closer to +/- 11% at the 80% confidence level. The survey was mailed to those selected followed by a reminder and thank you to those that had already submitted their survey. A second survey was mailed out to those that had not responded. The results from the survey are summarized in this report.

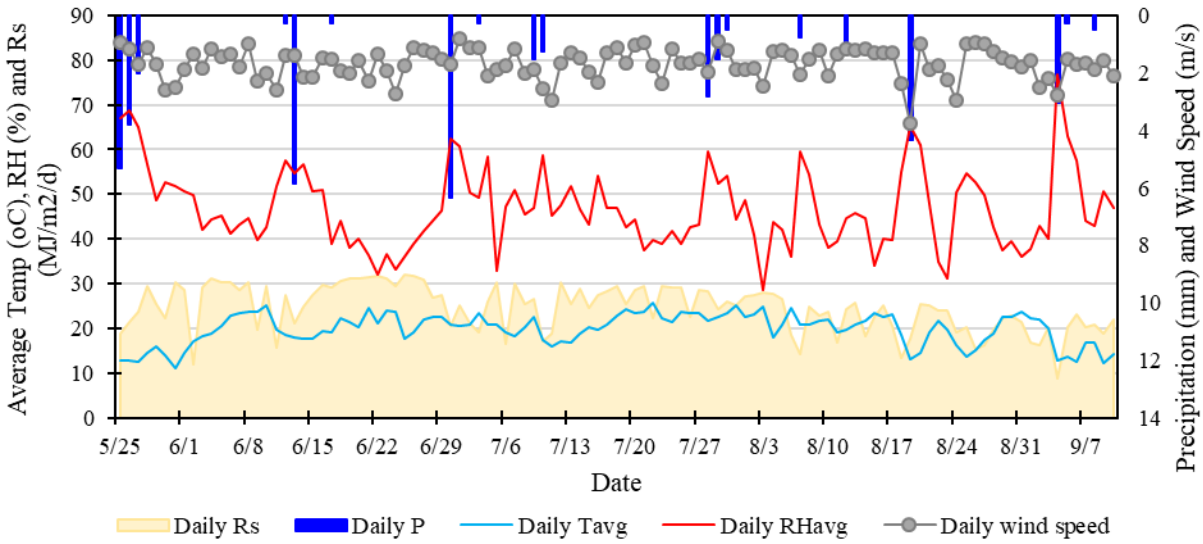
GOALS AND OUTCOMES ACHIEVED

Objective 1. Identify dry bean genotypes tolerant to drought.

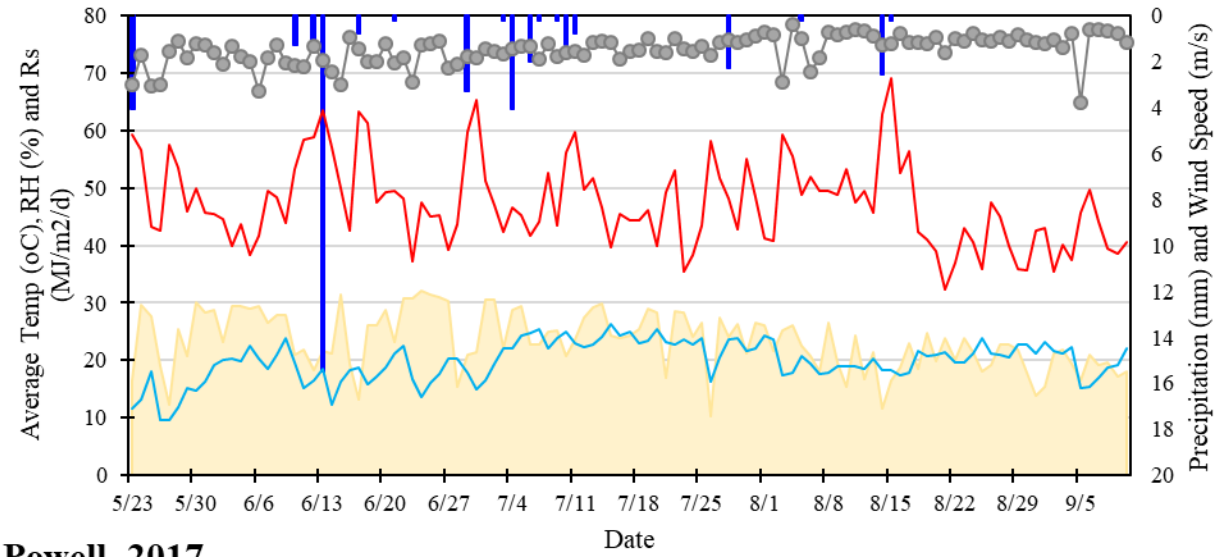
Climatic Variation

A summary of measure meteorological data including average air temperature (Tair), relatively humidity (RH), incoming solar radiation (Rs), wind speed (u) and precipitation (P) for year 2016 and 2017 at Powell and Lingle WY is presented in Figure 7a, b, c and d, respectively. All the data was obtained from University of Wyoming Agricultural Climate Network (WACNet) weather station located at PREC and SAREC.

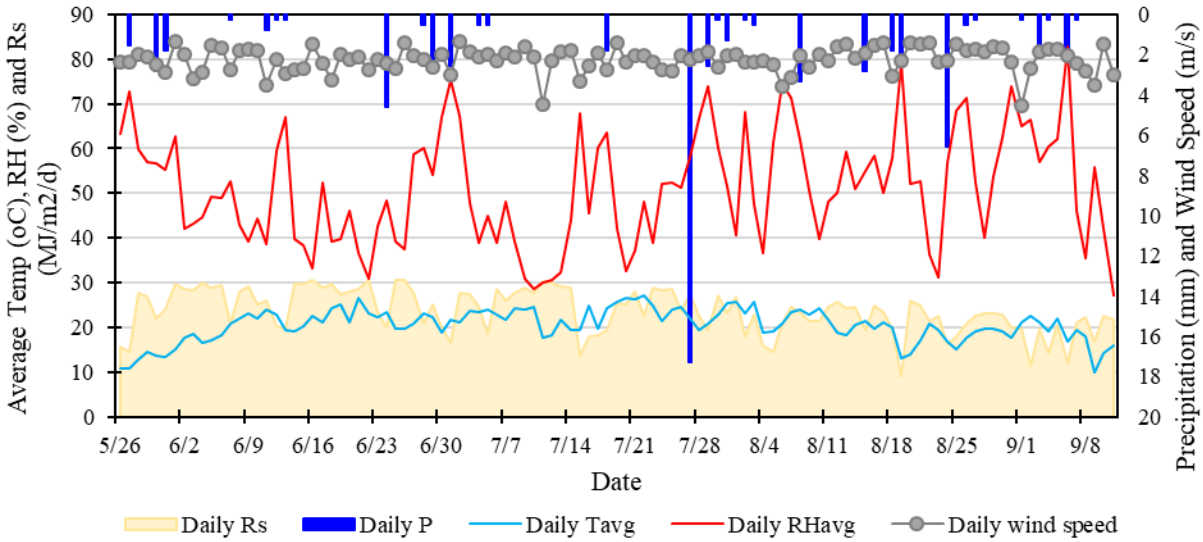
At Powell, year 2017 was a relatively dry year as seasonal precipitation for the dry bean growing season (May 25 to September 10) was 37 mm only compared to 42 mm in 2016. A total of 19 and 17 precipitation events occurred in 2016 and 2017 growing season, with maximum precipitation of 6.35 mm and 15.5 mm was observed on June 30, 2016 and June 13, 2017, respectively (Figure 7a and b). Growing season Tavg was 0.4 and 0.2^{o}C higher than the long-term average from May to September in 2016 and 2017, respectively. Remaining variables were very similar to the long-term average values on seasonal bases. Daily and cumulative standardized Penman-Monteith alfalfa reference evapotranspiration (ETref) and Growing Degree Days (GDD) for 2016 and 2017 dry bean growing season at Powell and Lingle, WY is presented in Fig. 8. ETref values ranged from 2.77 to 1.32 mm/d with an average of 6.88 ± 1.55 mm/d in 2016 and 2.77 to 7.49 mm/d with an average of 5.08 ± 1.1 mm/d in 2017. The seasonal cumulative ETref was 750 mm in 2016 and 564 mm in 2017. Daily growing degree days (GDD) for 2016 and 2017 growing season is presented in Figure 8. GDD was calculated from measured Tmax and Tmin on a daily basis as GDD = [(Tmax + Tmin)/2] -5 ^{o}C. For both growing seasons, GDD follow the quadratic distribution, with maximum GDD of 20.73^{o}C and 21.35^{o}C occurring in the middle of the growing season on July 22, 2016 and July 15, 2017, respectively. The seasonal cumulative GDD from planting to harvest for 2016 and 2017 was 1619°C and 1648 ^{o}C, respectively.



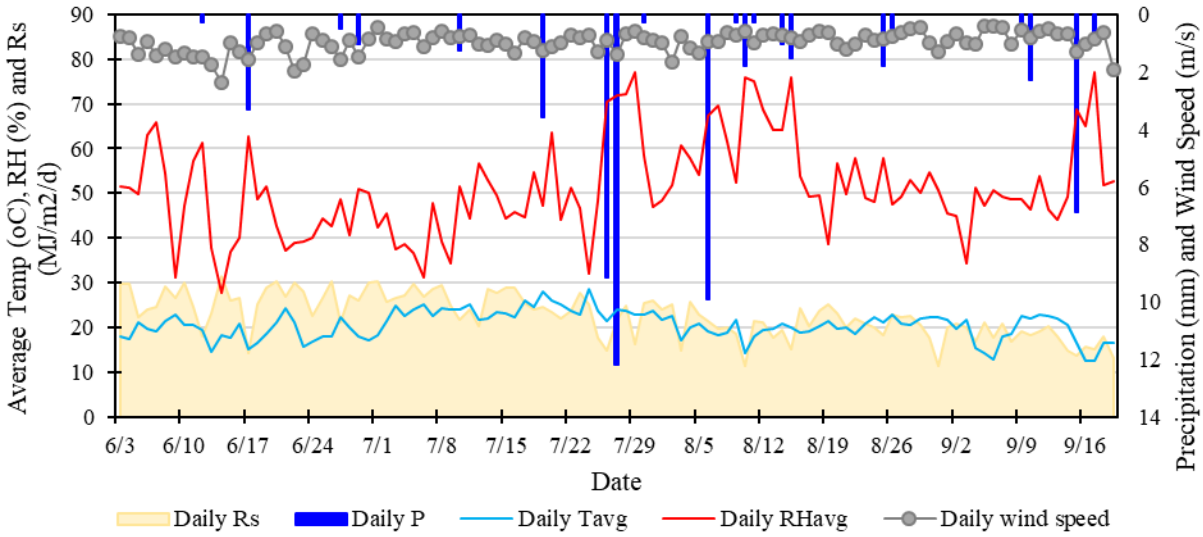
(a) Powell, 2016



Powell, 2017



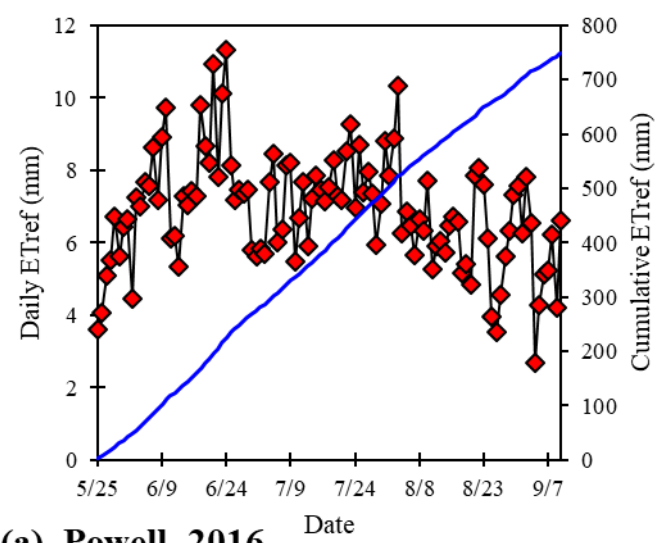
(c) Lingle, 2016



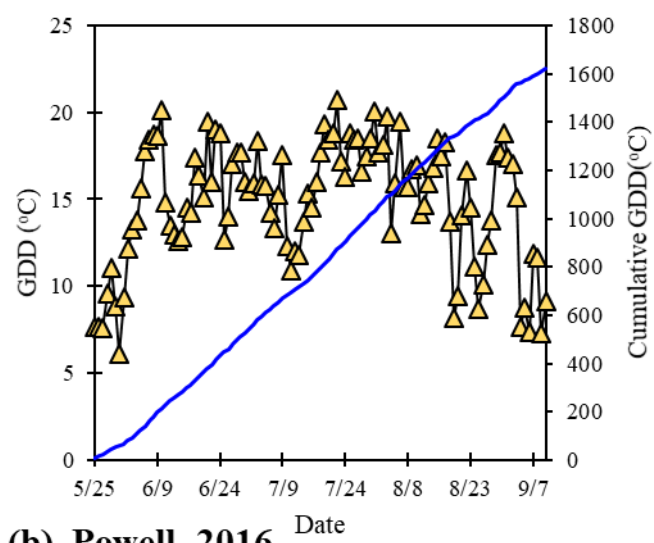
(d) Lingle, 2017

Figure 2. Daily variation in average air temperature (°C), relative humidity (%), solar radiation (MJ/m^2), precipitation (mm) and wind speed at Powell (a and b) and Lingle (c and d), WY for 2016 and 2017 dry bean growing season.

Seasonal precipitation for the dry bean growing season at Lingle (May 26 to September 10) was 65 mm in 2016 compared to 59 mm in 2017 in Lingle. A total of 32 and 21 precipitation events occurred in 2016 and 2017 growing season, with maximum precipitation of 17.2 mm and 12.2 mm was observed on July 27 in both 2016 and 2017, respectively (Figure 7c and d). Daily and cumulative standardized Penman-Monteith alfalfa reference evapotranspiration (ETref) and Growing Degree Days (GDD) for 2016 and 2017 dry bean growing season for Lingle, WY is presented in Fig. 8. ETref values ranged from 1.96 to 8.05 mm/d with an average of 5.36 ± 1.29 mm/d in 2016 and 2.1 to 6.71 mm/d with an average of 4.47 ± 1.04 mm/d in 2017. The seasonal cumulative ETref was 585 mm in 2016 and 487 mm in 2017. Daily growing degree days (GDD) for 2016 and 2017 growing season is presented in Figure 8. GDD was calculated from measured Tmax and Tmin on a daily basis as GDD = [(Tmax + Tmin)/2] -5 °C. For both growing seasons, GDD follow the quadratic distribution, with maximum GDD of 21.41°C and 23.56°C occurring in the middle of growing season on July 21, 2016 and July 24, 2017, respectively. The seasonal cumulative GDD from planting to harvest for 2016 and 2017 was 1686°C and 1697 °C, respectively.



(a) Powell, 2016



(b) Powell, 2016

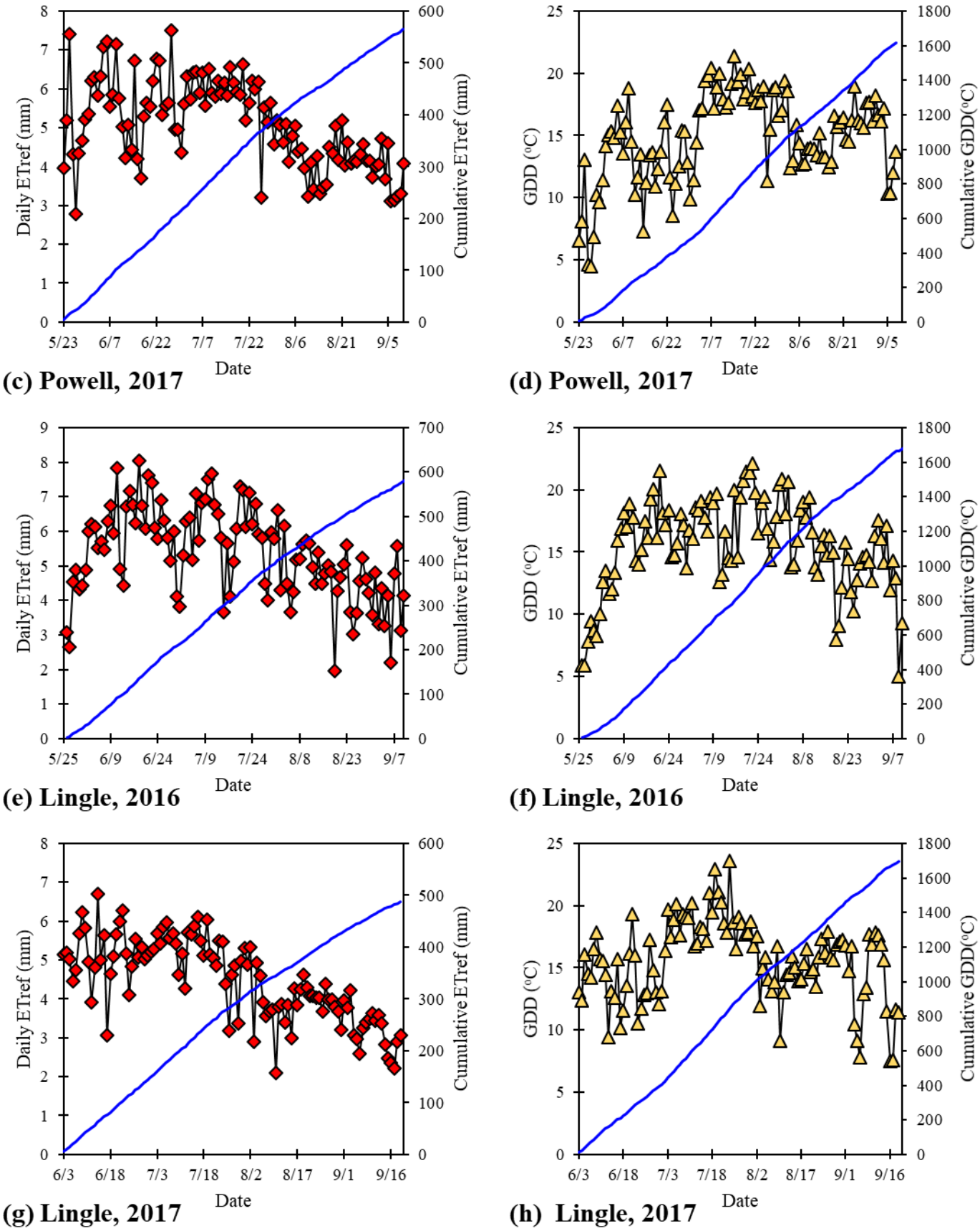


Figure 3. Daily and cumulative variation in alfalfa based reference evapotranspiration (a, c, e, and g) and dry bean growing degree days (b, d, f, and h) for 2016 and 2017 growing season in Powell and Lingle, WY.

Results:

Powell 2016:

Stands were assessed visually (0 = no stand to 10 = full stand with no gaps) on 15 June 2016 and canopy temperatures were recorded on 18 July, 12 August, and 16 August (both morning and afternoon). Stands ranged from 8.5 for the cultivar Rosie to 4.2 for the cultivar T 9905. Typically, the smaller-seeded lines had lower stand ratings but there were several large-seeded lines that had stand ratings below 7.0 (data not shown).

Canopy temperature on the morning of 18 July was cooler in the well-watered plots (26.4°C) than in the drought-stressed plots (29.0°C). In the afternoon, canopy temperatures were again cooler in the well-watered plots (31.2°C) than in the drought-stressed plots (35.0°C). Genotypes varied in canopy temperatures but there was no genotype-by-drought interaction observed (Table 4). For the 36 genotypes, morning and afternoon canopy temperatures were correlated (r = 0.82). Grain yields (corrected to 14% moisture) of the 36 dry bean genotypes at Powell can be found in Table 4.

Canopy temperatures on 12 and 16 August were unaffected by the irrigation treatments (data not shown). Temperatures on the 12 August were 20.7 vs. 20.5°C for the dry and wet treatments, respectively. Temperatures on the 16 August were 24.0 vs. 24.2 for the dry and wet treatments, respectively. Canopy temperatures varied significantly among genotypes (Table 5). There was a genotype-by-drought interaction on plant height; thus, genotype heights are presented separately for each watering regime. Yield of the 36 different cultivars was correlated with canopy temperature on 18 July, 12 August, 16 August, and with plant height (Figures 1-4).

Yield was unaffected by the drought treatments. Cultivars varied in seed yield significantly as is the usual case (Table 4). PT9-5-6, LaPaz, Poncho, Stampede, and Common Red Mexican were among the highest yielding genotypes (Table 4).

Table 4. Canopy temperatures recorded in the morning and afternoon on 18 July 2016 and grain yield (corrected to 14% moisture) for 36 dry bean genotypes at Powell. Values are averaged across watering regimes.

Genotype	Canopy Temp (am)	Canopy Temp (pm)	Grain Yield
	°C	°C	lbs/ac
Avalanche	28.9	34.8	3810
CELRK	28.4	34.8	2540
Centennial	27.1	32.6	4100
Common Red Mexican	26.5	32.2	4690
COSD-7	27	32.8	3670
COSD-35	28.4	34.4	3990
CO-46348	26.4	30.9	3690
Coyne	26.4	32	4070
Croissant	26.9	31.6	4130
Desert Song	27	32.5	3920
Dynasty	28.4	34.8	3610
Eclipse	28.5	34.4	3480
ISB96-3156	28.8	34.5	3570
ISB1259-60	26.9	32.1	3730
LaPaz	28.1	32.7	4440
Lariat	26.9	31.8	4240

Long's Peak	27.2	32.1	4350
Monterrey	28.1	32.6	4240
ND-307	26	31	3860
Othello	26.3	31.1	4390
Poncho	26.4	30.9	4640
PowderHorn	28	32.8	3510
PT9-5-6	27.7	32	4750
Rio Rojo	29.7	34.4	3650
Rosie	28.1	33.6	3010
Stampede	27.2	32.1	4610
Talon	29	34.3	2400
T-39	28.4	35.5	3810
T-9905	29.4	35.6	3860
UCD-0908	29.5	34.9	3240
UI-259	26.3	32.4	3870
UI-537	26.4	31.6	3960
UIP-35	28	32.4	3840
Yeti	29.9	35.8	3140
Zenith	28.2	35.3	3910
0863Per	27.4	32.7	3770
LSD (0.05)	1.5	2.2	790

Table 5. Canopy temperature recorded on August 12 and 16, 2016 at Powell. Plant height was recorded during pod-fill.

Genotype	**Canopy Temp (^oC)**		**Height Dry**	**Height Wet**
	12-Aug	**16-Aug**	**inches**	**Inches**
Avalanche	20.3	24.6	30.3	28.3
CELRK	22.3	25.4	12.7	18.0
Centennial	20.1	23.2	25	29.7
Com. Red Mexican	21	24.2	14.7	13.3
COSD-7	20.4	24.6	27	27.3
COSD-35	20.5	23	30.7	30.3
CO-46348	21.1	24.5	21	30.3
Coyne	20.9	24.3	27.7	23.7
Croissant	20.6	23.7	28	17.3
Desert Song	20.6	24.5	25.7	23.7
Dynasty	21.2	24.5	15.7	19.7
Eclipse	18.7	23.7	23	26.3
ISB96-3156	20.9	24.3	27	30.0
ISB1259-60	20.7	24.4	24.7	27.3
LaPaz	21	24.3	28	29.3
Lariat	19.8	23	29.7	30.7

Long's Peak	20.5	23.8	26.3	27.3
Monterrey	20.1	23.4	29.3	30.7
ND-307	19.9	23.5	27	30.3
Othello	20.4	24.3	21.7	26.7
Poncho	20.8	24	32.7	26
PowderHorn	20.1	23.7	21.7	27.3
PT9-5-6	20.4	23.8	30.3	29.3
Rio Rojo	21.4	24.7	24.7	22
Rosie	20.8	24.4	13.3	21
Stampede	20.2	23.7	26.7	26.3
Talon	21.5	25.3	16	21.7
T-39	21	24.3	31	24.7
T-9905	20	23.7	24.7	26.3
UCD-0908	21.2	25.2	17	20.7
UI-259	20.5	23.8	19	31.7
UI-537	20.6	24	19.7	26.7
UIP-35	20.5	24.1	32.7	27.7
Yeti	22	24.7	20	28.6
Zenith	19.6	23.8	20.7	26.2
0863Per	21	24.6	20.3	24.7
LSD (0.05)	1.2	1.1	5.5	5.5

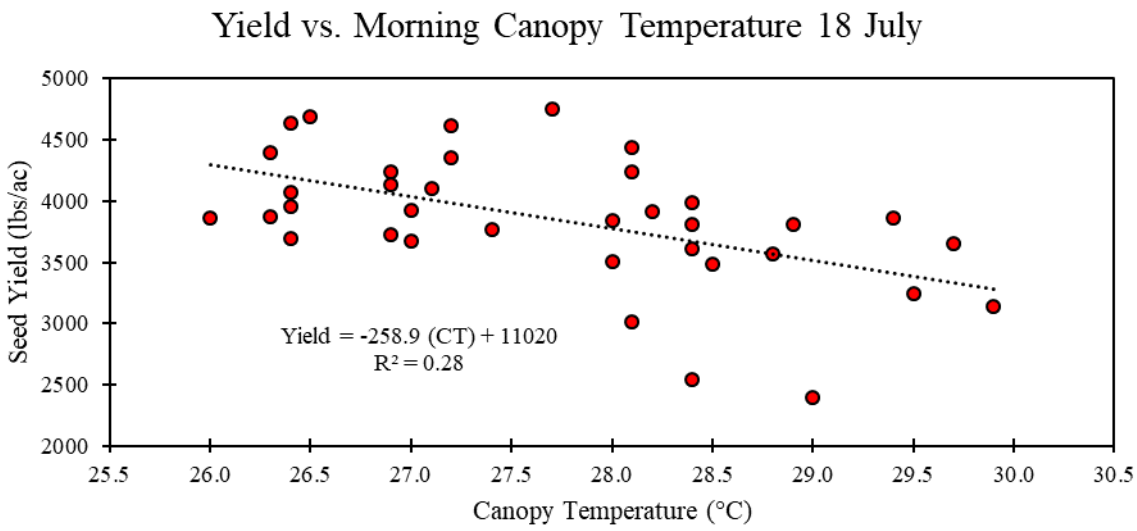


Figure 4. Seed yield of 36 dry bean genotypes as affected by canopy temperature recorded on the morning of 18 July 2016. Values are averaged across watering regimes.

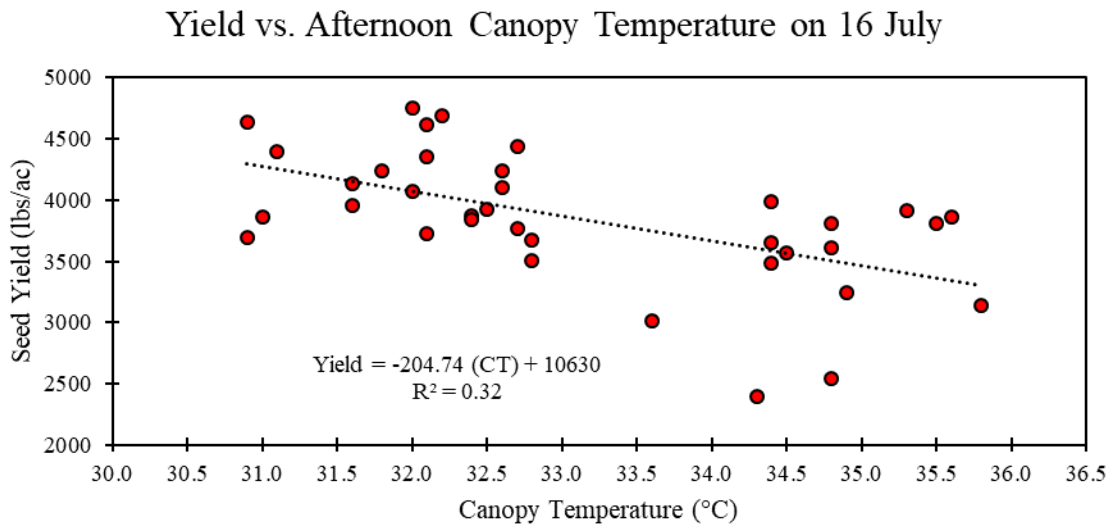


Figure 5. Seed yield of 36 dry bean genotypes as affected by canopy temperature recorded on the afternoon of 18 July 2016. Values are averaged across watering regimes.

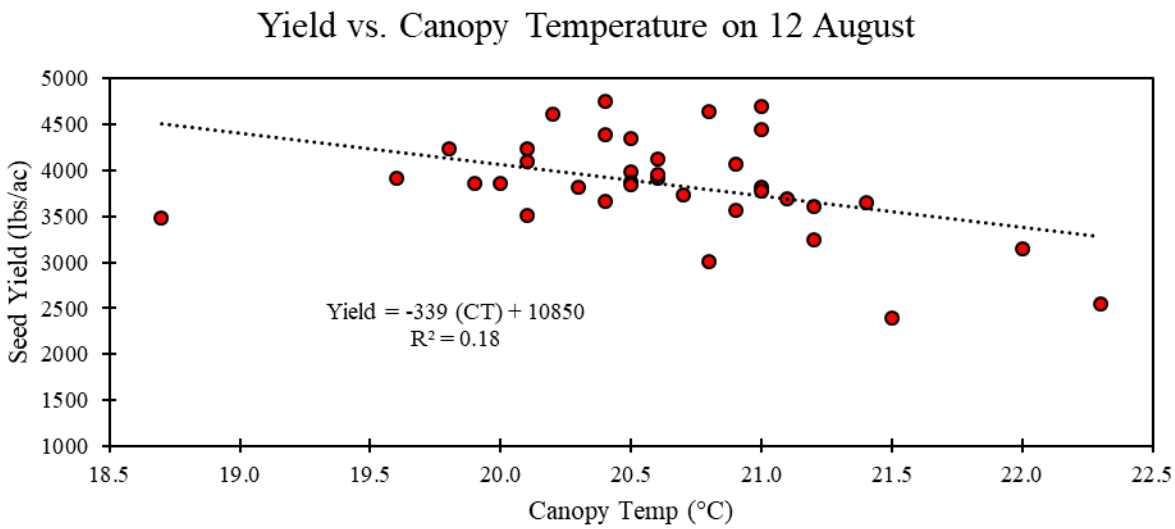


Figure 6. Effect of canopy temperature on 12 August date on seed yield of 36 dry bean genotypes at Powell. Temperatures are averaged across watering regimes.

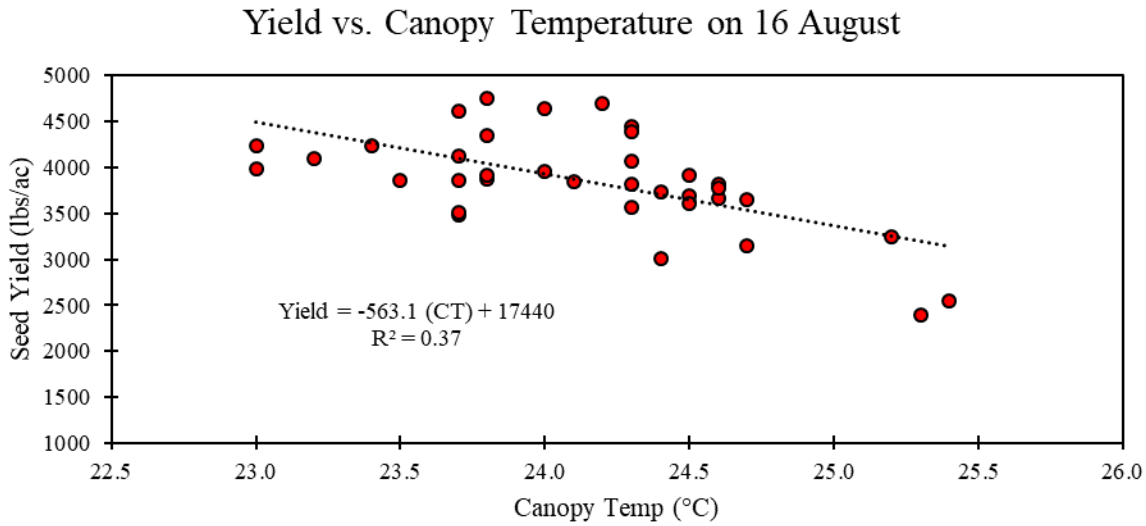


Figure 7. Effect of canopy temperature on 16 August on seed yield of 36 dry bean genotypes at Powell. Temperatures are averaged across watering regimes.

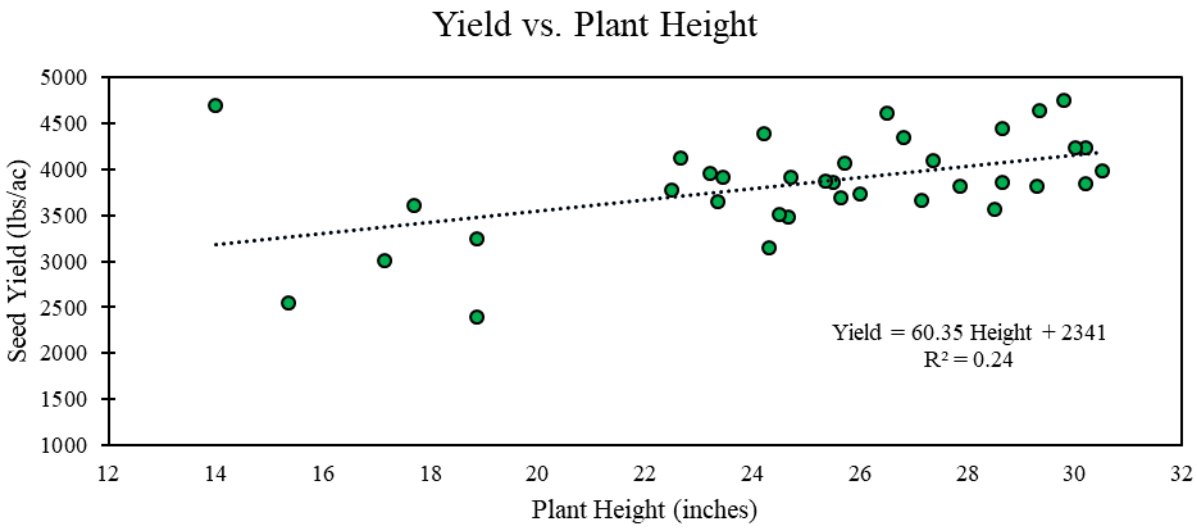


Figure 8. Association of plant height on seed yield of 36 dry bean genotypes at Powell. Heights and yields are averaged across watering regimes.

Powell 2017:

Similar to year 2016, stands were assessed visually (0 = no stand to 10 = full stand with no gaps) on 15 June and June 22, 2017. Stands ranged from 8.5 for the cultivar Rosie to 4 for the cultivar CO33176-1, CELRK and CO14790-3 under well-watered treatments and Rio Rojo under dry treatment. On average, the majority of cultivars had stand count ratings of 7 or greater (data not shown).

Canopy temperatures were recorded on July 12, July 28, August 9, August 16 and August 22 (Morning and Evening (Figure 14 a to 14f) and represent the average temperatures observed for well-watered and dry treatments on the aforementioned dates. Canopy temperatures on July 12 were unaffected by irrigation treatments. The average temperature of 42.22 ^{o}C and 42.41 ^{o}C was observed in well-watered and dry treatments, respectively. Genotypes varied in canopy temperature but no significant genotype-by drought interaction was observed (p values > 0.05). This may be due to no or small difference in irrigation rates between well-watered and dry treatments on July 12. Different irrigation rates were applied after the dry bean flowering stage reached (from July 10 to July 15, 2017).

A significant difference was observed between canopy temperature between well-watered and dry treatments July 28, August 9, August 16 and August 22. On average, the well-watered treatment was 1.8^{o}C, 2.04^{o}C, 3.08^{o}C, 4.2^{o}C and 3°C cooler than dry treatment on July 28, August 09, August 16, August 22 (morning) and August 22 (afternoon), respectively (Figure 14). For all the dates, genotypes varied in canopy temperature except on July 12. Significant genotype-by-drought interactions were observed on all dates except July 12 and August 22 (morning) (Table 6).

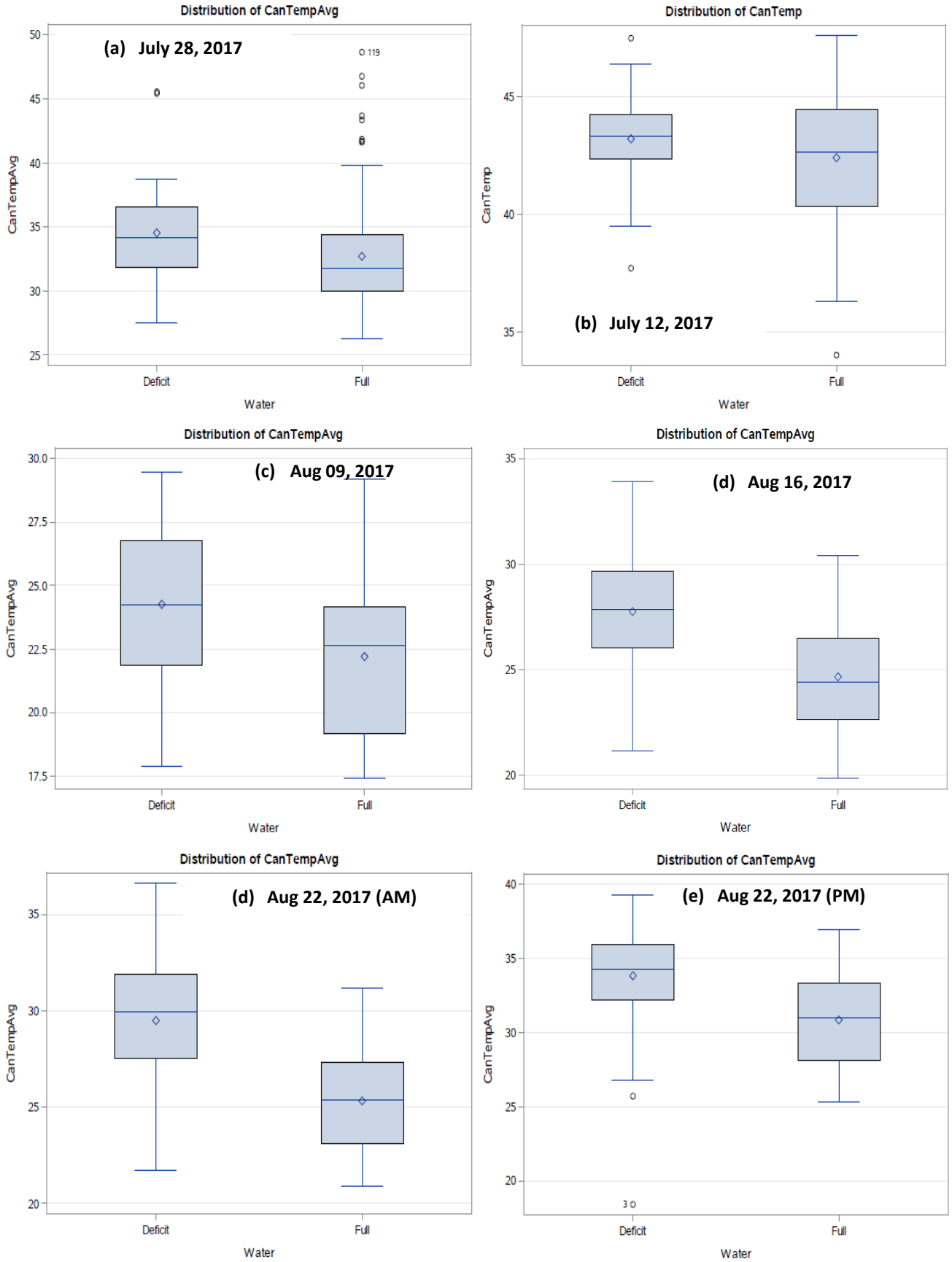
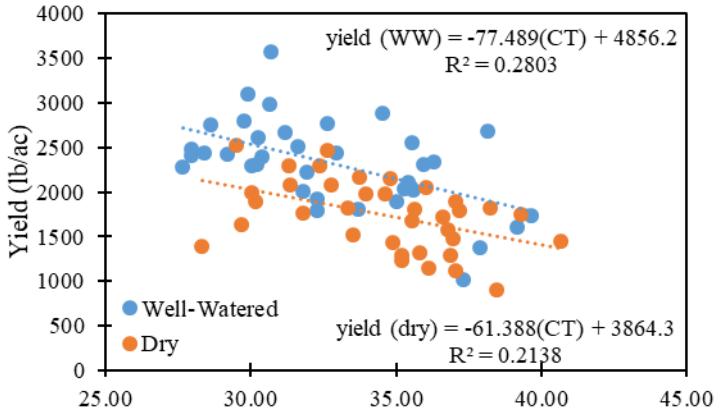


Figure 9. Average canopy temperature between well-watered and dry irrigation treatments on (a) July 12, (b) July 28, (c) August 09, (d) August 16, (e) August 22 (morning) and (f) August 22 (afternoon), 2017

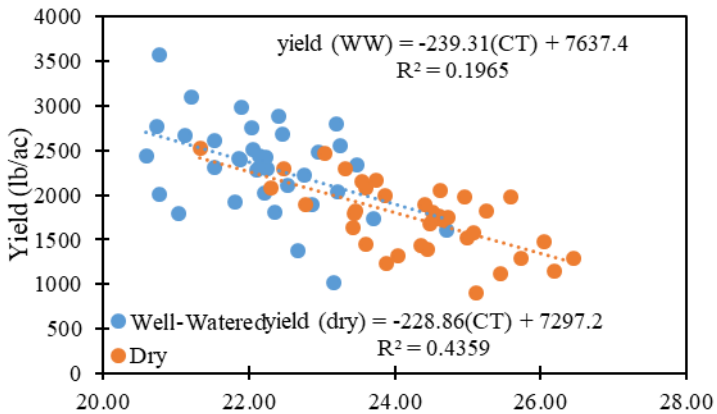
Table 6. Dry bean yield (lb/ac) and canopy temperature (°C) for well-watered and dry irrigated treatments for different cultivars on July 28, August 09, August 16, August 22 (morning) and August 22 (afternoon).

		Yield		28-Jul		9-Aug		16-Aug		Aug 22 (morning)		Aug 22 (afternoon)	
ID	Cultivar	Well-Watered	Dry	Well-Watered	Dry	Well-Watered	Dry	Well-Watered	Dry	Well-Watered	Dry	Well-Watered	Dry
		lb/ac		°C		°C		°C		°C		°C	
1	ComRedMx	3565.40	2295.37	30.68	32.37	20.78	23.32	23.40	26.32	23.90	29.27	29.28	34.32
2	CO-46348	1785.85	2075.70	32.30	32.75	21.03	23.60	24.37	27.07	25.42	28.85	30.10	34.03
3	COSD-35	2433.68	1750.66	28.40	39.30	20.60	24.73	23.00	26.42	23.33	28.67	27.63	33.92
4	Poncho	3093.10	1979.69	29.88	34.60	21.22	24.95	24.42	27.40	25.32	30.32	30.90	33.88
5	CO14790-3	2483.92	2152.79	27.97	34.78	22.95	23.55	24.72	27.22	24.88	28.25	30.47	32.63
6	RioRojo	1895.69	1288.95	35.02	35.18	22.87	26.45	24.80	28.55	26.12	30.08	31.70	34.23
7	PT9-5-6	2881.36	2079.16	34.55	31.35	22.42	22.30	24.82	27.20	25.28	28.25	31.65	32.82
8	CELRK	1610.11	1583.27	39.18	36.78	24.72	25.08	28.45	29.75	29.05	32.25	34.43	36.52
9	MedicineHat	2436.73	2469.89	32.93	32.65	22.15	23.05	25.52	26.32	26.92	28.72	32.50	33.90
10	UI-537	2685.29	1982.74	38.17	33.95	22.47	25.58	24.28	27.62	25.27	31.37	33.03	35.05
11	CO14330-10	2511.38	1234.64	31.62	35.20	22.05	23.88	23.62	28.33	24.68	30.07	30.33	33.35
12	Stampede	2286.22	1677.64	27.67	35.55	22.12	24.48	24.83	27.82	25.68	28.53	31.38	33.65
13	CO33176-1	1377.83	1426.44	37.87	34.90	22.67	24.37	25.85	28.30	26.07	30.23	32.08	34.97
14	CO25069-2	2296.59	1384.14	30.03	28.32	22.25	24.45	24.85	28.98	24.22	31.43	28.92	35.02
15	Croissant	2988.56	2048.85	30.65	36.05	21.90	24.62	23.25	28.30	23.85	29.60	28.10	33.88
16	Othello	2425.75	1991.69	29.22	30.03	22.23	23.87	23.98	26.13	24.87	30.05	30.20	32.58
17	CO91216-15	1919.69	1763.68	32.30	31.82	21.82	24.60	23.77	27.68	23.92	29.82	28.70	35.45
18	Zorro	2309.20	1799.28	35.95	35.62	21.53	24.52	24.50	27.45	24.82	27.93	30.60	31.93
19	Palomino	2396.66	1144.94	30.37	36.13	21.88	26.18	22.97	29.85	24.32	30.85	29.13	34.83
2	Scout	2307.7	1122.5	30.22	37.0	22.15	25.4	25.67	30.5	27.00	31.2	31.85	36.2

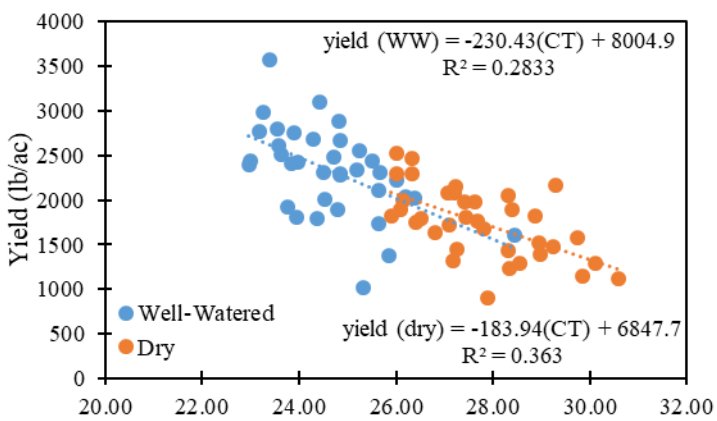
0		8	6		7		5		8		0		5
21	Montrose	1740.49	1820.84	39.65	33.33	23.72	23.47	25.65	25.90	26.68	27.30	33.30	32.23
22	UIP-35NezPerce	2409.48	1524.28	27.98	33.53	21.87	24.98	23.85	28.95	25.08	31.27	30.63	35.82
23	UIP-40TwinFalls	2014.27	1897.52	31.82	30.18	20.78	22.78	24.53	26.08	25.55	28.90	31.18	32.02
24	LongsPeak	2764.82	1720.76	32.65	36.62	20.75	24.65	23.17	27.08	24.45	30.43	29.63	34.32
25	UI-259	2797.56	1891.62	29.75	37.07	23.20	24.42	23.55	28.40	24.48	30.02	29.75	35.55
26	CO33176-15	2031.15	1315.39	35.27	35.82	23.22	24.05	26.20	27.18	25.92	28.65	32.08	33.63
27	DesertSong	2335.44	2521.75	36.28	29.52	23.48	21.33	25.18	26.00	26.70	28.08	33.22	33.67
28	Zenith	1804.77	1452.07	33.68	40.65	22.35	23.60	23.93	27.27	24.20	27.33	29.43	32.62
29	Avalanche	2112.51	1793.17	35.40	37.18	22.53	23.45	25.63	26.52	25.33	28.33	30.22	26.37
30	Talon	1019.24	896.38	37.32	38.45	23.17	25.12	25.33	27.88	27.07	29.93	33.70	34.75
31	ND-307	2660.07	1292.20	31.17	36.87	21.13	25.73	24.83	30.12	25.02	30.70	29.70	35.70
32	LaPaz	2612.27	1631.06	30.27	29.68	21.53	23.43	23.57	26.82	24.00	29.38	28.58	34.35
33	Monterrey	2558.16	2168.04	35.57	33.72	23.25	23.75	25.25	29.30	25.55	28.63	32.50	34.25
34	Powderhorn	2746.92	2298.01	28.62	31.33	22.03	22.48	23.88	26.02	24.32	27.63	29.72	32.83
35	Eclipse	2221.74	1826.33	31.93	38.23	22.77	25.25	26.02	28.87	26.27	28.28	31.48	32.07
36	Centennial	2027.29	1474.65	35.60	36.95	22.22	26.05	26.38	29.25	26.35	31.43	32.47	35.53



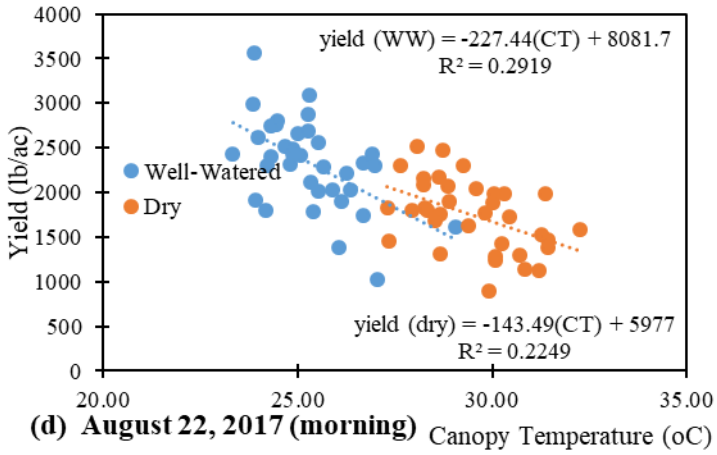
(a) July 28, 2017 Canopy Temperature (oC)



(b) August 09, 2017 Canopy Temperature (oC)



(c) August 16, 2017 Canopy Temperature (oC)



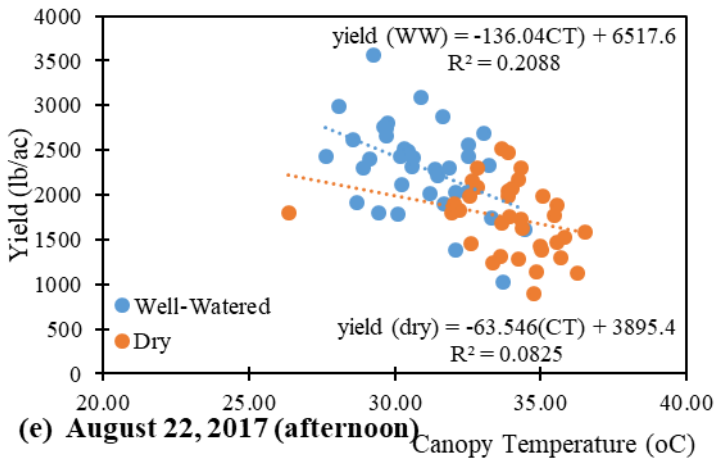


Figure 10. Effect of canopy temperature on July 28, August 09, August 16, August 22 (morning) and August 22 (afternoon) on well-watered and dry irrigated dry bean yield of 36 dry bean genotypes at Powell.

Soil Water Dynamics:

The volumetric water content was also measured at three soil depths (i.e. 1 ft., 2 ft., and 3 ft.) every week in the two irrigation treatments for LaPaz genotype using the model 503 neutron attenuation soil moisture meter (CPN, An Instrotek Company; Triangle Drive Raleigh, NC) for both 2016 and 2017 dry bean growing season. In 2016, a total of five irrigations were applied for the wet treatment on July 5, July 15, July 25, August 04 and August 19. For dry treatment a total of four irrigations were applied on July, 8, July 22, August 5, and August 19. Figure 11 represents the seasonal distribution of soil moisture for both treatments at each depth. Throughout the growing season, maximum depletion was observed within the top 0.3 m layer for both the treatments. The greater depletion from the upper surface is due to greater rate of plant water uptake and soil water evaporation from the topsoil than from deeper soil layers. However, no difference was observed in total available water between the wet and dry treatments (Figure 12).

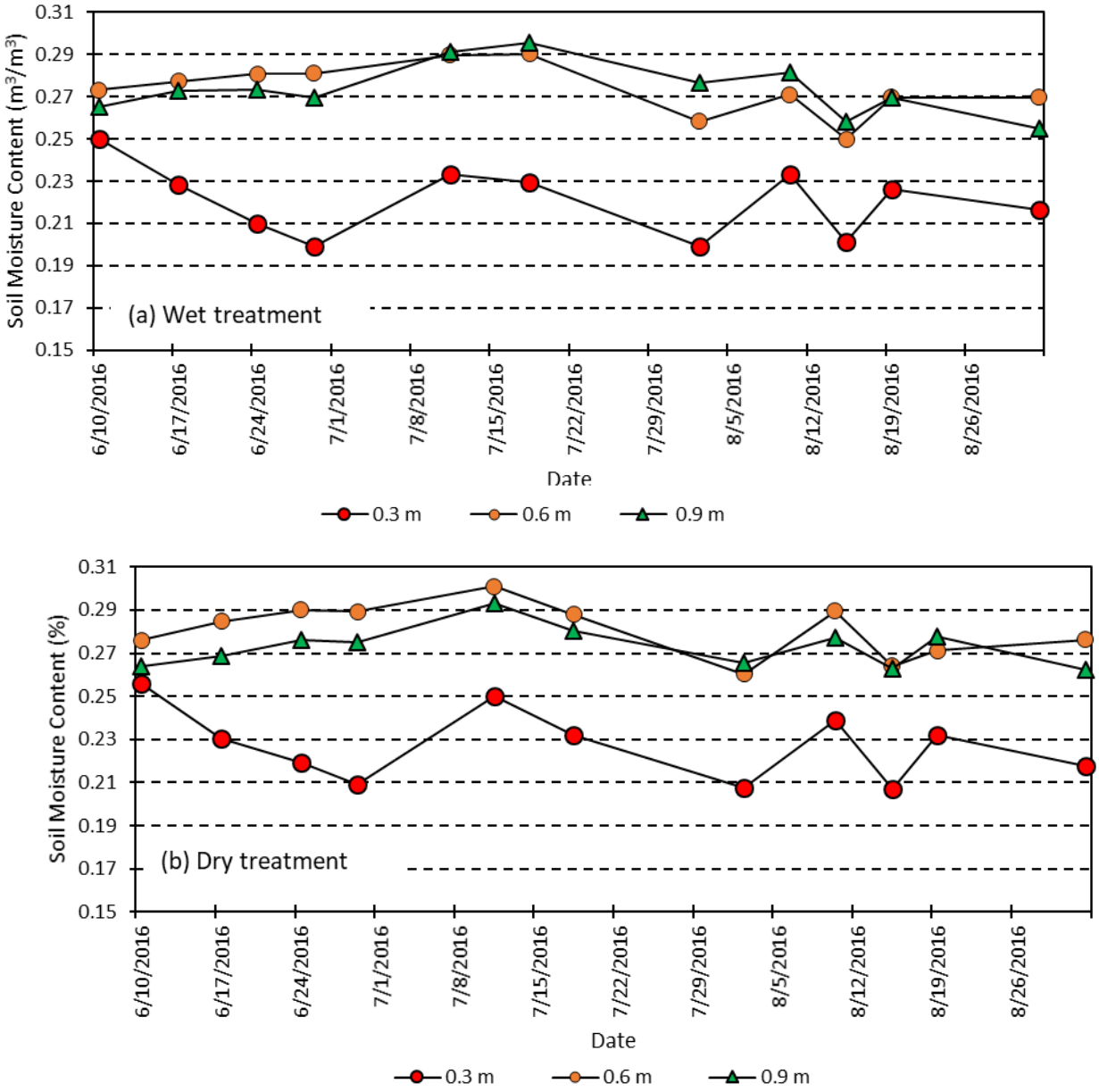


Figure 11. Seasonal distribution of neutron probe soil moisture content at each measurement depth (0.3 m, 0.6 m and 0.9 m) for different irrigation treatments (a) wet and (b) dry treatments.

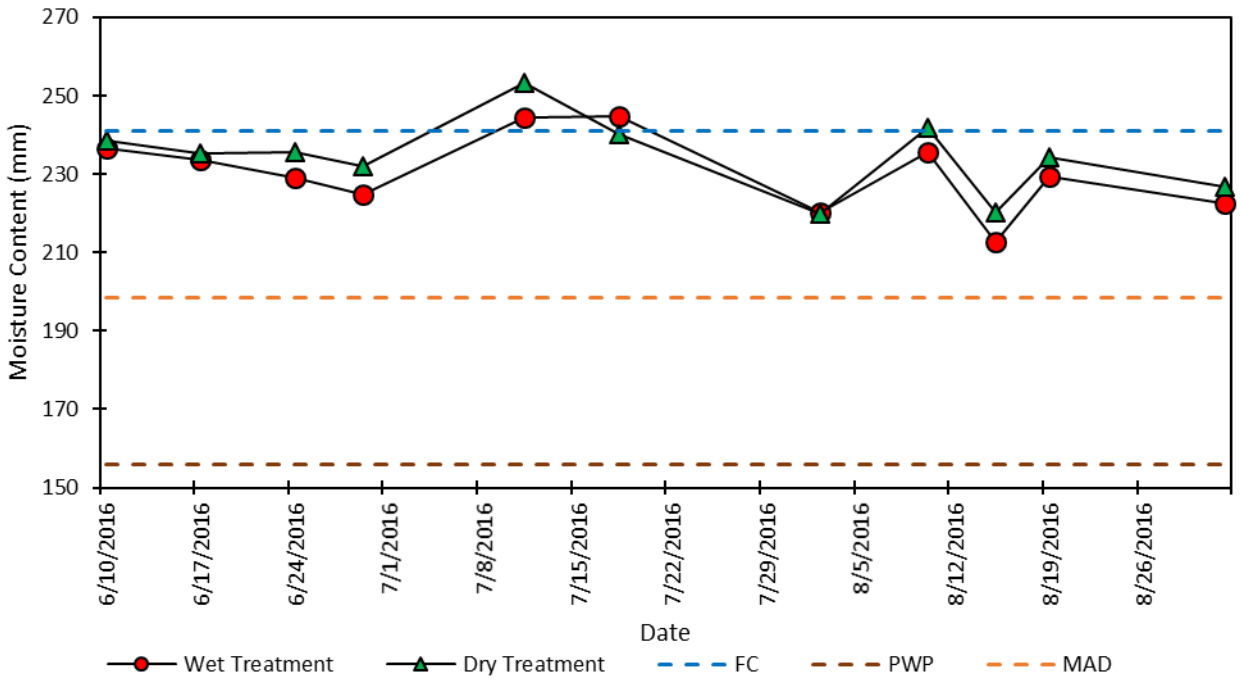
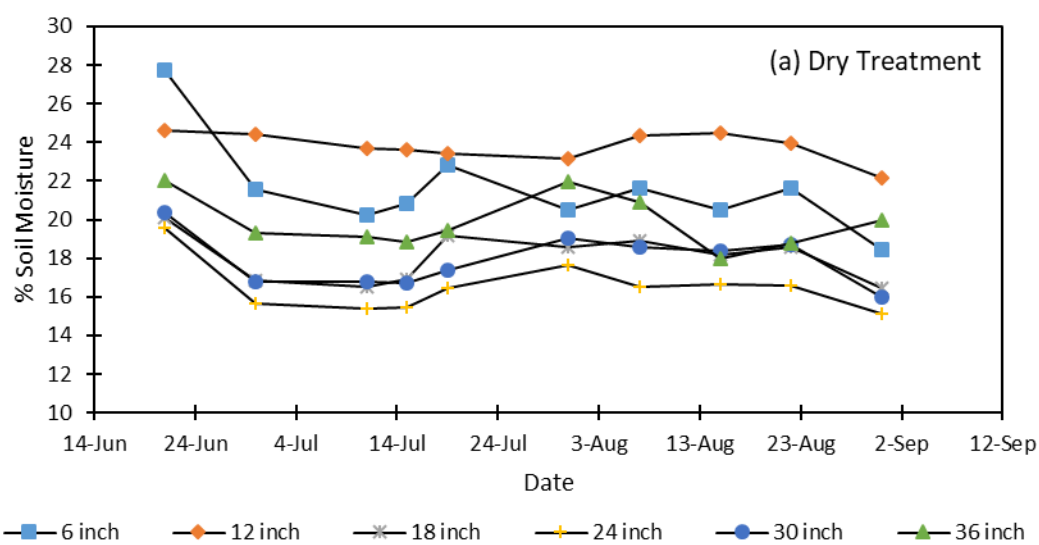


Figure 12. Seasonal distribution of total soil water in the crop root zone (0-0.9 m soil profile) for the wet and dry irrigation treatments.

In 2017, the study was conducted under sprinkler irrigation systems. A total of 15 irrigated events were applied to both wet and dry irrigation treatments with varying rates. A total of 13.5 inches of irrigation water was applied to wet plots compared to 10 inches for dry plots. Figures 13 and 14 represent the seasonal distribution of soil moisture for both treatments at every 6-inch depth. Contrary to 2016, small differences were observed between the total available water for wet and dry regimes in 2017 (Figure 14).



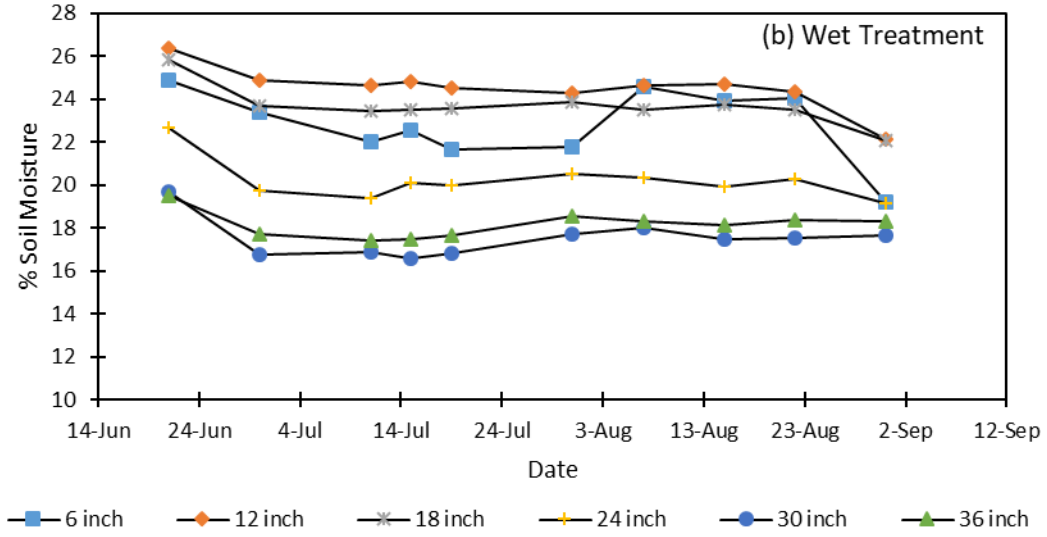


Figure 13. Seasonal distribution of neutron probe soil moisture content at each measurement depth 6-inch, 12-inch, 18-inch, 24-inch, 30-inch and 36-inch for different irrigation treatments (a) dry and (b) wet treatments.

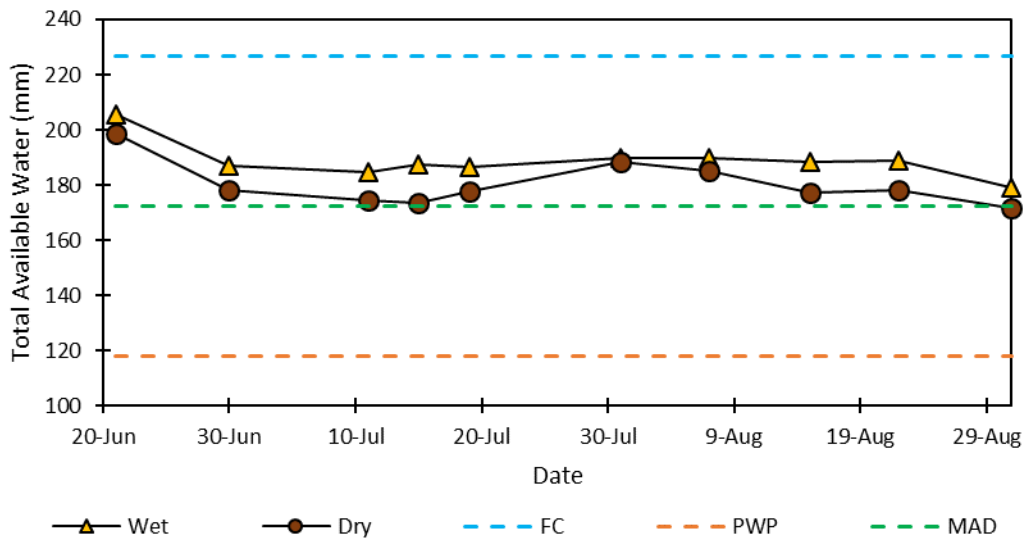


Figure 14. Seasonal distribution of total soil water in the crop root zone (0-0.9 m soil profile) for the wet and dry irrigation treatments.

Lingle 2016:

Plant stands were rated visually on 15 June 2016 and although some differences were apparent, overall, the stands were excellent. The exceptions were the small seeded navy and black seeded genotypes which rated slightly lower. Leaf chlorophyll (3rd uppermost fully expanded leaf) was measured on 28 June prior to imposing water stress. As expected, no differences between main plots were observed (46.1 vs. 45.4 for the soon-to-be-designated well-watered and drought-stressed sections, respectively). However, leaf chlorophyll did vary among genotypes (Table 7). NDVI was not affected by drought when measured on 8 July. Genotypes did differ and the NDVI values paralleled chlorophyll and stand ratings with the small-seeded genotypes exhibiting the lowest NDVI (Table 1). Higher NDVI values are associated with healthier canopies. Stomatal conductance was not significantly affected by any of the treatments

although leaves from well-watered plots had numerically higher conductance than from drought-plots (727 vs. 445 mmol m^{-2} s^{-1}). As expected, canopy temperatures on 23 July were lower in the morning (31.1° C) than in the afternoon (32.6°C). Differences in canopy temperature were not significantly different between watering regimes although a noticeable trend was apparent. In the morning, drought plots exhibited a canopy temperature of 32.6°C vs. 29.5°C for the well-watered plots. In the afternoon, the difference was 33.8°C vs. 31.4°C. Genotypes that are considered more adapted to southeast Wyoming tended to have lower canopy temperatures than genotypes not adapted to Wyoming (Table 1). No yield data were collected in 2016 because of the late July hail damage.

Table 7. Leaf chlorophyll (28 June) using a SPAD meter, normalized difference vegetation index (NDVI) on 8 July, and canopy temperature on July of 23 dry bean genotypes at Lingle. Values are averaged across watering regimes.

Genotype	Chlorophyll	NDVI	Canopy Temp (am)	Canopy Temp (pm)
	(SPAD Units)		°C	°C
Avalanche	44.1	0.54	31.5	33.4
Bill-Z	48.3	0.72	31.2	32.7
Centennial	43.5	0.61	30.4	32.0
Com. Red Mexican	43.9	0.69	30.9	32.2
CO-46348	49.1	0.72	30.3	31.9
COSD-25	42.7	0.62	30.5	32.4
COSD-35	47.9	0.65	32.9	32.6
Croissant	45.1	0.70	31.4	31.8
Desert Song	53.4	0.62	30.0	32.1
Eclipse	41.4	0.49	32.2	34.1
El Dorado	46.8	0.62	30.4	31.8
ISB1231-1	48.8	0.69	31.2	31.7
LaPaz	45.3	0.59	30.3	32.9
Long's Peak	43.1	0.66	29.9	32.0
Monterrey	48.3	0.65	30.6	33.0
Othello	49.9	0.71	29.9	32.3
Poncho	48.2	0.71	31.2	32.4
Rosie	44.2	0.72	33.3	35.1
T-9905	45.3	0.44	31.8	33.5
UI-259	42.7	0.69	31.6	32.9
UIP-40	42.0	0.59	30.2	32.5
UIP-46	43.9	0.65	30.7	32.3
Zorro	43.3	0.45	31.7	33.4
LSD (0.05)	3.7	0.06	1.7	1.7

Lingle 2017:

As of mid-December 2017, all 150 plots have been threshed but have not yet been cleaned. Project team is currently working on the yield analysis and data will not be available until mid-January 2018.

At Powell and Lingle, the 19 LPID lines were harvested and threshed but have yet to be cleaned; thus, yield data has yet to be processed. Several of the lines are still segregating from their pink and pinto parents so further single-plant selections from our bulk plantings will be made in 2018.

Objective 2: Evaluate the impact of different dry bean germplasm (market classes, as well as varieties within a market class) in how they respond to previous crop residue or cover crops in a direct-harvest dry bean system.

In the field study, average unifoliate node heights ranged from 4.1 to 7.3 cm (1.6 to 2.9 inches) were observed between cultivars (Figure 15). In general, the unifoliate node height correlated well with the lowest pod height for each cultivar. On average, for each cm of increased unifoliate node height, a corresponding 1.7 cm increase in pod height was observed. For Pintos, the relationship was stronger, with each cm increase in node height corresponding to a 2.2 cm increase in pod height. These data suggest that early season node heights are a good predictor of late season pod heights. However, there were several cultivars that had relatively high node heights without a corresponding pod height; those included 'Poncho' and 'CO46348'.

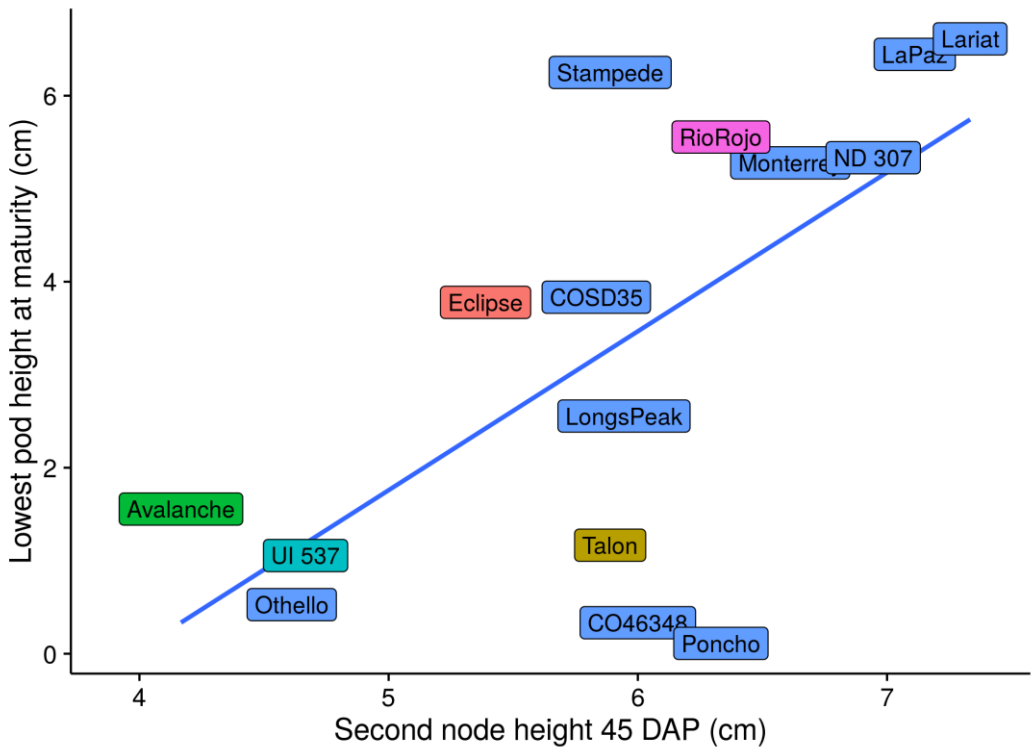


Figure 15. Relationship between node height 45 days after planting (DAP) and the lowest pod height at dry bean maturity for 15 dry edible bean cultivars from a field study at SAREC, Lingle, WY 2017.

In the Laramie study, the presence of sod adjacent to bean plants increased the unifoliate and 1st trifoliolate node heights on all cultivars (Figure 16). With respect to the unifoliate node height, cultivar appeared to have a greater impact on node height than the presence of sod (MS = 3.3 vs 1.8); however, the presence of sod had a greater impact on the first trifoliolate height compared with cultivar (MS = 4.5 vs 2.7). This suggests that both factors may contribute to the ability of beans to hold their pods higher off the ground, and that the effect of cultivar selection and cultural practices may have a complementary role in reducing harvest losses from direct-cut beans.

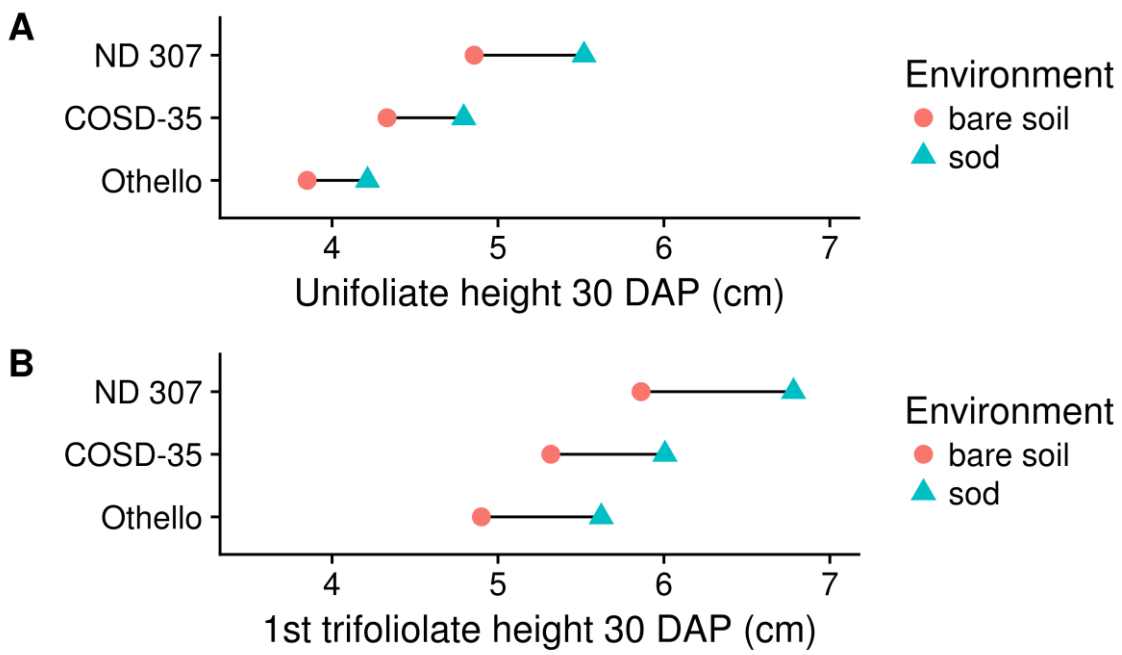


Figure 16. Unifoliate (A) and 1st trifoliolate (B) node heights for 3 dry edible bean cultivars grown in planter boxes surrounded by soil or sod, Laramie, WY 2017.

Objective 3. Explore alternatives for late season weed control in dry beans.

The PPI treatments (Eptam® + Sonalan® and Eptam® + Outlook®) helped reduced the number of Venice mallow present before the application of the POST treatments (Table 9). Venice mallow plant density was significantly reduced 15 DAT by all POST treatments, and control was similar among treatments. The levels of Venice mallow control recorded before harvest were similar to those 15 DAT.

Dry beans yields were higher when Eptam® + Sonalan® applied PPI was followed by Raptor® + Basagran 5L®, Raptor® + Basagran 5L® + Outlook® (7 oz.), and Raptor® + Basagran 5L® + Permit® (0.66 oz.) (Table 10). No visible crop injury was observed during the study after the application of the tested herbicides. Venice mallow plant density at the time of inspection was very low in all treated plots, for this reason 100% of the treated plots were certified for seed production.

Table 8. Weather conditions for all application timings

Date	5/19/2016	6/27/2016
Time	5:30 PM	4:00 PM
Application method	Sprayer	Sprayer
Timing	Pre-plant	2-3 trifoliate leaf
Placement	Broadcast	Broadcast
Air temperature	75 F	85 F
Relative humidity (%)	18	14
Wind speed (MPH)	8	5
Wind direction	S	NE

Table 9. Venice mallow (pl. / 2.7 ft^2), before post application, 15 DAT, and before harvest.

	Treatment	Rate		Before Post	15 DAT	Pre harvest
1	Untreated Check			6 a	5.3 a	7.8 a
2	Eptam®	3	pt./a	2 bc	0.3 b	0.3 b
	Sonalan®	2	pt./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
3	Eptam®	3	pt./a	2 bc	0.3 b	0.7 b
	Sonalan®	2	pt./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	Outlook®	7	fl oz./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
4	Eptam®	3	pt./a	1 c	0.1 b	0 b
	Sonalan®	2	pt./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	Outlook®	21	fl oz./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
5	Eptam®	3	pt./a	4 ab	0.4 b	0.5 b
	Sonalan®	2	pt./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	Permit®	0.66	oz. wt./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
6	Eptam®	3	pt./a	1 c	0.3 b	0.3 b
	Outlook®	14	fl oz./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
7	Eptam®	3	pt./a	2 bc	0.3 b	0.2 b
	Outlook®	14	fl oz./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	Outlook	7	fl oz./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
8	Eptam®	3	pt./a	2 bc	0.1 b	0.3 b
	Outlook®	14	fl oz./a			
	Permit®	0.66	oz. wt./a			
	Raptor®	4	fl oz./a			
	Basagran 5L®	1.2	pt./a			
	NIS	1	qt/100 gal			
	UAN	2	qt/a			
LSD P=.05				***2.8***	***1.8***	***1.8***

Table 10. Dry bean yields (lb. /a) and percent area approved for seed production for each treatment.

	Treatment	Rate		% Certified	Yield (lb.
1	Untreated Check			0.25 b	2597 b
2	Eptam®	3	pt./a	1 a	3320 a
	Sonalan®	2	pt./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
3	Eptam®	3	pt./a	1 a	3347 a
	Sonalan®	2	pt./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	Outlook®	7	fl oz./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
4	Eptam®	3	pt./a	1 a	2850 ab
	Sonalan®	2	pt./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	Outlook®	21	fl oz./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
5	Eptam®	3	pt./a	1 a	3187 a
	Sonalan®	2	pt./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	Permit®	0.66	oz. wt./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
6	Eptam®	3	pt./a	1 a	2947 ab
	Outlook®	14	fl oz./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
7	Eptam®	3	pt./a	1 a	2549 ab
	Outlook®	14	fl oz./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	Outlook	7	fl oz./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
8	Eptam®	3	pt./a	1 a	2690 ab
	Outlook®	14	fl oz./a		
	Permit®	0.66	oz. wt./a		
	Raptor®	4	fl oz./a		
	Basagran 5L®	1.2	pt./a		
	NIS	1	qt/100 gal		
	UAN	2	qt/a		
LSD P=.05				***0.2***	***729***

In order to verify if the PPI applied by the farmer had affected Venice mallow plant density, weed counts were performed before the POST applications. Venice mallow distribution was uniform across the trial and averaged 13. 6 plants per 2.7 ft^2. All tested POST treatments reduced Venice mallow plant density when compare to the non-treated check, but no differences were observed between treatments 15 DAT (Table 12). A significant reduction in Venice

mallow plants in the non-treated checks was observed between the counts before POST and 15 DAT. This reduction can be attributed in part to the cultivation between rows performed during that time. No visible crop injury was observed during the study after the application of the tested herbicides. Venice mallow plant density before harvest was low in general, but numbers were higher when Raptor® + Basagran 5L® + Outlook® (7 oz.) was the POST treatment. For this reason 100% of the treated plots were certified for seed production. No major differences in yield were recorded between treatments.

Table 11. Weather conditions

Date	6/27/2016
Time	9:00 AM
Application method	Sprayer
Timing	POST
Placement	Broadcast
Air temperature	70 F
Relative humidity (%)	33
Wind speed (MPH)	4
Wind direction	W

Table 12. Venice mallow (pl. / 2.7 ft^2), before post application, 15 DAT, and before harvest.

				Before Post	15 DAT	Pre-Harvest	Certifie	YIELD (lb. /a)
1	Untreated			16	4.3	3.9	0.38	2754
2	Raptor	4	fl oz./a	13	0.3	1	1	3335
	Basagran 5L	1.2	pt./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
3	Raptor	4	fl oz./a	12	1	2.3	1	2960
	Basagran 5L	1.2	pt./a					
	Outlook	7	fl oz./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
4	Raptor	4	fl oz./a	10	0.1	0.6	1	3122
	Basagran 5L	1.2	pt./a					
	Outlook	14	fl oz./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
5	Raptor	4	fl oz./a	10	0.6	1.1	1	2482
	Basagran 5L	1.2	pt./a					
	Outlook	21	fl oz./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
6	Raptor	4	fl oz./a	15	0.6	0.7	1	2767
	Basagran 5L	1.2	pt./a					
	Permit	0.6	oz. wt./a					
	NIS	1	qtr./100 gal					

	UAN	2	qtr./a					
7	Raptor	4	fl oz./a	18	0.8	0.8	1	3389
	Basagran 5L	1.2	pt./a					
	Outlook	7	fl oz./a					
	Permit	0.6	oz. wt./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
8	Basagran 5L	1.2	pt./a	15	0.9	0.8	1	3155
	Outlook	7	fl oz./a					
	Permit	0.6	oz. wt./a					
	NIS	1	qtr./100 gal					
	UAN	2	qtr./a					
		LSD		***8.7***	***2.1***	***2.0***	***0.1***	***749***

No further information is available from this objective because the lead investigator was killed in a motorcycle accident before the study was completed.

Objective 4. Determine if a single in-furrow application of different fungicides at planting is sufficient to protect the dry bean crop until harvest from soil-borne disease.

No phytotoxicity due to treatments was observed on the pinto bean crop in 2016. Stands were somewhat variable in the plots most likely due to the open furrow planting procedure. Effects of in-furrow fungicide applications on the bean crop and stem rot in Table 13. In-furrow fungicide treatment had no effect on vigor, final stand count, and incidence of stem and root disease ($P \leq 0.05$). A severe hail storm defoliated the trial on 27 July, therefore the trial was terminated (disked under) after the stem /root ratings were conducted.

Table 13. Management of stem and root rot diseases of pinto bean with in-furrow fungicides (W.L. Stump et al., U of WY; 2016).

Treatment and rate/A[1]	Application timing	Plant vigor (1-10) [2]	Final stand (# plants/40 ft)	% Incidence of stem and root rot[3]
		23 Jun	11 Jul	6 Aug
1. Untreated inoculated check	NA	9.3 a[4]	173.3 a	30.0 a
2. Proline (5.7 fl oz)	In-furrow	10.0 a	167.8 a	30.0 a
2. Endura (8 oz)	foliar			
3. Velum Prime (3 fl oz)	In-furrow	9.3 a	159.0 a	15.0 a
3. Endura (8 oz)	foliar			
4. Propulse (6 fl oz)	In-furrow	9.3 a	175.3 a	40.0 a
4. Endura (8 oz)	foliar			

[1] Treatment rates (per acre) were concentrated in furrow

[2] Plant vigor rating scale (1-10) where 1= no stand and 10= best stand in the replicate.

[3] % disease incidence due to presumptive Fusarium and or Rhizoctonia infection was based visual ratings of 5 stems pulled from each plot.

[4] Means followed by the same letter were not significantly different, ($P \leq 0.05$).

In-furrow fungicide treatments had no effect on plant stands on either evaluation date in 2017 and there was no phytotoxicity observed on the bean plants (Table 13). Most treatments improved plant vigor as measured on 5 July, compared to the untreated/inoculated check ($P \leq 0.05$). The exceptions were the treatments of Velum Prime and

Serenade ASO, which resulted in plant vigor similar to the untreated/inoculated check. Only the in-furrow treatment of Proline had comparable vigor to that of the untreated/uninoculated check ($P \leq 0.05$).

Treatment effects on disease are shown in Table 14. Treatments had no effect on early disease incidence but by 10 July all fungicide treatments except Velum Prime and Serenade ASO, had on average 81% less disease incidence than the untreated/inoculated check ($P \leq 0.05$). Stand decline due to disease was evaluated from early July to early September. The area under the disease progress curve (AUDPC) was generated and represents an overall measure of disease for this time interval. Again, all fungicide treatments except Velum Prime and Serenade ASO had AUDPC values less than the untreated/inoculated check (smaller values equate to better disease suppression). The order of disease suppression was Proline> Propulse, Quadris>Headline ($P \leq 0.05$). Toward the end of the season (8/29) plants were pulled from the ground and evaluated for stem and root lesions. The two checks had similar levels of disease indicating endemic Fusarium was probably responsible for the majority of the root lesions rather than the inoculated Rhizoctonia. These ratings can be a little misleading since live plants were evaluated, and some plant death did occur in the plots over the course of the season. Case in point was the poor preforming treatments like Velum Prime and Serenade ASO had less root disease than the untreated checks at season end. Proline however, the consistently best performer, had the least amount of disease compared to all other treatments.

Treatment effects on yield and quality are shown in Table 15. Due to weed pressure, bean yields were highly variable and there were no significant treatment effects on yield or on quality parameters.

Table 14. Management of stem and root diseases of pinto beans with in-furrow fungicides, crop effects (W.L. Stump and W. Cecil, U of WY; 2017).

In-furrow treatment and product rate (fl oz/A)[1]	Plant stand (per 40 row ft)		% Phytotoxicity (0-100%)	Crop vigor (1-10)[2]
	19 June	10 July	19 June	5 July
1. Untreated/non-inoculated check	186.50 a[3]	190.30 a	0.0 a	9.00 a
2. Untreated/Inoculated check	173.50 a	186.50 a	0.0 a	4.75 c
3. Proline 480SC (5 .0)	185.30 a	189.00 a	0.0 a	9.00 a
4. Velum Prime (3.0)	174.80 a	192.00 a	0.0 a	5.50 c
5. Propulse (6.0)	182.80 a	181.00 a	0.0 a	7.25 b
6. Serenade ASO (32.0)	164.00 a	176.50 a	0.0 a	5.00 c
7. Quadris (8.7)	179.80 a	184.30 a	0.0 a	7.25 b
8. Headline (10.4)	178.30 a	183.80 a	0.0 a	7.00 b

[1]All treatments were applied at planting, in-furrow. Listed broadcast per acre rates were adjusted for row applications for 30" rows.

[2]Crop vigor takes into consideration plant appearance and size. Plots were compared to the best looking plot in the replicate which was assigned a "10".

[3]Means followed by the same letter were not significantly different, ($P \leq 0.05$).

Table 15. Management of stem and root diseases of pinto beans with in-furrow fungicides, disease effects (W.L. Stump and W. Cecil, U of WY; 2017).

In-furrow treatment and product rate (fl oz/A)[1]	Disease incidence		% stand decline			Stand decline AUDPC rating[2]	Stem/root rating (0-11)[3]
	19 June	10 July	5 July	24 July	24 August		
1. Untreated/non-inoculated check	1.00 a[4]	1.80 b	0.0 d	0.0 d	0.5 c	1.39 d	7.00 a

2. Untreated/Inoculated check	2.30 a	12.50 a	21.0 a	21.0 a	31.0 a	65.56 a	6.75 a
3. Proline 480SC (5.0)	1.00 a	0.50 b	0.0 d	0.0 d	0.5 c	1.39 d	4.00 c
4. Velum Prime (3.0)	1.80 a	15.00 a	17.0 ab	21.0 a	28.0 a	62.88 a	5.00 bc
5. Propulse (6.0)	2.30 a	0.80 b	6.0 c	6.0 bc	4.0 b	21.71 c	5.50 b
6. Serenade ASO (32.0)	2.00 a	11.30 a	21.0 a	23.5 a	28.0 a	64.21 a	5.50 b
7. Quadris (8.7)	2.80 a	3.30 b	5.0 c	4.0 c	3.0 b	23.07 c	7.00 a
8. Headline (10.4)	2.30 a	4.50 b	12.0 b	7.0 b	5.0 b	36.51 b	7.00 a

[1]All treatments were applied at planting, in-furrow. Listed broadcast per acre rates were adjusted for row applications for 30" rows.
[2]Area under the disease progress curve.
[3]Root lesions were due to the combined effects of Rhizoctonia and Fusarium root rot disease.
[4]Means followed by the same letter were not significantly different, ($P \leq 0.05$).

Table 16. Management of stem and root diseases of pinto beans with in-furrow fungicides, seed yield and quality effects (W.L. Stump and W. Cecil, U of WY; 2017).

In-furrow treatment and product rate (fl oz/A)[1]	Lbs/A	100 Seed weight (g)	# abnormal seed per 100 seed[2]
1. Untreated/non-inoculated check	2380.2 a[3]	37.6 a	8.80 a
2. Untreated/Inoculated check	2272.3 a	37.3 a	12.30 a
3. Proline 480SC (5.0)	1638.3 a	36.0 a	15.00 a
4. Velum Prime (3.0)	2800.0 a	38.3 a	14.80 a
5. Propulse (6.0)	1966.5 a	36.9 a	13.50 a
6. Serenade ASO (32.0)	2178.3 a	37.1 a	12.30a
7. Quadris (8.7)	1881.5 a	36.0 a	21.00 a
8. Headline (10.4)	1906.3 a	35.5 a	13.00 a

[1]All treatments were applied at planting, in-furrow. Listed broadcast per acre rates were adjusted for row applications for 30" rows.
[2]Abnormal seeds included small, shrunken and/or discolored seed.
[3]Means followed by the same letter were not significantly different, ($P \leq 0.05$).

Objective 5. Determine what sorts of research and outreach is needed as well as other activities that would be useful to handlers and growers of dry beans.

Of the respondents, 27 felt that there needed to be more research for Pinto beans and 13 felt Great Northern beans needed more research (Table 17). The rest of the bean classes had less than 3 respondents selecting it as more need for research. When respondents were asked what bean class needed research in a given area, Pinto beans were overwhelmingly selected as the top class of bean needing more research. Of the research needed for Pinto beans, applied herbicide injury, weed management, harvest method, and disease management were the top production problems they were interested in (Table 18). In addition to those problems, respondents felt fertilization needed more research. No respondents felt drought, field scouting, or soil salinity where issues that warranted further research (Table 19).

Many respondents chose not to complete the portion of the survey regarding pests, diseases, and weeds. Of those that did the bean leaf beetle was identified as the worst pest, followed by grasshoppers (Table 20). When asked about diseases affecting dry beans, white mold was selected as the worst disease, followed by common rust. Root rot was also a disease of concern (Table 21). An overwhelming number of respondents identified nightshade as the worst weed affecting dry bean operations. The respondents did not strongly identify any other weed as a problem, though Canada thistle, lambs quarter, and redroot pigweed were ranked higher than the remaining weeds (Table 22).

Respondents were asked about the best way for them to learn about research results. Field days were selected by the most respondents, while classroom workshops, local newsletters, extension bulletins, and websites were also good sources for learning about research (Table 23).

Open ended questions regarding future concerns and research needs closely resembled the results in the quantitative portion of the survey. However, a concern mentioned by several producers was regarding economics. Specifically, respondents were concerned about prices and markets. Additionally, many respondents stated that they would be very interested in research on direct harvesting.

Table 17. Number of Respondents that felt research was needed for each bean class.

	Count
Pinto	27
Great Northern	13
Black	3
Kidney	2
Navy	1
Pink	1
Small Red	1
Other Class	1

Table 18. Number of Respondents from each bean class that said they were interested in each production problem.

	Pinto	All	Black	Greater Northern	Navy	Others	Pink
Applied herbicide injury	15	1	2	1		1	
Weed management	15		3	1			
Harvest Method	13			4			
Fertilization	12		2	3	1		
Disease management	9		1	1	1		
Hail damage	8						
Delayed planting	7						
Fertilizer Application Method	7	1					
Frost damage	6		1	1	1		
Innoculation	6			1			
Micronutrient deficiency	6	1	1				
Soil salinity	6						
Row spacing	5	1		2			

Drought	4						
Emergence/stand	4		1	1	1		
Insect management	4						
Use of ground roller	4			1			
Herbicide drift injury	3	1					
Seed treatment insecticides	3	1					
Use of dessicants	3						
Water damage (beans drowned/not harvested)	3		1	1			
Water damage (beans still harvested)	3		1	1			
Wind damage	3		1	1			
Field scouting	2						
Incorporating beans into a rotation	2						
Seeding rate	2			1			
Fungus management	1				1		1
Pop up fert	1						
Foliar feed	1						
Residual herbicide	1						
dry down response to water and heat day length	1						

Table 19. Number of Respondents that felt each production issue needs more research.

	Count
Weed management	16
Harvest Method	15
Applied herbicide injury	14
Fertilization	13
Micronutrient deficiency	11
Fertilizer Application Method	10
Seeding rate	10
Fungus management	8
Disease management	7
Row spacing	7
Innoculation	6
Insect management	4
Wind damage	4
Hail damage	3
Seed treatment insecticides	3
Use of ground roller	3
Delayed planting	2
Emergence/stand	2
Frost damage	2
Herbicide drift injury	2

Water damage (beans still harvested)	2
Direct Harvest	2
Incorporating beans into a rotation	1
Use of desiccants	1
Water damage (beans drowned/not harvested)	1
National annual production information	1
Not a program crop (GN-Pinto)	1
Pop up fert	1
Foliar feed	1
Residual herbicide	1
dry down response to water and heat day length	1
Bean Sale Activity	1
Drought	0
Field scouting	0
Soil salinity	0

Table 20. Number of Respondents that ranked each insect/mite, with 1 being the worst.

	1	2	3
Bean Leaf Beetle	5	1	1
Grasshopper	3	5	2
Wire Worms	2	2	0
Aphids	1	1	1
Other	1	0	0
Mexican Bean Beatle	1	0	0
Leafhopper	0	1	1
Spider Mites	0	1	2

Table 21. Number of Respondents that ranked each disease, with 1 being the worst:

	1	2	3
White mold	8	1	4
Common rust	5	0	5
Fusarium	2	0	1
Halo blight	2	2	1
Bacterial brown spot	1	1	0
Bean common mosaic virus	1	0	0
Common bacterial blight	1	2	1
Root rot	1	5	1
Anthracnose	0	0	0
Bacterial wilt	0	1	0
Beet curly top	0	0	1
Rhizcotonia	0	3	0
Other viruses (general)	0	0	2

None	0	0	0

Table 22. Number of Respondents that ranked each weed, with 1 being the worst.

	1	2	3
Nightshade	12	2	1
Canada thistle	1	3	1
Foxtail	1	0	0
Lanceleaf sage	1	0	1
Ragweed	1	0	0
Cocklebur	0	1	3
Kochia	0	0	3
Lambsquarter	0	4	0
Redroot pigweed	0	1	4
Smartweed	0	0	0
Sunflower	0	2	1
Venice mallow	0	3	0
Waterhemp	0	0	0
Wild buckwheat	0	1	0
Wild mustard	0	0	1
Other	0	0	0
None	0	0	0
Fetid Marigold	0	0	1

Table 23. Number of Respondents that ranked the best way to learn about research results with 1 being the least:

	1	2	3
Field Days	4	5	2
Classroom Workshops	4	4	1
Websites	4	1	4
Local Newsletter	4	4	3
Extension Bulletins	3	3	4
Scientific Journals	0	0	0
Trade publications	0	2	1
Other	0	0	1

BENEFICIARIES

The beneficiaries for this project will be the 267 dry bean producers in Wyoming. Results of the survey revealed that projects supported thus far by the Wyoming Bean Commission are consistent with research needs identified by producers. Other beneficiaries will be our region's seed producers seeking to market dry bean lines that can withstand drought tolerance and direct-harvest practices to a greater extent than existing cultivars. In 2019, the most promising one or two LPID test lines will be submitted into the Cooperative Dry Bean Nursery for comparison with elite lines from other parts of the U.S. If one of these lines is worthy of a variety release, our region's seed companies and producers will have access to that variety but this outcome is not anticipated prior to the year 2020.

LESSONS LEARNED

There was strong evidence at the beginning of this project to suggest that at least two varieties would be released, at least in part, by the Wyoming Agricultural Experiment Station. Extenuating circumstances prevented this from happening, but the two lines that were under consideration remain in the public domain. It is our understanding that grower contracts were prepared to advance these two lines in the Big Horn Basin.

First year results for objective 4 were confounded by low disease development and a crop-ending hail event. Results from this this year's research show there is some potential of some fungicides applied in-furrow at planting to protect against the effects of soil-borne diseases. Whether or not this management equates to improved dry bean yields has not been satisfactorily answered from our research efforts the past two seasons.

The survey response rate was surprisingly low. Because of the small return rate for the survey, statistical validity of the results is outside the limits of what was hoped for in our design. Nevertheless, there is some information that can be derived from the results in terms of what those that responded think is important. It was encouraging to discover that future concerns and research needs of survey respondents closely resembled the results in the quantitative portion of the survey. If this survey or anything similar were to be done again, more effort needs to be made by those involved in the industry to stress its importance to the growers. Perhaps as results from already funded Wyoming Bean Commission research becomes available and results disseminated, more growers would participate the next time. Survey results also revealed that the commission could support its growers in the area dry bean prices and markets.

CONTACT INFORMATION

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Photo 1. Dry bean planting in 2017 growing season. [In the picture, Dr. Jim Heitholt along with Dr. Sharma's graduate student Abhijit Rai, PREC research associate Andi Pierson and summer helper Bonnie Bates helping Dr. Sharma in planting.]

Photo 2. PREC crew and summer helper helping in 2016 planting.

Photo 3. Dr. Sharma's graduate student is helping Dr. Sharma in installing the neutron probe access tube in dry bean sprinkler irrigation field.

Photo 4. Leaf Area Index (LAI) measurement using Plant Canopy Analyzer LAI 2200.

Photo 5. Summer helper taking plant height.

Photo 6. Hand harvest at Powell, WY in 2016.

Photo7. Hail damage at Lingle in July 2016

HIGH TUNNEL CONSTRUCTION AND USE FOR SPECIALTY CROP FOOD PRODUCTION

PROJECT SUMMARY

The purpose of this project was to educate individuals on construction, maintenance and management of high tunnels for use in specialty crop production. At the end of the workshop they will have gained sufficient knowledge to be able to construct and manage their own projects. Fresh vegetable and fruit production in Wyoming is a challenge. Seasonal temperature fluctuations, wind, and hail can all negatively influence production specialty crop commodities. In addition to protection from the biotic factors listed above, high tunnels also offer season extension benefits. These benefits greatly increase the production and variety of specialty crops available to Wyoming producers in the local food distribution channel. Production of fresh, locally or regionally grown produce and fruit is being demanded by more of the population. The use of high tunnels allows local producers the opportunity to fill some of this demand for longer periods of time. They have also been popular with schools to augment Farm to School programs, non-profit organizations promoting local food production and local gardeners. Interest remains high in these types of structures, and grant funds were used to continue to expand the knowledge of high tunnel construction, management and specialty crop production in Wyoming. This project was a continuation of previously funded SCBCP. The Wyoming hoop house educational workshop program was initiated in 2009 via SCBCP funds. Since the beginning of the project, over 60 high tunnels have been constructed in Wyoming via educational workshops. The workshops have been conducted in nearly all counties of the state but demand for more workshops has continued to remain high. Rural schools are discovering the value of hoop houses as outdoor classrooms to teach horticultural to all grade levels, nonprofits are using them to produce fresh produce and as an educational tool and researchers have utilized them for experimentation on season extension. Most farmer market vendors have embraced them for season extension of weather sensitive specialty crops.

PROJECT APPROACH

Objective 1 Increase the knowledge of individuals on how to construct and maintain high tunnels.
Objective 2 Increase the knowledge of individuals on use of high tunnels.
Objective 3 Increase use and awareness of high tunnels for specialty crop production.

- Identified six possible locations and working partners. Including the Meeteetse Sr. Community Garden, Casper food for thought, Central Wyoming College, and the Thermopolis middle school.
- Provided communication outlining Expectations from the project and participants. A list of expectations has been developed that is shared with each local project leader. This list outlines what is expected of the project owner and the workshop participants and what they can expect from this project as a final output.
- Project owners are critical to the recruitment of workshop participants and the management of the hoop house when completed.
- Set project dates. Dates are selected for the workshop that are compatible with everyone's schedules – extra time is built in as a corrective measure to foul weather.
- Publicized events on UW Calendar and local information to project.
- Logistics - organize materials, supplies, and tools. For a 16' X 32' high tunnel we have an extensive supply list. For each project materials are ordered a head of time and delivered to the site prior to the project. Logistics for these materials can be challenging and must be available the day of the project.
- Local project leader cleared the site by calling 811, one week to project start date.
- Organized volunteers into a work crew and instructed them in the use of tools and how to build the project one piece at a time. Approximately 40% of the participants have never tackled such a project and we take the time for safety review and an overview of the tools we use for the construction of the project.

- Time to complete the project was dependent on the weather and number of volunteers. A 16' X 32' project will take between 9 and 12 hours to compete.
- Education is more than how to build the high tunnel. Maintenance, management and production are all discussed during the workshop.

Hoop house workshops were held at schools, local community gardens, county fairgrounds, Community Colleges and the Wind River Reservation Extension. Each year far more workshops are requested than time available. Although the workshops can be done in a day to a day and a half, the planning, travel and material acquisition consume a week's worth of project manager time. The Wyoming Farmers Marketing Association, Lander Conservation District and the Wyoming Department of Education were significant partners in the project. They provided contact information, help organizing volunteers on projects and food for the volunteers.

GOALS AND OUTCOMES ACHIEVED

Goal: To educate individuals on construction, maintenance and management of high tunnels for use in specialty crop production.

Target: 90 growers will gain knowledge about science-based (high tunnel construction, maintenance and production) through the workshop outreach and education program.

Performance measures: Individuals who complete the workshop will be surveyed for pre and post knowledge on high tunnel construction, maintenance and production. Organizations who utilize high tunnels constructed during the workshops will be surveyed for number of individuals and ways they have benefited from their use.

Follow up surveys of participant revealed that only one participant has built their own – however, multiple individuals have participated in multiple workshops – we are finding that individuals may miss a portion or a step and feel the need to refresh and are still somewhat intimidated by a portion or just are not comfortable building one their own. Individuals who participate in the construction of these projects for a school or non-profit have different goals than self-serving and they attend the workshop to help the school or non-profit benefit – their interests do not appear to be to build their own.

Six workshops were conducted with 83 individuals participating. A total of 2,336 square feet were built. The project owners at each of these locations report that the high tunnels are being used to produce specialty crops used for food to support the children and adults in these communities and at these locations.

Date	Location	Style Size	Count	Sq ft
Jul-16	Meeteetse	Traditional hoop 16 X 32 (Senior Community Garden)	8	512
Aug-16	Casper	Traditional hoop 16 X 32 (Food for Thought) Non Profit Garden	13	512
Dec-	Cheyenne	Traditional Hoop 12 X	10	144

16		12 Farm to Market Conference		
April 15	Laramie	Laramie Rivers Conservation Expo 12x12	6	144
May-17	Lander	Traditional Hoop 16 X 32 (Central Wyoming College Sinks Canyon field Station)	10	512
Jun-17	Thermopolis	Traditional Hoop 16 X 32 (Middle School)	36	512
			83	2,336

Respondents to surveys from individuals involved in the workshops had an aggregated increase in knowledge of 43%. Some volunteers had never picked up a power driver or drill while others had prior construction knowledge that helped translated into aspects of building hoop houses.

BENEFICIARIES

83 individuals directly benefited as volunteers in one or multiple high tunnel educational workshops in this funding cycle. They gained an understanding of the construction, management and use for specialty crop production. Multiple individuals are benefiting directly as recipients of instruction on how to produce specialty crops and the recipients of food items produced from these structures. As these high tunnels were built for the use of non-profits or schools additional beneficiaries will include students and other community gardeners. The workshop at the Laramie Rivers Conservation Expo indirectly impacted an additional 540 plus individuals attending the expo as the hoop house was constructed in the exhibit hall next to the exhibitors. Also impacted were 109 students in Meeteetse and 228 Students at Thermopolis Elementary who will use the structures as outdoor horticultural classrooms as well as the over 400 children served by Casper Food for Thought.

LESSONS LEARNED

In the original grant application we projected that a 16'X32' project would cost approximately $1,900. We have made some changes to the structure to lessen the maintenance required for production which increased the cost of each high tunnel. The final cost of a 16' X 32' structure costs approximately $2,900.
Building their own high tunnel often times is not the primary goal of individuals assisting with a workshop for a non-profit organization. Several individuals chose to participate in multiple projects with us around the state. Their goal was not build their own, but to contribute their time to one or more community service projects. When the projects they have completed are for a non-profit they may or may not get to use and benefit from the completed project – without building their own.

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REGIONAL ASSESSMENT OF FENUGREEK FOR PRODUCER PROPAGATION

PROJECT SUMMARY

Fenugreek (*Trigonella foenum-graecum* L.) is a valuable specialty crop in the family of *Fabaceae*. Studies have shown that consumption of fenugreek can decrease cholesterol levels in liver and blood plasma and reduce blood sugar levels--thus decreasing diabetes incidence. It has also been reported to be a good breast milk stimulator. There was not any information available until 2010 on fenugreek in Wyoming or the surrounding states. Through a previous Specialty Crop Grant from the Wyoming Department of Agriculture, production and management strategies of fenugreek were researched. Selection of well-adapted, high yielding fenugreek cultivars/genotypes with high herbal, medicinal, and spice value would provide information bank of the west in development of fenugreek cultivar(s) that would be specifically suitable for the environments of Wyoming and neighboring states and benefit specialty crop producers. The goal of this project was to evaluate five promising cultivars/genotypes of fenugreek in varying Wyoming environments for the phenotypic adaptability and stability for growth, biomass production, and seed yield. Seeds of these cultivars/genotypes of fenugreek were planted in replicated experiments at two locations (Lingle and Laramie) of the University of Wyoming Research and Extension facilities under irrigation. Data on growth, biomass, and seed yield were collected and evaluated. Data showed differences in growth, biomass, and seed production among locations and years. However, there was little to no differences among cultivars/genotypes for growth and yield. All entries performed well at both locations and years. The highest growth and yield were obtained in 2017. Overall, the project generated important information on production and agronomic management of fenugreek which will be useful for the producers in Wyoming and perhaps, in neighboring states. The proposal was developed based on local producers' interest generated by the first project. It was timely as the sale of local food produce in the United States is expected to increase by approximately 50% over the next several years. .

PROJECT APPROACH

Five fenugreek cultivars/genotypes (Tristar, F96, LRC3375, LRC3708, and F75) were planted at two locations: James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle and Laramie Research and Extension Center in Laramie in spring of 2015, 2016, and 2017. Plot management, especially weed management, was done throughout the growing seasons either by hand weeding or by applying herbicide at early growth stage. Data recording included growth and biomass production. Biomass production was estimated by harvesting plants. Whole plots were harvested for seed yield determination in late of the growing season, either in October or November each year. Seeds were cleaned with a thresher and cleaner followed by hand cleaning. Soil samples were collected before planting and after seed harvesting.

Table 1. Emergence, plant coverage and plant height of fenugreek entries at Laramie Research and Extension Center (LREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2015 and 2016 growing seasons.

Entries	Emergence[†] (%)				Plant coverage (%)				Plant height (cm)			
	2015		2016		2015		2016		2015		2016	
	LREC	SAREC	LREC	SAREC	LREC	SAREC	LREC	SAREC	LREC	SAREC	LREC	SAREC
Tristar	77 a[‡]	80 a	78 a	46 a	27 ab	58 a	74 a	17 ab	26 a	36 a	31 a	32 a
F96	75 a	81 a	79 a	47 a	37 a	60 a	71 a	26 a	24 a	35 a	34 a	32 a
LRC3375	76 a	81 a	80 a	48 a	17 b	53 a	68 a	21 a	22 a	36 a	30 a	33 a
LRC370	76 a	81 a	81 a	44 a	22 b	58 a	68 a	22 a	23 a	35 a	29 a	33 a

F75	79 a	81 a	80 a	47 a	27 ab	54 a	67 a	10 b	23 a	33 a	30 a	30 a
Mean	**77**	**80**	**80**	**46**	**26**	**56**	**69**	**19**	**24**	**35**	**30**	**32**

†Emergence was recorded on 2 July and 3 July, respectively at Laramie and Lingle in 2015. Similarly, emergence was recorded on 24 June and 6 July in 2016 at Lingle and Laramie, respectively.
‡Values followed by different lowercase letters within a column differ significantly.

Table 2. Dry matter yield of fenugreek entries at Laramie Research and Extension Center (LREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2015 and 2016 growing seasons.

	Dry matter yield (kg ha^{-1})			
	2015		**2016**	
Entries	**LREC**	**SAREC**	**LREC**	**SAREC**
Tristar	1404 a	3778 a	3476 a	1005 a
F96	1396 a	3013 a	2702 a	1087 a
LRC3375	809 a	2827 a	2702 a	887 a
LRC3708	1244 a	3369 a	2293 a	1153 a
F75	1067 a	2587 a	2284 a	730 a
Mean	**1184**	**3115**	**2692**	**974**

†Values followed by same lowercase letters within a column do not differ significantly.

Table 3. Seed yield and 1000-seed weight of fenugreek entries at Laramie Research and Extension Center (LREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2015 and 2016 growing seasons.

	Seed yield (kg ha^{-1})				**1000-seed weight (g)**			
Entries	**2015**		**2016**		**2015**		**2016**	
	LREC	**SAREC**	**LREC**	**SAREC**	**LREC**	**SAREC**	**LREC**	**SAREC**
Tristar	152 a†	1391 a	384 a	304 a	15 a	15 a	19 a	16 a
F96	212 a	1588 a	458 a	298 a	16 a	16 a	20 a	19 a
LRC3375	64 a	1738 a	490 a	254 a	15 a	17 a	19 a	16 a
LRC3708	142 a	1535 a	309 a	234 a	15 a	16 a	19 a	16 a
F75	119 a	1388 a	444 a	183 a	15 a	16 a	18 a	15 a
Mean	**135**	**1530**	**417**	**254**	**15**	**16**	**19**	**16**

†Values followed by same lowercase letters within a column do not differ significantly.

Table 4. Growth and dry matter yield of fenugreek entries at James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2017 growing season.

Entries	**Plant coverage (%)**	**Plant height (cm)**	**Number of branches (number plant^{-1})**	**Dry matter yield (kg ha^{-1})**
Tristar	88.3	53.1	5	7711
F96	89.4	52.7	5	8799
LRC3375	90.0	60.3	5	8346
LRC3708	91.1	55.1	5	8528
F75	88.9	48.7	5	8709
Mean	**89.6**	**54**	**5**	**8437**
P-value	0.89	0.02	0.34	544

LSD (0.05)	5.80	6.40	0.80	1542

GOALS AND OUTCOMES ACHIEVED

GOAL: The major goal of this proposal was to evaluate five promising genotypes/accessions of fenugreek in varying Wyoming environments for the phenotypic adaptability and stability for growth, yield, and quality.
PERFORMANCE MEASURE: The intension of this project was to measure vegetative production and seed propagation potential. Growth and yield (vegetative and seed) will be measured at two UW research and extension centers and one producer's field and compared.
BENCHMARK: The fenugreek crops have been shown to grow to their full potential in Wyoming environments.
TARGET: Selection from the five well-adapted high performing fenugreek genotypes/accessions provided results for development of cultivar(s) that are specifically suitable for Wyoming and neighboring states. Site-specific best production, management, and propagation options for the cultivars were generated.
Performance Measure - The findings will be presented to conferences/producer meetings and participants will be surveyed on level of knowledge before and after the presentations to measure increased knowledge.

Outcomes

Emergence was higher than 70% at both locations in 2015 and 2016 except for Lingle in 2016, where the emergence ranged from 33 to 53% (Table 1). In general, in 2015, Lingle plots had higher emergence than Laramie plots ($P < 0.05$). In 2016, Laramie plots had higher emergence than Lingle plots ($P < 0.05$). This was probably due to the varied weather conditions between the locations.

In 2015, Lingle plots had higher coverage than Laramie plots ($P < 0.05$), whereas in 2016, Laramie plots had higher coverage than Lingle plots ($P < 0.05$) which reflected the emergence effect on plant growth. In 2016, fenugreek entries F96, LRC3378, and LRC3708 had higher coverage compared to other two entries (Table 2). There was no difference in plant height in fenugreek entries in both years at both locations (Table 2).

Dry matter production was different among years and locations. In 2015, Lingle had higher dry matter production compared to Laramie ($P < 0.05$) whereas opposite occurred in 2016. There was no difference in dry matter production among different fenugreek entries in both years at both locations (Table 2).

Seed yield of fenugreek varied significantly at both locations in both years ($P < 0.05$). In 2015, Lingle plots had higher seed yield than Laramie plots, however, in 2016, Laramie plots had higher yield than Lingle plots, reflecting the same pattern of dry matter yield. However, there was no difference among fenugreek entries for seed yield at both locations in both years (Table 3). All fenugreek entries produced the same size seed with a range of 15-20 g of 1000-seed weight (Table 3). This is a necessary component of the research as healthy seed development rates are needed to expand opportunities for fenugreek propagation for salad green production in Wyoming.

Better weather conditions favored growth and yield of fenugreek in 2017. Similar but much higher values were obtained in 2017 for growth and dry matter (Table 4). It is expected to obtain similar but higher seed yield in 2017 (seeds are being processed).

The results of the study were demonstrated at the Lingle and Laramie AES field days in each year. It is anticipated that the results will be disseminated more through these attendees to their neighbors and other producers, especially specialty crop growers.

The study results were demonstrated at the Lingle and Laramie AES field days every year during the study period. The results were published in the field day bulletin of AES. Three poster presentations were made at the field days of AES in Laramie and Lingle. Additionally, the PI gave two concurrent invited presentations on fenugreek results at the Master Gardener/Farmers Market State Conference which was organized by Wyoming Master Gardener Association and Wyoming Farmers Market Association and held on March 31-April 2, 2016 in Riverton with 69 attendees. This was a unique opportunity for the PI to disseminate results obtained in this study directly to Master Gardeners and producers who are specifically interested in Specialty Crop Production and Management. Several requests for fenugreek seeds were received during the presentations. Limited amount of seeds were distributed to the producers for their experiments. More than 100 people attended in the field and plot demonstrations at both locations in 2017. Compared to earlier years (2015 and 2016) increase of knowledge averaged around 75% when surveyed in the last field day on fenugreek production. Many people had visited for the second and third time. When asked "How many of you know about fenugreek and how to grow it?" More than 90% people answered that they knew fenugreek and they were interested to know more about production methods, agronomic practices, seed harvesting, and best management options. Three producers are presently trying to produce fenugreek in Wyoming.

Planting of fenugreek at Lingle (May 20, 2016)

Fenugreek plots at Lingle before hail damage (July 1, 2016)

Fenugreek plots at Lingle after hail damage (August 1, 2016)

Growth data collection and biomass harvest at Laramie (August 31, 2016)

Fenugreek plots at Lingle in 2017; uniform and better growth compared to growth in 2015 and 2016.

BENEFICIARIES

The benefits and beneficiaries of the project are large. The results of the study benefit producers, extension educators, stakeholders, students, master gardeners, researchers, and especially specialty crop producers. Outcomes of the study were demonstrated at the AES field days, specialty crop workshops, Master Gardener/Farmers Market State Conference, scientific meetings (locally and nationally), regional professional and international meetings, and finally at the classroom teaching at the University of Wyoming. More than 250 growers/producers from three field days came into close contact with the fenugreek project and improved their current knowledge on fenugreek and its production systems. At the beginning of the project, producers had little or no knowledge about how to grow fenugreek because they were not familiar working with this crop. Many emails and phone calls were received requesting fenugreek seeds and management options after workshops, conferences, and meetings. Several producers requested and received seeds from the PI and planted fenugreek in their local production systems. These interested growers are beneficiaries of this study. In addition, results from this study benefited 69 Master Gardeners and Farmers market growers statewide. The results of the study will continue to be distributed via future events such as during specialty crop seminars/workshops and Master Gardener/Farmers Market State Conference. Overall, the project provided valuable trainings and demonstrations that benefit farmers/producers and extension educators for production and management of fenugreek. It is anticipated that the information generated in this project will continue to be useful for producers in Wyoming, and perhaps in neighboring states, especially who are interested in growing specialty crops.

LESSONS LEARNED

The results of the study demonstrated no to minimal differences in emergence, growth, dry matter yield, and seed yield among fenugreek entries selected and used in this study. However, large differences were observed among all measured parameters between locations and years. All entries performed well and demonstrated their ability to grow in Wyoming conditions. Among three years (2015-2017), 2017 was the best in terms of growth and productivity indicating that in a good year, fenugreek has the potential to produce more growth and yield compared to a normal or harsh year. Overall, the project generated important information on production and agronomic management of fenugreek which will be useful for producers in Wyoming and perhaps, in neighboring states.

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WYOMING POLLINATOR EDUCATION PROGRAM

PROJECT SUMMARY

The purpose of this project was to educate producers and the general public about Wyoming's pollinators, encourages the practice of planting food plots for pollinators, be able to make specific recommendations for doing so, and document pollinators in Wyoming. Native and European pollinators can be threatened by a variety of abiotic and biotic factors. For the European honey bee, colony establishment, maintenance, and honey production are increasing in interest and popularity as the media exploits the multitude of factors contributing to colony collapse disorder (CCD). Honey bees are a business opportunity for Wyoming producers and are always an educational opportunity for the general public. Recent surveys of pollinators were lacking in Wyoming. The local seed suppliers had available "pollinator" mixes that were planted and surveyed for establishment and pollinator species.

The specific objectives of this project included:

1. Select, Plant, and Evaluate commercially available pollinator seed mixes annually for viability and attractiveness to pollinators for three consecutive years.
2. Annually survey and document pollinators at test plot locations for two consecutive years.
3. Provide four educational opportunities annually for three consecutive years to the producers and general public concerning pollinators in Wyoming. Those being the Bee College and one at each of the established pollinator plot locations.

This project was not built on a previously funded specialty crop work.

PROJECT APPROACH

1. Select, Plant, and Evaluate commercially available pollinator seed mixes annually for viability and attractiveness to pollinators for three consecutive years.

A commercially available pollinator seed mix (Table 1.) was selected and approved (by Mike Moore Wyoming Seed Lab) as to not contain any invasive species. Also selected were New Zealand White Clover, & a Wyoming developed Sainfoin var. 'Delany'. A plot was designed and planted as individual treatments and in combination with each other. Locations around the state were selected based on their willingness to participate and included:

a. Powell (elevation 4,393) – all treatments established year one, plant and pollinator data collected year two and year three.

b. Laramie (elevation 7,220) – evaluation of planting date timing as it relates to plant establishment. Two planting times: fall of year one and spring of year two. Summary included.

c. Ft. Washakie (elevation 5,571) – planted and established year one, replanted year two and replanted year three. Educational programs included basic bee keeping and the use of a Flow Hive™. No plot data collected.

d. Lingle (elevation 4,173) – small demonstration plots (4 ft X 8 ft) established within raised beds of high tunnel, one each of Sainfoin, New Zealand White Clover and wild flower mix; neither the irrigated or dryland field plots established. Viability and attractiveness (to pollinators) observations recorded and demonstrated.

e. Evanston (elevation 6,749) – plots did not establish in either year one or year two – site abandoned.

SHARP'S WESTERN WILDFLOWER MIX

Lot: WSMX0 15

Mixture/Variety	PURE %	GERM %
PERENNIAL LUPINE	15.49	84
PERENNIAL GAILLARDIA	13.58	84
CALIFORNIA POPPY	11.64	93
ANNUAL CANDYTUFT	11.64	80
BLUE FLAX	07.76	94
CORN POPPY	07.76	85
DWARF BLUE CORNFLOWER	03.88	87
POLKA DOT MIX CORNFLOWER	03.88	91
ANNUAL GAILLARDIA	03.88	85
ROCKY MTN PENSTEMON	03.88	87
GREEN THREAD	03.88	88
CLARKIA	01.94	82
GLOBE GILIA	01.94	85
DWARF EVENING PRIMROSE	01.94	86
PALMER PENSTEMON	01.94	91
PRAIRIE CONEFLOWER	01.94	87
SHOWY GOLDENEYE	01.28	89
DEERHORN CLARKIA	00.97	88
PLAINS COREOPSIS	00.78	84

Crop: 0.03 % Inert: 1.03 % Weeds: 0.02 % Net Wt: 6.0#

Noxious Weeds: NONE FOUND Tested: JAN 2015

Sharp Bros. Seed Co.

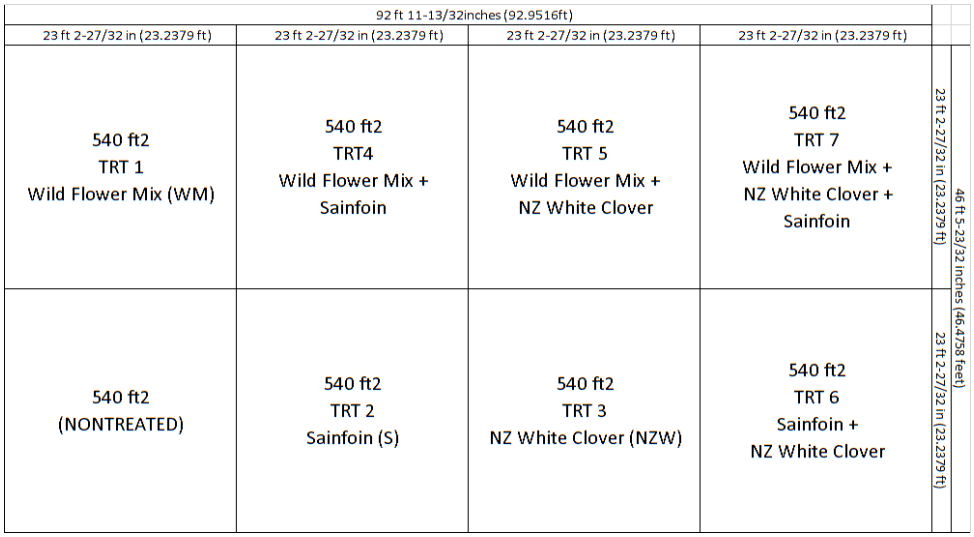
Not the Biggest……..Simly the Best

101 EAST 4TH STREET GREELEY, CO 80631

970.356.4710

2. Annually survey and document pollinators at test plot locations for two consecutive years.

Data collected consisted of three random observations (replicates) within the boundaries of a ¼ meter subsample of treatments 1, 3 and 5 (Table 2.) Replicates consisted of 5 minute observations each while noting the total number of blooms present and pollinators visiting within the ¼ meter sample during the 5 minute interval. Plots containing Sainfoin were determined to be too difficult to evaluate reliably due to the aggressive growth habit of the plants.



3. **Provide four educational opportunities annually for three consecutive years to the producers and general public concerning pollinators in Wyoming. Those being the Wyoming Bee College and one at each of the established pollinator plot locations.**

Educational Opportunity provided			
Location	**2015**	**2016**	**2017**
Wyoming Bee College	Yes	Yes	Yes
Powell	No	Yes – Field Day	Yes – Field Day
Lingle	Yes – Field Day	Yes – Field Day	Yes – Field Day
Laramie	No	Yes – Field Day	Yes – Field Day
Ft. Washakie	No	Yes	Yes

Participant data collected from the Wyoming bee college.

GOALS AND OUTCOMES ACHIEVED

GOAL 1: Annually for three consecutive years document a 20% increase in perceived knowledge gained (PKG) by participants in the educational programs conducted at the **Wyoming Bee College**.

PERFORMANCE MEASURE: Survey of participants via the use of a modified (1-5) Likert scale at the conclusion of each session of the Bee College. The questions asked them to rate their level of knowledge for a particular topic both prior to and after the session. This method of survey allows the determination of the perceived knowledge gained (PKG).

BENCHMARK: The benchmark will be the Likert values collected of the perceived pre-session knowledge of the topic. This is a self-assessment value. The rating scale (1-5) was defined as: 1 = no prior knowledge; 2 = some prior knowledge; 3 = moderately knowledgeable in the subject; 4 = educated in the subject matter; 5 = expert in the subject matter.

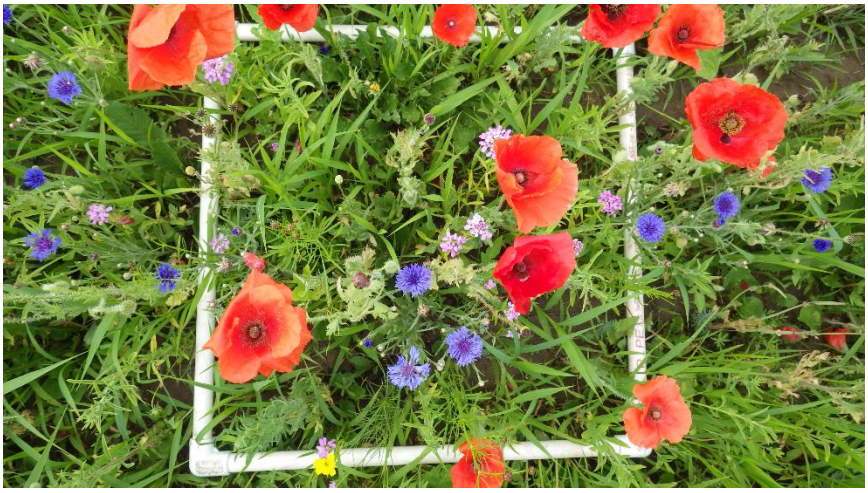
TARGET: We anticipated that there would be a 20% increase in perceived knowledge gained (PKG) at the conclusion of the bee college for each of the three years conducted.

Wyoming Bee College (year)	Participants	Educational Tracts	Total Overall Estimated Increase in Knowledge
2014 (pre-grant)	127	3	NA

2015	143	4	55%
2016	235	5	25%
2017	347	5	35%

We exceeded the 20% PKG target all three years of the program and increased participation nearly 3X (n=347) from the level of participants pre-grant in 2014 (n=127).

GOAL 2: Evaluate commercially available pollinator seed mixes annually for viability and attractiveness to pollinators for two consecutive years and gain an understanding of pollinators visiting plots.



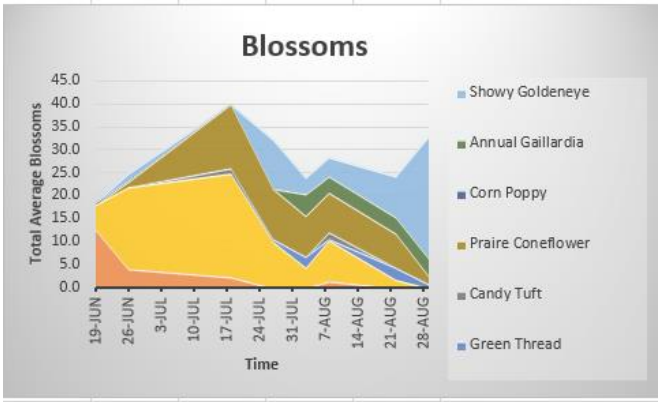
PERFORMANCE MEASURE: Select commercially available pollinator seed mixes, plant and monitor for establishment 2X per year for first and second years. Survey insect pollinators visiting plots 2X per year for second and third year. Identify insects to family.

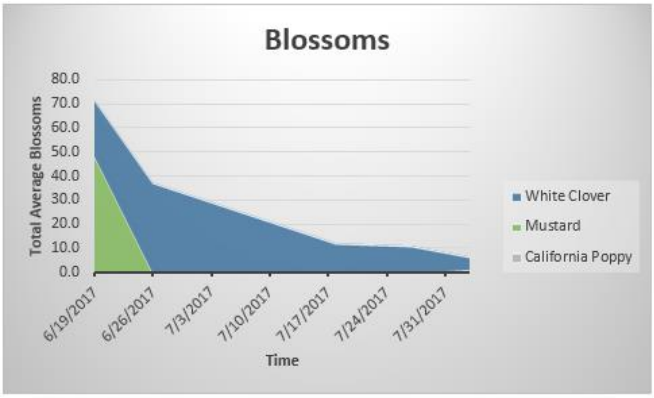
BENCHMARK: No benchmark data available at this time.

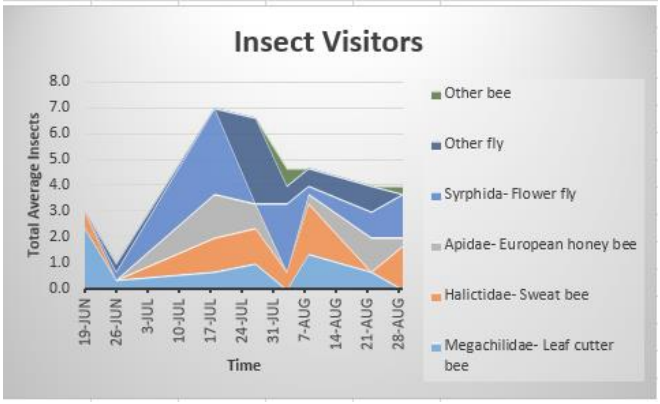
TARGET: We anticipated that 80% of plants contained in commercially available seed mixes would become established at 50% of the trial locations (two trial locations will establish total).

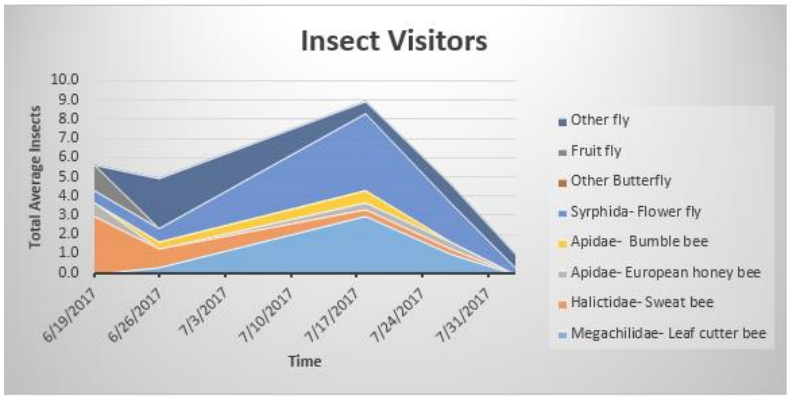
Plot establishment was difficult and highly variable – the commercially available seed mix when planted in raised beds in the controlled environment of a high tunnel (Lingle, WY) performed quite well and the majority of the plants in the mix established (80%) however, all dryland locations failed and only the two locations was the commercial mix considered "established" (Powell and Laramie). Powell showed only a 30% establishment rate (6 out of 19 varieties – listed on the contents) in the variety of the seed mix and appeared to decline with time.

Wildflower mix data. Total average number of blossoms and total average number of insects visiting ¼ meter subsample within plot for 5 minutes per observation event. Each ¼ subsample was replicated 3 times.









New Zealand white clover data. Total average number of blossoms and total average number of insects visiting ¼ meter subsample within plot for 5 minutes. Per observation event. Each ¼ meter subsample was replicated 3 times.

Summary observation for all data collected: As the season progresses the total number and variety of blossoms increases as does the number and variety of pollinators visiting the plot. Interesting to note that bumblebees were only observed in the white clover plot. Data between observation years 2016 and 2017 very similar. **Bottom line:** if there are blossoms available pollinators will show up. A variety of blossoms throughout the season will result in greater variety of pollinators present for a longer period of time.

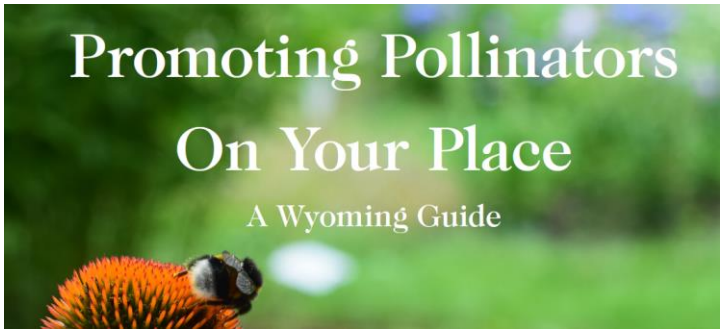
Other related outputs:

We anticipate that the data will be published in University of Wyoming Publication Barnyards and Backyards published on wyomingextension.org website and submitted for publication in the Journal of Extension.

BENEFICIARIES

The collaborators on this project contributed content to the above guide. This was part of another effort but happened at the same time we were looking at this project. 4,000 print copies of UW publication B-1305. Promoting Pollinators on your place a Wyoming Guide. Schell, S., J. Thompson, J. Edwards, J. Downey & J. Russell. 2017. Electronic access scheduled for 11/1/2017.

Attendees of the field days (250) and the Wyoming bee colleges (725) that included producers, master gardeners, back yard gardeners and other individuals who receive and utilize UW publication B-1305. 2017. Promoting Pollinators on your place a Wyoming Guide. Schell, S., J. Thompson, J. Edwards, J. Downey & J. Russell. Wyoming bee keepers and Wyoming pollinators. Post 2015 Bee College: 60 individuals gathered to start Southeast Wyoming Beekeepers club). 20 participants from Cheyenne attended an additional workshop to learn how to construct their own hives.



LESSONS LEARNED

Wyoming Bee College

Attendees left with the understanding that the number one problem facing all our pollinators is lack of flowers or flora resources. A situation that can be resolved in one or two growing season by planting flowers, flowering shrubs and trees, gardening for pollinators. Beekeepers left better prepared to take, seriously, an animal husbandry approach to beekeeping, to take a long-term, multiyear, year-round mindset to habitat development, parasite, disease mitigation, bee nutrition, over wintering and continuing education. They left understanding that beekeeping is no longer a casual hobby.

Laramie Plant establishment

Fall seeding had better establishment for both commercial and native wildflowers. The total number of weeds for each plot regardless of commercial or Wyoming native status is almost the same (Native plots 15.3 weeds/.25m^2, SD=4.07 and commercial 15.0 weeds/.25m^2, SD=4.07). The total number of commercial wildflowers (6.38 flowers/.25m^2, SD=4.87) established is greater than native wildflowers (1.1 flowers/.25m^2 SD=.99) established.

Lingle and Powell pollinator data collection:

Gained understanding the various kinds of pollinators present in WY, and the activity levels of pollinators as it relates to the weather and the availability of blossoms. Commercial pollinator plant mixes & New Zealand White Clover provide a nectar source all season long, whereas Sainfoin flowers are available mid to late season. When flowers are present pollinators will also be present. Sainfoin once established is much tolerant to severe drought than either commercially available seed mixes or New Zealand white clover.

Ft. Washakie demonstration and utility of Flow Hive™:

The Wind River Indian Reservation Extension office piloted a Flow Hive™ as a demonstration hive for the community. Bees were placed in the hive in April of 2016 and the hive was harvested for the first time in the summer of 2017. A total of 2.5 gallons of honey was produced.

CONTACT INFORMATION

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WFMA/BFBL SPECIALTY CROP SCHOLARSHIPS, WORKSHOPS, CHEF DEMOS AND ANNUAL CONFERENCE

PROJECT SUMMARY

This project addressed increase in consumer demand for local specialty crop foods in an area where growing these crops can be difficult. Providing education on specialty crop production, season extension and marketing provide producers, vendors and consumers with accurate information and resources on how to knowledgeably produce and procure specialty crops safely and effectively. The Farmers' Marketing Conference targeted producers but its reach and benefits go far beyond to consumers and communities. With more diverse specialty crop availability, the consumers enjoy more local food opportunities and positive experience at the Farmers Market. Over the past eight years, the number of farmers markets in Wyoming has increased from 12 markets to 50+. Training sessions at past workshops and conferences covered areas such as high tunnel construction and production, local marketing, production methods and food safety in addition to many more. Through the annual conferences and educational workshops, producers continued to have access to education on specialty crop production, marketing, food safety and food preservation presented by knowledgeable experts. Additionally, Wyoming producers have greater access to BFBL resources for marketing their Wyoming Grown or value added specialty crop products. Any expenses that are not related to specialty crops will be tracked and paid for from non specialty crop funds.

This project was built on a previous work designed to increase the knowledge of farmers' market managers and vendors by providing expert speakers on topics relative to specialty crop education, production, and consumption. The Farmers Marketing Association recruited expert speakers on specialty crop related topics to speak at the annual conference and workshops. This project continued to provide information to producers on specialty crop production, marketing, and food safety. Most producers in Wyoming are small and this created significant financial burdens to producers from other parts of the State to attend the annual Farmers Marketing Conference. The goal of the project was to increase the knowledge of Wyoming producers on Specialty Crop production and marketing by providing producer scholarships and expert speakers on topics specific to specialty crop education, production, and consumption. The Farmers Marketing Association presented expert speakers on specialty crop related topics at the annual conference and workshops. Secondly, WFMA's "Buy Fresh Buy Local program" increased specialty crop awareness efforts for the through specialty crop cooking demos at local markets. This project built on a previous specialty crop project that

PROJECT APPROACH

The project had three objectives:

Provide education for Farmers' Market Managers on selling and promoting specialty crops products at the farmers markets in Wyoming.

Provide information to consumers and producers on production, season extension methods and marketing/promotion specific to specialty crops in Wyoming.

Increase marketing/promotion efforts on specialty crops in Wyoming utilizing events sponsored by Wyoming Buy Fresh Buy Local chapter.

Project activities:

2015 Wyoming Farmers Marketing Association Annual conference

2016 Wyoming Farmers Marketing Association Annual conference

2017 Wyoming Farmer to Market Workshops and Annual meeting

2015-2017 10 Specialty Crop chef Demonstrations

2017-2017 Three specialty crop workshop/trainings

Educational workshops were specific to specialty crop topics on production, marketing and education. For the Chef Demo program specialty crop funds were only used to fund expenses related to specialty crops. A previous project was completed utilizing specialty crops funds for the promotion and education of specialty crop development in Wyoming.

Previous activities included education and training on acidified food processing of specialty crop foods and scholarship monies to aid Wyoming producers in attending trainings, workshops and conferences

The following activities the projects were supported by the Wyoming Department of Ag, individual county farmers markets, Wyoming Department of Education, University of Wyoming Cooperative Extension, Wyoming Business Council and our specialty crop producers in the state.

Conferences

- 2015 Wyoming Farmers Marketing Association Annual Conference
- 2016 Joint Wyoming Farmers Marketing Association and WY Master Gardeners Annual Conference, Riverton, WY March 31-April 2, 2016, which included multiple speakers on the topic of specialty crops.
- The 2017 Farm to Market Conference was a collaborate effort between the WFMA, UWYO Extension and the WDA. Workshops on Acidified Foods, Fermented Food, Heritage apple Orchard Management, and hoop house building were held.
- The Laramie Higher Ground Fair received a sponsorship for the travel expenses of Specialty Crop speakers

Workshops

- 2015 Good Agricultural Practices workshop and Market Managers Certification workshop as part of the Wyoming Farmers Marketing Association's annual conference.
- 2016 Acidified Food Workshop was held in November in Cheyenne
- 2017 The Veterans Garden project received funds to put on a workshop to build a 16x32 hoop house in Casper.
- 2017 The Wheatland Specialty Crop Workshop sponsored by the WFMA
- 2017 Farm to Market Conference. Acidified Food Certification Course, Fermented Foods Workshop.

Chef Demo's

- 2015 Chef Demo for Farm to School/Specialty Crop Regional Workshop- Sheridan, WY
- Chef Demo: February 11, 2016: Farm to School workshop with Jr. Master Gardener Training Gillette.
- Chef demo at Farm to School Conference February 23, 2016 in Rock Springs, WY
- 2016 Three Chef Demo's were held by the Fremont County Fresh Foods Group at the Riverton, WY farmers market. July 20, 2016, July 27, 2016, September 14,
- Four Chef Demo's were held by the Big Horn Basin Farmers Market between June-Oct 2016. These demonstrations focused on using unique specialty crop foods and fall vegetables.
- 2017 Chef demonstrations at Riverton and Gillette farmers markets

GOALS AND OUTCOMES ACHEIVED

Goal 1: Increase WY producers' knowledge on specialty crop marketing, production and preservation by providing scholarships and access to expert specialty crop related speakers at the Wyoming Farmers Marketing Annual Conference and specialty crop workshops.

Performance Measure: The number of producers attending the trainings will be tracked and evaluated as to new production and diversification.

Target: Host three specialty crop trainings and annual conferences 10/2014 to 8/2017 providing topic specific workshops for specialty crop producers to increase their knowledge or diversify their operations.

Goal 2: Increase consumer awareness of specialty crops through specialty crop chef demos.

Performance Measure: Public awareness of specialty crops will be tracked and evaluated.

Target: Host 10 chef specialty crop demo's at local markets.

Performance Monitoring:

Attendance was tracked. Additionally, surveys to gauge increase in knowledge and performance. Data was collected at the completion of each annual conference or training/workshop. Attendance records and evaluations were collected at this time. Market Managers will report the number of people who are exposed to chef demos and the specialty crops dishes sampled.

2015 Wyoming Farmers Marketing Association Annual Conference (52): The conference included GAP Training and Market Manager Training. Surveys indicated that average increase in knowledge was 37% and varied from 10 % to 70%.

Conferences

2016 Joint Wyoming Farmers Marketing Association and WY Master Gardeners Annual Conference, Riverton, WY (69 attendees, 9 scholarships), March 31-April 2, 2016, which included multiple speakers on the topic of specialty crops. Topics included bees, honey, how to be utilize season extension for growing specialty crops, grafting fruit trees and tomatoes, fenugreek, quinoa and berries (see program flyer include with report).

Thursday, March 31, 2016

2:00pm Registration Open

3:00pm - 5:00pm Hands On Workshops

Seed Saving — Mac Smith

Making Containers — Chris Hilgert

5:30pm - 9:00pm Welcome Reception

Welcome: Lars Baker - Mayor of Riverton

Wildflowers of WY: Jack States

Poetry: Echo Klaprath

50/50 Raffle: Drawing at Dinner Friday night. Proceeds go to WFMA/BFBL. $5.00/ticket (Contact: WFMA Board Members. Tickets available beginning Thursday. Winner drawn at Friday Banquet.)

Seed Swap: Bring your seeds to share and swap with other members. (Contact: Bob Prichal or Tina Russell for more information.)

Silent Auction: Friday Evening-All proceeds go to Master Gardeners. Be sure to bid on these great items donated by the Wyoming Master Gardeners. (Contact: Carol Morrison)

Friday, April 1, 2016

7:00am Registration Open

7:30am - 8:45am Breakfast/WFMA Annual Meeting

8:45am - 9:00am Welcome/Opening Remarks

Session One 9:15AM - 10:30AM

Track #1: Fenugreek/Quinoa — Anowar Islam

Track #2: Wood Plant Diseases — William Sheep

Track #3: Cover Crops — Caitlyn Tromquist

Track #4: Growing Great Vegetables — Catherine Wiener

Session Two 10:45AM - 12:00PM

Native Landscaping — Jenny Thomas/Mac Smith

Strawberries — Chris Hilgert

Poultry — Bree Loske

Pollinators — Catherine Wiener

Lunch 12:00PM - 1:00PM — Network and Visit Vendors

Session Three 1:00PM - 2:15PM

GMO/Heirloom/Hybrid — Mike Moore

How to Apply for SMAP/EBT — Zara Cobb USDA

Worms — Erika Rogers

High Yield/Hoop Houses — Catherine Wiener

Session Four 2:30PM - 3:45PM

Mushrooms — Steve Miller

Hops — Micah Humphreys

Bees — Michael Jordan?

Site Analysis/Landscape Design — Catherine Wiener

Session Five 4:00PM - 5:15PM

Specialty Crop Pros/Cons — Anowar Islam

GMO/Heirloom/Hybrid — Mike Moore

Marketing your Produce — Mark Sivor

Berry Basics — Jeff Edwards/LeRoy Jong

Saturday, April 2, 2016

7:30am - 8:45am Breakfast/MG Annual Meeting

9:00am - 10:15am Market Manager Discussion Panel

10:30am - 12:30pm Hands On Workshops

Grafting — Steve Miller

Soil — Jay Norton

12:00 - 1:00PM Box Lunch Complete Evaluations

Thank you! Have a safe trip home!

Hotel Information

Holiday Inn Convention Center

900 E. Sunset Dr.

Riverton, WY 82501

(307) 856-8100

Rooms: [illegible]

Block: Wyoming Farmers Market

Room Block Closes: March 5, 2016

Reservations made after this date will be a [illegible]

Cancellation Policy

Cancellations received in writing prior to March 15th, will receive a full refund. A $10 fee will be assessed for all cancellations after March 15, 2016

No Refunds for No Shows!

Wyoming Master Gardeners & Wyoming Farmers Marketing Assn. 2016 Joint Conference

March 31- April 2, 2016 — Riverton, WY

Registration

Name:

Organization:

Address:

City, State, Zip:

Phone:

Email:

Fees valid for Early Registration ONLY!

Thursday

Hands-On Workshop $ 40 ____

Conference (FRI&SAT) $100 ____

Friday Only $ 50 ____

Saturday Only $ 50 ____

WFMA/BFBL Membership $ 65 ____

Registration received after March 15th or at the door:

Hands-On Workshop (Thurs.) $ 75 ____

Conference (FRI&SAT) $150 ____

Friday Only $ 75 ____

Saturday Only $ 75 ____

Mail Registration and Payment to:

WFMA

PO Box 20939

Cheyenne, WY 82003

Register Online:

https://2016joinconference.eventbrite.com

Wyoming Farmers

master gardener

2017 Higher Ground Fair. Attendance at fair was 1944. Demonstrations on gardening, an app developed by students on where to find local produce and a how to build a cold frame planter box were part of the fair. Individuals also toured the hoop house at the community garden on the fair grounds.

The 2017 Farm to Market Conference was a collaborate effort between the WFMA, University of Wyoming Extension and the WDA. Workshops on Acidified Foods (19 attendees) Fermented Food (13 attendees), Heritage apple Orchard Management (attendees 18), and hoop house building (7) attendees) were held. Acidified Foods Certification had an average increase in knowledge of 74% Fermented Foods Workshop had an average increase in knowledge of 80%.

Workshops

- 2015 Good Agricultural Practices workshop as part of the Wyoming Farmers Marketing Association's annual conference. (36 people with an average increase in knowledge of 33%)

- November 2016 Acidified Food Workshop was held in Cheyenne on with 19 participants receiving their certificates which enable them to produce acidified foods to FDA standards. The workshop ensured that the participants who had increased their knowledge to the level that they are able to safely produce or supervise others on production of acidified foods and were awarded certificates.
- 2017 Wheatland specialty Crop Workshop was sponsored by the WFMA (20 day on 1 and 13 day 2) Average increase in knowledge on a 1 to 10 scale increased and average of 3.7 points.

- The Veterans Garden project received funds to put on a workshop to build a 16x32 hoop house in Casper. (13 volunteers) Increase in knowledge ranged from 10% to 90% with an average of 43%

Chef Demos

- Gillette Chef Demo: February 11, 2016: Farm to School workshop with Jr. Master Gardener Training. 36 educators were in attendance.
- An additional chef demonstration in conjunction with a Farm to School Conference was held on February 23 of 2016 in Rock Springs, WY. We were able to impact 54 teachers at the Ag in the Classroom Conference.
- Three Chef Demos were held by the Fremont County Fresh Foods Group at the Riverton, WY farmers market. July 20, 2016 (48 people), July 27, 2016 (39 people), September 14, 2016 (34 people). A demonstration using apples, homemade bread, mint, honey and pecans. The apples were purchased locally. The mint, honey, and pecans were all purchased at the Farmers Market. The apples were made into applesauce using a food processor and sweetened with honey. The pecans were ground into butter using a blender. The mint was added to half of the applesauce. Bread was toasted, and topped with the pecan butter and applesauce.
- Four Chef Demos were held by the Big Horn Basin Farmers Market between June-Oct 2016. These demonstrations focused on using unique specialty crop foods and fall vegetables.47individuals attended the chef demonstrations and workshops. Participants were willing to provide their contact information. Out of the Forty-seven people, an astonishing 47 out of 47 learned something new. What the participants learned was: Different ways to prepare specialty crops. New information about the nutritional values of specialty crops. Easier ways to peel and cut specialty crops.

- 3 Chef demonstrations at Riverton in 2017 Individuals who sat or stood through demo totaled 73
- 3 Chef Demos were held at the Gillette farmers market were in 2017. Total attendance at the markets was 2148. People who sat through chef demonstrations averaged 20 per demo.

BENEFICIARIES

525 direct beneficiaries included market managers, specialty crop producers, consumers, agricultural professionals, and value added specialty crop producers. The total number of individuals directly impacted at conferences was 159 producers, workshops 95 producers and chef demo's 371 consumers. Indirect consumer impact at events was reported to be 1944 at higher ground fair and 2148 at farmer markets. The farmer market number only represents Gillette market.

LESSONS LEARNED

Putting on conferences and workshops is not easy. The development of agendas \, securing space and recruiting speakers is time consuming. As the WFMA is a volunteer board it is doubly difficult with member's busy schedule. Having advisors who work for State Agencies and can devote time to being on the committees and some board members who are affiliated with the University and Community colleges has helped with the planning and implementation process.

CONTACT INFORMATION

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HOPS PRODUCTION EXPLORATION IN THE BIGHORN BASIN

PROJECT SUMMARY

With an increasing number of small craft breweries opening in Wyoming, the need for hops has increased. At the same time, crop producers are looking for crops that will increase diversity in their operations. In order to begin to address these two opportunities, this project served to establish a hops variety trial in the Bighorn Basin, publish variety yield data and methods of establishment, develop a workgroup of interested growers and brewers, and carry out a public workshop on hops. The project was successful in the development of the hops industry in our region, seeing two growers establish hop yards, and several breweries beginning to be open to using locally-sourced hops. Our variety trial successfully narrowed the best varieties for growing in our region, and this information is being used to help in the establishment of new hop yards. Our public hop growing seminar was attended by 72 participants, signaling a high level of interest in the community. This project did not build on a previously funded SCBGP work.

PROJECT APPROACH

This project had the following three outcomes

1. Established a hops variety trial at two locations in the Bighorn Basin region and publish complete data and methods of establishment, growth, and economics of hop yards
2. Established a workgroup of interested growers and brewers, and
3. Facilitated hops growing workshops for the public.

The initial impetus of the project was to establish baseline data and information for potential producers to begin producing this alternative crop to meet a specific need of locally-grown hops for our local and regional brewers. With the increasing market share of craft breweries, and the increased number of regional breweries coming online, the ability to distinguish themselves in product is key. From an agricultural production perspective, this allows the development of a new way for diversification or initial production of hops as a specialty crop.

The project was a new venture that had no precedent in our area. While anecdotal evidence suggested that hops could grow well in the region, no field-scale implementation existed. To determine the feasibility of hops production here, this project undertook the tasks of variety analysis, discovery of agronomic best-practices, sourcing of hop yard materials, exploration of post-harvest processing, and determination of possible sales outlets for brewing or medicinal use.

Regarding the original goal to provide information on foundational hops variety production data, production methods, and vital economic indicators for the Bighorn Basin region, we met this goal by means of performing the variety trials and all related set-up and then publishing those results on our project website, www.nwchops.org. This site houses all data, economic analyses, equipment lists, galleries of pictures, etc. describing both the project as a whole and each phase of the project. (See Figures 1-3 at the end of the report)
Regarding the project activities, while there were many activities listed, we would like to highlight several. First, we were able to hold a potential growers meeting near the beginning of the project and this was key to understanding the kinds of needs that producers in our area have. It was clear that there would need to be very basic agronomic information given out to any audience that came in contact with the project, but that the interest level was high. The first grower's workgroup meeting had 14 attendees. Second, our website was published early in the project, providing for a clear way to communicate with the interested public. As of this report, we have had 1,719 page views since publishing. We had several informal meetings with participants in the workgroup over the course of the project as well. Third, the harvest of the variety trials was very successful and happened in a timely manner each year. The first year, all the harvesting was done by hand in coordination with the student employee hired with the grant funds. The second year we were able to

obtain another grant for a hop harvester and that began to make harvest an easier process, but about half of the trial was harvested by hand and yields significantly increased. The third year, the majority of the variety trial was harvested with the hop harvester. We knew that harvest would be a very important time in the grant Work Plan and it was a priority for us. What we did not take into account in planning was the time involved in processing the hops by drying and then vacuum packaging each batch for cold storage. We have since created the necessary space and procedures for handling the hops post-harvest. Our trial indicated that Columbus, Centennial, Cascade, and Chinook are varieties that we will be recommending to growers in the region. Fourth, we had originally planned for two workshops to happen for the public to attend, but since our funding did not come in on time, we were not able to carry out the first year's workshop planned for March 2016. Instead, we focused on the 2017 workshop which happened in early April 2017. The workshop was very well attended by 72 people. These attendees included some of the initial workgroup members and many new interested parties. We were able to include a field visit with this event as well. Fifth, our initial plan was for two variety trials to be established, one at the NWC Ag Pavilion Field and another in collaboration with a grower outside of Powell. While both of the variety trials were established, the second variety trial had establishment problems during the 2016 growing season, which resulted in less regrowth and the need for an additional year of establishment during the 2017 season. While variety resilience was noted, we did not get harvests off of the second variety trial. We expect that this trial will be ready for harvest during the 2018 season.

The project made very significant progress in other ways as well. After creating the variety trials and beginning to spread our results through a variety of presentations besides the scheduled workshop, we began to have interest from growers on the larger production side (anything over 1/4 Acre would be considered large for our region). As of this report, we have one producer who has planted approximately 13,000 hop plants (about 15 Acres), and another who has 250 plants (just under ½ Acre). We have also been consulting with three other potential producers in the region who are considering installing hop yards. The interest in hops as a potential new crop in the area has been sustained over the three-year period. We have given presentations at the Wyoming Master Gardener's Meeting, Cody Rotary, Cody Library Speaker's Series, Ten Sleep Brewing Company Guest Speaker Series, the Wyoming High School Agriculture Instructor's summer conference, and Governor Mead's ENDOW research group. Another unforeseen outcome of the project was the discovery of a native variety of Hops from the Meeteetse, WY area, which has proven to be both vigorous in growth and useful in brewing – as noted by Big Lost Meadery producing a "Wyoming Pale Ale" with the native hops and our variety trial hops. We will be continuing to grow clones of this plant in the variety trial to evaluate the response to fertility and sufficient water. During the grant period we were also approached by the University of Wyoming Engineering program to provide details of hop harvesting for their engineering student final project. The students worked on a proposal to design a portable hop drier and processor.

While no funds were expended related to the brewing process, we did pursue the possibility of larger breweries using the whole cone dried hops in their brewing processes, as a way to give feedback to producers on how to handle the hops and how they can be used. We have sent hops from the variety trials to WYOld West Brewery, Millstone Brewery, Gillette Brewing Company, and Big Lost Meadery. So far, WYOld and Big Lost have both used our hops in the brewing process.

Project partner University of Wyoming Powell Research and Extension Center was able to contribute to the project in the initial field work/tillage for NWC Variety Trial #1, attended both the workgroup meeting and the workshop meetings, and continues to spread our results to the agricultural community. The Powell Economic Partnership (PEP) was a key part of inviting us to speak to Governor Mead's ENDOW research group, and also brought us before the Cody Economic Partnership. PEP continues to champion and represent the work that we are doing to increase the awareness of hops as a specialty crop at PEP meetings, and with the broader agricultural community. Finally, the NWC Greenhouse Assistant

partnered in field work for the project and greenhouse assistance related to cultivation of hops plants for replanting of varieties that had for some reason not made it through the winter in a given season.

GOALS AND OUTCOMES ACHIEVED

Related to the original goals set forth in the proposal, below are outcomes achieved related to those goals

1) Provide foundational hops variety production data, production methods, and vital economic indicators for the Bighorn Basin Region
    a. Three years of hop variety yield information posted at www.nwchops.org
    b. Production methods detailed at www.nwchops.org, at six presentations (105 contacts), and at the April 2017 public growing workshop (72 contacts)
    c. Economic evaluation of growing hops in the Bighorn Basin carried out by students in AGRI 2395 Agriculture – a 31 page document based on a 20 Acre hop production farm in the region. This detailed normal costs for establishment and operation of a hop yard in the Wyoming economy. Published at www.nwchops.org and a presentation on the material given at the April 2017 public growing workshop
    d. Hosted a total of 62 field visits to the variety trial
    e. Website statistics: 659 unique visitors; 900 visits; 1,719 page views; 62% direct access, 16% search queries, 14% social media links, 8% referrals
2) Establishment of a Hops Grower and Brewer Workgroup to facilitate sharing of information on results and networking
    a. 33 contacts interested in the project as growers or brewers, all in Wyoming, the majority from the region
    b. 15.5 acre increase in hops in the Bighorn Basin
    c. Two breweries actively using hops grown from the variety trial with two additional breweries given samples for use and feedback
3) Facilitate and host hops growing workshops to disseminate information
    a. April 2017 workshop attended by 72 participants included several talks on hop morphology and history, hop agronomy, economics of a hop yard, and variety trial results. We also hosted a brewer's roundtable with two local breweries represented. Field tour of variety trial included in the event. (See schedule and promotional material Figures 4 & 5)
    b. Feedback from the event (n=24):
        i. "How satisfied were you with the conference? 5 is very satisfied, 1 is not satisfied."
            1. 87.5% at a 5 rating, 12.5% at a 4 rating
        ii. "Do you feel that the conference was a learning experience?"
            1. 100% yes, 0% no
        iii. "If you are currently growing hops, how many plants do you have?"
            1. 18 respondents "I do not currently grow hops", 5 respondents "1-10 plants", 1 respondent "more than 100"
        iv. "Did your interest level in hops increase as a result of the conference?"
            1. 87.5% yes, 12.5% no
        v. "Would you be interested in another meeting like this, perhaps next year?"
            1. 75% yes, 25% no
        vi. "Were you satisfied with the facility and staff at the event?"
            1. 100% yes, 0% no
        vii. "Was the even length too long, too short, or just right?"
            1. 87.5% just right, 8.3% too short, 4.2% too long
        viii. Is there anything else you'd like to share about the event?

1. “Give out a hop cutting to everyone who wants one. More discussion about possible markets. Two brewers at approximately 1000 lbs. per year per brewer is not much of a market.”
2. “We’re not able to locate the field after the session, a map or written instructions would have been helpful.”
3. Although I did not attend the field trip to the actual farm after the seminar, I did end up at WYOld West Brewing and found value in tasting the IPA made with the variety of hops grown last year – delicious! It was a pleasure meeting the brewers and other potential farmers as well as key players within the community. Cheers on a job well done!”
4. “Can’t wait for the next conference. Great job by all, especially Micah Humphreys.”
5. “You do good work!”
6. “Very informative, we need more programs like this. Thank you!”
7. “This seminar was VERY informative. We learned A LOT!!”

Based on a review of the attainment of these goals, we would recommend the continuation of evaluation of the possibility of the hop industry growing in our area. We did not factor into the project reaching out to the nearby border community in Montana, specifically Billings, which boasts 9 different breweries. The comment above about the market being “not much of a market” would expand significantly if those breweries are taken into account. We are very positive about the potential of this specialty crop becoming part of the diversity of crops grown in this region as we are consistently being asked about our work from interested parties in the region.

BENEFICIARIES

The total number of people reached in the region is difficult to know, but the website reached 1,719 page views and the conference had 72 attendees, Production methods detailed at www.nwchops.org, at six presentations (105 contacts) and the three articles about our project printed by the Powell Tribune reached a readership of 4,000 print subscribers and 10,000 online subscribers. The project benefitted Bighorn Basin crop producers, brewers and smaller specialty crop growers who have been made aware of the potential for a new crop in our area. Currently growers have had major shifts in barley and sugar beet production and are looking for alternative crops that would provide diversity to their operation. We saw two new growers come online as a result of our efforts as well as several other interested growers who are currently pursuing production. Wyoming breweries are beneficiaries of our work as they are most likely going to be purchasing locally-grown hops in order to make their product stand out in a field of similar products. Two local breweries have used our hops in their beers, and this has enabled us to speak directly to the questions that potential growers have about how breweries would use local hops. Home-brewers also became beneficiaries as several of them planted hops as a result of this project. (Again, no funds from the project were used for the purchase of any brewery products). Northwest College benefitted in that our ability to provide meaningful research to our community and state has increased. Approximately 50 students were involved in the project through coursework and field visits. Also, during the summer of 2017, Governor Mead’s ENDOW research group visited Powell and we presented our work in hops to them as an example of diversification of agricultural products in the region (20 contacts). The general public benefitted from the project as we had many participants in the various presentations or who visited the website who may not be involved in large-scale productions, but who may still grow and use hops in smaller amounts. We were able to give some of the hops to people interested in medicinal uses (teas, essential oils) of hops. The SCBGP grant funds were used in a manner that was exclusive to enhancing the competitiveness of hops as a crop in our region. All funds were expended in line with the original grant document.

LESSONS LEARNED

The following lessons will be helpful for future projects involving hops in our state:

1) The interest in craft brewing and therefore hops is very high. We have phone calls and conversations regularly involving interest in hops usage, growth and agronomics. Brewers are very interested to learn about our project and have been active in pursuing the utilization of the hops.
2) Variety trials are a successful way of evaluating potential strains, but with several hundred varieties to choose from, we were not able to test them all. There is still work to be done to evaluate varieties in different climates in Wyoming. Additionally, we have some initial data that specific varieties exhibit higher alpha acid levels than normal, which may be due to our climate, soils, water, etc. This "terroir" effect needs to be explored in order to determine if Wyoming hops are indeed exhibiting favorable brewing qualities.
3) The project proposed two separate variety trials carried out by only a few individuals. While they were both established, the shortage of labor and time affected our ability to carry out both trials to the extent we had envisioned. It would be advisable to propose a focused single-site variety trial in the future for a different set of varieties.
4) Since this is the first hop research at a large scale in Wyoming, several contacts were made that were unforeseen. First, we established a relationship with another University of Wyoming faculty member not originally named in the project who has been sharing our yield and economic information. Second, a Farm Service Agency representative contacted us who were interested in approximate yields in order to begin to prepare loan calculations. Third, several people were interested in the ethnobotanical applications of hops. Fourth, we had three separate news articles in the Powell Tribune published covering our project and the potential impact on the community and farmers in the region.

CONTACT INFORMATION

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Figure 1. NWC Hops Variety Trial #1.

Figure 2. NWC Variety Trial #2

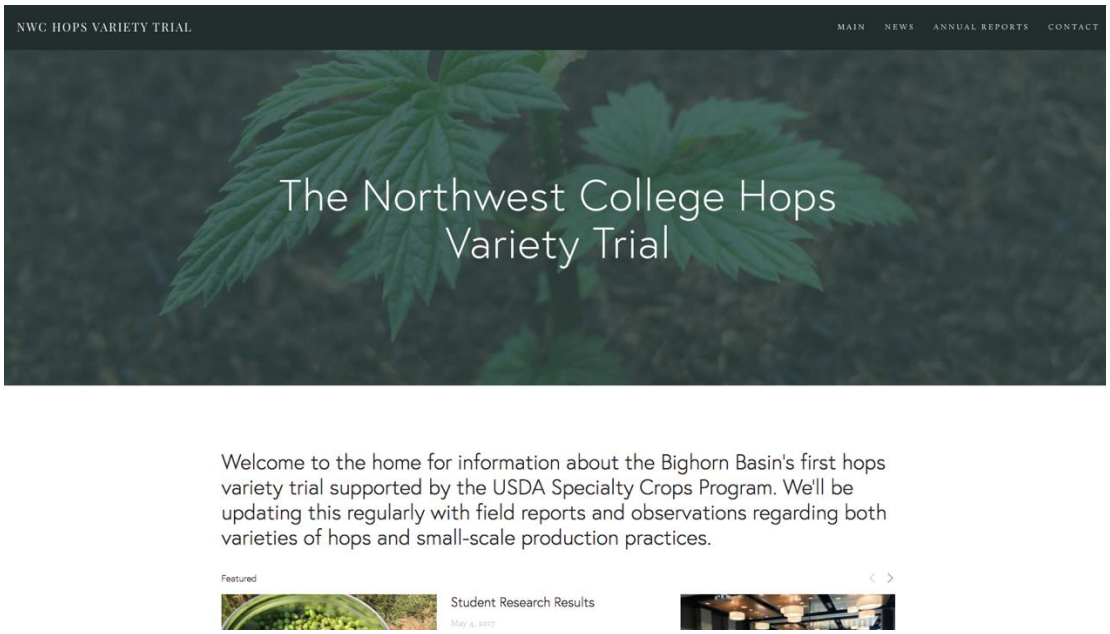

Figure 3. Website established at www.nwchops.org

Growing Hops Seminar Schedule

1:30pm
- Welcome, Announcements, Housekeeping
- All About the Hops Plants

2:30pm
- Break

2:40pm
- NWC Variety Trial
- Growing Hops at Home
- Enterprise Budget for Hopyard

3:40pm
- Break

3:50pm
- Hops in Brewing and Beyond, Food Safety
- Brewer Thoughts on Trends, Prices, Local v. Commodity

4:15pm
- Field Trip!

Figure 4. Growing Hops Seminar Schedule.

Figure 5. Promotional poster for the Growing Hops Seminar.

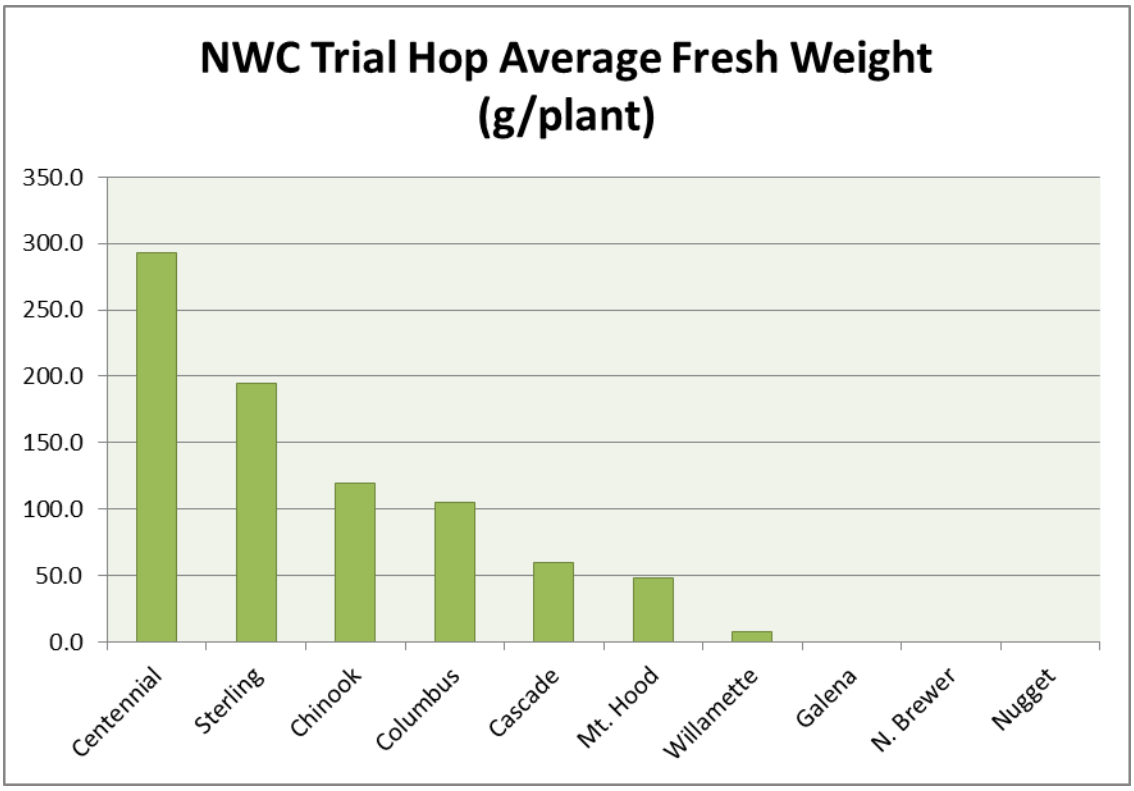

Figure 6. 2015 Variety Trial Results by Species.

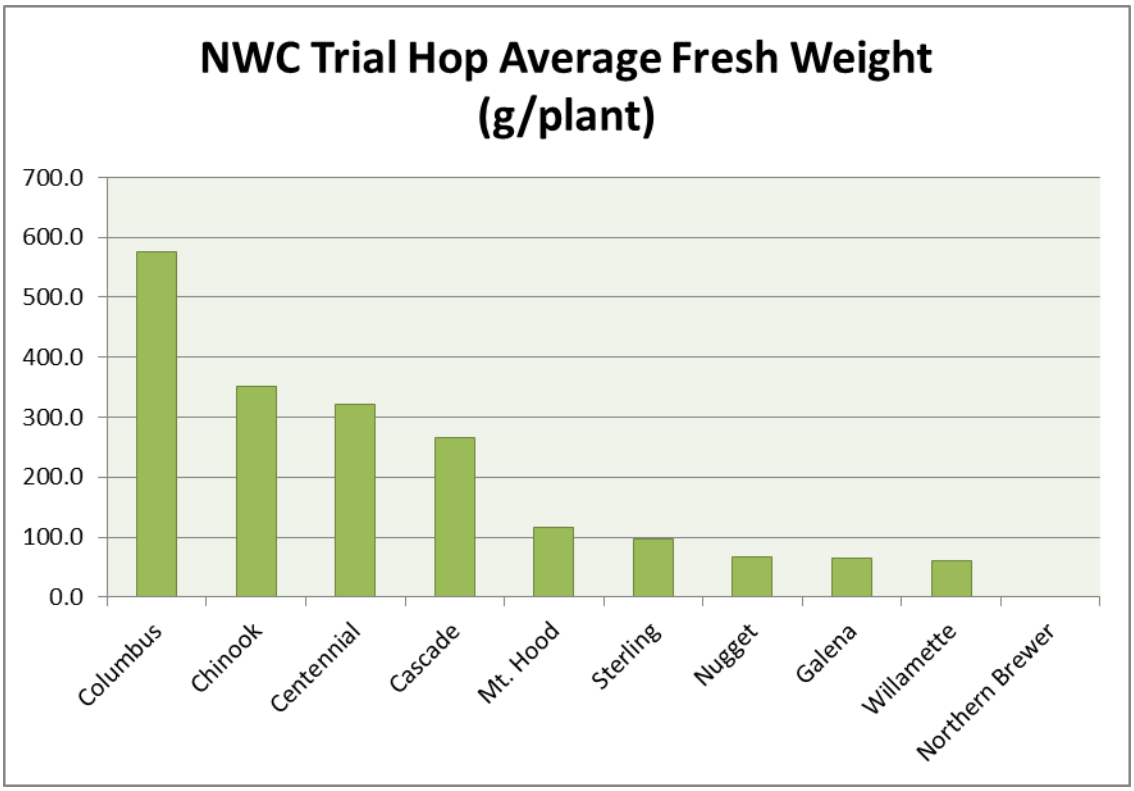

Figure 7. 2016 Variety Trial Results by Species.

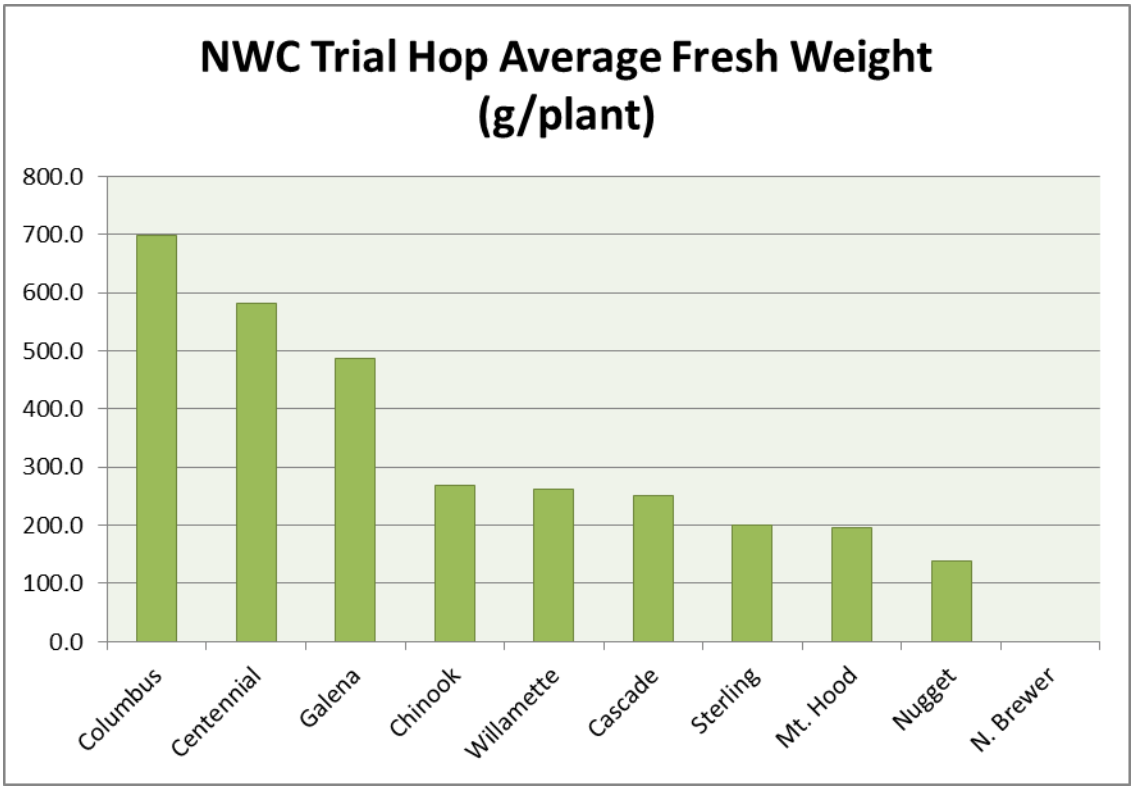

Figure 8. 2017 Variety Trial Results by Species.

JR MASTER GARDENER PROGRAM

PROJECT SUMMARY

The intention of this grant was to provide trainings to teachers, extension educators, and Master Gardener volunteers who would then take the Junior Master Gardener (JMG) curriculum into youth programs in local communities. This was accomplished by offering 2 “Train the Trainer” sessions in Casper and Gillette which were attended by a total of 57 adults. Attendees included teachers from 13 different schools, Wyoming Dept. of Education administrator, extension educators, 4-H leaders, Master Gardener volunteers, and other community members involved with various youth programs such as Casper Community Greenhouse Project (garden coordinator), Wyoming Food for Thought Project (manager), Boy Scouts and Girl Scouts, the Wyoming Girls’ School, and even a couple of employees from commercial greenhouses. As a result of the trainings, over 1,200 youth have participated in JMG programs throughout Wyoming through involvement in school gardens, community gardens, garden clubs, 4-H, and various extension programs.
With an aging population of farmers and specialty crop producers the project was timely as it is important to engage youth in agriculture production. While it is impossible to measure the impact at this point in time, engagement at an early age will result in more young people entering the agriculture field as a career path which will address global food needs for a growing population. This project did not build on previously funded SCBGP projects.

PROJECT APPROACH

JMG Train-the-Trainer Sessions were scheduled
Advertisement of JMG train-the-trainer session was developed and completed by Chris Hilgert using social media and email lists.
JMG trainers from Texas A&M provided the first training to me and others. Other partners included Master Gardeners, teachers, and Extension educators who were trained and then took the JMG curricula into the classroom
JMG curricula and classroom materials were provided to all attendees.
The JMG Train the Trainer Session was evaluated by attendees
JMG was offered in schools in Sheridan, Gillette, Casper, Cheyenne, Laramie, Thermopolis, Cody, Dubois, Rock Springs, and Wheatland, Wyoming.
Impacts of JMG on Youth Participants were evaluated: JMG teachers/leaders were asked to survey youth participants with the following questions. After participating in the JMG program, do you eat more fruits and vegetables now than you did before? After participating in the JMG program, have you increased your gardening and other healthy living activities? 100% of the responses to those questions were yes. (n=285)
Project manager then offered an additional training in Gillette attended by 36 adults. Those attending the training would participate in selected JMG activities and become familiar with 4 JMG curricula (Level 1, Level 2: Operation Thistle, Level 2: Operation WATER, and Learn Grow Eat Go). Attendees received teacher/leader guides and materials to take with them to implement JMG programs in their communities.
As a result, over 1,200 youth were reached.
Funds were only used to pay travel for JMG trainers who provided horticultural training and for curricula to trainees.

Junior Master Gardener®

growing good kids℠

Wyoming Department of Agriculture Specialty Crop Grant funding has provided an opportunity for University of Wyoming Extension to host a Junior Master Gardener (JMG) train the trainer workshop August 17 and 18, 2015 in Casper, Wyoming. A JMG trainer from Texas A&M will provide the two day training. Space is limited to 40.

Please share this information with Master Gardeners, teachers, Extension Educators and Program Coordinators who might be interested!

Who is this training for?
Extension educators (horticulture, 4-H, and nutrition), Master Gardeners, teachers, home schoolers, and school administrators who are interested in implementing Junior Master Gardener curricula into their classrooms, 4-H clubs, and after-school programs are invited. Extension employees and Master Gardeners interested in this training are encouraged to recruit a teacher from your home town to attend this training with you. This will help build a stronger partnership between UW Extension and Wyoming's schools. Our goal is to reach at least 1000 students in Wyoming.

What is JMG?
The Junior Master Gardener program is a nationally recognized K-12 curriculum covering horticulture, gardening, pest management, environmental stewardship, health, and nutrition designed to engage youth in age-appropriate, hands-on projects that teach skills in plant and health sciences. To learn more about the JMG program and how it helps kids grow and develop, visit their website: http://jmgkids.us

What does this training cover?
The two day training will cover selected lessons from each of the JMG curricula, how to implement JMG into the classroom, the benefits of JMG programs, and how to align JMG programs with teaching standards and expectations.

How much does this training cost?
Travel, some meals, and lodging expenses are not covered by the grant and are the responsibility of the individual trainees.

Funds from Wyoming Department of Agriculture Specialty Crop grant will cover the costs of:
- Registration for the workshop
- 4 JMG teacher/leader guides per trainee
  - JMG level 1
  - JMG Learn Grow Eat
  - JMG level 2
  - JMG Operation Water
- JMG kit for each trainee with $50 worth of supplies to bring back to the classroom
- Lunch and snacks both days

How do I register?
To register, or if you have questions, please contact Chris Hilgert – chilgert@uwyo.edu or 307-766-6870
Space is limited to 40, so please register early.

University of Wyoming Extension | master gardener

TEXAS A&M UNIVERSITY

Junior Master Gardener®

growing good kids℠

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University of Wyoming Extension | master gardener

TEXAS A&M UNIVERSITY

GOALS AND OUTCOMES ACHIEVED

Goal: Provided training to increase the knowledge of forty (40) Extension educators, teachers, and Master Gardeners JMG curriculum.

Outcome: A total of 57 graduated from the JMG trainings that provided them with the level of knowledge necessary to teach the JR Master Gardener Program. The two trainings were rated by attendees. On a scale of 1-5 (1=Poor, 5=Excellent) overall average rating response was 4.2

Goal: Educated youth using the JMG curriculum is to increase knowledge, skills, and lifetime interests in food production, nutrition, and agriculture.

Outcome: Over 1,200 youth have been reached through JMG programs around Wyoming. JMG programs have been offered in Sheridan, Gillette, Casper, Cheyenne, Laramie, Thermopolis, Cody, Dubois, Rock Springs, and Wheatland. Program evaluations indicate 100% of youth increased consumption of healthy foods, and 100% of youth surveyed indicated they increased gardening activity and other healthy living activities.

BENEFICIARIES

Beneficiaries were 57 UW Extension Educators and Master Gardeners and 1200 students, UW Extension 4-H youth , Boy Scouts, and Girl Scouts in Albany, Laramie, Natrona, Park, Sheridan, Platte, Campbell, Hot Springs, Fremont, and Sweetwater Counties schools and the Wyoming Girls' School

LESSONS LEARNED

Gardening is not something most youth are experiencing at home, but youth enjoy being outdoors and gardening. An observation is that kids are more interested in eating vegetables that they grew themselves. There is a natural connection between gardening, nutrition, and healthy living. The JMG curricula is a helpful tool for school garden coordinators, community garden managers, and other youth activity leaders to help guide the youth's learning through horticulture and nutritional subject matter in a fun, hands-on learning approach. It can be challenging to implement a JMG program into a community organization. From my experience, the one key to success is to have a community partner with interest in the program. For example, the program will be more successful if a teacher approaches me about the JMG program rather than me approaching the teacher and suggesting they implement JMG curricula into their classroom. The buy-in is critical to the success of the program. Also, existing 4-H programs are a great place to start if an Extension educator wants to start a JMG program in their local area. Instances where an Extension educator initiated the conversation with a school or community youth program (boy scouts, girl scouts, etc.) were largely unsuccessful.

CONTACT INFORMATION

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THE WYOMING HERITAGE APPLE PROJECT A CONTINUATION

PROJECT SUMMARY

The Wyoming Apple project was initiated because many of the apple trees planted during the Golden Age of the apple in Wyoming are reaching the end of their lives and many are in poor condition. The project was initiated to save many of these heritage cultivars for future generations. This is a continuation proposal that was intended to allow visitation of known orchards that couldn't be visited in the previous proposal. Locations of sweet apple orchards, remnant orchards, and individual trees of note throughout Wyoming were located and visited. Scions were collected and bench-grafted onto 2-year old hardy rootstock. Including earlier work from a previously funded Specialty Crop Grant, nearly 1000 bench grafts were created. A specimen orchard (germplasm repository) for these young trees representing the diversity of apple cultivars from Wyoming was developed at the University of Wyoming Sheridan Research and Extension Center (ShREC), in Sheridan, Wyoming. Bench-grafted trees from this project were out planted on the site on 26 May 2017, and are being maintained by the students and staff at Sheridan College and ShREC. Bench-grafted trees were supplied for the Central Wyoming College Field Station Apple Orchard Restoration Project, at the CWC Field Station near Lander, Wyoming in conjunction with a weekend apple of apple workshops on 29-30 April 2017. Bench-grafted trees were also supplied to the old Ed Young orchard, now called the Spear S orchard located near Lander, WY, and to individual landowners who gave us access to their trees. In addition, a website providing information on the Wyoming Apple Project and growing and caring for apples is in the testing phase. This project built on a previously funded work that began the work to obtain scions from 100+ year old orchards and trees in Wyoming and graft them onto hardy rootstock. The previously funded project provided inroads into known orchards in the state as well as knowledge of the people who were interested in apple cultivation in Wyoming, i.e. the previous project provided an excellent starting point in order to find samples for future DNA analysis.

PROJECT APPROACH

The approach to this project was to 1) continue work on a database of sweet apple producers, orchards (historic and in current production), hardy and prolific individual trees and varieties of apples for the state of Wyoming. The database of contacts included who either have apple trees or who know about others who have suitable apple trees; 2) individuals in the database were contacted by telephone or email, and a follow-up meeting scheduled with the highest priority contacts during the fruiting cycle to examine orchards and individual trees and their fruits to flesh out the database.

New heritage orchards were identified throughout the state. These orchards as well as several homesteads have trees that are up to one hundred years old and were visited in order of priority to harvest scions for grafting on to drought and cold tolerant root stock. Because the examination of the apples during fruiting is not the appropriate time to collect scions, it was necessary to travel to apple locations again during the late winter of year two. Approximately 30 sites were visited. The site of the former Ed Young orchard which was the first orchard planted in Wyoming continues to be an invaluable source of scions, as does the Experimental Fruit Farm in Lander, the McMurray orchard in Powell planted in 1929, and the Pope orchard panted in 1905 to name a few.

The final sampling included the following locations in Wyoming: Lander, Casper, Wheatland, Sheridan Kaycee, Laramie, Powell, Douglas, Lingle, Pavilion, NE-WY, Buffalo, Big Horns, Cheyenne, and Burns. Thirty cultivars were IDed in the State of Wyoming, with a 58% ID to cultivar. Many more orchards/orchard remnants or trees were brought to our attention

throughout the state but we were not able to visit the sites during the duration of the grant. Many of these orchard remnants were on the sites of former homesteads and we have documentation to suggest that a most trees were likely planted nearly a hundred years ago. Other sites were from more recent homesteads that were developed after irrigation projects were completed. These sites were visited in an attempt to harvest scions for grafting on to drought and cold tolerant rootstock. As in past years it is difficult to visit all of the sites in the necessary pre-leaf emergent portion of the spring.

GOALS AND OUTCOMES ACHIEVED

Expected Measurable Outcomes

Goal 1: Increase the awareness of sweet apple producers, orchards (historic and in current production), hardy and prolific individual trees and varieties of heritage apples for the state of Wyoming.

PERFORMANCE MEASURE: We proposed that the number of orchards and individual trees visited will increase by 100% to an additional 30 and the number of trees grafted from heritage apple trees will be increased by 300-400.

BENCHMARK: At the beginning of this project there were 60 orchards and remnant orchards and individual trees of note in the Wyoming Apple Project Database. Only 30 have been visited to date. Approximately 700 bench grafted trees have been produced from the sites visited.

TARGET: Visit an additional 30 sites for documentation. The individuals will be contacted initially by telephone or email, and a follow-up meeting scheduled with the highest priority contacts during the fruiting cycle to examine orchards and individual trees and their fruits to flesh out the database. Continue to work with producers and individual land-owners to obtain scions from the best (most hardy, most productive) trees for grafting onto 1,800 hardy rootstocks. These grafted saplings will be used in proposed workshops, demonstrations, and specimen orchard. Since the examination of the apples during fruiting is not the appropriate time to collect scions, it will be necessary to travel to apple locations again during the late winter/early spring.

PERFORMANCE MONITORING PLAN. To monitor success of our project we will track the number of sites visited and the number of trees grafted and entered into a database that will be available online. A presentation of the results of the project will be developed and shared with specialty crop producers at conferences and workshops in Wyoming to increase the awareness of heritage apples suitable for Wyoming. A survey at presentations will be given to determine increased awareness.

During the proposed research activity, interaction with orchardists and land owners around the state resulted in identification of an additional 70 orchards or individual heritage tree sites. Scions were collected from approximately 30 orchards, with a total number of bench-grafted seedlings at approximately 1800. Awareness of sweet apple producers, orchards (historic and in current production), hardy and prolific individual trees and varieties of heritage apples for the state of Wyoming has also been increased through presentation of three grafting workshops and four talks on growing apples in Wyoming around the state. Workshops included three half-day workshops on grafting (see photos), pruning and planting. Increase in knowledge as judged by pre and post-survey data take at the workshops was High, approximately 90-95% for each workshop. In all, over 700 trees bench-grafted by participants of the Lander workshop and the other workshops held since 2013 have been dispersed into many locales throughout Wyoming. In addition, four seminars on the Wyoming Apple Project were presented (Wheatland 2016, Lander 2017, Cheyenne 2017, and Rawlins 2017). Increase in knowledge was lower than in previous years in Wheatland, ranging from 10% to 50%. The other scores ranged from 80-100%. We actually feel good about the low numbers in Wheatland because many of the attendees had previously participated in seminars or grafting workshops, or both.

A complete summary of information gathered during the proposed research activity has been made available to the public through the Wyoming Apple Project website. Information on over 200 apples tested or found still living in Wyoming has been compiled into a series of brochures by region (i.e. by city) and made available at the Wyoming Apple Project Website. The history of the apple cultivars (i.e. origin, date, synonyms, characteristics, photos) and a brief history

of the local homestead, orchards and nurseries selling these apples are included for each area. A document that summarizes all cultivars (i.e. Apples of Wyoming: Lost and Found) is also available to allow apples enthusiast the ability to observe all 200 apples in a single page. Additionally, photos of 200+ apples have been compiled together to create a Wyoming apple ID photo and illustration booklet for those who may have missed the sampling during 2016-2017. This consists of over 400 drawings and photos of apples collected from the USDA Watercolor drawings and GRIN date base. They can use this data set to narrow down which cultivars they may have. The test phases of the Wyoming Apple Database, including the city brochures can be found at https://jmagby.wixsite.com/mysite

Goal 2: Increase the knowledge of specialty crop producers by developing a series of educational deliverables designed to educate potential producers about grafting and growing sweet apples in Wyoming.
PERFORMANCE MEASURE: Increase the number of workshops held by at least four and increases the awareness of heritage apple history and production to an additional 100 individuals. Website developed will be updated and launched to provide a central repository of information-- including videos-- on growing, maintaining, pruning, grafting, etc. apples in Wyoming.
BENCHMARK: To date eight grafting workshops and eight talks on growing apples in Wyoming have been presented around the state. A website has been created but not brought on-line.
TARGET: A series of at least four additional workshops will be presented in parts of Wyoming where workshops have not been previously held. Topics for additional talks on apple growing will include planting techniques, grafting and pruning methodology, variety characteristics and climate parameters, and pests and their control. An Agriculture brochure will be produced in year three of this continuing project summarizing the findings from the project, and will be made available to the general public. Work on website will be completed and made available to the public.
PERFORMANCE MONITORING: Short-term outcomes will be measured through pre- and post-assessment surveys during workshops and other educational opportunities. Surveys will utilize MCQ and yes/no questions in order to provide a meaningful measurement of knowledge increase. Website hits will be tracked.
GOAL: The goal the research was to work with producers and individual land-owners to obtain scions from the best (most hardy, most productive, best tasting, worst condition) trees for grafting onto hardy rootstock.
Outcome
These grafted saplings were used in apple grafting workshops, demonstrations and to provide planting stock back to the orchardists and individuals and for the germplasm specimen orchard. The final total for Wyoming trees sampled and genotyped was 1012. Including earlier work from a previously funded Specialty Crop Grant, nearly 1800 bench grafts were created (see photos).

The final sampling included locations in Wyoming as follows: Lander (8), Casper (9), Wheatland (5), Sheridan (8) Kaycee (2), Laramie (2), Powell (2), Douglas (8), Lingle (1), Pavilion (4), NE-WY (1), Buffalo (33), Big Horns (5), Cheyenne (3), and Burns (1). The final total for Wyoming trees sampled and genotyped was 1012. Thirty cultivars were ID in the State of Wyoming, with a 58% ID to cultivar. Many more orchards/orchard remnants or trees were brought to our attention throughout the state but we were not able to visit the sites during the duration of the grant. Many of these orchard remnants were on the sites of former homesteads and we have documentation to suggest that a most trees were likely planted nearly a hundred years ago. Other sites were from more recent homesteads that were developed after irrigation projects were completed. These sites were visited in an attempt to harvest scions for grafting on to drought and cold tolerant rootstock. As in past years it is difficult to visit all of the sites in the necessary pre-leaf emergent portion of the spring.

Bench-grafted trees from this project were out-planted on the site on 26 May 2017 (see photos), and is being maintained by the students and staff at Sheridan College and ShREC.

Bench-grafted trees were also supplied for the Central Wyoming College Field Station Apple Orchard Restoration Project, at the CWC Field Station near Lander, Wyoming. Bench-grafted trees were also supplied to the old Ed Young orchard, now called the Spear S orchard located near Lander, WY, and to thirty landowners who granted access to their trees.

Goal: Delivery of the bench-grafted trees to the CWC Field Station was in conjunction with a weekend apple of apple workshops on 29-30 April 2017.

Outcome: Workshops included three half-day workshops on grafting (see photos), pruning and planting. Increase in knowledge as judged by pre and post-survey data take at the workshops was High, approximately 90-95% for each workshop. In all, over 700 trees bench-grafted by participants of the Lander workshop and the other workshops held since 2013 have been dispersed into many locales throughout Wyoming. In addition, four seminars on the Wyoming Apple Project were presented (Wheatland 2016, Lander 2017, Cheyenne 2017, and Rawlins 2017). Increase in knowledge was lower than in previous years in Wheatland, ranging from 10% to 50%. The other scores ranged from 80-100%. We actually feel good about the low numbers in Wheatland because many of the attendees had previously participated in either seminars or grafting workshops.

A website providing information on the Wyoming Apple Project and growing and caring for apples is in the testing phase and is available for view at https://jmagby.wixsite.com/mysite

We have also produced a series of pamphlets on apple cultivars found in each locale/city in Wyoming where we have visited orchards.

The PI also contributed a great deal of time toward helping to develop an episode of Farm to Fork Wyoming on the Wyoming Apple Project for Wyoming Public television. The episode aired for the first time on 12 November 2016. The URL for this episode is http://video.wyomingpbs.org/video/2365890965/

BENEFICIARIES

It is estimated that between the Wyoming Master Gardeners and the Wyoming Specialty Crop Producers and Nurseries the project has the potential to impact over 500 hundred people interested in growing apples. Several other states

including Montana, Colorado, Nebraska, and New Mexico are interested in our findings. Because there are few sweet apple producers in Wyoming, relatively few individuals in the state were educated on the techniques required for growing and maintaining sweet apple trees. Farmers and potential producers that participate in the workshops and other educational opportunities afforded by this project were directly impacted by becoming more knowledgeable about different varieties of sweet apples and production practices and by taking home their own bench-grafted trees. The earlier funded project was the first to begin the establishment such a database, which now includes over 60 orchards/ remnant and individual trees. This continuation proposal allowed for continued development and expansion of this database, which will be helpful in establishing best practices for sweet apples as a specialty crop in Wyoming--and allowing potential producers to become more confident in a commitment to produce and market sweet apples. The pamphlets we have produced on the Wyoming Apple Project and the cultivars found at each city/locale where we visited will be very popular and could reach many hundreds of people in years to come. We also believe that the Website will be very popular with people in Wyoming as well as the entire US, especially following completion of grafting and pruning videos, and the numbers viewing the website could reach easily into the thousands.

LESSONS LEARNED

People in the State of Wyoming are very passionate about apples and apple trees. They are thirsty for knowledge regarding the history of apples in Wyoming, the care of apples, and how to graft their own favorite cultivars onto hardy rootstock. Of particular interest is for them to know the names of the cultivars they have growing on their land. This is the subject of another proposal. Secondly, most of the people who now have older orchards on their property are interested in knowing how to care for the older trees to get them back in shape again. This topic has arisen more than any other topic in visiting with orchardists and in seminars and workshops. Thirdly, people are also interested to find out good choices for which cultivars to choose when planting new trees. Many are open to replanting heritage apple cultivars.

CONTACT INFORMATION

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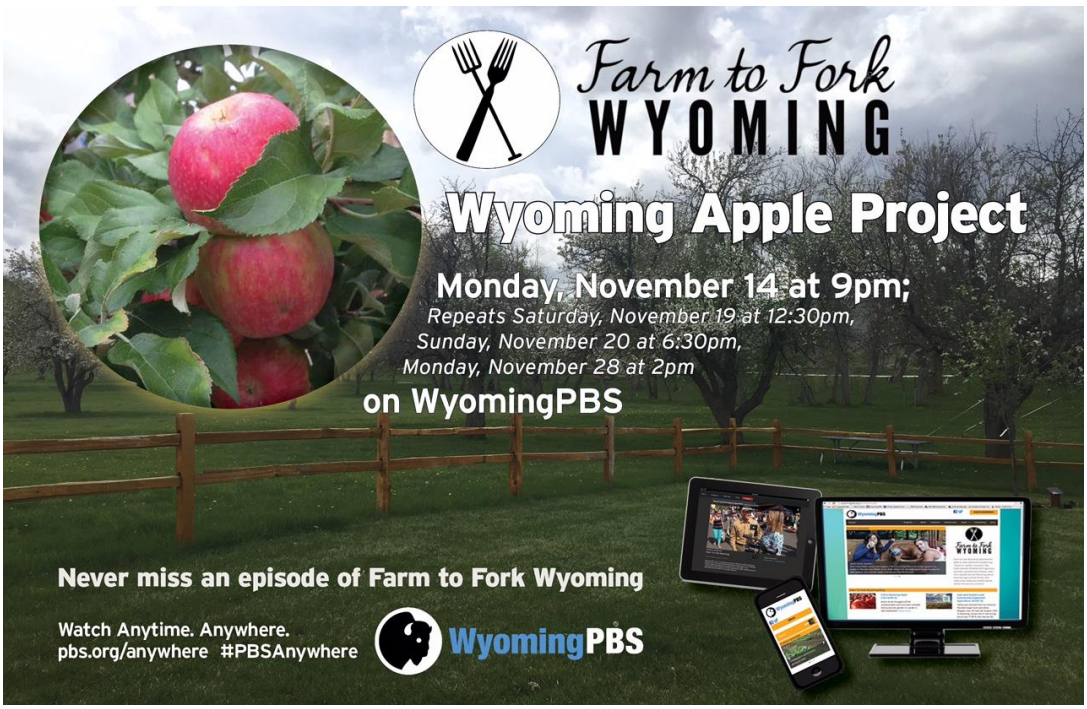

GLUTEN FREE PRODUCTION AND HANDLING OF WYOMING'S SPECIALTY CROP PULSES

PROJECT SUMMARY

The specific that was addressed was the lack of any program for pulses to be verified as free of gluten cross contamination. Verification would allow producers to take advantage of this growing domestic and international marketing opportunity. Although traditional grains such as wheat rye and barley are an important part of the regional agricultural landscape, gluten free crops such as dried peas, dry edible beans, lentils and chickpeas are produced in the region as well. The project was important and timely as the market for gluten free products has seen an 18 percent growth rate per year over the last five years. Around 3 million Americans have celiac disease and an estimated 40 million have gluten sensitivity. There are also millions more, in the United States alone, who may be undiagnosed for either of these conditions. To meet the consumer demands, pulses being naturally free of gluten are being sought by food processors and manufacturers. The products that result are required by those suffering from celiac disease or sensitivity to gluten as well as those in search of a perceived "healthy" diet. The number of pulse producers attempting to market to the gluten-free industry remains small, due in part, to its newness and producers lack of knowledge. Just as with organic and certified seed production there continues to be an added level of care that must be taken to assure that a gluten free crop remains free of contamination during production, harvesting, storing, and transporting to market. The overall goal of the project was to increase the marketing opportunities of pulse growers interested in production and sale of pulses to gluten free processors. The project developed a manual for a set of procedures for pulse certification that includes field/crop documentation, planting seed, harvest equipment, transportation equipment and storage to prevent cross contamination of pulses with gluten containing crops. Secondly, training information was provided to assist local pulse farmers on how to produce for and market to the gluten-free market. The project was not built on a previous specialty crop project.

PROJECT APPROACH

The contractor hired for the project had prior experience working with a business producing gluten free products, which was the basis for much of the manual, which was hoping to add value to the dry beans already being produced in the state. Additional research was done to better understand the needs and expectations of people purchasing gluten free products, including medical reasons for a gluten free diet. Federal regulations, certifying agencies, and customer needs regarding gluten free products were also used in the development of the manual. A brief and general section on marketing was included by the contractor, with a more in-depth marketing manual developed by another author.
A manual was developed for a set of procedures for pulse crop gluten free verification that included: field/crop documentation, planting seed, harvest equipment, transportation equipment, and storage; to prevent cross contamination of pulses with gluten containing crops.
Three meeting were organized to assist local farmers on how to produce for and market to the gluten-free market.
December of 2015 Tim Larsen was selected for marketing research portion of project.
January -Consulted with Dry Bean Commission regarding specialty crop programs and projects that will help on marketing and production efforts for the dry bean industry.
January -Mike Moore selected for protocol and manual development.
September- Mike Moore finished review on existing literature and developed protocols for gluten free production manual that has been submitted to WDA.
September-Tim Larson finished research on existing and potential opportunities for marketing of gluten free commodities.
November-Seminar on Gluten free as marketing tool presented at Farm to Market Conference
December-WDA completed review of protocol manual.
The manual includes the following topics

Introduction
Gluten-free Diet
Planning
Standard Operating Procedures (SOP)
Recordkeeping
Inspections
Field selection
Market Class and Variety Selection
Seed Stock
Field Preparation and Planting
Growing Season – Flowering to pod maturation
Cleaning Equipment
Processing
Inspections in General
Inspections – Timing

1. In the
2. Field production equipment inspections
3. Processing equipment

Sampling and Testing
Packaging
Marketing the Product Overview
What Is the Current Market for Pinto Beans?

- US Consumption
- Export Market
- Trends in the Imports of dry beans

Review of U.S. Gluten-Free (GF) Market

- What is Gluten?
- How does gluten get into our processed foods?
- Typical gluten containing foods you may not be aware of

Review of US Gluten-Free (GF) Market.

- What is the market for Gluten-Free Products?
- Who is the Gluten-Free Consumer?
- How large is the market?
- Key trends in the Gluten-Free market include:
- Realities of marketing dry beans (Gluten-Free or not)

Current Market for Gluten-Free certified pulses

- Market premiums for Gluten Free crops
- Review of pulse prices from farm to finished product
- Trends in dry beans

Marketing venues to consider

- Direct retail marketing (internet)
  - From the source
  - Through existing outlets (Thrive Market)
- Certified GF bulk sales to processors
- Association with retail source verified products

Shopping Behaviors of Gluten-Free Consumers

Developing Integrated Marketing
How to Position Pinto and Dry Beans in the US Market.

- Functional Food
- Gluten Free
- Best consumer value in Protein

The manual was developed specially for specialty crop dry bean producers but is also useful to other pulse producers.

GOALS AND OUTCOMES ACHIEVED

GOAL: Provide guidance and training to increase the knowledge of pulse producers on how to assure that a naturally gluten free pulse crop remains free of contamination during production, harvesting, storing, and transporting to market
PERFORMANCE MEASURE: Success of the project will be measured by attendance at the trainings and interest by producers in pursuing a gluten free production.
BENCHMARK: None available
TARGET: At least 25% of the pulse growers who attend the training will use the knowledge on gluten free production and marketing to enhance their farm operations.
PERFORMANCE MONITORING: Research on the development of a set of procedures for pulse crop gluten free verification that include field/crop documentation, planting seed, harvest equipment, transportation equipment and storage to prevent cross contamination of pulses with gluten containing crops will be documented in a manual. Self-assessment surveys will be administered at the trainings.
Outcomes: A gluten freed dry bean manual was produced, as well as a PowerPoint presentation, both of which are available to interested parties through the Wyoming Seed Certification Service office and Extension educators. Three presentations were made, one in Burlington, Wyoming, to 4 producers and two industry representatives, and one in Torrington, WY, to one producer and two industry representatives. In the case of the Torrington industry representatives, their company was already marketing dry gluten free dry beans. A third training was done in Wheatland Wyoming to 13 producers. Surveys returned indicated 74% increase in knowledge and 62.5 percent found information very useful to operation. In order to continue are goal of impacting 25% of bean producers we are continuing to make available the manual to bean producers at various trade events including Fremont County Farm and Ranch Days, Worland Westi Days and at the upcoming Wyoming Bean Commission winter meeting in Powell.

BENEFICIARIES

A total of 22 producers and industry representatives attended the three presentations. Individual conversations with producers have also occurred. The overall beneficiaries are the 267 dry bean growers of Wyoming. Over 150 manuals were distributed at events in 2017 that included the Wyoming State Fair, The Bee College, and Farm to Market Conference, Westi Days, and the Fremont County Farm Days. The project is also beneficial for handlers as the USDA's Agricultural Marketing Service recently amended its commodity specification for purchases of canned dried beans. The specification now states that all canned dried bean products shall be processed and packaged using equipment that is separate from equipment used for any products containing major allergens. This will only increase the need for producers to avoid cross contamination with crops containing gluten.

LESSIONS LEARNED

There are multiple definitions of gluten free. The federal government has set a 20 part per million standards for the purposes of food labeling, while some gluten free certification programs have a standard of 10 ppm or even 5 ppm. That is then complicated by consumers who have a varying sensitivity to gluten. There are people who follow gluten free as a fad diet, others who are self-diagnosed gluten intolerant, and finally medically diagnosed Celiac disease sufferers who

are incredibly sensitive to even low level gluten contaminants. Producing to one or more of those standards and markets will take planning as well as financial decisions as to cost of production and potential value of the final product.

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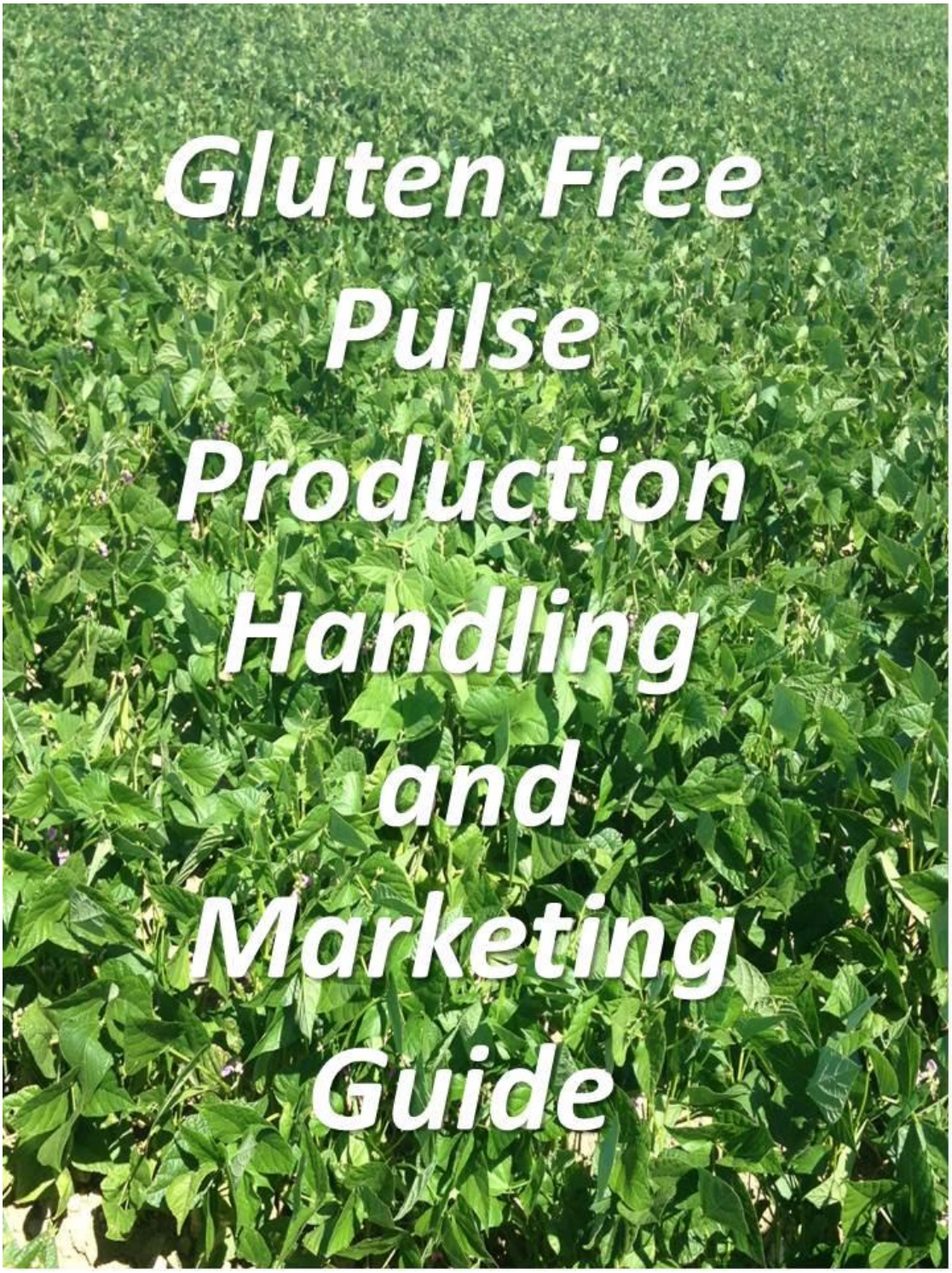


SPECIALTY CROP PRODUCTION, MARKETING, EDUCATION AND CONSUMPTION PROGRAM

PROJECT SUMMARY

In order to enhance the development and availability of Wyoming the specialty crop industry continued support was needed in providing marketing and technical outreach. The overall goal was it to increase awareness of specialty crops through a continued presence at conferences, workshops, trade events and provide publications that provide information on production, marketing, education, and food safety of specialty crops. This project compliments and enhances earlier efforts by supporting the marketing, travel and support materials for the program manager to cooperate with other state and federal agencies; UWYO, WRDC, NRCS, FSA, Community Colleges, associations and nonprofits. Prior to the SCGP there were no state funds specifically directed toward specialty crop marketing efforts. The purpose of the project was to support the efforts of Wyoming Department of Agriculture Specialty crop position to increase the availability of information on specialty crops by providing support for marketing, education, season extension production, research, food safety and product distribution. When the first SCGP funding was introduced there were few specialty crop producers or farmers markets in Wyoming. Through efforts funded by the SCBG program the number of markets grew from 12 to over 50. As the number of markets grew the demand for local specialty crop producers has grown as well. Each year there are new small acreage specialty crop producers starting up in various parts of Wyoming. This project complimented and enhanced earlier efforts by supporting the marketing, travel and support materials for the program manager to cooperate with other state and federal agencies; UWYO, WRDC, NRCS, FSA, Community Colleges, associations and nonprofits. The support continued to be timely as the demand for locally produced specialty crops has increased dramatically. There is a constant demand for information by the industry as many of the new producers have steep learning curves with little farming background.

PROJECT APRROACH

The WDA program manager continued to provide technical assistance and outreach to other agencies and organizations to develop the specialty crops industry in Wyoming through workshops, conferences and publications. At the conferences and workshops the specialty crop grant programs, conferences and workshops sponsored by Wyoming SCBGP information was made available at specialty crop booths to distribute publications and market the program.

Project Objectives:

1. The project manager worked to increase awareness of specialty crops on marketing, production and consumption by providing specialty crop information at conferences and workshops through displays, trade show booths, seminars, and presentations.
2. The project manager worked to promote the Specialty Crop Grants Program and industry through the publications on specialty crop topics of interest that include marketing, production, season extension and consumption.
3. The project manager worked to increase sales of Wyoming specialty crops through trade event marketing.

Activities performed

The project manager worked to increase awareness of specialty crop opportunities on marketing, production and consumption by providing specialty crop information at conferences and workshops through displays, trade show booths, seminars, and presentations.

October 2015 Specialty Crop Workshop held October 29-30 in Wheatland
November 2015 Lander Local Fest.
February 2016 Fremont County Farm and Ranch
March 2016 Bee University
July 2016 Meeteetse Hoop house workshop
August 2016 Food for Thought Hoop House workshop
August 2016 Wyoming State Fair

February 2017-Booth at Organic Conference
February 2017 Booth at Westi Days
February 2017 Booth at Farm and Ranch Days
March 2017 Booth Bee College
April 2017 Lander Garden Expo
2017 Sinks Canyon Hoop House Workshop
August 2017 Wyoming State Fair
August 2017 Food for Thought Veterans Hoop House Build
September 2017 Wheatland Specialty Crop Workshop
November 2017 Farm to Market Workshops.

Horticultural show judging

In 2016 and 2017 we met with researchers at the Laramie, Lingle, Powell and Sheridan stations to audit progress on various specialty crop projects Including Fenugreek, Grapes Pollinator education, apples hops and pulses. Site visits of specialty crop projects were also done in Casper, Meeteetse, Thermopolis, Lusk, Lander and Laramie as time permitted in 2017. The program manager attended the Wyoming Dry Bean Commission and the Small Acre Team meetings.

2. The project manager worked to promote the Specialty Crop Grants Program and industry through the publications on specialty crop topics of interest that include marketing, production, season extension and consumption.

We provided the printed informational materials on specialty crop programs that included specialty crop grant programs for producers and nonprofit, and highlighted past and ongoing specialty crop projects. The following were either developed or updated; Tuesday tidbit articles, Back yard and Barnyard articles, newspaper articles small grant program brochures, small grant applications and specialty crop manuals

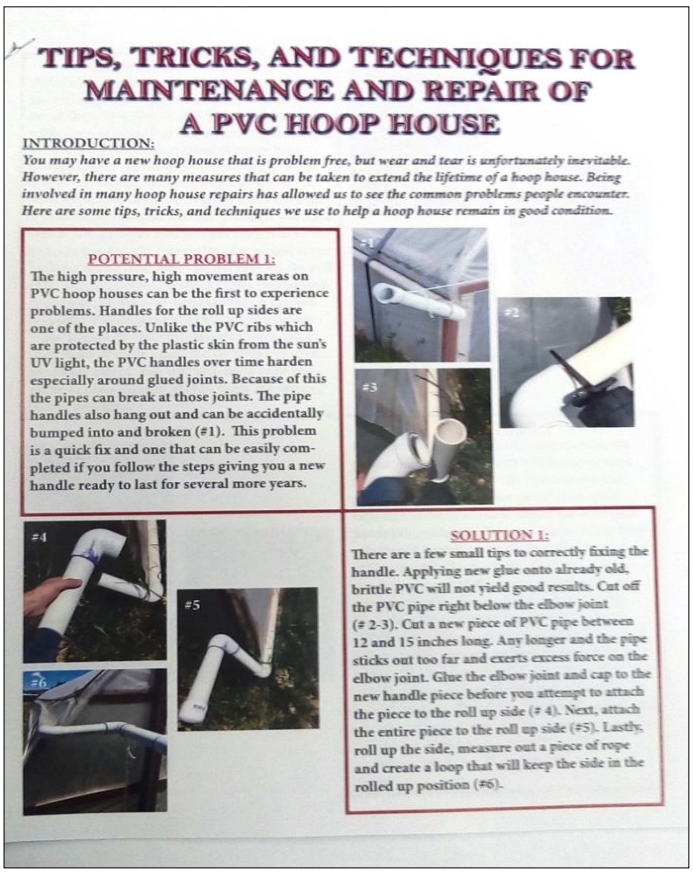
3. The project manager worked to increase sales of Wyoming specialty crops through trade event marketing.

We provided an opportunity for five specialty crop producers to attend the 2017 Natural Products Expo to market their specialty crops.

Intern Outcomes

An intern was hired in May to assist with Specialty Crop publications and marketing. This is a continuation of past activities that have resulted in training college students to work on specialty crop marketing and education. He also provided assistance with several hoop house repair activities around the State, at the State Fair and on publications.

The intern developed a publication for hoop house repair from what was learned during the summer. From this an article for the Backyards and Barnyards was submitted and published.



TIPS, TRICKS, AND TECHNIQUES FOR MAINTENANCE AND REPAIR OF A PVC HOOP HOUSE

INTRODUCTION:

You may have a new hoop house that is problem free, but wear and tear is unfortunately inevitable. However, there are many measures that can be taken to extend the lifetime of a hoop house. Being involved in many hoop house repairs has allowed us to see the common problems people encounter. Here are some tips, tricks, and techniques we use to help a hoop house remain in good condition.

POTENTIAL PROBLEM 1:

The high pressure, high movement areas on PVC hoop houses can be the first to experience problems. Handles for the roll up sides are one of the places. Unlike the PVC ribs which are protected by the plastic skin from the sun's UV light, the PVC handles over time harden especially around glued joints. Because of this the pipes can break at those joints. The pipe handles also hang out and can be accidentally bumped into and broken (#1). This problem is a quick fix and one that can be easily completed if you follow the steps giving you a new handle ready to last for several more years.

SOLUTION 1:

There are a few small tips to correctly fixing the handle. Applying new glue onto already old, brittle PVC will not yield good results. Cut off the PVC pipe right below the elbow joint (# 2-3). Cut a new piece of PVC pipe between 12 and 15 inches long. Any longer and the pipe sticks out too far and exerts excess force on the elbow joint. Glue the elbow joint and cap to the new handle piece before you attempt to attach the piece to the roll up side (# 4). Next, attach the entire piece to the roll up side (#5). Lastly, roll up the side, measure out a piece of rope and create a loop that will keep the side in the rolled up position (#6).

GOALS AND OUTCOMES ACHIEVED

GOAL 1: Increase awareness of specialty crop opportunities on marketing, production, and consumption.

PERFORMANCE MEASURE: Provide information on specialty crop at 9 conferences and workshops through specialty crop displays, trade show booths, seminars, publications and power points.

BENCHMARK: 8 conferences were attended in 2013

TARGET: Increase the number conferences that we will attend to 9 or 11.25%

PERFORMANCE MONITORING PLAN: The attendees were surveyed at workshops to see if the information presented was of value to their knowledge base and if it will cause them to change practices on their operation. Topics that provide the best benefit for specialty crop production, education, marketing and consumption were focused on.

We had informational booths at the following events

November 2015 Lander Local Fest (82)

Riverton Joint Farmers Marketing and Master Gardener Conference (69)

2016 Cheyenne Bee College (235)

February 2017-Booth at Organic Conference (100 plus)

February 2017 Booth at Westi Days (118)

February 2017 Booth at Farm and Ranch Days (312)

March 2017 Booth Bee College (347)

Laramie River Conservation Expo (582)

April 2017 Lander Garden Expo (1500 plus)

August 2017 Wyoming State Fair Attendance (41,200)

September 2017 Wheatland Specialty Crop Workshop (20)

<u>Workshops</u> in 2017 that the WDA helped facilitate included

2017 Thermopolis hoop house workshop (36)
2017 Sinks Canyon Hoop House Workshop (10)
August 2017 Food for Thought Veterans Hoop House Build (13)
Meeteetse Hoop House Workshop (8)
November 2017 Farm to Market Workshops that included a hoop house building workshop, and Acidified Food workshop and a Fermented Foods workshop. (43)

Surveys were done at workshops to determine level of knowledge gained on topics. For workshops the increase in knowledge ranged from 10% to 80% and we are seeing an average of 40-50% increase in knowledge as we have all levels of experience in attendance. Surveys indicated that 16% plan to construct and use hoop houses in the future to grow vegetables. The feedback from a survey of small acre folks was analyzed and our selection of topics of interest was modified to include bees and pollinator habitat as surveys indicated that 20% were interested in bee keeping and 40% in growing native plants. 20% wanted more information on growing vegetables/fruits and 34% wanted additional information on the construction and use of high tunnels.

Wyoming Dry Bean Commission meetings and Small Acre Team meetings were also attended to gauge interest in various areas of interest for future specialty crop projects. The Dry Bean industry is interested in detailed longer term crop research and marketing while the small acre landowners are more interested in practical information that is of use immediately.

GOAL 2: Increase awareness of the Specialty Crop industry and programs through the publications.
PERFORMANCE MEASURE: Provide publications on specialty crop topics of interest that include processing marketing, production, season extension and consumption.
BENCHMARK: Baseline is 9 articles and publications
TARGET: Increase the number of articles and publications 11% from 9 to 10
PERFORMANCE MONITORING: We will survey to see if the information presented was of value to their knowledge base and if they made any changes to their operations. The publications will be saved for the duration of the grant. The feedback will be analyzed and our selection of topics of interest will be modified when necessary. The publications will be saved for the duration of the grant to track materials.
Activities for goal 2: The general Specialty crop brochures were updated. Additional specialty crop publications included 10 Tuesday Tidbit articles, 1 Backyard and Barnyards feature article, 2 newspaper articles and updating 2 hoop house manuals. These do not include the numerous articles submitted by UWYO Extension and printed over the course of the grant. Many of the articles were developed because of present and past research projects by UWYO Extension personnel.
PERFORMANCE MONITORING: Survey results provided by over 1200 small acre owners indicated the following: 40% of small acre producers were interested in growing native plants, 34% on hoop house and green house production, 29% weed control, 27% on windbreak information, 22% on bee keeping and 20% on fruit and vegetable production.

GOAL 3: Increase sales of Wyoming specialty crops through trade event marketing.
PERFOMANCE MEASURE: Promote Wyoming specialty crops through a marketing booth at the Produce Marketing Association annual trade show.

BENCHMARK: NA
TARGET: Increase the sales of participating companies by 2%
PERFOMANCE MONITORING: Initially WDA planned to attend Produce Show in October of 2016. After consultation with Wyoming Business Council it was decided to partner with them at the Natural Products Expo West (NPEW) in Anaheim in March 2017 would provide a better opportunity for value added producers and organic producers of specialty crops. Five specialty crop producers were recruited. A survey Wyoming specialty crop participants indicated that gross sales after trade event were $520,000. This was the first time for any of the five producers at the Natural Products West trade show.
The phytosanitary bean certs issued by the Wyoming Department of Agriculture were analyzed for 2016 and 2017. In 2016 there were 4730,500 lbs. of beans exported and this increased to 6,064,000 lbs. in 2017. This increase was not related to the NEPW show but general marketing efforts by Wyoming bean handlers. A previous specialty crop grant partially funded the travel of a Wyoming handler to the Caribbean on a trade mission. Most of the beans exported were to the Dominican Republic.

BENEFICIARIES

Partnerships with Universities, Colleges, nonprofits and producers was continued to be fostered. The support of UWYO Extension, Community Colleges and several nonprofits around the State allowed us to expose 3800 producers and consumers to the specialty crop program. The 40,000 plus visitors to the Wyoming State Fair were exposed to multiple specialty crop displays planted by the State Fair personnel/Master Gardeners that are managed during fair time by the SCBGP Manager. The State Fair also promotes specialty crops through the horticultural show and the 4H project displays.

LESSONS LEARNED

Sub-grantee reporting has always required extensive oversight. It often takes constant reminders to get the information needed. Producers who have limited experience with grants are particularly challenging. The previous grants specialist position was eliminated due to budget cuts. State Agency is still under a hiring freeze which makes it more difficult for the WDA Specialty Crop Program Manager to manage multiple conference and event activities. The intern was of great help with some workshops, promotional material and marketing. We will be hiring another intern in the spring of 2018 to help with some project based activities.

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