Steve Bullock
Governor

MONTANA Department of AGRICULTURE
302 N Roberts, PO Box 200201
Helena, Montana 59620-0201

Ben Thomas
Director

406.444.3144 • Fax: 406.444.5409 • agr@mt.gov • www.agr.mt.gov

Montana Department of Agriculture

Jim Auer, Grants Coordinator

USDA AMS

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Contents

Determining the Role of Pathogens on Honey Bee Colony Health

Final Report - Accepted 2017

Project Summary

Background:

The long-term goal of the research is to improve the health of Montana's honey bee population by better understanding the role of pathogens, colony strength, and additional factors in the almond pollination system. Honey bees have a dual role in agriculture; they are producers of honey and essential pollinators of numerous specialty crops (i.e., cherries, almonds, apples, blueberries and legume seed). In 2013, Montana commercial beekeepers ranked 2nd in honey production producing 15 million pounds valued over $30 million.

Beekeepers generate a large part of their revenue through pollination services and the majority of Montana's commercial beekeepers transport their colonies to California each fall to pollinate the almond groves. In almonds, colony rental fees depend on colony health (frame counts). Almond pollination season is also when the majority of colony deaths occur; annual colony losses have averaged 32% since 2006. Honey bee colony losses attributed to Colony Collapse Disorder (CCD) are associated with pathogens, but the role of specific pathogen(s) in colony losses remain unknown. We hypothesize that pathogens play a primary role in colony losses.

To investigate the role of pathogens on colony losses we obtained honey bee samples from 50 colonies before, during, and after almond pollination season. We performed molecular diagnostics and quantitative assessment of 14 bee-associated pathogens, and analyzed data. Project success should be measured by the development of successful research collaborations, the number of samples assessed/analyzed, and statistical assessment of the correlation between pathogen incidence/abundance and colony health.

Timeliness:

Honey bees are important pollinators of agricultural crops that comprise much of the U.S. diet (valued at $15 billion annually) and species that augment the biodiversity of both agricultural and native landscapes. Since 2006, the U.S. honey bee pollination force has experienced increased annual losses (averaging 32%), which are partially attributed to Colony Collapse Disorder (CCD). Although previous research indicates that colony losses correlate with elevated pathogen incidence (i.e., viruses, bacteria, fungi, mites), neither the cause of CCD nor the reason(s) for increased colony losses have been identified.

Previous Funding:

This project is new and different, but it built on previously funded work. Dr. M. Flenniken received MT SCBGP support for a project entitled "Monitoring Pathogens and Health of Montana Honey Bee Colonies Before, During, and After Almond Pollination". The results from the first honey bee colony

monitoring project were informative, but because that study relied on beekeeper sampling and shipment, we did not always receive high quality, timely samples (i.e., frozen samples, obtained at specific dates). Data from this project indicate pathogen load correlates with colony health during almond pollination, and suggest that beekeeper and sample location influence pathogen incidence and abundance. This project builds upon results from previously funded work, but differs in that it (1) involves a collaborating bee biologist for sampling honey bees from one almond pollination area, (2) obtains/analyses new samples, and (3) it involves an additional Montana-based beekeeper. A Bee Biologist at Paramount Farms/Wonderful Orchards collected and shipped honey bee samples obtained from MT-based colonies involved in almond pollination at Paramount Farms/Wonderful Orchards in California. Colony health is directly tied to pollination service contracts; rental fees for larger colonies are greater. In addition, healthier colonies produce more honey. Therefore, honey bee colony health directly benefits Montana honey bee colonies, beekeepers, and honey production. Dr. Flenniken is an expert in honey bee health and molecular diagnostics, therefore it may be that in the future a fee-for-service diagnostics lab at MSU will be developed, which would make this project self-sustainable, but at this time grant funding is needed to support this research.

Project Approach

Activities:

We completed our goals/targets, objectives, outputs, and outcomes for this grant. Project Goals and Results Summary:

(1) Obtain honey bee samples before, during, and after pollination.

We continued collaborative relationships with a Montana based commercial beekeeper and a Bee Biologist at Paramount Farms / Wonderful Orchards in California, and obtained honey bee samples from 50 colonies of differential health (i.e., weak, average, and strong; using colony population size as a proxy for health). The samples were obtained in November 2015 (near Fort Benton, MT/ before almond pollination), in March 2016 (near Bakersfield, CA / during almond pollination), and in April 2016 (after almond pollination).

(2) Assess pathogen incidence and abundance in colonies of differential strength.

We assessed pathogen prevalence for 12 pathogens: (ABPV - Acute bee paralysis virus, DWV - Deformed wing virus, CBPV - Chronic bee paralysis virus, BQCV - Black queen cell virus, IAPV - Israeli acute paralysis virus, KBV - Kashmir bee virus, LSV1 - Lake Sinai virus 1, LSV2, LSV3, LSV4; Nos - Nosema ceranae, and Tryp -a trypanosomatid parasite (i.e., Lotmaria passim (formerly known as Crithidia mellificae), using pathogen specific PCR, in the honey bee samples collected for this study. Over 1,650 PCR-pathogen diagnostic tests were performed.

(3) We included a "target" of performing additional quantitative assessment, using 150 qPCR tests, but we far exceeded that target and carried out over 1,200 qPCR tests (which were performed in triplicate ? thus 3,600 tests).

(4) Increase public awareness regarding the role of honey bees as important pollinators and the factors affecting colony losses.

During this funding period Dr. Flenniken gave several public lectures on the importance of bee health to Montana agriculture (e.g., Café Scientifique March 2017, MSU Science Roadshow 10x10 Talks March 2017, and Museum of the Rockies Nov. 2016). Three graduate students in the Flenniken Lab (Laura Brutscher, Will Glenny, and Alex McMenamin) gave short presentations at the Pollinator Symposium in Bozeman on April 19, 2017.

(5) Increase stakeholder (beekeeper) knowledge regarding the role of pathogens in honey bee colony losses.

During this funding period Dr. Flenniken gave several lectures to beekeepers and bee researchers, including presentations to the Montana State Beekeepers Association during their annual October meeting. In addition, Laura Brutscher, a PhD student in the Flenniken lab, gave a presentation at the American Bee Research Conference (Jan. 2017).

Flenniken and students acknowledged MDA-SCBG funding at each of these events.

Benefits to other Commodities:

Not applicable

Significant Contributors:

- Montana Beekeepers provided bee samples
- Michelle Flenniken, Project Director - coordinated and analyzed data
- Katie Daughenbaugh - coordinated study, helped contact beekeepers throughout study, performed PCR and qPCR analysis, directed undergraduate and graduate student research assistants, assembled data
- Undergraduate and Graduate Students - assisted with sample collection, PCR and qPCR analyses
- Gordon Wardell, Bee Biologist, Paramount Farms / Wonderful Orchards, CA - assisted with sample collection

Goals and Outcomes Achieved

Activities Completed:

Project Activities included (1) Establish collaborative research effort with bee biologist at almond producer (i.e., Gordon Wardell, Paramount Farms, CA) and MT-based beekeepers, (2) Obtain first samples and train beekeeping staff, (3) Obtain samples before, during, and after almond pollination,

(4) Assess pathogen incidence in pooled samples by PCR , (5) Assess pathogen abundance in select samples by qPCR, (6) Complete data analysis and prepare final reports for beekeepers, MT Department of Agriculture, and for publication. We completed the majority of each of the Project Activities. Specifically, (1-3) we continued collaborative relationships with a Montana based commercial beekeeper and a Bee Biologist at Paramount Farms / Wonderful Orchards in California, and obtained honey bee samples from 50 colonies of differential health (i.e., weak, average, and strong; using colony population size as a proxy for health).

We obtained honey bee samples before, during, and after pollination. The samples were obtained in November 2015 (near Fort Benton, MT/ before almond pollination), in March 2016 (near Bakersfield, CA / during almond pollination), and in April 2016 (after almond pollination). (4-5) We assessed pathogen incidence and abundance in colonies of differential strength. We assessed the prevalence of 12 pathogens: (ABPV - Acute bee paralysis virus, DWV – Deformed wing virus, CBPV - Chronic bee paralysis virus, BQCV – Black queen cell virus, IAPV – Israeli acute paralysis virus, KBV – Kashmir bee virus, LSV1 - Lake Sinai virus 1, LSV2, LSV3, LSV4; Nos - Nosema ceranae, and Tryp -a trypanosomatid parasite (i.e., Lotmaria passim (formerly known as Crithidia mellificae), using pathogen specific PCR, in the honey bee samples collected for this study. Over 1,650 PCR-pathogen diagnostic tests were performed. We included a "target" of 150 qPCR tests, but we far exceeded that target and carried out over 1,200 qPCR tests (which were performed in triplicate – thus 3,600 tests). (6) We completed our final report for MDA, but are preparing this data for publication (i.e., performing additional analyses, generating informative figures, and writing the manuscript). We collected additional samples that we will analyze prior to publication.

Long Term Outcomes:

The goals of this project were completed and the data obtained will contribute to the long-term goal of better understanding the role of pathogens on honey bee colony losses. We obtained honey bee pathogen prevalence and abundance data for 50+ Montana-based honey bee colonies, which were primarily healthy during the samples collected as part of this funded project. We extended sampling, and during the extended period the health (i.e., population size) of many of the monitored colonies declined, therefore we plan to assess pathogen abundance in these samples.

Major successful outcomes in quantifiable terms:

We continued collaborative relationships with a Montana based commercial beekeeper and a Bee Biologist at Paramount Farms / Wonderful Orchards in California, and obtained honey bee samples from 50 colonies of differential health (i.e., weak, average, and strong; using colony population size as a proxy for health).

We assessed pathogen incidence and abundance in colonies of differential strength. We assessed the prevalence of 12 pathogens using PCR, in the honey bee samples collected for this study. Over 1,650 PCR-pathogen diagnostic tests were performed. We included a "target" of 150 qPCR tests, but

we far exceeded that target and carried out over 1,200 qPCR tests (which were performed in triplicate – thus 3,600 tests).

Beneficiaries

Description:

Montana beekeepers were impacted in the following ways (1) obtained data on the pathogen status of bees before, during, and after pollination, (2) obtained information on the relationship between colony strength and pathogen load, (3) further supported relationship with large-scale almond producer in California that rents numerous bee colonies each year, and (4) established a collaborative relationship with MSU scientists. Flenniken routinely speaks at International, National, State, and Local beekeeping association meetings. This work facilitated public understanding of the importance of honey bees and conveyed research findings to commercial beekeepers, scientists, small-scale beekeepers, and the general public. Lastly, undergraduate students involved in this project received advanced molecular pathogen diagnostic training.

Number of Beneficiaries:

We worked directly with a single beekeeping operation, and shared our results with ~ 50 Montana Beekeepers each year at the Montana State Beekeepers Association meeting. There are ~ 60 commercial beekeepers that manage ~ 150,000 honey bee colonies in Montana (Ian Foley, MDA).

In 2013 the rental fee was ~$175 per colony, thus Montana beekeepers collected ~$26.3 million for pollination services (Project Apis m.). Understanding the factors that contribute to the over 30% annual colony losses could lead to strategies that mitigate these losses and in the long-term will economically impact beekeepers, but an economic impact as a direct result of this study would be difficult to measure. We need to better understand the factors most responsible for honey bee colony losses before the economic impact of our research and recommendations can be measured.

Lessons Learned

Insights:

(1) Sample collecting needs to be improved.

The majority of samples were obtained, but we still experienced difficulty with sample collection. Surprisingly, the bee biologist that we worked with in California did not provide colony population estimates (i.e., frame counts) for the samples collected "during almond pollination" (i.e., March 2016). We emphasized the importance of this data in several letters, emails, and phone calls, but almond pollination season is a busy time for beekeepers and growers, and thus it is difficult to obtain quality samples during this time of year. That said, the samples were still usable because the colonies were strong enough to be accepted for the almond pollination contract.

(2) Larger number of samples needed. Due to the variable distribution of colony strength data, specifically the overwhelming number of strong, healthy colonies, our statistical analysis wasn't as robust as we predicted.

We initiated the study with colonies of variable strength (i.e., 15 each of weak, average, and strong), but may need even greater sample numbers for future studies.

(3) Longer monitoring of colonies, one year (with three sample dates) may be too short. The 50 colonies that were monitored as part of this study, were healthy during the study, but started to fail later in the year. Therefore, we continued to obtain samples.

Unexpected Outcomes:

As described above, this study enabled us to collect samples from failing honey bee colonies. If a collaborative relationship with a Montana-based beekeeping operation was not established via this grant, we would not have had the opportunity to collect these samples.

Outcomes Not Achieved:

Not Applicable

Contact

Michelle Flenniken
Assistant Professor- Ph.D.
Montana State University
215 Plant BioScience Building
406-994-7229
michelle.flenniken@montana.edu

Additional Information

None

Developing Integrated Weed Management Strategies for Organic Chickpea Production

Project Summary

Objectives:

1) **to evaluate commercial varieties and breeding materials in greenhouse for seedling vigor and N-fixation;**
2) **to evaluate integrated practices for improved weed control in organic systems. The variety evaluation will be conducted at the Eastern Agricultural Research Center.**

Chickpea (*Cicer arietinum*) is a cool-season legume. This crop has an exceptionally high nutritive value and is also an excellent rotational crop. Like other legumes, it adds nitrogen to soils, thereby reducing nitrogen input costs. In addition to N fixation, chickpea provides many additional rotational benefits, such as breaking disease cycles and conserving soil water.

The primary challenge to growing chickpeas is the pest management, particularly in organic production system where synthetic fungicides and herbicides are prohibited. Advances have been made in disease control with the recent development of varieties resistant to *Ascochyta* blight and use of *Ascochyta* free seed. Yet organic growers continue to be challenged by weed infestation. In a recent survey of Montana organic grain growers conducted by the Organic Advisory and Education Council, weed control is the most challenging agronomic issue for nearly 60% of producers, especially in pulse crops like chickpea.

Research on other crops has shown that improving crop vigor by breeding or increasing seeding rates can improve crop competition with weeds. However, these methods have not been tested in chickpea. In this project, we screened chickpea varieties with vigorous seedling establishment and high nitrogen fixation capacity. It is expected that these selected vigorous seedlings will enhance the crop competition with weeds, reduce disease infestation, and increase yield. In this project, we also investigated weed management strategies that integrate agronomic practices, such as increased seeding rate, shallow tillage and flaming before seedling emergence. The research was carried out at the Western Agricultural Research Center (WARC) and Eastern Agricultural Research Center (EARC) of Montana State University. To improve producer awareness of the integrated weed management, we held a field day annually at both EARC and WARC to disseminate the results to growers. We also presented the results to growers at Montana Organic Growers Association annual conferences.

Project Approach

The following objectives for the project were completed:

- Evaluate commercial varieties and breeding materials in greenhouse and field for seedling vigor and N-fixation.
- Evaluate integrated practices for weed control in organic systems.
- Increase stakeholder's knowledge

Related to Objective 1: Evaluate commercial varieties and breeding materials in greenhouse and field for seedling vigor and N-fixation.

Twenty-five breeding lines and named chickpea varieties were evaluated in the EARC research greenhouse and on the dryland farm. Seedling emergence, above and below

ground biomass, and final seed yield were measured to assess the seedling vigor in relation to final seed yield (see attached manuscript).

Related to Objective 2: Evaluate integrated practices for weed control in organic systems.

Field trials that combined two varieties (Black chickpea and CDC Orion), two seeding rates (1.0x and 1.5x), and two pre-emergent weed control practices (flame weeding and shallow tillage) plus an untreated control were carried out at EARC and WARC in 2016, 2017, and 2018. We evaluated the efficacy of the treatments on stand densities and weed biomass early in the growing season, and final yields. Increasing seeding rates consistently increased yields. The black chickpea variety had consistently higher stand densities and yields relative to the CDC Orion possibly due to higher vigor and better competition with weeds. Flame weeding was not effective at either reducing weed biomass or increasing chickpea yields. Shallow tillage did increase yields and reduce weed biomass although effects on yields and weed biomass depended upon timing of application. Results suggest that competitive varieties, increasing seeding rates, and shallow tillage can be successfully integrated to improve yields and reduce weed pressure in organic chickpea, but efficacy of shallow tillage depends strongly on proper timing and is affected by planting date and weather conditions. Therefore, selecting chickpea varieties with early seedling vigor and competitive to weeds is a promising approach.

Related to Objective 3: Increase stakeholder's knowledge.

Field days held annually at EARC and WARC. About seventy people attended the EARC dryland field day and 160 people attended the WARC field day.

Benefits to other Commodities:

N/A

Significant Contributors:

Goals and Outcomes Achieved

Activities Completed:

Any chickpea cultivar is identified to have 1) high seedling vigor index, and 2) high N-fixation ability: We evaluated 23 commercial varieties and breeding lines. We found a few Kabuli chickpea showed greater vigor. One desi chickpea was found to use growth resource more efficiently and produced a higher yield. We also found significant difference in chickpea nodule number and weight.

Percentage of weed control in the alternative agronomic practices: Shallow tillage decreased weed biomass by 27% in Corvallis and 42% in Sidney; Black chickpea field has 13% less weed biomass in Corvallis and 40% less weed biomass in Sidney; and weed biomass was reduced by 4% in Corvallis and 15.8% in Sidney when the seeding rate was increased by 50%. These practices increased chickpea grain yield too (see data attached). Shallow tillage is effective in control weeds, but is constrained by weather condition. Therefore, variety selection is the most promising approach to compete with weeds and increase chickpea yield in organic production.

Number in attendance at the Field Day at EARC and WARC where results of research are disseminated: Around 70 people attended the EARC dryland field day and 150 people attended the WARC field day each year.

Long Term Outcomes:

None

Major successful outcomes in quantifiable terms:

We evaluated 23 commercial varieties and breeding lines. Around 70 people attended the EARC dryland field day and 150 people attended the WARC field day each year.

Beneficiaries

Description:

Current or potential Montana chickpea farmers

Number of Beneficiaries:

500

Lessons Learned

Insights:

The EARC research site has been operated without chemical herbicide for a decade. Therefore, there are a lot of weed seeds in the soil. Although the shallow tillage controlled the emerged weeds, the weed seed bank in the soil continued to emerge, which made the shallow tillage less effective at the EARC site. The lesson we learned is that growers must prevent the seed bank building up in the soil in the organic production system.

Unexpected Outcomes:

N/A

Outcomes Not Achieved:

N/A

Contact

Chengci Chen
Professor of Agronomy/Superintendent
Eastern Agricultural Research Center
Montana State University
1501 N Central Ave.
Sidney, Montana 59270
Phone: 406-433-2208
cchen@montana.edu

Additional Information

Development of Pheromone Based Monitoring and Mass Trapping for Pea Leaf Weevil in Pulse Crops

Project Summary

Objectives:
(1) Develop an efficient pheromone trap for catching pea leaf weevil,
(2) Implement and evaluate effectiveness of mass trapping as a management tool for pea leaf weevil
(3) Disseminate information in local, regional, and national media for use and testing in other pulse growing regions.

Field pea, *Pisum sativum* (L.) (Fabales: Fabaceae), is a significant pulse crop worldwide and in the United States, 0.5 million hectares were planted in 2017. Presently, Montana is one of the leading pulse producers in the United States, ranking #1 in field pea, producing 48% of the U.S. crop. Field peas are grown as an annual crop for human consumption (whose benefits include high fiber, low fat, high protein, and low glycemic index) and their cultivation improves soil health and provides crop biodiversity.

The pea leaf weevil, *Sitona lineatus* (Coleoptera: Curculionidae), is a major pest of field peas and faba beans, *Vicia faba* (L.) (Fabales: Fabaceae), worldwide. This weevil is believed to be of European origin, but has spread to most field pea regions of the world, including Asia, Africa and North America over the last 50 years. In North America, this pest was first reported in 1936 by Downes. In Montana, *S. lineatus* has been a serious economic pest of field pea in most of the state's pulse growing region since 2010.

Sitona lineatus is typically univoltine and in the fall, adults migrate to field shelterbelts, alfalfa fields, and roadside areas where they feed on secondary leguminous hosts before

overwintering in soil. In spring, when temperatures reach 12.5 °C, overwintered adults emerge and move into new plantings of field peas. Oviposition, larval development, and pupation all occur in the soil. New adults emerge in late summer and migrate to secondary hosts to overwinter. Adult feeding on pea seedlings leaves characteristic ''U'' shaped notches along the leaf margins. Both larvae and adult feeding reduces photosynthesis, pod production, and formation of root nodules. Larvae feed on the rootlets and on *Rhizobium* root nodules, causing weak root growth and decreasing nitrogen fixation. In addition, larval feeding reduces seed protein content, particularly in nutrient-poor soils, as well as the amount of nitrogen returned to the soil. It is believed that adults have less effect on yield than larvae, but this remains to be quantified. El-Dessouki reported in 1971 that infestation of pea plants with 100 *S. lineatus* eggs per plant reduced yield by 27%.

In North America, pea leaf weevil management is currently based on the use of imidacloprid or thiamethoxam treated seeds, combined with foliar applications (often in combination with insecticide or fungicide products) if adult damage levels reaches 30% (3 out of 10 plants along a seed row) during the 2nd to 6th node stages of field pea growth. However, foliar insecticide applications alone have not been found to effectively protect yield. In addition, current adult damage assessments are often labor intensive, time consuming, requires repeated sampling and is not highly reliable as adult feeding is temperature dependent. For this reason, the development of other pest monitoring methods, such as semiochemical-based traps could improve pea leaf weevil management.

There is substantial worldwide interest in the development of a pheromone-trap monitoring system and management program for *S. lineatus*. Blight et al. in 1984 were the first to run bioassays on an adult male-produced aggregation pheromone of this weevil that was found to attract both males and females. They later in 1991 isolated, identified, synthesized and assessed the attractiveness of the active component of this pheromone, 4-methyl-3,5-heptanedione. Field studies conducted worldwide have shown that this pheromone attracts both males and females in both spring and fall. In addition, Landon et al. in 1997 showed that adults are also attracted to host plant volatiles in both spring and fall. The use of pheromone-baited traps offers a convenient and potentially potent tool for monitoring *S. lineatus* adult populations. Work on pheromone traps for *S. lineatus* has been conducted since the pheromone compounds was first identified and being used for monitoring. This trap allows early detection of the pest and allows differences in within-field pest infestations to be measured. The use of pheromone traps for this pest can improve decision-making in pea leaf weevil management.

Insect capture in pheromone-baited traps can be influenced by several factors, including trap design (e.g., type, color, height and placement), lure type, pheromone dose, and environmental conditions during the trapping period. Except for studies by Nielsen and Jensen in 1993 and by St. Onge et al. 2017, that demonstrated that pheromone-baited cone and pitfall traps are effective in capturing adults, little information is available on how to optimize monitoring *S. lineatus* adults with pheromone traps. Here, we report field studies

to assess the effects of trap and lure type and trap placement on adult pea leaf weevil catch to further enhance the trap efficacy for this pest.

Describe the importance and timeliness of the project

This project is timely because, although Montana, North Dakota, Saskatchewan are initiating control methods for the pea leaf weevil based on the sweep nets, this method has not been reliable for timing of insecticidal applications. Secondly, there is no current monitoring for the pea leaf weevil that allows growers to make decisions about their timing of insecticidal applications. Without monitoring and raised awareness now, we are highly likely to lose yield levels due to pea leaf weevil in pulse crops. Therefore, the development of pheromone based monitoring methods is both novel and timely. As well, pheromone baited traps will help in monitoring and mass trapping the weevil population. Pheromone based systems also have the ability to incorporate this pest into state or nationwide monitoring efforts in order to accurately predict pest populations not only in this season, but also across seasons through modeling of pest population dynamics. The Pestweb website (pestweb.montana.edu) in an ongoing pheromone based monitoring project in which our research team is involved. This project is a web based volunteer system where participants maintain pheromone traps in their area. When traps are monitored across a wide-area, farmers can see localized hot-spots of activity before they are impacted directly and may then take appropriate action. This type of monitoring is immensely powerful, but cannot be accomplished without first establishing a monitoring system.

Project Approach

Activities:

Montana is the number one pulse producer in the United States. Forty-six percent of the country's lentil production occurs in Montana. Growing pulse crops in crop rotations benefits soil productivity by creating macropores in the soil and through nitrogen fixation. Damage caused by pea leaf weevil, particularly the root nodule damage by the larvae significantly affects nitrogen fixation. Previous studies reported that even a low level of weevil infestation can reduce crop yield. The presence of 2 adult weevils per ten plants can reduce the number of seeds by 18% and larval abundance ranging from 4.3 to 13.5 larvae per plant can destroy up to 48% of nodules on the primary roots. Negative impacts of larval and adult damage severely impact the grower's initiative to grow susceptible legume crops. With proper monitoring tools farmers will be better able to identify pest risk and take appropriate action. Pheromone based traps developed for Montana will give farmers the tools they need to properly manage for pea leaf weevil, identify sources of the pest, and mitigate them before they cause widespread damage to their crop. Best management practices need to be continually updated as pulse crop acres increase in the state. The development of this

monitoring technology goes a long way toward developing an effective pest management plan for pea leaf weevil in the state of Montana. The result of which could mean higher yields and greater profits from the already existing acreage, but also potential expansion of the market as relative profits increase in the market.

Effective Trap type

Regardless of experimental site, more *S. lineatus* adults were caught in traps baited with pheromone lures than in control traps. There were no significant differences in adult captures in control traps among fields (southern: $\chi^2 = 4.56$; $df = 3$; $p = 0.21$, Kruskal–Wallis test; central: $\chi^2 = 3.11$; $df = 3$; $p = 0.38$, Kruskal–Wallis test). Most adults were caught early in spring, with nearly 90% of captures occurring in April or May, 2016. The average number of adults caught per trap and collection period declined over with the growing season. Among experimental sites, adults were caught in higher numbers in northern followed by central and southern areas of the Golden Triangle region. Trap type had a significant impact on adult captures at all study clusters (southern: $\chi^2 = 18.27$; $df = 3$; $p < 0.001$, Kruskal–Wallis test; central: $\chi^2 = 26.67$; $df = 3$; $p < 0.0001$, Kruskal–Wallis test; northern: $\chi^2 = 8.56$; $df = 3$; $p = 0.03$, Kruskal–Wallis test). At the southern and central field clusters, significantly higher number of adults were caught in pitfall and ramp traps baited with pheromone lures than in ground or delta traps, while there were no significant differences in adult captures between pitfall and ramp traps or between ground and delta traps. Similarly, at the northern field clusters, pitfall and ramp traps caught higher adult populations than ground and delta traps but without significant differences. Across fields, the range of mean number of *S. lineatus* captures per trap and collection period for pitfall, ramp, ground, and delta traps varied from 11-64, 9-57, 0.27-5 and 1-4, respectively, irrespective of study clusters. Although ramp and pitfall traps were equally effective, the pitfall traps was selected for all further experiments because it is less expensive and easily fabricated.

Effective Lure type

Lure type significantly affected mean *S. lineatus* adult trap captures in the pea fields, with rubber septa lures capturing more weevils than traps with membrane lures or unbaited controls at all experiment clusters (southern: $\chi^2 = 10.38$; $df = 2$; $p < 0.01$, Kruskal–Wallis test; central: $\chi^2 = 13.12$; $df = 2$; $p < 0.01$, Kruskal–Wallis test; northern: $\chi^2 = 10.07$; $df = 2$; $p < 0.01$, Kruskal–Wallis test). Average seasonal total catch in the southern clusters were 43.37 ± 3.66 per pitfall trap baited with rubber septa, 21.12 ± 1.77 baited with membrane lure and 10.00 ± 1.26 for unbaited traps. In the central clusters, mean adult captures were 40.75 ± 6.89 per pitfall trap baited with rubber septa, 14.50 ± 0.60 baited with membrane lure and 10.75 ± 0.85 for unbaited traps. The corresponding values at the northern clusters were 27.00 ± 4.25, 10.33 ± 1.17 and 4.16 ± 1.01, respectively. Similarly, in the lentil fields, significantly higher numbers of adults were recorded for the pitfall traps baited with rubber septa compared to those baited with membrane lures and unbaited traps at all experiment clusters (southern: $\chi^2 = 7.95$; $df = 2$; $p = 0.02$, Kruskal–Wallis test; central: $\chi^2 = 9.99$; $df = 2$; $p = 0.01$, Kruskal–Wallis test).

Trap placement

We found no significant differences in *S. lineatus* adults captured in pitfall traps placed in northern and southern parts of pea fields ($\chi^2 = 1.19$; $df = 2$; $p = 0.27$, Kruskal–Wallis test). However, there was a tendency to capture relatively higher numbers in the southern parts (48.33 ± 24.89 [SE]) compared with the northern parts (23.68 ± 7.89 [SE]).

Plant volatiles mediate orientation behavior of pea leaf weevil

Volatiles emitted by pea leaf weevil-infested plants elicited stronger behavioral responses in pea leaf weevil males and females than uninfested healthy plants. Odors from mechanically damaged plants also attracted the pea leaf weevil. Therefore, the results suggest that odors from pea leaf weevil and mechanically infested plants are attractive to pea leaf weevil.

Bio-pesticides against Pea Leaf Weevil Sitona lineatus (L.) Adults

Overall, this study showed that all tested bio-pesticide products have abilities to cause mortalities on pea leaf weevil adults. However, the difference in pea leaf weevil adult mortalities were observed across products or at their concentration levels. Among the five tested products, Spinosad (Entrust WP®) seems to be most effective product, Mycotrol ESO® and Xpectro OD® as moderately effective and the Xpulse OD® and PyGanic EC® as less effective products. The total mean mortality of pea leaf weevil adults caused by bio-pesticide products ranged from 16 to 100% for Spinosad product, 9 to 64% for Mycotrol ESO® product, 9 to 63% for Xpectro OD®, 7 to 36% for Xpulse OD® and 5 to 21% for Pyganic EC®. The similar results were also found for fall population of pea leaf weevil adults but with slightly lower mortalities (from 8-10%) for Mycotrol ESO® and Xpectro OD® bio-pesticide treatments.

Benefits to other Commodities:

This project has impacted pulse growers in the Golden Triangle by providing the information on the damage and yield loss attributable to this pest insect. It will slowly increase awareness and initiate appropriate control strategies. Moreover, the project staff worked with stakeholders and industry people other than specialty crops. The extension articles and scientific papers were published that were informative and reference materials for the general readers and community. The pheromone techniques developed in this project were useful and can be adapted for another insect pest organism also.

The potential to effectively treat a pest with a low cost monitoring/mating disruptor decreases the need for pesticide applications. Low pest levels can be accurately assessed and chemical applications can be avoided. Furthermore, effective monitoring improves pesticide efficacy through appropriate application timing. The ability to predict and treat pest problems has the potential to increase the competitiveness of peas and lentils in the market as greater yields result in greater profit per acre for the farmer. This project is the first step toward developing strategies to reduce yield losses due to pea leaf weevil.

Significant Contributors:

Dr. A. C. Oehlschlager: ChemTica Internacional SA (Costa Rica): Two types of pheromone lures- a gray rubber septum and membrane, each impregnated with 4-methyl-3,5-heptanedione were provided.

The authors would like to thank several pulse growers from the Golden Triangle, Montana for providing the field sites to conduct experiments.

We would also like to thank summer intern Kendell Frank and research associate Ramadevi Gadi (WTARC, Montana State University) for their help with insect sampling.

We also appreciate the three anonymous reviewers for the critical comments of the published paper.

The principal investigator Gadi V.P. Reddy conceived and designed the experiments; Debra A. Miller performed the experiments; Govinda Shrestha, Gadi VP Reddy and A. C. Oehlschlager analyzed the data and wrote manuscript. All authors have read and approved the manuscript.

Goals and Outcomes Achieved

Activities Completed:

The following goals were achieved.

1. Developed a reliable pea leaf weevil monitoring platform for use in pulse crops.
2. Tested the efficacy of biopesticides against pea leaf weevil.
3. Integration of pheromone monitoring into integrated pest management strategies and forecasting of potential pest outbreaks.
4. Several outreach presentations and training workshops were presented to growers during field days.
5. The method of monitoring of pea leaf weevil populations were disseminated to the county extension agents.

The following activities were successfully completed

1. Developed an efficient pheromone trap with trap design, placement and lure type for catching pea leaf weevil.
2. Determined the trapping of pea leaf weevil from major pulse growers in the region.
3. Identified the pest status in the grower's field and region.
4. Disseminated the information in local, regional, and national media for use and testing in other pulse growing regions.

5. Published one scientific and several new paper articles.

Long Term Outcomes:

Although it will be hard to determine economic impact of the project, the project has significantly reduced the pea leaf weevil damage. Damage from this pest can account for as much as 30% yield loss. The trapping technique could be easily adapted to other areas. The crop is of high value and we are being determined what the damage levels and extent of chemical control methods being used. Since the trapping technique could be used for mass trapping and mating disruption, the insecticidal sprays could be reduced or avoided. Therefore, millions of dollars could be saved across the growing region in the coming years.

Major successful outcomes in quantifiable terms:

1. This study has provided the information on the pheromone trapping technique for maximization of trapping pea leaf weevil.

2. This project identified the biopesticides that can be used to reduce or eliminate the high risk pesticides for the control of pea leaf weevil.

3. The possibilities of including the trapping technique into an integrated pest management will be explored with other researchers and stakeholders.

4. The generated information from the project has been disseminated through various media so that growers will use this technology.

Beneficiaries

Description:

The beneficiaries of this project are the pulse industry growers, ag professionals and stakeholders in Montana. This includes businesses that provide consulting and pesticide sales. The project also provided an opportunity to work with our international partners from Spain (Dr. Angel Guerrero) and Costa Rica (Dr. A. C. Oehlschlager).

The group was able to learn the mass rearing and sex differentiation of the pea leaf weevil.
Identified and fabricated on our own different pheromone traps for pea leaf weevil.
Got good cooperation and acquaintance from the pulse growers.
Published several research and extension publications.

Number of Beneficiaries:

Although it is difficult to count the number of beneficiaries, it is expected that at least 2000 pulse growers are directly benefited from this project.

Lessons Learned

Insights:

The project staff were able learn lots of methods and techniques pertaining to the project. Our staff was able to learn in identifying the sex of pea leaf weevil from the collaborators from Canada. The monitoring method for pea leaf weevil is very useful and friendly tool in monitoring so the growers were very interested in implanting this method in their field.

Unexpected Outcomes:

There were no any unexpected outcomes or results that were an effect of implementing this project as all the goals were achieved.

Outcomes Not Achieved:

There were no any unexpected outcomes or results that were an effect of implementing this project as all the goals were achieved.

Contact

Gadi V.P. Reddy, Ph.D.
Professor of Entomology/Insect Ecology
Montana State University-Bozeman
Western Triangle Agricultural Research Center
9546 Old Shelby Rd., P. O. Box 656
Conrad, MT 59425, USA

Additional Information

The performing institute website: http://agresearch.montana.edu/wtarc/index.html

Contributor

Pest Management Strategic Plan for Pulse Crops (Chickpeas, Lentils, and Dry Peas) in the United States, 91p.

Pulse Crop Insect Diagnostic Series, Insect cards (Pea Weevil), (Editor: Janet K. Knodel), North Dakota State University.

Presentations

Cropping Seminar, Shelby, MT, Integrated Pest Management Updates in the Golden Triangle Areas of Montana, January 10, 2017.

Biological Control of Montana Pests, Northern Ag Research Center Ag Technology and Science Tour, Havre, MT, May 26, 2017.

Good and Bad Bugs, Elementary School Children, Youth Services at the Great Falls Public Library, May 24, 2017.

2017 Spring Pest Update, Broadwater County Extension, April 06, 2017.

Pulse Crop Pest Management Strategic Planning Workshop, Bozeman, MT, November 09–10, 2016.

Pulse Insect Pests and Their Management, Hill County Pulse Meeting, Havre, MT, January 13, 2017.

Western Triangle Ag Research Center-Insect and Crop Updates, Knees School, March 2016.

Entomology research work at Western Triangle Ag Research Center to the Glacier County Growers Field Day (Glacier County Conservation District), Cut Bank, MT, July 28, 2015.

Alternative Crop Entomology Program, Kremlin, MT, June 23, 2015.

Developing Integrated Pest Management Program for Insects in the Golden Triangle Agricultural Areas of Montana during "2015 Golden Triangle Cropping Seminars" at different locations in Montana (Fort Benton, Chester, Shelby, Cut Bank, Conrad, Chouteau, Great Falls, and Stanford) January 12–15, 2015.

Media publications (PDFs are available, http://agresearch.montana.edu/wtarc/news.html)

Traders Dispatch: Southern cowpea weevil appears as new pest on pulse crops. October 2018.

Traders Dispatch: Pulse entomology experts exchange ideas". December 2017.

Farm & Ranch Guide: New damaging pest in Montana: Pea weevil actually a beetle, February 03, 2017.

Traders Dispatch: "Developing management strategies for the pulse insect pest". July 2017.

The Prairie Star:" Ground-breaking pheromone research at WTARC 'catches' pea leaf weevil". February 03, 2017.

Farm & Ranch Guide: "New damaging pest in Montana: Pea weevil actually a beetle". February 03, 2017

Traders Dispatch, Watch out for a new pest in Montana – pea weevil, September 2016.

Montana AgAlerts-

Montana Ag Alerts: "Cutworm incidence and damage on peas". May 23, 2017. Montana Ag Alerts: "Pea leaf weevil on chickpea". May 22, 2017.
Montana Ag Alerts: "Insecticides for pulse crops (Cropland Insects)". March 08, 2017.

Publications (peer reviewed journals)

G.V.P. Reddy, G. Shrestha, D.A. Miller, and A. C. Oehlschlager. 2018. Pheromone-trap monitoring system for pea leaf weevil, *Sitona lineatus*: Effects of trap type, lure type and trap placement within fields. *Insects* 9: doi:10.3390/insects9030075.

Reddy, G.V.P. 2018. Editorial: Special issue on pulse crop insect pests and their management strategies: An emerging concern. *Annals of the Entomological Society of America* 111: 137–138.

Reddy, G.V.P., A. Sharma, and R.L. Gadi. 2018. Biology, ecology and management of the pea weevil, *Bruchus pisorum* (Coleoptera: Chrysomelidae). *Annals of the Entomological Society of America* 111: 161–171.

Gahukar, R.T., and G.V.P. Reddy. 2018. Management of insect pests in the production and storage of minor pulses. *Annals of the Entomological Society of America* 111: 172–183.

Economic Benefits from Certified Virus Screened Potatoes

1. Estimate the cost of PVY to commercial potato growers in Idaho, Oregon, and Washington, the top commercial potato-producing states to which Montana ships seed.
2. Estimate the economic benefits from planting PVY-screened seed to growers.
3. Estimate the economic benefits of the Montana Seed Certification Program to the three-state region as a whole. (Many of these regions source a large portion of seed potatoes for commercial production (ranging from 15-37%).
4. Create online decision tool that illustrates tradeoffs between disease in seed and end of season losses, yield, and net revenue.

Project Summary

Potato Virus Y (PVY, also known as Potato Mosaic Virus), the most important virus disease of potatoes worldwide, has large current and potential impacts on seed and commercial potato production throughout the United States. Montana has the premier seed potato program in the

country and produces roughly 10 percent of all seed potatoes planted in the United States. PVY is spread from infected plants by aphids and often results in decreased yield and quality of potatoes. Yield losses of up to 80% have been reported from PVY. The most effective method of avoiding losses from PVY is the planting of virus-free seed. The Montana Seed Potato Certification Program housed at Montana State University provides testing and certification for a variety of viruses including PVY. While Montana-grown potatoes sold for seed are required to be certified, this is not the case for all states. Many commercial potato growers (those that sell potatoes for processing, chipping, and fresh) are unaware of the importance of PVY, and of planting certified seed. Specific information that quantifies the benefits of using certified seed will allow growers to make better, more informed decisions about whether to plant certified seed. We obtained data and drew upon existing economic models for Idaho, a major purchaser of Montana seed. We estimate the total benefit of Montana's program to Idaho to average $8,518 per acre or $897 million in total over a 15-year time horizon.

This project reflected a growing desire for cost-benefit analysis of programs to understand and quantify how and if important economic objectives are being met. By examining the costs and benefits of using certified seed at both the producer and state/regional levels, we were able to obtain information that is valuable to stakeholders in establishing the value of using certified seed and the value of the Montana Seed Potato Certification Program.

Project Approach

Activities:

Work Plan Items

Met and interviewed growers at the Seed Potato Board of Directors Meeting in 2016.

Attended, presented and met with growers and other researchers at the Montana Seed Potato Seminar (2016)

Presented at Idaho Seed Potato Seminar and Idaho Potato Conference.

Analyzed disease test data, estimated economic costs of PVY and benefits of certification program. Drafted an article documenting findings for submission to Agribusiness.

Created web-based decision tool for seed and commercial growers estimating value of disease-free seed.

Published article on genetic engineering and variety selection in potatoes: https://doi.org/10.1093/ajae/aax098

Completed draft of online decision tool: http://msuextension.org/econtools/pvy_calc/

Fuller presented at the MSU Dept of Ag Econ and Econ Outlook Conference in November 2016

Fuller posted on the AgEconMT blog (http://ageconmt.com/spooky-scary-pests-diseases/)

Fuller and Zidack recorded a podcast for the AgEconMT blog (http://ageconmt.com/podcast-episode-013-montanas-seed-potato-industry/)

Fuller presented at the Australian Agricultural and Resource Economics Society Meeting in February, 2017

Fuller presented at the annual meeting of the "Impact Analyses and Decision Strategies for Agriculture" NIFA multistate group in February, 2017

Fuller and McIntosh presented at the Agricultural and Applied Economics Association Meeting in July, 2017

Fuller and Zidack guest lectured in an agricultural economics class in April, 2017 and April, 2018.

Benefits to other Commodities:

N/A

Significant Contributors:

The main project partners were Chris McIntosh, Professor of Agricultural Economics and Department Head of Agricultural Economics and Rural Sociology at the University of Idaho and Nina Zidack, Director of the Seed Potato Lab at Montana State University. Zidack provided data on PVY testing that we used to estimate disease spread from season to season. She also provided opportunities for meetings with growers and coordinated several presentations in Montana. McIntosh assisted and advised on the statistical analysis and available economic models of the potato industry. He also coordinated opportunities to present findings in Idaho and at national agricultural economics meetings.

Goals and Outcomes Achieved

Activities Completed:

Long Term Outcomes:

We are still finalizing checks on our working paper, as well as soliciting feedback on it. We plan to submit the paper before the end of the calendar year.

Major successful outcomes in quantifiable terms:

We found strong evidence of a net benefit to PVY screening in seed potatoes--an average annual net benefit of $568 per acre from Montana certified seed to Idaho growers over a 15-year time horizon.

We reached 1927 individuals with information regarding the economic importance of PVY and PVY screening through presentations, blog posts, the decision tool, a podcast, and Fuller's first topic-related article.

Beneficiaries

Description:

This project provided benefits to Montana seed potato growers, as well as commercial growers that use Montana-sourced seed, by providing them with information regarding the importance of using certified seed and funding the Montana Seed Certification Program through acreage fees.

Number of Beneficiaries:

We estimate 1927 people were reached by metrics we can track directly. More are likely since AgEconMT blog posts and articles written in the American Journal of Agricultural Economics are often picked up by secondary news sources.

Lessons Learned

Insights:

This project grew over time, and in fact continues today. If I were to go back and apply for funding, I would have extended the time period over which the outcomes were promised instead of doing that later. But overall, I learned a great deal about the seed and commercial potato industries in the Northwest. I have since obtained funding and participated in three federal potato-related grants through USDA SCRI that are directly related to knowledge I gained through this project.

Unexpected Outcomes:

N/A

Outcomes Not Achieved:

All goals were achieved, although some took longer than anticipated initially.

Contact

Kate Fuller
Box 172920
Bozeman, MT 59715
406-994-5603
Kate.fuller@montana.edu

Additional Information

N/A

Integrated Pest Management of Insect Pests in Fruit Trees

Project Summary

Objectives

- **Survey and monitor tree insect pests in several commercial orchards in western Montana including the invasive spotted wing Drosphila and the brown marmorated stink bug**
- **To test whether tree fruit pest densities are lower in orchards managed with integrated pest management techniques versus conventional**
- **Develop and publish a MontGuide on Montana fruit tree insect pests**
- **Awareness and outreach for the brown marmorated stink bug and spotted-wing Drosphila through training of "first detectors"**

This project addressed insect pests of concern and potential invasive insects for tree fruits in Montana. Monitoring for key pests was conducted in commercial apple fields in the Bitterroot Valley of Montana. An ultimate goal of this project was to determine what invasive insect species are currently present in Montana, increase the ability of growers and county agents to identify and manage these pests, and reduce the impact of invasive insects on our tree fruit industry. Several communities throughout Montana grow and maintain fruit trees in their urban environments and can benefit from knowledge of insect pests and their management for apple trees. Monitoring of insect pests in commercial orchards will also help to prevent economically-damaging insects from entering the urban environment. Additionally, the brown marmorated stink bug, *Halyomorpha halys*, a potential invasive insect, has not yet been detected in Montana. It is a pest of agricultural crops, woody ornamentals, and is also a nuisance home invader. Monitoring and early detection is critical to reduce potential economic impacts of this pest.

This project is important because tree fruits are a common commercial crop in Montana. The brown marmorated stink bug, though not yet detected in Montana, is established in 44 states and attacks over 170 different plant species. In particular, it is a serious pest of economic importance for tree fruits and has caused more than $37 million worth of damage in the mid-Atlantic states in 2010. Early identification and rapid response to contain this important pest will be necessary to mitigate its damage to our tree fruit industry. The spotted-wing Drosphila, *Drosphila suzukii*, was first found by Montana growers in 2011 and became established in Flathead and Lake Counties. Monitoring of this pest in other counties is important.

Project Approach

Activities:

Biweekly sweep net and beat sheet samplings were conducted June through September in 2016 and June through September in 2017. The sorting and processing of samples was completed during the fall/winter months of 2016, 2017, and 2018. Samples were sorted for pests and predators of economic importance.

Brown marmorated stink bug traps were placed at six sites in 2016 and 2017 and five sites in 2018 (May through September). Traps were placed at one site in the Bitterroot (Stevensville, MT) to monitor for the spotted wing *Drosphila* and the apple maggot from July through September in 2017. Spotted-wing *Drosphila* traps were placed at three additional sites July through September 2018 (Bozeman-*several small fruits*, Hamilton-*cherries, blackberries*, and Corvallis-*several small fruits*). One additional apple maggot trap was placed in a Corvallis apple orchard in 2018. The spotted-wing *Drosophila* was detected in a spotted-wing *Drosphila* trap in Hamilton, MT (Ravalli County) on July 30, 2018 at a cherry orchard that also grows blackberries. This is the first time the pest has been detected in the county, to date. Neither the brown marmorated stink nor the apple maggot were detected during the study period.

Benefits to other Commodities:

N/A

Significant Contributors:

N/A

Goals and Outcomes Achieved

Activities Completed:

A total of 18,527 arthropods from 11 orders were collected in the 2016 and 2017 sampling seasons (17,540 from sweep net sampling and 987 from beat sheet sampling). I specifically looked for pests/predators of economic importance. I also looked for potential invasive insects. Spiders were identified to the family level with two subsequent student research projects resulting from this study. Additionally, the life history of several arthropods in apple orchards in Montana is further understood.

A workshop targeted at beginning orchardists was held in Missoula on March 14, 2018, entitled "Integrated pest management in Montana apple orchards". Thirty-five people were at the workshop. Insect and arthropod pests were discussed in addition to weed management. Also, Dr. Ken Johnson, a world-renowned fire blight expert, was invited as a speaker for the workshop with funding from this grant. Ninety-four percent of the workshop attendees that responded to the survey (16 people) found the workshop content useful. Sixty-three percent found the workshop very useful. Seventy-five percent of the workshop attendees indicated that they were likely to make management changes based on material learned at the workshop. Seventy-five percent also found that the information learned at the workshop will help the grower/s increase their revenue.

I also mentored and advised two students, Katelin Hancock and Megan McGill (Hager), on the identification of the spiders collected from the 2016 and 2017 samples. Two projects resulted from these samples. For Megan McGill (2016), her undergraduate research project was entitled, "Influence of management practices on spider communities in six apple orchards in the Bitterroot Valley, Montana" and a research paper was also written. A total of 190 spiders from 11 different families were sampled. Five families of hunting spiders (Anyphaenidae, Philodromidae, Thomisidae, Salticidae and Lycosidae) and five families of web building spiders (Araneidae, Dictynidae, Linyphiidae, Tetragnathidae and Theridiidae) were collected. We found that both the density and diversity of

spiders were greater in the orchards using more integrated pest management techniques compared to the more conventionally managed sites. Katelin Hancock (2017) also conducted an undergraduate project from this study. She identified the spiders from 2017 and her project was entitled, "Density and diversity of spiders in managed and unmanaged apple orchards in western Montana". A total of 171 spiders from 10 families were collected from all orchards in 2017 (103 from sweep net and 68 from beat sheet samples). We found that management practices had an impact on spider density and diversity in the orchards. Our data show that density and diversity were higher in the sites that were managed with less insecticide use and were highest at sites with increased surrounding vegetation. Katelin presented a poster as part of the Undergraduate Scholars Program's Annual Conference at Montana State University in Bozeman, MT in April of 2018 and at the Buffalo Undergraduate Conference in Niagara Falls, NY in July 2018. All spiders from 2016 and 2017 samplings have been identified to family and presented in professional posters and papers. Both the density and diversity of spiders in several apple orchards in the Bitterroot Valley of Montana have been described.

Four additional talks were given by the PI, Lauren Kerzicnik, during the course of this study on tree fruit pests, where apple pests were discussed as well as potential invasive insects that might enter Montana.

Long Term Outcomes:

I updated and added Montana-specific insect information to the *Intermountain Tree Fruit Guide* (in collaboration with Utah State, Idaho State, and Colorado State Universities). It is a publication geared toward commercial fruit tree growers. An updated 2018 version is available online. ***www.intermountainfruit.org***

Major successful outcomes in quantifiable terms:

- A total of 18,527 arthropods from 11 orders were collected in the 2016 and 2017 sampling seasons (17,540 from sweep net sampling and 987 from beat sheet sampling).
- Pest updates for the brown marmorated stink bug and spotted-wing *Drosphila* were included in the *Intermountain Tree Fruit Guide.* One hundred of these guides were ordered with funds from this grant, and these guides were distributed to attendees of the beginning orchardists pest workshop. Additional copies were given to the Western Agricultural Research Center and the Missoula and Ravalli County Extension Agents for distribution to orchardists in the Bitterroot Valley of Montana.
- The spotted-wing *Drosophila* was detected in a spotted-wing *Drosphila* trap in Hamilton, MT (Ravalli County) on July 30, 2018 at a cherry orchard that also grows blackberries.

Beneficiaries

Description:

This project benefited extension agents, beginning orchardists, commercial tree fruit growers, Association of the Montana Turf and Ornamental Professionals, Montana Nursery and Landscape Association, natural enemy suppliers, industry, and homeowners.

Number of Beneficiaries:

About 250 beneficiaries were affected by the project.

Lessons Learned

Insights:

One of the most positive aspects of this project was the cooperation with the growers. They were engaged and curious about both insect pests and predators in their orchards. All growers were concerned with potential invasive insects, and they were supportive of the project. We had frequent conversations to discuss the status of insect sampling and potential insects of concern. I also wanted to thank the Montana Department of Agriculture and SCBG funding for supporting this project. Connecting with the growers and grower-supported research is the foundation for establishing valuable research programs in Montana.

Unexpected Outcomes:

I had one grower that didn't want to participate in the project for the second sampling year, 2017, for family related reasons. I also had a second grower that had an unexpected family emergency at the start of the season, and I wasn't able to sample at his orchard.

Some of the project funds were not spent on student salaries and/or technical assistance. This is because student workers were shared with the Western Agricultural Center at MSU in the summer of 2016 and they had extra funds available for these workers.

Outcomes Not Achieved:

Pre- and post-surveys were not completed due to time constraints on behalf of the PI. I frequently spoke with the growers to discuss the status of the project. However, for future projects, it would be beneficial to have surveys to the growers at the start of the project. This would help them to think about integrated pest management practices and what they mean during the course of the project. One of the growers was concerned about broad-spectrum insecticides he was spraying and whether they would have a negative impact on beneficial arthropods. We were then able to engage in a conversation about integrated pest management and using insecticides that were more specific to certain pests.

Contact

Laurie Kerzicnik, PhD
Insect Diagnostician and Asst. IPM Specialist
Montana State University
119 Plant BioScience Bldg (mailing)
56 Marsh Lab (physical)
Bozeman, MT 59717
Lauren.kerzicnik@montana.edu
406.994.5704

Additional Information

The website for the tree fruit guide that is available for commercial growers and beginning orchardists is www.intermountainfruit.org.

Survey of Montana State for Pathogens of Economic Importance in Field Peas

Final Report – Accepted 2017

Project Summary

Background:

Montana is the largest producer and exporter of peas in the United States. A major constraint to pea production are diseases which can reduce yield, lower seed quality, and limit seed exports due to phytosanitary restrictions. Control and management of pea diseases involve identification of the pathogens and characterization of the variability within the pathogen populations. In 2015, we proposed gathering baseline data on pea diseases in Montana for three years because the state has not been surveyed for diseases and their causal agents, and to capture diseases that might be expressed within 3 years of favorable weather.

Timeliness:

We have an extremely poor understanding of pathogen composition and threats in Montana because pulse crop fields have not been systemically surveyed.

Field pea diseases are known to cause yield losses, reduce seed quality, and limit exports due to phytosanitary and crop quality concerns. Management of diseases, which includes avoidance, quarantine, breeding for crop for disease resistance, requires early detection and identification of pathogens that have an economic impact on pea production. For example, Aphanomyces root rot, caused by Aphanomyces euteiches, is the most economically important disease of pea in Midwest and Northeast U.S. because it can reduce seedling emergence and yield in a number of dicot crops including pea. The pathogen overwinters in debris as viable oospores for at least 20 years, and no effective resistant cultivars or fungicides are available, making it difficult to manage. The presence of different strains of the oomycete fungus complicates resistance breeding programs and necessitates the identification of types present in Montana. Also, Fusarium wilt of peas is a fungal disease caused by Fusarium oxysporum. There are over ten races of the pathogen that can cause wilting of peas. Race 1 causes true Fusarium wilt, while other races cause near wilt. Knowing the race is important for breeding resistant varieties of peas across races. The race in Montana is currently unknown, but the disease has been diagnosed and the pathogen isolated several times in the last two years. Without a survey of Montana field pea farms to determine the pathogens of high economic risks and proactively develop risk management plans, we might lose our competitive advantage as a result of yield and quality reduction, and exports may decrease as a result of the presence of restricted

pathogens in seeds. Also, farmers might be discouraged and switch to other competitive crops if field pea diseases threaten their profitability.

Previous Funding:

Not Applicable

Project Approach

Activities:

1.Surveyed Montana fields for pea diseases.

During the 2016 growing season, two surveys of pea diseases were conducted in June and July during the vegetative and maturity growth stages, respectively, across four production zones (Northeast (NE), North Central (NC), Central (C) and Southwest (SW)) in Montana State. In both surveys, 18 fields from 8 counties were sampled. At the vegetative stage, plants with as much root and soil as possible were dug up from 17 fields (NE = 8, NC = 4, C = 2 and SW = 3) targeting the root, foliar and soil-borne disease pathogens. At maturity stage, 11 fields were sampled (10 from the previous survey and 1 new field) targeting foliar and pod disease pathogens.

The major diseases found in pea fields were blight, lesions (turning necrotic), mosaic/vein chlorosis, and wilt-associated root rots. Disease-associated organisms in infected pea tissues (bacteria, fungi, oomycetes, and nematodes) were identified using microscopy, special growth media, polymerase chain reaction (PCR) and DNA sequencing. Pea leaf plants with virus-like symptoms were tested for known pea viruses: Alfalfa mosaic virus (AMV), Pea seedborne mosaic virus (PSbMV), Pea enation mosaic virus (PEMV), Bean yellow mosaic virus (BYMV), Bean leafroll mosaic virus (BLRV, Cucumber mosaic virus (CMV) by Enzyme-Linked Immunosorbent Assay (ELISA).

Bacterial blight was the most common foliar, pod, and stem disease found in Montana pea fields. It was present in all the eight counties surveyed. Confirmed causal agents were Pseudomonas syringae pv pisi and Pseudomonas syringae pv syringae. Alternaria spp. (90% Alternaria alternata) were the most common fungi isolated from leaves with lesions and blight. They were found in all the 8 counties surveyed. The next most prevalent fungal pathogens isolated from leaves were Fusarium, Stemphylium, and Didymella (formerly Ascohyta). Fusarium species were dominant fungi recovered from the roots of wilted pea plants with root rot issues. They were isolated from roots of diseased pea plants in 6 out of the 8 counties surveyed. Fusarium and Pythium spp. were recovered from pea field soil in 6 and 8 counties, respectively. The most common nematodes present in the soil in the pea fields were Pratylenchus spp (lesion nematodes) and Tylennchorynchus spp. The levels of these nematodes in the soil were below economic thresholds. All the pea leaf samples with mosaic symptoms tested negative for all the six most common pea viruses by ELISA. Since the diseased plants were not randomly distributed but along specific paths, it suggests that it was caused by the chemical (herbicides) applied or spilled as farm machines move along.

We now have polymerase chain methods (PCR) for the detection of Fusarium avenaceum, F. graminearum, and F. triticum. We also developed multiplex PCR method to differentiate between the pathovars (pisi and syringae) of Pseudomonas causing bacterial blight of pea.

From our survey, bacterial blight, wilt-associated root roots, and Ascochyta blight were the major diseases. Grant for the second year survey of pea diseases in Montana has been awarded. Combined with the second year survey results, we will be able, with confidence, arrive at a conclusion and make recommendations, since disease levels are affected by weather conditions that vary with year

Benefits to other Commodities:

Not applicable.

Significant Contributors:

Dr. Mary Burrows, Montana State Extension Plant pathologist, co-supervised the project and did the extension part of this project.

Goals and Outcomes Achieved

Activities Completed:

A) Survey of pea fields for diseases

During the 2016 growing season, 2 surveys of pea diseases were conducted twice in June and July during the vegetative and maturity growth stages respectively across four production zones (Northeast (NE), North Central (NC), Central (C) and Southwest (SW)) in Montana State. In both surveys, 18 fields from 8 counties were sampled. At the vegetative stage, plants with as much root and soil as possible were dug up from 17 fields (NE = 8, NC = 4, C = 2 and SW = 3) targeting the root, foliar and soil-borne disease pathogens. At maturity stage, 11 fields were sampled (10 from the previous survey and 1 new field) targeting foliar and pod disease pathogens. Plant materials were placed in plastic bags, kept on ice before transporting to the laboratory and stored at 40C until processed. Six of the fields from the different production zones were not sampled at the maturity growth stage. Forty sampling units of five plants each were collected in a 'W' pattern from a 20-acre portion of each field. A total of 680 and 440 sampling units were collected at vegetative and maturity stages, respectively. During the survey, information on field size, growth stage, cropping history, pesticide application, irrigation, sowing time, previous disease history, seed treatment and plant cultivar were documented.

B) Isolation and Identification of disease pathogens

Fungal and bacterial isolation

Fungal and bacterial isolations were made from pod, leaf, stem and root tissues showing necrotic lesions, yellowing/wilting, leaf blight lesion and root discoloration. Roots were washed under a slow running tap to remove soil particles and rated for root rot infection on a 5-point scale where 0

indicates healthy plant, 1 = 1-10% root discoloration, 2 = 11-25% root discoloration, 3 = 26-50% root discoloration and 4 = 51-100% root discoloration. Plant materials with typical fungal infection were cut from the edge of leaf, stem and pod tissues, surface sterilized in 10 % free chlorine prepared from household bleach for 3 min, rinsed in two changes of sterile distilled water and blotted dry on sterile paper towel. Two to three pieces of tissues were plated on potato dextrose agar (PDA) in a 9 cm diameter petri plates and incubated at room temperature for 5 days under light. Root tissue (2 cm long) were sampled from infected plant and cut into smaller pieces 1 cm long. Root pieces were surface sterilized as previously described and plated on 2% water agar, PDA and Vancomycin–Benomyl-Metalaxyl agar (VBM) for isolation of Pythium, Fusarium and Aphanomyces spp. Plates were incubated at room temperature under light for 5 days. Agar plug from actively growing cultures were transferred onto a new PDA, peptone-pentachloronitrobenzene (PCNB) and Spezieller Nährstoffarmer (SNA) (Díaz et al., 2013) plates and incubated at room temperature for 14 days. Soil borne fungi were isolated based on dilution plate method. About 2.5 g of homogenized soil samples were transferred into 22.5 ml of sterile water in a 50 ml conical flask, vortexed vigorously and serially diluted in 10 folds. Fifty microliters of the suspension from three dilutions 102, 103 and 104 were plated on PDA and incubated at room temperature for 2-5 days (Weiland, 2011). Resulting fungal colonies were transferred onto fresh PDA, PCNB and corn meal agar (CMA) amended with 5 µg pimarcin, 250 µg ampicillin, 10 µg rifampicin and pentachloronitrobenzene (PARP) agar plates (Weiland, 2011). Fungal pure cultures were obtained by excising the hyphal tips. Infected pea tissues with typical water soaking and leaf blight were surface sterilized as described above. Tissues were transferred to 1.5 ml microfuge tube and ground with sterile plastic pestle in 1 ml of sterile distilled water. Twenty microliter of the suspension was spread onto PAF agar (Difco, Becton Dickinson, MD, USA) amended with 35 mg Nystatin (Fisher Bioreagent, PA, USA) (Schaad et al., 2001). Plates were incubated at room temperature for 3 days. Pure fungal colonies were stored in 15 % sterile glycerol at -80 oC for long term storage. Single bacterial colonies were purified by serial plate dilution and stored in 15 % sterile glycerol at -80 oC for future use.

Fungal identification

Fungal species were identified based on their growth and morphological characteristics. In addition, molecular identification of the fungal species was performed on a subset of 234 isolates by amplification and sequencing of the internal transcribed region, elongation factor and specie-specific primers. Fungal DNA was extracted from about 50 mg of mycelia scrapped from actively growing cultures using PrepMan™ Ultra (Life Technologies, Carlsbad, CA) following the manufacturer's protocol. DNA was diluted with sterile distilled water to 1:25 and stored at – 20 oC. The primer pairs ITS 4 and 5 (600bp) (White et al., 1990), EF 201 and EF 202 (350bp) (Carbone and Kohn 1999) and specific oomycota ITS (Nikolcheva and Bärlocher 2004) were used for amplification. Polymerase chain reaction (PCR) for sequencing was conducted in 50 µl volume containing 2 µl of DNA template, 25 µl Taq master mix (life technologies, Carlsbad, CA), 1 µl each of forward and reverse primers and 21 µl of sterile water. The cycling profile were an initial denaturation at 95 oC for 5 min followed by 40 cycles of denaturation at 30 secs, annealing at 45 oC for 30 sec (ITS), 54 oC for 30 sec (EF), and 55 oC for 30 sec (ITS Oomycota), extension at 72 oC for 1 min and a final extension at 72 oC for 5 min.

Amplified products were electrophoresed on 1.5% agarose gel in Tris-acetic acid EDTA stained with syBR® safe and viewed on UV light. PCR products were purified by ethanol precipitation. The purified PCR product were sequenced commercially at MCLAB in California. The sequences were edited in BioEdit and submitted for BLAST searches in NCBI for comparison to known DNA sequences. Identification of oomycetes was performed on a subset of 50 isolates.

Bacterial strain identification

The bacterial strains were subjected to classical biochemical testing which includes gram reaction using 3% KOH test, fluorescence on KB medium, levan production (L), oxidase reaction (O), potato soft rot test (P), arginine dihydrolase activity (A), tobacco hypersensitive test (T), utilization of homoserine, betaine, D-tartrate, trigonelline as carbon sources, gelatin and aesculin hydrolysis. All test was repeated twice in duplicate tubes or plates. Molecular identification was based on PCR amplification with the AN3 (132 bp) and AN7 (272 bp) (Arnold et al., 1996) markers and the syrB gene marker PSSB1/PSSB2 (752 bp) (Sorensen et al., 1998) using DNA from purified colonies as template. Each amplification reaction was carried out at least twice, positive controls Pseudomonas syringae pv. syringae (B301D and B3A) and Pseudomonas syringae pv. pisi (PsP1, PsP4 and 875A) were obtained from Plant, Soil and Entomological Science, University of Idaho and sterile distilled water served as negative control. Bacterial DNA template was prepared by heated bacterial cell. One microliter loopful of purified single bacterial colony was transferred into 100 µl sterile distilled water, diluted 1:10, heated at 98 oC for 10 min and incubate on ice. PCR amplification was conducted in 12.5 µl volume containing 1 µl of DNA template, 6.25 µl Taq master mix (life technologies, Carlsbad, CA), 0.25 µl each of forward and reverse primers and 4.75 µl of sterile water. The cycling profile were an initial denaturation at 95 oC for 5 min followed by 34 cycles of denaturation at 94 oC 30 secs, annealing at 58 oC for 30 secs, extension at 72 oC for 30 sec and a final extension at 72 oC for 5 min for the ANS3 (132 bp), AN7 (237 bp) and syrB (752 bp) gene primers. The PCR products were electrophoresed in 1.5 % agarose gel stained with syBR® safe (10,000X) and the product size estimated using 100 bp DNA ladder (O'GeneRuler, Thermo Scientific). Pathogenicity of the isolates was determined on pea pod and lemon fruits in the laboratory (Martin et al., 2013).

Virus detection and Nematodes Identification

Pea leaf plants with virus-like symptoms were tested for known pea viruses: Alfalfa mosaic virus (AMV), Pea seedborne mosaic virus (PSbMV), Pea enation mosaic virus (PEMV), Bean yellow mosaic virus (BYMV), Bean leafroll mosaic virus (BLRV, Cucumber mosaic virus (CMV) by Enzyme-Linked Immunosorbent Assay (ELISA) using kits. For nematodes identification, the soil samples were sent to Nematode Diagnostic Lab at the University of Florida.

C) Diagnostic methods Developments

A conventional multiplex Polymerase chain reaction was developed to differentiate Pseudomonas syringae pv pisi (Psi) from Pseudomonas syringae pv syrinage (Pss) using PCR primers. Syr (for Pss), AN3 and AN7 (for Psi) were used together differentiate the two pathovars. Also, sets of primers

specific for some Fusarium species have been mixed and used to detect specific Fusarium species e.g. Fusarium avenaceum, F. graminearum, etc. The method is still being perfected.

Based on the pathogens we have identified in pea in Montana, the Regional Pulse Crop Diagnostic Laboratory have now prioritized the pathogens to test for in peas. We now know that bacterial blight disease of pea is not caused only by Psuedomonas syringae pv pisi, but also by P. syringae pv syringae. So, seedlots for bacterial blight agent tests and now tested for the two pathovars of P. syringae using the multiplex PCR method developed.

The regional Pulse Crop Diagnostic Laboratory provides diagnostic services for pulse crop growers in Montana and other pulse crop-growing states in the United States – over 500 pulse growers.

D) Presentation of project results to growers and other stakeholders.

We have presented our results to the United States Dry Pea Lentil Council (USADPLC), at Grower's meetings, MSU Research Center field days, and at the Richland Pulse Tour. We have presented the results of our project at American Phytopathological Society and next week, we shall be presenting at the North American Pulse Improvement Association meeting at Michigan State University, East Lansing. Our extension has been mostly through Dr. Mary Burrows, the Extension Pathologist for MSU.

Goal	Performance Measure	Target	Actual
Disseminate information about field pea diseases and pathogens identified in field surveys in Montana and suggest management strategies to field pea growers and other stakeholders through extension activities.	Project results will be presented yearly at the NPGA, USDPLC, APS, and growers' meetings (~300, 25, 2000, and 1000 attendees, respectively). We will attend > 3 to 5 MSU Research Center field days (~300) and the Richland Pulse tour (~80). The information will be used as part of the Montana AgAlert system (~800 subscribers) as appropriate, and also used in growers' education via sample submission to the Schutter Diagnostic Laboratory and the new Regional Pulse Crop Diagnostic Laboratory (RPCDL).	Educate a minimum of 1000 pea growers, consultants, and other agricultural professionals about plant disease issues and their management.	Over 1,000 pea growers in Montana and other pulse producing states

Long Term Outcomes:

Not Applicable

Major successful outcomes in quantifiable terms:

- Agents of bacterial blights, Psuedomonas syringae pv syringae and Psuedomonas syringae pv pisi, were detected in 7 out of 8 counties.
- Agents of Stemphylium blight, Stemphylium spp), were detected in 5 out of 8 counties.
- Agents of ascochyta blight, Ascochyta (now Didymella) spp., were in 5 out of 8 counties.
- Fusarium spp were detected from symptomatic pea plants (leaf, stem & pods) in 8 out 8 counties.
- We have developed diagnostic tools for the detection of pathogens of economic interest identified.
- We have developed multiplex PCR for simultaneous detection of agents of bacterial blight of pea: Psuedomonas syringae pv pisi and syrinage. We have also developed mutiplex PCR for the detection multiple Fusarium spp., including Fusarium avenaceum, F. graminarea, and F. triticum
- Through the extension activities of Dr. Mary Burrows, we have disseminated this project results to over 1,000 growers. See the list of extension publications under Additional Information.
- Our postdoctoral Scientist, have two presentations to at the American Phytopathological Society Meeting at San Antonio, Texas, and the North American Pulse Improvement Association meeting at East Lansing, Michighan.

Beneficiaries

Description:

Montana Pea growers and those from other states who are interested in knowing the important diseases of peas that might reduce their yields and qualities. USA Dry Pea Lentil Council (USADPLC) and Northern Pulse Growers' Association (NPGA), will also benefit because they invest and promote pulse businesses and research. Pulse crop diagnostic laboratories, breeders, and pulse crop pathologists benefit from the pea disease information and developed diagnostic methods.

Number of Beneficiaries:

Over 1,000 pea growers in Montana and other pulse producing states. Montana is the leading producer of peas in the United States. Since bacterial blight and root rots are the major diseases in Montana from our surveys, the USA Dry Pea Lentil Council (USADPLC) and Northern Pulse Growers' Association (NPGA) will most likely focus their attention on research efforts towards breeding efforts to select for pea resistant varieties to these diseases.

We have 463 growers that send seed samples to the Regional Pulse Crop Diagnostic Laboratory. For 2017 planting season, we tested 954 seedlots for non-nematode pathogens and 948 seedlots for export for nematode pathogens, making a total of 1,902 seedlots.

Lessons Learned

Insights:

The project should have focused on one class of pathogens, say fungi/oomycetes, instead of all classed of pulse pathogens. It was overwhelming for a postdoctoral scientist to handle it all alone.

Doing field disease survey twice on the same fields in the same year is more practical than doing it thrice due to distance and labor constraints.

The results of the second year pea disease survey are needed to get a better idea of pea diseases in Montana.

Unexpected Outcomes:

Not Applicable

Outcomes Not Achieved:

Not applicable

Contact

Bright Agindotan
Research Assistant Professor-PhD
Plant Sciences & Plant Pathology
406-994-7738
bright.agindotan@montana.edu

Additional Information

Conference Presentations
Mgbechi-Ezeri, J., Owati, A., Peluola, C., Burrows, M., Agindotan, B. M. 2017. 216-P Identification and distribution of pathogens associated with field pea diseases in Montana State. Montana. American Phytopathological Society (APS) Meeting. August 5-9. San Antonio, Texas. Poster.
Mgbechi-Ezeri, J., Owati, A., Peluola, C., Burrows, M., Agindotan, B. M. 2017. 216-P Variability within Pseudomonas syringae pathovars infecting pea in Montana. North America Pulse Improvement (NAPIA) Meeting. American Phytopathological Society (APS) Meeting. Nov. 1-3, 2017. East Lansing, Michigan. Poster.

Extension Presentations
Burrows, M. 10/3/2016. Diseases of Wheat and Pulses. 30 attendees. Pest Management Tour. Scobey, MT.
Burrows, M. 10/3/2016. Diseases of Wheat and Pulses. 25 attendees. Pest Management Tour. Glasgow, MT.
Burrows, M. 10/4/2016. Diseases of Wheat and Pulses. 45 attendees. Pest Management Tour. Plentywood, MT.
Burrows, M. 10/4/2016. Diseases of Wheat and Pulses. 19 attendees. Pest Management Tour. Froid, MT.
Burrows, M. 10/5/2016. Diseases of Wheat and Pulses. 65 attendees. Pest Management Tour. Circle, MT.
Burrows, M. 10/5/2016. Diseases of Wheat and Pulses. 36 attendees. Pest Management Tour. Sidney, MT.

Burrows, M. 10/6/2016. Diseases of Wheat and Pulses. 45 attendees. Pest Management Tour. Miles City, MT.
Burrows, M. 10/6/2016. Diseases of Wheat and Pulses. 15 attendees. Pest Management Tour. Baker, MT.
Burrows, M. 10/7/2016. Diseases of Wheat and Pulses. 25 attendees. Pest Management Tour. Forsyth, MT.
Burrows, M. 10/7/2016. Diseases of Wheat and Pulses. 15 attendees. Pest Management Tour. Jordan, MT.
Burrows, M. 10/9/2016. Montana Ag Live. 10000 attendees. Montana PBS: Montana Ag Live. Bozeman, MT.
Burrows, M. 11/29/2016. Research Panel: Diseases of pulse crops. 250 attendees. Northern Pulse Growers Association Meeting. Great Falls, MT.
Burrows, M. 2/22/2017. Healthy Seed, Healthy Start: The Importance of Seed Testing in Preventing Diseases of Pulse Crops. 400 attendees. Field Crops Disease Summit; Top Crop Manager. Saskatoon, SK.
Burrows, M. 3/30/2017. Montana Ag Live. 10000 attendees. Montana PBS: Montana Ag Live. Bozeman, MT.
Burrows, M. 5/21/2017. Montana Ag Live. 10000 attendees. Montana PBS: Montana Ag Live. Bozeman, MT.
Burrows, M. 6/11/2017. Montana Ag Live. 10000 attendees. Montana PBS: Montana Ag Live. Bozeman, MT.
Burrows, M. 6/21/2017. Art and science of Diagnostics, WSMV refresher, pulse diseases and crop rotations. 92 attendees. National Crop Insurance Services. Moccasin, MT.

Farm to Institution: Building the Capacity of Mission Mountain Food Enterprise Center through Product Development

Project Summary

Objectives

1. Increase consumption and competitiveness Montana specialty crops by developing ready to serve value added specialty crop products for public institutions.
2. Establish production of value added Montana specialty crop products
3. Expand the farm to institution supply by increasing distribution efficiencies, for Montana specialty crops.
4. Communicate results of Farm to Institution project to specialty crop producers and stakeholders.

As demand for year round local products continues to increase in public institutions, product development of more complicated culinary recipes using Montana specialty crops must increase to meet those demands. The initial purpose of this project was to develop specialty crop-value added products to address seasonal availability of specialty crops for institutional markets and increase sales of specialty crops in Montana. Institutions were interested in purchasing local produce, however only minimally processed frozen vegetables were available. The Farm to Institution program sought to increase institution's local food purchasing ability by offering value-added

products that are available year round. The project focused on developing products with institutional, dietetic, food science and specialty crop producer input to create healthy, local year round products. Recipes will be tailored to use specialty crop storage crops such as carrots, beets, squash, apples, potatoes and onions among other non-storage crops. Most institutions do not have the storage capacity to handle fruits and vegetables for year round consumption. By increasing proper storage, Montana specialty crops such as squash and lentils would be stored until ready to process into a value-added product The project sought to increase economic opportunity for specialty crop growers throughout the state as extensive outreach will be made to assure that a diverse group of growers participates and quantities needed can be met for institutional demand to enhance specialty crop competition within the market.

Increasingly, institutions want to purchase local products year round while producers seek to diversity their farm incomes. The Farm to Institution project created year round economic opportunities for Specialty crop growers throughout the state by partnering with organizations such as the Western Montana Growers Cooperative and Quality Food Distribution to distribute from producers around the state to process at MMFEC. Scratch cooking with whole or minimally processed specialty crops is not always feasible for public institutions due to time constraints, amount of meals to be served, or simply lack of kitchen capacity. MMFEC has been contacted on multiple occasions by specialty crop producers and institutions asking to create and/or scale up and make more complex local, value-added products such as soups, sauces and purees. MMFEC used resources such as Montana State University's Dietetic Intern Program and Oregon State University's Food Innovation Center to create these products. MMFEC expanded their relationship with Specialty crop producers and included growers such as Triple Divide Organic Seed Cooperative, who reached out to MMFEC looking for institutional outlets for their products. Traditional partnerships, such as the Western Montana Grower's Cooperative (WMGC) expanded their sales through specific coordination. For example, previous to this grant period, with coordinated assistance with MMFEC, WMGC sold fresh processed carrots to a local Western Montana school district until March, drastically extending their season and offering unexpected revenue. The demand for season extended and value added Montana Specialty crops is clear, as is the desire of producers to meet this demand.

Yes, this did build on a previous specialty crop block grant "Montana Grown Specialty Crop Nutrition and Promotion Campaign in Schools". This grant developed Mission Mountain Food Enterprise Center's first specialty crop value-added product, the Montana Lentil Burger. The lentil burger was developed through a partnership with Oregon State University's Food Innovation Center. It was tested in regional schools and although it was not popular amongst elementary students, it was popular with secondary and collegiate students. This grant also developed marketing materials that spoke to the importance of purchasing local and coloring books for children to learn about specialty crops and their nutritional value.

Project Approach

Activities:

1A: Project coordinator communicated with participating institutions quarterly and visited annually with ten regional school food service directors. In 2016, the project coordinator traveled to 7 school districts, 5 healthcare facilities and one university in the region. The project coordinator also met individually with two hospitals about local food purchasing. A roundtable was held in early 2017 with 15 food service professionals to taste test MMFEC value-added products, as well as receive feedback on local procurement strategy. Project coordinator also traveled regionally to meet with institutions (2 Early Care & Education centers, 6 school districts, and one healthcare facility) to receive feedback on using value-added, specialty crop products in spring 2018. The project coordinator also served as a resource for 10 institutions in Kalispell and Missoula who were implementing Harvest of the Month in their institutions.

1B: 4 Memorandums of Understanding were established and enacted with local institutions, including two schools, one healthcare facility and one Early Care & Education center.

1C: Two different strategies have been developed to assist local schools with participating in the Farm to Institution program. For minimally processed produce, schools have been combining orders to increase the production run, therefore decreasing the price. A minimum processing run must be 600 pounds. Also, different products that have similar processes (i.e. chopping, dicing, slicing, shredding) can be combined to decrease the overall price point. This has been an effective solution for smaller schools who cannot purchase a large quantity at once.

2A: Through working with the Oregon State University Food Innovation Center, six specialty crop, value-added recipes have been developed under this grant: lentil, mushroom (51%) and beef (35%) meatball, tomato sauce, breakfast bar, vegetable tater tot, salsa and hummus. There were 12 initial recipes developed and through taste testing and analysis and narrowed to 6 recipes to develop production processes. In addition to processing protocol, complete nutritional analysis was completed and food safety plans were put in place. The OSU FIC staff visited MMFEC to make test batches of products for taste testing with institutions.

2B: After the recipes from OSU FIC had been finalized, MMFEC ran larger scale batches of products for preliminary cost analysis utilizing the Montana Manufacturing Extension Center cost analysis tool. Adjustments were made to insure the final product cost met market costing.

3A: Western Montana Grower's Cooperative and Quality Foods Distributing are working together to distribute the Farm to Institution products. LINC Foods, a producer owner cooperative out of Spokane, is working with Western Montana Grower's Cooperative to backhaul produce. Superior Meats, Superior MT, was interested in working with WMGC in a backhaul to Superior schools and hospital. One run was organized in 2017.

3B: This outcome was not acheived. The distributors that MMFEC works with did not feel the need to have a formal MOU in place.

4A: Quarterly e-newsletters were sent via NCAT's Producer Database (72 regional producers) and institutions (45) on the Farm to Institution program and related activities, such as upcoming trainings

and events. These program updates transitioned to the Montana Food and Agriculture Development Center monthly e-newsletter.

4B: MMFEC has used a variety of ways to share outcomes of the Farm to Institution program, by using online outreach tools such as social media and e-newsletters and presenting at regional, state-wide and national conferences, such as the Governor's Food and Agriculture Summit, Montana Farm to School Summit, and National Good Food Network Conference. The Farm to Hospital video was produced in collaboration with NCAT and screened at the Governor's Food and Agriculture Summit to 200 attendees and the Flathead Lake International Cinemafest to 100 attendees. Project coordinators also attended the 2017 and 2018 Montana School Nutrition Association Conferences and taste tested the value-added, specialty crop products with Montana food service professionals. In 2018, the program coordinator presented on the history of the Farm to Institution program to conference attendees.

Benefits to other Commodities:

This project specifically benefitted specialty crops that were used to develop frozen value-added products. These specialty crops included lentils, mushrooms, squash, carrots, onion, apples, cherries and tomatoes. All of the recipes that were developed have over 50% specialty crop ingredients. Project staff insured grant funds were used specifically on activities that benefited specialty crops by:

1) Understanding specialty crop eligibility and insuring those crops were used over 50% in any products developed for the project

2) Proper billing staff time spent on project to specialty crop grant fund number.

3) All promotional materials highlighted specialty crops only

Significant Contributors:

Western Montana Growers Cooperative: WMGC played a significant role in this project as the main distributor of Mission Mountain Food Enterprise Center. All of MMFEC's minimally processed produce that went to local institutions came from WMGC and a majority of the specialty crops were distributed through WMGC. WMGC is a co-signer on the MOUs with local school systems and MMFEC as the distributor for the minimally processed produce.

Quality Foods Distributing: QFD is another distributor that distributes MMFEC's specialty crop products and has significantly increased the reach of MMFEC through new distribution routes. They have also assisted MMFEC in production planning for the upcoming year.

National Center for Appropriate Technology: NCAT has been a significant contributor to this project through the Farm to Cafeteria Network. This interactive map shows what schools in our area are participating in Harvest of the Month and are interested in procuring local products. Recently, the Harvest of the Month has formed community teams in Kalispell, Missoula and Livingston. MMFEC has attended the Kalispell and Missoula meetings as a resource for participants.

Montana Farm to School Leadership Team: The leadership team is comprised of regional and statewide organizations that focus on different aspects of farm to school, such as community hunger, food safety, nutrition education, and agriculture. It meets quarterly and has been an asset to this project through the sharing of ideas and networking with other statewide partners.

Montana Team Nutrition: Montana Team Nutrition houses the Montana Harvest of the Month program, which is a resource that MMFEC shares with schools looking to purchase more Montana specialty crops. For several of the Harvest of the Month months, schools can purchase Montana specialty crop products through MMFEC.

Oregon State University Food Innovation Center: The OSU Food Innovation Center has developed all of the recipes under the Farm to Institution specialty crop grant. They visited MMFEC several times to develop recipes and processing procedures.

Montana FoodCorps: FoodCorps provides the nutrition education in the classroom to connect students with the importance of specialty crop products. In the participating school districts, FoodCorps members use Harvest of the Month and have frequently used MMFEC's value-added specialty crop products as a teaching tool.

Montana State University Dietetic Intern Program: MMFEC has been added to the rotations for the MSU Dietetic Intern program. Since September 2017, MMFEC has hosted two interns and will host two more in the upcoming school year.

Timeless Foods: For the MMFEC value-added specialty crop products that includes lentils, those lentils are exclusively bought from Timeless Foods.

Institutions: Participating network institutions routinely give feedback and input on MMFEC value-added specialty crop products that they have purchased.

Goals and Outcomes Achieved

Activities Completed:

Objective 1: Increase consumption and competitiveness of Montana specialty crops by developing ready to serve value added specialty crop products for public institutions

Performance Measure: Number of Institutions participating in network to identify, develop and test new products

The benchmark for this goal was 10 public institutions that are currently purchasing Montana specialty crop products and the target was to have a 20% increase. A variety of different activities were performed to achieve this goal. The Project Coordinator traveled regionally to meet with local schools and institutions and there was an institutions roundtable held at MMFEC. Within the first year of the grant, WMGC sales to institutions increased 36%. In 2016, sales continued to climb by 25%. In 2017, there was a decrease in sales by 32%. So far in 2018, WMGC has sold $95,130 worth of specialty crop products to regional institutions.

Objective 2: Establish production of value-added Montana specialty crop products

Performance Measure: number of ready to serve products developed and served in public institutions

Oregon State University's Food Innovation Center worked with MMFEC to develop the most recent products, including their recipes and production processes. MMFEC and OSU's FIC produced six value-added, specialty crop products, including a lentil and mushroom meatball, tomato sauce, breakfast bar, vegetable tater tot, salsa and hummus. Schools have purchased the blended meatball and the other products are being marketed to local institutions for purchase.

Objective 3: Promote and communicate results of Farm to Institution project to specialty crop producers and stakeholders

Performance Measure: Project results are communicated effectively through institutional and producer network. Product posters will be designed and printed and distributed throughout network.

Quarterly e-newsletters were sent to regional producers and institutions on the Farm to Institution program and related activities, such as upcoming trainings and events. These program updates transitioned to the Montana Food and Agriculture Development Center monthly e-newsletter. Product posters for the Montana Lentil Burger, beef/lentil meatball, tomato sauce and breakfast bar have been created and distributed to Western Montana Grower's Cooperative and Quality Foods Distributing. They have also been distributed to potential customers through social media networks.

MMFEC has used a variety of ways to share outcomes of the Farm to Institution program, by using online outreach tools such as social media and e-newsletters and presenting at regional, state-wide and national conferences, such as the Governor's Food and Agriculture Summit, the 2016 Montana Farm to School Summit, Montana Food Show and National Good Food Hub Network Conference. In 2016, the Farm to Hospital video was highlighted at the Governor's Food and Agriculture Summit to 200 attendees. In 2017, it was showcased at the Flathead Lake International Cinemafest to 100 attendees. It has been viewed 943 times on YouTube.

Objective 4: Establish production of value added Montana specialty crop products

Performance Measure: MMFEC will increase sales of specialty crops to new institutional markets through value added products

The Western Montana Growers Cooperative have had a total of $872,678 worth of specialty crop products sold to Montana institutions during this grant. In 2018, Quality Foods Distributing has sold 108 cases of Montana Lentil Burger to new institutions. This has dramatically expanded MMFEC's capacity to purchase more specialty and pulse crops.

Long Term Outcomes:

To increase the competitiveness and consumption of Montana specialty crops and developing value-added specialty crop products were both long term outcome measures. As one of the four Food & Agriculture Development Centers in Montana, promoting and increasing market access for Montana producers is a main goal of Mission Mountain Food Enterprise Center. Increasing competitiveness

and consumption of Montana specialty crops is an on-going outcome for MMFEC, and therefore will continue to be the primary focus of future programs.

Another goal of this grant was to develop value-added specialty crop products and the establish production and sales of these products. The recipes and production processes have been established. These products will continue to be produced and sold to local institutions through the Western Montana Grower's Cooperative and Quality Foods Distributing.

In terms of achievement, both of these goals are on-going and will continue to expand.

Major successful outcomes in quantifiable terms:

- Memorandums of Understanding: 4 MOUs were signed with local institutions (2 schools, 1 Early Care & Education Center, and 1 Healthcare Center) to participate in purchasing minimally processed produce through the Western Montana Growers Cooperative and Mission Mountain Food Enterprise Center.

- Roundtable: 15 representatives from local institutions attended a taste test and roundtable discussion at MMFEC.

- Products: 6 frozen, value-added, Montana specialty crop products were developed under this grant program. Several of those specialty crop products are being purchased by local institutions.

- Sales: Throughout the duration of this grant, the Western Montana Growers Cooperative have had a total of $872,678 worth of specialty crop products sold to Montana institutions. For every dollar of profit that WMGC earns, 76 cents of every dollar is returned to the member farmer. In the first year of the grant, there was a 36% increase in institutional sales. The following year had a 25% increase, followed by a 32% decrease. So far in 2018, WMGC has sold $95,130 worth of specialty crop products to institutions.

- Newsletters: Quarterly newsletters were sent out to approximately 70 producers and 26 institutions across Montana to share project outcomes, as well as relevant trainings and events.

- Montana Dietetic Interns: MMFEC has hosted two dietetic interns who have completed cost analysis work, production formulation statements, and MMFEC product marketing materials.

Beneficiaries

Description:

Western Montana Grower's Cooperative: WMGC is an agriculture marketing cooperative in Missoula with 39 member farmers. They are the primary distributor for MMFEC for the Farm to Institution specialty crop products, as well as the minimally processed produce. WMGC had a total of $872,678 worth of specialty crop products sold to Montana institutions since 2015. For every dollar of profit that WMGC earns, 76 cents of every dollar is returned to the member farmer.

Quality Foods Distributing: QFD is a distributor based out of Bozeman. They recently started distributing our Montana Lentil Burger to Yellowstone National Park and a few smaller retail outlets.

Montana Institutions: Students and staff in participating Montana institutions have benefited from the Farm to Institution program by increasing access to value-added, Montana specialty crops.

Specialty Crop Producers: All of the products developed under this grant feature Montana specialty crop ingredients. MMFEC has increased purchasing of various specialty crops for product ingredients, such as lentils, oats, tomatoes, and squash.

Number of Beneficiaries:

- 39 member owners of WMGC
- 50 farms that partner with WMGC
- students in participating institutions
- 34 Timeless Seeds lentil growers

Lessons Learned

Insights:

- Staff turnover, in institutions and at Mission Mountain Food Enterprise Center, can cause delays and changes within the program. There were cases where the food service director or main supporter of MMFEC left their position, and therefore caused a disruption in the normal purchasing pattern. At MMFEC, staff turnover caused delays in achieving work plan outcomes.

- Public school budgets can change dramatically, which can negatively or positively affect their food budget. Decreases in food budgets negatively affects how much money food service directors will spend on MMFEC products. Several of the schools that have previously purchased MMFEC products were unable to due to budget cuts.

- When Mission Mountain Food Enterprise Center started the Farm to Institution program, FoodCorps was a primary program partner. However, the primary focus of FoodCorps has shifted from local procurement to school gardens and the number of FoodCorps sites in Montana has significantly decreased. These changes have negatively affected the Farm to Institution program. In the future, program staff will have to build stronger relationships with the food service director themselves rather than a third party.

- Recipe and product development is a very time intensive process. Oregon State University's Food Innovation Center visited MMFEC on three separate occasions and MMFEC staff also visited Oregon. Many different decisions about packaging, ingredients, taste testing, and other decisions slowed down the process.

Unexpected Outcomes:

One of the unexpected outcomes or results from this project was the expansion of the Farm to Institution program into other institutions than originally intended. Since this project has started, an Early Care & Education center (i.e. day cares, Head Starts) have become a partner and customer of

MMFEC and WMGC. Northwest Montana Head Start has signed a MOU with MMFEC and WMGC to continue purchasing.

Another unexpected outcome was the program coordinator and project manager presented at the National Good Food Network Conference in Albuquerque in March 2018. They presented on the Farm to Institution program, specifically product development.

Outcomes Not Achieved:

A goal that was not fully achieved was determining backhauling opportunities with participating distributors, including Western Montana Grower's Cooperative, Quality Foods Distributing, and the Montana Food Bank Network. This goal was not achieved due to logistic capacities.

Contact

Jan Tusick
407 Main St SW
Ronan, MT 59864
406-676-5901
jan.tusick@lakecountycdc.org

Additional Information

N/A

Food Safety Training for Montana Specialty Crop Growers, Producers, Processors, and Manufacturers

Project Summary

All Montana specialty crop growers, producers, and manufacturers, are either already impacted or soon will be impacted by one or more food safety regulations. Failure of value-added specialty crop producers to obtain the appropriate food safety certification(s) or meet the appropriate food safety standard(s) will limit market opportunity for these producers. MMEC worked in conjunction with the Montana Department of Agriculture and other partners to identify training needs across the state and to provide that training. Depending upon the need, this training was available on-site or in public sessions where multiple specialty crop growers and producers could attend the same session. Customized training was developed for local producer needs and provided locally to reduce the need for producers to travel long distances to obtain the training. In addition to providing training to producers, this partnership intended to provide training to county extension agents so that these agents may continue to meet the need to provide food safety training to producers in the local area after conclusion of this effort.

Food safety regulations have been increasing. This increase is not just in the number of regulations, but also in the impact of these regulations across a greater portion, including to earlier stages, of the value chain. This means that some producers are now subject to one or more regulations that they were not subject to in the past either due to the small size of their enterprise, or the fact that they operate early in the value chain. Helping these value-added producers identify the specific food safety training required and providing that training is important because this will help these producers either establish or maintain compliance with required regulations. This training may also help to prevent some producers from being pushed out of the market due to these existing and emerging regulations.

Project Approach

Activities:

Taught 16 HACCP classes, 8 PCQI classes, and at least 10 FSMA overview classes to over 200 participants from at least 25 Montana specialty crop producers and processors, as well as government and non-profit partners including DPHHS, AERO, Lake County Community Development, Mission Mountain Food Enterprise Center, Montana Department of Agriculture, and others. Provided consultations and customized projects for development, implementation and /or improvement of food safety and processing systems for over 50 Montana specialty crop producers and processors. Participated in and spoke at statewide, regional and/or national events, such as a FSMA presentation at the Western Ag Station annual meeting in Corvallis with over 200 specialty crop producers and processors. Exceeded the work plan requirements of 9 overview trainings (conducted 34) and 8 food safety training projects (conducted 17). Collaborated extensively with various partners around the state, including the Food and Ag Development Centers in Ronan and Butte, on individual assistance to specialty crop processors and multiple training events.

Benefits to other Commodities:

In order to ensure grant funds were used solely to enhance the competitiveness of specialty crops, a fee structure was developed for public trainings that were attended by both producers and processors of specialty crops as well as non-specialty crops, which provided a substantial discount to specialty crop producers/processors. Specialty crop grant funds were used to supplement the discounted fees paid by specialty crop producers/processors while non-specialty crop producers/processors paid their full share of the training costs. In addition, some trainings were customized and conducted for only specialty crop producers/processors. Salary for Claude Smith (MMEC Food Safety Specialist) was partially paid from specialty crop grant funds and partially paid from other sources. Time and effort records were maintained to document that the portion of Claude's paid time supported by specialty crop grant funds was used solely to further the objectives of the specialty crop block grant.

Significant Contributors:

The Montana Department of Agriculture (MDoA) was an amazing partner in this effort. MDoA provided guidance, expertise when needed, and potential leads. Great Falls Development Authority

(GFDA) provided leads as well as office space for the MMEC staff to conduct this work. Lake County Community Development and Headwaters RC&D, with their Food and Ag Development Centers, were also great partners in providing leads and additional expertise when needed.

Goals and Outcomes Achieved

Activities Completed:

Taught 16 HACCP classes, 8 PCQI classes, and at least 10 FSMA overview classes to over 200 participants from at least 25 Montana specialty crop producers and processors, as well as government and non-profit partners including DPHHS, AERO, Lake County EDC, Mission Mountain Food Enterprise Center, Montana Department of Agriculture, and others. Provided consultations and customized projects for development, implementation and /or improvement of food safety and processing systems for over 50 Montana specialty crop producers and processors. Participated in and spoke at statewide, regional and/or national events, such as a FSMA presentation at the Western Ag Station annual meeting in Corvallis with over 200 specialty crop producers and processors. Exceeded the work plan requirements of 9 overview trainings (conducted 34) and 8 food safety training projects (conducted 17). Collaborated extensively with various partners around the state, including the Food and Ag Development Centers in Ronan and Butte, on individual assistance to specialty crop processors and multiple training events.

Long Term Outcomes:

MMEC receives feedback from a client survey conducted by a third party through the NIST Manufacturing Extension Partnership program. Clients who work with MMEC on a customized project receive the survey approximately 6 months to a year following the completion of the project, and may continue to provide results on impact to their company for multiple years. In the table in the report section below is a summary of impact reported to date that was collected from clients via an independent third party.

Major successful outcomes in quantifiable terms:

Montana specialty crop producers and processors received knowledge, certifications required by FDA, and assistance with company-specific projects such as designing and starting up new facilities. In the words of Roger Sammons of Pardue Grain, "MMEC's assistance with the design and startup of our new facility has allowed Pardue Grain to stand up a new, state of the art manufacturing facility in Cut Bank which will add 12 permanent employees with good paying jobs. Without them working alongside our team throughout the process, it would have taken us twice as long to get up and running, but more importantly, MMEC was instrumental in designing this project around a high level, food safety protocol. This is the first plant of this design at this level of processing that anyone is aware of. MMEC has been a critical asset in all aspects of designing and building an SQF2 compliant facility, explaining the hiring and on-site education of a capable and dedicated workforce, and ensuring efficient and safe production of high quality products. MMEC brought a level of professionalism that caused for the creation of professional drawings and design that is uncommon in the agricultural sector."

Total deliverables	Target	Outcome
New jobs	6	33
Retained jobs	64	48
Increased sales	$400,000	$435,001
Retained sales	$400,000	$24,565,000
Overview trainings (total)	9	34
Food safety training projects (total)	8	17
Food & Ag Ctr collaboration	4	Complete
Train Ag Ext. Agents	3-5	Incomplete
Train MMEC staff	NA	Complete
SCMT & GF Food Mfg Networks collaboration	2	Complete
New investments	NA	$32,214,819
Cost Savings and Unnecessary Investments	NA	$2,351,383

Beneficiaries

Description:

The main group benefiting directly from this project consists of Montana-based food manufacturers using specialty crops in their products or processes, including any company adding value to a food product. Other groups benefiting directly or indirectly from this project include partner organizations, such as local economic developers, food and ag development centers, Montana Department of Agriculture, and others, who also assist Montana food manufacturers using specialty crops.

Number of Beneficiaries:

55 Montana companies utilizing specialty crops in their production and/or value-added processes participated in an MMEC-sponsored event or customized project. In addition, a large number of companies participated in events where Claude spoke on food safety and related manufacturing processes, as well as a number of companies to whom he provided information and advice. There were also a significant number of partners who also provided assistance to food producers and processors who benefited from the food safety trainings and events. Based solely on the jobs created and retained and the individual income tax paid to the State of Montana, these new and retained jobs resulted in approximately $520,000 additional tax revenue to the state of Montana. Given that this grant was $260,135, the State of Montana received a 2:1 ROI. For details on the logic behind these calculations, please see link to report on MMEC's website: http://www.montana.edu/mmec/documents/2017-MMEC-Impact-report.pdf).

Lessons Learned

Insights:

One of the most surprising lessons learned from this project was that county extension agents showed little interest in participating in the training provided, despite significant attempts to make them aware of the training opportunities in various locations around the state. Another lesson

learned was that the impact to clients was quite a bit higher than expected in terms of jobs created and sales generated and retained.

Unexpected Outcomes:

See previous comments on lessons learned.

Outcomes Not Achieved:

The only outcome measure not achieved (or possibly achieved but not documented, since some trainings were put on by other organizations and we were not provided with a roster of participants) was that of training 3-5 extension agents in food safety. Despite invitations being sent directly by email as well as marketing the MMEC-hosted training events through multiple partner organizations, the extension agents did not register for a single training. We surmise this is due to the fact that extension agents do not consider this type of training of value, or a requirement of their job. While the number of retained jobs was also lower than expected, this was more than offset by the number of new jobs created; therefore, we consider the metric exceeded (total goal of 70 jobs created or retained, total reported 81 jobs).

Contact

Tricia Cook
Business Manager
406-994-4507
patricia.cook@montana.edu

Additional Information

Web page dedicated to Food Safety on MMEC's website:
http://www.montana.edu/mmec/services/FSMA.html

Montana Based Pulse Crop Fractionation Industry Opportunity

Project Summary

Objectives:

1) **Secure investment into the Great Falls trade area that will add value to currently produced Pulse crops.**
2) **Increase the production of Pulse Crops within Montana.**

The issue and need addressed by this project is the lack of specialty crop processors in the Golden Triangle region. Over 80% of our crops leave the state non-value added. As a state, we must increase the number of companies that process pulse crops here in Montana. Low commodity prices have

hurt our Agriculture Industry and exporting the majority of our crops raw hurts our economy. We utilized this project to help Montana Agriculture producers secure additional, diversified revenue streams; help Montanans secure high wage, primary sector jobs; and increase our tax base.

Montana is now the number one pulse producing state at 1.5 million acres of pulse crops (2017 MT Department of Ag) compared with 5 million acres of wheat. The majority of our crops are exported non-value added. Estimates place exportation at over 80%. Our crops go to other countries and states to be processed into ingredients and packaged for consumer sales. The other countries and states get the tax base, jobs, and primary sector revenue to build their communities. We need additional agricultural processing in Montana to grow our economic base. Domestic and international pulse consumption is on the rise. According to the Montana Department of Agriculture's website, "Potential exists for substantial growth of the pulse industry in Montana in the coming years. If additional acres of pulse crops were grown on 25% of Montana's fallow cropland (approximately 900,000 acres) the annual benefit to Montana's economy could exceed $240 million." Now is the time to approach these companies that are expanding their pulse ingredient lines domestically and to approach companies abroad looking to take advantage of tax breaks through Foreign Direct Investment. We are working with existing companies to grow and diversify their pulse processing; producers to help them connect with companies for direct sale; and prospective companies to locate here.

Project Approach

Activities:

Promote business case: Identified 81 Pulse & AgriProcessors: 22 pulse fractionation targets; 12 ingredient processors; 3 pasta processors; 1 snack food processor; & 43 pulse ingredient agri-processors. Attended industry events & tradeshows. Scheduled meetings with individual pulse processors. Identified eight Japanese companies purchasing Montana grains with divisions processing pulse products. Met with and pitched business case.

Exhibit at industry trade shows & attend industry meetings: Exhibited &/or attended 28 trade shows & industry meetings. Including Northern Pulse Growers Conference; Montana Pulse Day; Montana Organics Association; MT Grain Growers; MT Wheat & Barley Commission; MT Farm Bureau; MT Farmer's Union; Canadian Specialty Crop Association; Global Pulse Convention; Institute of Food Technologists; & Food Expo West.

Promote business case through media: We promoted business cases through media including Great Falls Tribune; KRTV; KFBB; Montana Technology Association Roundtable Newsletter; GFDA Top Ten email distribution to 3,500 plus business & community leaders; Signature Montana Magazine; National Public Radio; & GFDA website.

Promote business cases through speaking engagements, articles, trade shows, website, & social media: Our first speaking engagement for the business case was at the Montana Organics Conference. We have spoken at the Montana Grain Growers convention. We've hosted & spoken at dinners for European pulse buyer groups. The case has been featured at additional industry events presented by the author Dr. Neil Doty.

Promote success of new Pulse Fractionation Facility through earned media in newspaper, television, & open house event: Received national attention for Pardue Grain Expansion. The open house event was held July 6, 2018.

Benefits to other Commodities:

N/A

Significant Contributors:

Dr. Neil Doty wrote the business case and aids us in promotion.

MT Department of Agriculture provided feedback and support as we developed the case and continues to aid in promotion.

Montana State University College of Agriculture provided feedback and support as we developed the case and continues to aid in promotion.

Montana Farmers Union provided feedback and support as we developed the case and continues to aid in promotion.

Columbia Grain provided feedback and support as we developed the case.

Montana State University Moccassin Agriculture Experiment Station provided feedback and support as we developed the case.

Pulse Producers provided feedback and support as we developed the case and continues to aid in promotion.

Montana Manufacturing Extension Center aids us in promotion.

Montana Wheat and Barley Committee aids us in identifying foreign companies purchasing our crops.

Goals and Outcomes Achieved

Activities Completed:

Per the workplan, we promoted the business cases in person to key targets in Alberta, Saskatchewan, Montana, North Dakota, and Illinois. We followed industry leaders and events and added, Toronto, Vancouver, California, Oregon, and Japan to our targeted markets.

We exhibited at industry trade shows and industry events connected to the Northern Pulse Growers, USA Dry Pea and Lentil Council, Northern Crop Institute, and State/Provincial/Federal Government agencies. We also exhibited and attended at additional industry events including Montana Grain Growers, Montana Pulse Day, Montana Organics, Natural Products Expo West, Institute for Food Technologists, Canadian Specialty Crops Association, and Global Pulse.

We presented the Pulse Fractionation opportunity through speaking engagements with the industry affiliated events.

We promoted the business case through media, national and local, websites, social media, and association newsletters.

We promoted the business cases through targeted business development trips in conjunction with industry events.

Long Term Outcomes:

Outcomes are long term. We have made significant progress. Our first tangible success attributed to the Pulse Fraction Business Case is Roger and Lisa Sammons with Pardue Grain. Pardue Grain broke ground on a new $7.1 million pulse crop processing facility near Cut Bank, MT, in Glacier County. The company's new 32,000 square-foot building will create a dozen jobs the first year. They project to be at 30 jobs by year three creating a gross payroll of approximately $1.1 million. They have expanded pulse processing operations including sorting, sizing, cleaning and bagging capabilities. Pardue plans to operate 20 hours a day, five days a week, processing 11 tons of pulse crops an hour.

Major successful outcomes in quantifiable terms:

$7.1 million capital investment in Glacier County.

30 new, high wage jobs with a payroll of $1.1 million.

57,200 tons of pulse crop processing

$1.355 million projected sales first year and $3.924 projected sales in year two.

Beneficiaries

Description:

Montana Pulse Producers have benefitted by the increased exposure of the growth of the pulse industry in Montana.

Montana communities and residents will continue to benefit from increased tax bases due to value added agriculture processing facilities and benefit from higher wage job creation.
Residents in Glacier County and Cut Bank are directly benefiting economically from the pulse processing facility.

Number of Beneficiaries:

$7.1 million capital investment in Glacier County
30 new, high wage jobs with a payroll of $1.1 million
120,000 residents of the Golden Triangle

Lessons Learned

Insights:

This is a long-term project. While we fully expect to see a pulse fractionation facility locate in the Golden Triangle, the companies are waiting for production to increase.
We found that we needed to be flexible during the project to respond to market research. For example, we initially thought Chinese companies would be good pulse targets because they are the largest pulse fractionators. We realized through market research that Chinese companies are not looking at locations in the USA but rather intended to remain importers; where as Japanese companies are also processing, have long standing relationships with Montana Farmers, and are interested in investing in the USA.

Unexpected Outcomes:

As described above this is a long-term project. We have learned that local companies expanding are using our business cases in their business plans, financing documentation, etc. but may not have a need to reach out directly to us so we will not know if they used our business case. We will be creating additional value-added business cases to continue to promote processing and manufacturing in Montana.

Outcomes Not Achieved:

We are still waiting on additional results. While we've had preliminary success, we are waiting on the final results.

Contact

Jolene Schalper
300 Central Ave, Ste 406
Great Falls, MT 59401
406-750-4481
Jschalper@gfdevelopment.org

Additional Information

Articles:

Food Ingredients First, Pardue Grain Breaks Ground on US$6.5m Pulse Processing Facility in Montana, US, appeared on July 16, 2018

AG Wired, Zimfo Bytes, appeared on July 13, 2018

World Grain, Pardue Grain Breaks Ground on Pulse Crop Processing Plant, appeared on July 12, 2018

FeedStuffs, Pardue Grain Breaks Ground on $6.5M Crop Processing Facility, appeared on July 12, 2018

Area Development, Pardue Grain Builds Pulse Crop Processing Complex in Great Falls, Montana, appeared on July 11, 2018

Feed and Grain, Pardue Grain Breaks Ground on New Montana Facility, appeared on July 11, 2018

No-Till Farmer, Pardue Grain Breaks Ground on Pulse Crop Processing Facility in Montana, appeared on July 11, 2018

Benzinga, Pardue Grain Breaks Ground on $6.5M, 32,000 Square-Foot Pulse Crop Processing Facility in Great Falls, MT, appeared on July 11, 2018

Commissioning a National Competition in Creative Uses Utilizing USA Grown Pulses

Final Report – Accepted 2017

Project Summary

Background:

Pulses dry peas, lentils & chickpeas are misunderstood ingredients in the value added sector of the food industry. As one of the most cost efficient sources of protein, an excellent source of fiber, and low fat and cholesterol benefits, pulses are ideal ingredients to use in consumer packaged goods. National and International companies in the food manufacturing/food service industries are interested in receiving more nutritional and technical information about new uses for pulses hence, enticing colleges and universities to incorporate pulse ingredients into their programs so their students are better equipped for the work force is the next natural step. Develop and execute the Food Product Development competition for the United States and an online toolkit for college and university food science programs to introduce, inform and inspire next generation food professionals in using pulse ingredients in consumer packaged goods in lure of the United Nations announcing 2016 the International Year of Pulses (IYOP). In addition, coordinate and execute the Global competition during the 2016 Institute of Food Technologists (IFT) annual conference; provide classroom resources to educate students about the benefits of eating and using pulse ingredients; provide applications to show the variety in which you can use pulses; develop tools to show resolutions for common obstacles and ingredient swaps; collect student food applications to share on the USA Dry Pea and Lentil Council (USADPLC) website to share with industry; collect marketing strategies for new applications; and survey participants on new findings, best practices, new markets and obstacles they encountered using pulse ingredients; host educational events at the 2016

Research Chef's Association and at 2016 IFT to announce the global winner and showcase all the products. The main goal was to get stakeholders to integrate pulse ingredients in value added consumer products.

Timeliness:

With the United Nations declaring 2016 the International Year of Pulses (IYOP) and the Farm Bill containing the Pulse Crops Products Program and the Pulse Crop Health Initiative, the pulse industry needs to provide up to date technical and educational resources helped us provide innovative events to catalyze increased interest in pulse crops.

Previous Funding:

Not applicable

Project Approach

Activities:

The main focus of the grant was to conduct a product development competition to promote the increase use of pulses in product innovation. The key targets were food science and culinary students. Working with the Research Chef Associations established competition was determined to be the most efficient way to accomplish this organization focused on merging culinary skills with food science. This competition was part of a larger competition that became the Global Pulse Innovation Showcase at the Institute of Food Technologists meeting in 2016. We worked closely with pulse industry groups around the world to highlight pulse innovation through this showcase. In support of this work we contracted with Northern Crops Institute, Washington State University, and University of Idaho in the updating of our online technical manual, development of factsheets and reports on utilizing pulse ingredients in new applications. Accomplishments include eleven schools entering the initial competition with 6 finalist schools. We showcased 2 US schools at the global showcase with one school featured on the IFT website. Students presented their work on pulses in new product development at IFT in both 2016 and 2017.

Benefits to other Commodities:

The focus of this project was entirely focused on promoting pulses.

Significant Contributors:

Pulse Canada
Global Pulse Confederation
Girish Ganjyal Washington State University
Charlie Baggs, Chef
Brennan Smith, University of Idaho
American Institute of Baking
Texas A&M

The Hot Plate (THP)

Goals and Outcomes Achieved

Activities Completed:

Contracted with Research Chef Association (RCA) on pulse food product development competition. 11 universities entered with 6 teams competing at the onsite competition. Materials printed included information brochures on pulses & baking with pulses. Completed pulse ingredient education session at RCA: Breakout session on Pulses as egg replacers and in baking and meat applications. Northern Crops Institute and North Dakota State University updated the technical manual, the student product development toolkits, and factsheets. Global Product Development Showcase at the Institute of Food Technologists Expo. Coordinated student presentations and recipe demos at the Pulses booth. Assisted in the organizing and implementation of the Love Pulses Global Showcase. Surveys of participants showed increased awareness and interest in using pulse ingredients. Supported research on pulse flours in tortillas deliverables include factsheets, report, and presentation at IFT booth. Continued support of food industry utilization of pulses in food products through high-moisture extrusion workshop at Texas A&M. Developed factsheets on peas and lentils specific to extrusion and functionality characteristics. Finalizing the surveys of competition participants and an extension request for the use of remaining funds. This request included the following components:

- Promotion of technical manual and fact sheets developed through this grant at the Research Chef Association meeting March 15-17, 2017
- Expansion of pulse crop curriculum and teaching tools developed for food science and culinary schools develop undergraduate handbook on pulses.
- Contracted with Washington State University Food Science Assistant Professor Extension Food Processing Specialist to create 4 additional factsheets specifically on pea, lentil, and chickpea functionality as it relates to extrusion processing. Content will be based on newly published article: "Chemical Composition, Pasting and Thermal Properties of Twenty-Two Different Varieties of Peas and Lentils." Chongjun Li1 and Girish M. Ganjyal. School of Food Science, Washington State University, Pullman, WA 99164 (U.S.A.)

Additional activities include working with the American Institute of Baking on cracker development utilizing pulse flours. This information is to be used in the undergraduate handbook as demonstrations on the functionality characteristics of different types of pulse flours and recommendations on how to incorporate in a wheat-thin style cracker. Samples of this product were produced and showcased at the American Association of Cereal Chemists. Additional samples will be sent with the materials developed for this project to food science programs and food scientists. We produced professional photographs of recipes to be showcased in the handbook.

Goal	Performance Measure	Target	Actual to date

Increased awareness.	Participants will have an increase in awareness of how to use dry peas, lentils and chickpeas.	50% of participants will report increased knowledge.	50% of the competition teams reported increased knowledge of using pulses after the competition
Increase the number of Colleges and Universities using pulse ingredients in their Food Science programs.	Colleges and Universities will adopt pulse ingredients and educational materials in their food science programs.	50 schools will report using the tool kits in their programs or have plans to do so.	11 schools participated in student competition
Increased interaction and networking opportunities between industry members, pulse ingredient experts and student teams.	Participants will have networking opportunities with industry stakeholders.	100% of participants stating they had networking opportunities that would not have presented themselves prior to these events.	6 schools at RCA and 2 schools at IFT g

Long Term Outcomes:

Not applicable

Major successful outcomes in quantifiable terms:

Beneficiaries

Description:

Through increased awareness and focus on pulse ingredient usage in new product development at high profile conferences the growers as well as the producers of pulse ingredients benefited as more product developers are looking to incorporate pulse ingredients into products.

Number of Beneficiaries:

In 2016, overall production of dry pea, lentil, and chickpeas exceed 2,000,000 metrics tons in the United States. This production level is the highest in more than 15 years. Promotion of the usage of pulses in the United States as ingredients expands the market opportunities to support this increased production. The expanding number of growers, processors, and food ingredient manufacturers of pulses benefit from promotion of U.S. pulses in new products. **The primary beneficiaries of this project will be the nearly 8000 U.S. pulse farmers** and beneficiaries involved in producing dry pea, lentil and chickpea crops are impacted by increased demand for pulses in the United States, which is the objective of this project.

Lessons Learned

Creating a competition from the ground up is extremely time intensive and expensive, by collaborating with an established competition we were able to have high quality products developed in a professional competition setting. Finding high quality technical expertise in an emerging market was more challenging than initially expected. Those with the knowledge are either working in the food industry with proprietary information and those with the knowledge and expertise in the academic world are in high demand for speaking and consultation. Finding partnerships with organizations interested in similar objectives and outcomes is extremely useful for extending the reach of projects especially with national focus.

Dr. Brennan Smith of University of Idaho originally agreed to work on the curriculum component of the project. However, he was unable to complete this work. He had a student develop a tortilla formulation using chickpea and yellow pea. This included a factsheet on the formulation and demonstration of the product at the Institute of Food Technologists meeting June 2017. When it became apparent the full scope of the objectives would not be accomplished by University of Idaho we looked to find alternative opportunities to promote the use of pulse ingredients in new products. Therefore, we were able to help fund an extrusion workshop on meat analogues at Texas A&M that was originally predominately soy, however we were able to include lectures and demonstrations of how to use pulse ingredients.

The production of the factsheets and the undergraduate handbook on pulses were dependent on the schedule of the researchers at Washington State University and University of Idaho. Due to their busy travel, work, and teaching schedule the undergraduate handbook was not finalized. At this report date 2 factsheets are completed. Dr. Ganjyal is finalizing the factsheet on chickpeas. A project focused on tortillas was completed with a factsheet on the procedure was completed.

Additional opportunities to build the content for the undergraduate handbook included the short course on high moisture extrusion with information on incorporating pulse ingredients.

Contact

Jessie Hunter
USA Dry Pea & Lentil Council
2780 W. Pullman Road
Moscow, ID 83843-4024
(208)882-3023
jhunter@usapulses.org

Additional Information

Not Applicable

Growing Markets for Montana Produce: Improving Efficiency, Access, and Food Safety in the Bitterroot Valley

Project Summary

Objectives

1) **Raise awareness among consumers and buyers about the importance and advantages of eating locally grown produce and supporting local food systems.**
2) **Build capacity for farmers by increasing efficiency of distribution and marketing through coordination and cooperation among farmers, consumers, and produce buyers.**
3) **Increase accessibility of local food to the community and underserved populations. The project will accomplish this through an increased availability of local specialty crops in mainstream markets provided by the work of the marketing coordinator.**
4) **Improve food safety for local food and expand farmer knowledge of food safety issues.**

The Bitterroot Valley in southwest Montana has historically been the center of fruit and vegetable production in the state. In the last 25 years, specialty crop production has declined with productive land converted to pastures, forage production, or suburban development. With rising local demand and many productive vegetable farms and orchards, there are opportunities to grow markets for local produce. However, the market growth has been slowed by lack coordination among growers, and access to distribution systems and markets.

While highly-motivated consumers are able to find local foods at the Bitterroot's six farmers' markets and direct from area growers, the majority of consumers and institutions have limited access to locally specialty crops. Wholesale buyers and other institutions are particularly reluctant to purchase small amounts of locally produced foods from multiple growers due to the extra time and effort required for additional orders, quality inconsistency amongst growers, and the food safety risks, both perceived and real. Producers generally lack adequate time during the growing season to coordinate production and distribution in order to meet institutional requirements. In addition to lack of coordinated marketing, Bitterroot farmers also lack access to adequate continuing education opportunities to increase their production capacity and improve the quality, quantity, and safety of their operations. Because of barriers to reach market opportunities and inadequate support to overcome them, at least two small producers go out of business every year in this area.

This project worked to meet these needs by building networks among farmers, consumers, and buyers. We educated retail consumers and wholesale produce buyers about the value of local food and the food safety measures in place on local farms. We also provided a unified platform for marketing, sales aggregation, and distribution of local specialty crops to make local purchasing simple for buyers and efficient for growers. The later was accomplished by developing a producer cooperative with a web-based marketing and sales platform managed by a marketing/distribution coordinator. The project also strengthened local markets through Good Agricultural Practice (GAP) education and improved on-farm food safety. We offered trainings and one-on-one assistance to help local producers to develop on farm food safety plans and pass GAP inspections. Marketing efforts to expand opportunities for local producers also included will advertising in local media, farm tours for wholesale produce buyers, and two billboards. The multi-farm CSA program brought together over a dozen producers to serve hundreds of customers, supporting the growth of produce farms in the region.

Project Approach

Activities:

To gather information on market challenges and opportunities, we surveyed both local produce growers and buyers. The 26 participating wholesale buyers including restaurants, groceries, and

schools in the Bitterroot Valley and Missoula as well as 34 Bitterroot Valley growers. The survey results were analyzed and shared with the Loyal to Local Cooperative and used to formulate a business and marketing plan for wholesale produce sales. With the 9 buyers who were ready to start purchasing immediately, the coop began wholesale ordering in the spring of 2017.

In order to build better relationships between growers and buyers, we utilized a variety of approaches and found that a mix of outreach activities worked well for reaching buyers. The first summer we hosted tours at 7 farms and had 13 wholesale buyers participate. In 2017 and 2018, we offered 3 events annually for buyers to meet growers and to sample products at local breweries around the valley. Each event had between 12 to 35 potential buyers sign up for additional information and many more customers who stopped by for a sample and brief conversation. Outreach also included posters, samples, sign-up sheets, and flyers all at growers' farmers' market stands which generated over a quarter of our signups. Finally, we used one-on-one discussions with wholesale buyers to increase interest and sales.

A web-based sales platform was developed to streamline both sales and deliveries. Using both Wix and Paypal, we developed a simple way for customers to purchase CSA shares online in the Co-op's first year of sales, and the website accounted for a little over a third of the season's sales. For the next year, we worked with Local Food Marketplace to build a more complex sales platform with the ability to tract inventory, payments, and delivery schedules.

Following the initial surveys, we brought samples and additional farm information to buyers. The Co-op board and project manager developed a logo, Facebook page, website, advertising in radio and newspapers, twice a season farmers market stands, multiple promotional events, and a 6 month rental of billboard signs along the main highway in the Valley. After the Co-op's first season, the board formed a marketing-specific committee who worked with the project coordinator to determine the most cost-effective outreach methods and develop them for the following year.

By collaborating with half a dozen or more farmers and a similar number of buyers, we worked to build an efficient, reliable, and cost-effective distribution system through the Cooperative. We began with weekly deliveries and then increased to by-weekly deliveries starting in late spring of 2017. In the Co-op's second year, we were delivering to 8 wholesale buyers from 7 farms, and total sales were averaging $1400/month with the Co-op receiving a 15-20% margin. The Co-op also partnered with a home-delivery company serving Missoula called Big Sky Family Foods which began generating large-volume sales twice a month. In the third season, buyers outside the Bitterroot Valley were added including the Real Food Market in Helena, and the project coordinator facilitated conversations with a large local distributor called Charlie's Produce working towards collaborating on regular larger-scale sales in the future.

In addition to wholesale distribution, this project helped the Cooperative expand its CSA program through marketing and organizational assistance, providing food from 17 farms to 81 customers in the second season of operation. The Co-op also added a fall CSA program starting in year two, offering customers two large deliveries of fall storage crops from six different farms. The CSA

program sells large and predictable volumes of produce for Co-op farmers and also serves as a marketing platform by allowing customers an opportunity to sample a wide variety of products from many farms along with weekly newsletters featuring participating growers.

Throughout the course of the project, the coordinator assisted individual farmers and those interested in processing and value-adding by regularly answering food safety questions, connecting producers to resources, and directly assisting with on farm food safety plans. The coordinator visited 5 farms to work through their produce handling procedures, develop check lists, and design improvements. In March of 2017, we hosted a two day GAP On-Farm Food Safety Plan training at the Western Agriculture Research Center in partnership with Jonda Crosby and David Wise. We had 8 farmers participate as well as a member of Ravalli County's Department of Environmental Quality and the MT Department of Agriculture's Food Safety Coordinator. The coordinator also wrote a GAP food safety plan for the Co-op itself, updating procedures for packaging, transport, and handling, and facilitated 4 board meetings over the course of the final year to develop a Group GAP plan for all Co-op members.

Benefits to other Commodities:

This project indirectly benefited several local dairy and meat producers who sold their products through the Cooperative, but all outreach and delivery done for products other than vegetables and fruits were performed by a volunteer board member rather than the staff person paid by the grant.

Significant Contributors:

MSU-WARC Dr Zach Miller:

WARC provided grant administration, hired the project coordinator, and hosted GAP trainings. Zach Miller was the primary contact point for all grant activities and produced employee oversight. WARC also helped disseminate educational materials to producers and local food organizations.

MSU Extension – Katrina Mendrey

MSU Extension provided training assistance for the producer workshops and gave support with development of food safety plans. Katrina Mendrey help train the project coordinator and was connected the coordinator with many producers, buyers, and local food organizations in the county. MSU Extension also assisted in dissemination of educational materials and acted as a resource for all southwest Montana farmers.

Ravalli County Economic Development Authority – Julie Foster

RCEDA provided support to the Cooperative with acquiring funding, establishing organizational structure, and developing a business plan. She was present at many of the steering committee and Co-op board meetings, offering advice and guidance for establishing the organization. RCEDA also provided a meeting space for the Cooperative and a location to post meeting minutes.

Lake County Community Development Corp. – Jan Tusick

LCCDC assisted the Co-op in connecting to other cooperatives and producer organizations around the state and with building a business plan. Jan Tusick also aided the Co-op with working towards its Group GAP Certification and developing plans for cooperative-run processing facilities.

Homestead Organics Farm – Laura Garber

Homestead Organics provided the primary location along with walk-in cooler storage for the Co-op producers to drop off and sort produce, and well as the main pick-up site for CSA customers. Laura Garber worked directly with the project coordinator on developing the Co-op and was heavily involved with its operation as the board president.

Mill Crick Farm – Randall Mark

Randall played an important role as a founding member of the Co-op, especially helping out with development of the wholesale program. He also provided cooler space on his farm as a drop off point for other producers.

David Wise – GAP Regional Independent Verifier

David Wise along with Jonda Crosby, taught the GAP training for producers in 2017 and has also offered advice on Group GAP Certification for the entire cooperative as well as support with other issues such as establishing safe packaging and handling practices for the wholesale program.

Loyal to Local Cooperative Board of Directors

The Co-op board of directors worked closely with the project coordinator to establish and manage the cooperative. The board provided a marketing committee which helped extensively with designing and disseminating marketing materials such as the logo, billboard, and flyers. Co-op board members also provided financial advising for establishing pricing and assisted with recruiting new producers as members.

Goals and Outcomes Achieved

Activities Completed:

The project has continued exceeding its targets for facilitating the development of a cooperative marketing and distribution system with steadily increasing sales and a growing number of participating farmers. The Loyal to Local cooperative now has 31 producer members and has been reaching more businesses and families through both its CSA program and wholesale accounts.

In the second year of the multi-farm CSA, the Co-op added products from 8 additional specialty crop growers, including honey, native plants, eggs, apple cider, and herb starts so it is now serving a total of 17 producers and 81 customers. An additional pick up location was added to expand the reach of our distribution network. Over the last two seasons, the Cooperative has facilitated $63,448 in CSA shares have been sold, well over twice the sales volume of the program's first year. The fall CSA program grew by 35% from year one to year two.

The project has also continued growing the Cooperative whole sale program, and now serving 18, groceries, and institutions with produce from 31 member farms. The co-op is also actively refining its strategy for continuing to expand sales volumes every year and possibly collaborate with other local distributors such as Charlie's produce and the Western Montana Growers Cooperative.

The Cooperative has an active marketing committee made up of board members focused on expanding outreach and building upon the success of last year's marketing. The committee has updated the marketing materials and approach for the coming season, focusing on newspaper articles, social media posts, flyers at farmers markets, and promotional events at three local breweries. The committee also sourced volunteers for events, organized producers to offer information at their farm stands, and helped arrange and promote farm tours and volunteer days to get buyers excited about local food. The Local Food Marketplace will make expanding wholesale sales, tracking orders, and taking payments much more efficient as the Cooperative grows

The Co-op has continued working towards improvements in local on-farm food safety developing a Group GAP certification program for all its members. The possibility of auditing within the co-op continues to be analyzed at board meetings as the organization works out the most feasible way to increase food safety as a group of both organic and conventional producers. Currently, 5 of the Co-op's members have completed food safety plans and 8 farms have partial plans. Individual producers are still being offered ongoing free assistance with their on farm food safety plans and improvement of packaging and storage facilities. We are also continuing to offer advice to buyers (such as the Corvallis School District

recently) about the food safety regulations, liability concerns, and their options for purchasing more local products.

Long Term Outcomes:

To meet the long term goal of building capacity for farmers, the Cooperative is working to ensure that the rapid growth of both the CSA program and the wholesale program from year one to two will continue. At the end of each season, the Co-op coordinator distributed a survey to all customers and producers to improve service and quality in order to retain and attract members and supporters. With the online sales hub in place, the Cooperative can continue expansion for many years into the future without expending time and resources on building a system for tracking sales, inventory, and delivery scheduling. As sales grow, the Cooperative will be able to support larger volumes from existing producers as well as add new producers and a larger diversity of products to the organization. The knowledge participating producers and buyers have gained about food safety will have an effect long into the future and potentially also benefit new producers who go to established growers for advice. Many of the 27 wholesale buyers who participated in tours and events have established relationships with farmers which will benefit the local food economy well beyond the two-year scope of this project. The over 70 CSA customers who have purchased a share over the course of the project also have direct knowledge of local producers and their products that will generate local food sales whether or not those customers continue to purchase directly through the cooperative in the future.

Major successful outcomes in quantifiable terms:

Local food sales for Western Montana specialty crop producers: $75,300 over 2 years, earning $64,000 for local growers and $ for the Loyal to Local Cooperative $11,300

Bitterroot stores, schools, and restaurants now selling local food (or significantly more local food): 18

Wholesale buyers reached with farm tours, outreach events, and one-on-one marketing: 36

Farmers participating in local food cooperative: 31

Individuals and families purchasing one or more multi-farm CSA shares in the last 2 seasons: 81

Farmers given training in GAP practices and on farm food safety: 15

Beneficiaries

Description:

Local Specialty Crop Producers Benefited: Total 37

The following types of producers were directly benefited by the project due to product sales and food safety trainings. Many other growers were benefited indirectly by the project's marketing efforts which promoted all locally-grown food and by education of local buyers and individual customers about the quality and availability of local produce.

Vegetable Growers - 18

Fruit Growers - 10

Honey Producers - 2

Herb and Flower Growers – 4

Value Added Producers – 3

Local Food Retail Outlets: 36

36 produce buyers in Western Montana received information about local farms and their products, many also receiving samples and getting the chance to meet with growers and tour farms. 18 wholesale buyers have purchased from the Cooperative over the last two years and are receiving regular product lists and information about the Co-op's members and their farms. 1 school in Darby is currently buying through the Cooperative, and four others have shown some interest are receiving regular information about available products.

Other Cooperatives and food hubs around the region: 8

Loyal to Local Cooperative has participated in multiple Farmers Union, AERO, and Montana Coalition of Cooperatives events, helping the organization connect with other food hubs and cooperatives around the state. The project coordinator and Cooperative board have also met with the manager and board of Western Montana Grower's Cooperative to ensure we are doing work that is mutually beneficial and continuing to seek ways to collaborate on producer support, distribution, and marketing. We have offered advice, support, and assistance with founding documents to several new food cooperatives around the region including two in Idaho and one in Billings.

Number of Beneficiaries:

$75,300 benefited 37 local agricultural producers as well as the Loyal to Local Cooperative over the course of the project. The Cooperative is structured so that it can continue growing

these sales every year and provide increasing support to local farmers. Purchasing more agricultural products from local growers rather than international distributors also creates direct benefit to the community as a whole, keeping money in the local economy and thus creating jobs and distributing wealth.

The benefits of food safety and GAP training are not simple to quantify, but farmers with GAP plans will undeniably have more sales opportunities well into the future, particularly for institutional sales such as to schools where food safety is of particular concern. Farmers with the food safety knowledge we provided are also at significantly lower risk for quality issues that damage customer loyalty and even potentially bankrupting disasters such as food-borne illness outbreaks. The Co-op and all its members will see benefit from its food safety plan and a Group GAP plan in process by gaining access to institutions, large retail chains with strict standards for approved sources, and other distributors such as Charlie's Produce and the Western Montana Growers Coop. Gaining these types of large accounts could help the Co-op and its members reach a cost-effective scale to make it financially sustainable long into the future.

Lessons Learned

Insights:

Marketing: Based on survey results from CSA customers after the first two seasons, we found that the marketing avenues that brought in the most business relative to the cost were (in order of greatest ROI): newspaper articles about the Co-op, evening promotional events at local breweries, and materials handed out at participating producers' farmers market stands. Radio advertising was the least profitable method for the Co-op, followed by the billboards. Farm tours for wholesale buyers were also very effective at building interest in local food, but only for a small percentage of buyers who were able to attend. The other wholesale buyers were best reached by bringing farmers directly into the store, school, or restaurant. The website, Facebook page, and online sales platform proved particularly beneficial for expanding the Co-op's CSA program, where we found that many customers preferred to pay with credit card and also wanted to browse the share options on their own time. Over a third of the Co-op's retail customers did choose to pay with a check or cash and responded well to mailed applications or those handed out at the farmers' market, so both methods of reaching customers were worthwhile. We found somewhat to our surprise that wholesale customers almost exclusively preferred hard copies of the product lists, sales calls by phone or in person, and payment with checks rather than online. In fact, the majority of our wholesale buyers did not use the internet at all in their businesses.

Distribution: Our buyer surveys indicated significant opportunities for local farmers. The key barriers limiting wholesale purchasing of local food were logistical efficiency (as expected)

and turn-over in produce buyers. While the majority of local buyers expressed interest in switching over to local products, these buyers such as grocery produce managers, chefs, and school kitchen managers shared with us that they struggled with very limited time and staffing for dealing with multiple product sources. We learned through our surveys and many interactions during sales calls that buyers, particularly large grocery chains, often preferred consistent bar codes and packaging that were not affordable for individual producers. While they initially demanded labeled tape and twist-ties equivalent to what was offered by the their primary distributors, we gradually found most grocery buyers were willing to compromise and accept simple PLU stickers in the proper color (indicating certified organic or conventional), which were far more affordable than the tapes and ties. As mentioned above, an additional challenge we learned about was the high rate of turn-over in these purchasing positions, which on several occasions led to a store or restaurant backing out of regular produce deliveries that were agreed upon by a previous employee. With this in mind, we would recommend for other food hubs to strive for written contracts whenever possible, preferably made with the knowledge of a supervisor or manager.

Sales to local restaurants and groceries turned out to be much smaller scale in the first two seasons than originally indicated in surveys and conversations with buyers (averaging $55/week each). While small restaurants were some of our most loyal customers, the quantities of their purchases almost never made up for the time and mileage spent on deliveries. Larger distributors such as Big Sky Family Foods and Charlie's Produce will likely form the foundation for the Co-op's wholesale business in the future. Another lesson we learned after the first year of deliveries was that customer loyalty can easily be lost in the months between growing seasons, and it would be worthwhile to recruit Co-op producers with products available throughout the winter such as honey and fermented goods.

Food Safety: We found that many small-scale growers are unaware of potential food safety risks and therefore unwilling to put much time or resources into analyzing their procedures or making improvements. Larger-scale growers in general seemed acutely aware of those risks and were very willing to commit to food safety plans and GAP certification. We also found that a surprising number of wholesale buyers are uneducated about food safety regulations and many mistakenly believe that they cannot legally purchase from any local producers at all. Because many who could benefit from food safety education were not actively seeking that information, the project coordinator found that bringing along basic fact sheets about food safety, GAP, and FSMA for any buyer outreach or farm visits proved very valuable to help answer questions and concerns as they came up.

Unexpected Outcomes:

The project's outcomes and results were as expected.

Outcomes Not Achieved:

Goals and outcome measures were achieved.

Contact

Zach Miller
Western Ag Research Ctr.
580 Quast Ln.
Corvallis, MT 59828
406-961-3026
zachariah.miller@montana.edu

Additional Information

Increasing Access to Regionally Adapted Organic Seed for Montana's Specialty Crop Growers

Objectives

1) **Assist organic specialty crop seed producers and producer groups in addressing post-harvest handling issues and in establishing quality assurance procedures;**
2) **Enable organic specialty crop producers to solve production issues by supporting the development of organically produced and regionally adapted varieties, and**
3) **Expand organic and sustainable practices in specialty crop seed production.**

Project Summary

The demand for locally produced vegetables has skyrocketed in Montana as evidenced by 65 farmers markets and dozens of Community Supported Agriculture (CSA) subscriptions, grocery stores, and restaurants now offering local vegetables. The demand for certified organic food is also increasing, and represented $35.9 billion in national sales in 2014 (an 11% increase from 2013). Montana has more than 200 certified organic farms and handlers. As demand grows, producers express frustration in accessing high-quality organic seed varieties for a number of specialty vegetable crops grown in Montana. Among these crops, stakeholders have identified three crops as priorities for variety improvement and organic seed production: beets, carrots, and storage onions. Farmers and seed companies are eager for open-pollinated varieties of these crops that can be grown for seed. This project built off prior work of project partners by identifying key crops, refining agronomic knowledge of these crops, and training growers in variety improvement and seed production to eventually bring them to the organic seed marketplace. This project supported expansion of organically produced specialty crop seed by supporting Montana farmers' ability to trial, produce, and sell seed. The project delivered improved skills and facilitated producers' ability to sell seed under contract with national seed companies, direct market on their own, or as a member of MT based, Triple Divide Organic Seeds cooperative. Trial results, educational workshops, and advisory

services supported growth of the Triple Divide network of producers, but also targeted additional producers seeking to expand into the organic seed market. Broad promotion of project publications and educational opportunities through OSA's network and regional agricultural organizations enabled a diversity of specialty crop producers access project benefits. This project helped expand the market for regionally produced organic specialty crop seed through producer education and marketing support for seed of vegetable and specialty crops. It also supported the agronomic success of specialty vegetable producers more broadly through access to varieties that grow optimally in Montana. This project addresses the MDA funding priorities of developing new and improved seed varieties and specialty crops, developing organic and sustainable production practices, and developing a local and regional food system.

There is a large unmet demand for seed adapted to Montana's organic farming conditions and climate. In a five year-period (2007 - 2011), organic vegetable acreage in Montana experienced a five-fold increase. The National Organic Program requires organic producers to use organic seed when available. Although the organic specialty seed industry is rapidly growing, there is still not enough organic seed on the market to meet producer demand, and supply is especially limited for vegetable crop seed adapted to Montana's climate. Fortunately, organic specialty seed producers now have access to a new seed company and marketing platform through Triple Divide Organic Seeds Cooperative (incorporated in April 2014). The cooperative is comprised of nine Montana specialty crop seed and vegetable farms. Their seed is marketed through a retail rack program at eight outlets throughout Montana and four farmers market stands. The cooperative's business plan includes expanding its seed production capacity to increase the number of retail racks and strengthen its handling and production practices to meet the quality and quantity demands of Montana's market farms. In the first year of sales, Triple Divide Organic Seeds has found a vigorous market with rapid growth potential. Its business plan projects growth in sales from nearly $10,000 in year 1 to approximately $50,000 by year 4. The market for organic specialty crop seed, in particular organic specialty crop seed that is regionally adapted to Montana and the Intermountain West's growing conditions, holds high growth potential. However, organic specialty crop seed is a demanding industry that requires special attention to quality and handling, in particular when selling directly to farmers who rely on high-quality seed for their business success. In addition, this project will build the skills and opportunities for Montana specialty seed producers to contract for production with national organic seed companies.

This project builds upon a specialty crop project awarded by the Montana Department of Agriculture in 2013 to Lake County Community Development Corporation. This previous project supported the development of marketing materials and a website for Triple Divide Organic Seeds. It also supported Organic Seed Alliance in delivering a workshop to existing and potential organic specialty crop seed producers at the Montana Organic Association annual conference as well as technical assistance to organic specialty crop seed growers. Furthermore, the project focused on potential vegetable crops that could be processed for seed sales and sold as a frozen product to retailers or institutions. This new proposal builds upon this previously funded project. In particular, issues with post-harvest handling have become even more apparent for Montana's organic seed producers as a result of their

increased production for the cooperative. This project will support and expand the network of producers that grew out of the previously funded 2013 project.

Project Approach

Activities:

The overall goal of this project was to improve the quality, quantity and market for Montana-grown organic seed. To address this goal OSA and Montana farmers delivered a series of training workshops from 2015-2018 both on-farms and in class rooms designed to advance the seed skills of Montana farmers. Workshops covered the basics of seed production and variety improvement including crop specific information on managing isolation, population size, diseases, harvest, and seed cleaning. Workshops also covered basics of crop variety improvement and how to conduct on-farm variety trials. In the final year the project team published a print and online guide to quality assurance in seed production, *Seed Quality: best practices for vegetable seed handling in Montana*, which covered quality aspects related to crop genetics, purity, seed born disease, physical quality, and handling recommendations. This report included quick reference guides on seed quality and best practices for 10 vegetable crops including beet, broccoli, carrot, cucumber, kale, onion, snap bean, sweet corn, tomato and winter squash. Access to seed testing and processing equipment is a barrier to efficiency and quality in seed production. This project provided funding for purchase of seed germination testing supplies that are available for use by MT growers and has enabled some growers to increase the scale and efficiency of their production. Finally, this project provided 9 Montana seed producers the opportunity to attend two biennial Organic Seed Growers Conferences. This national event brings together over 400 farmers, researchers, and seed trade in four days of educational workshops, an on-farm field tour and extensive networking opportunities to connect with seed growers from other regions, national seed companies for development of production contracts, and researchers who specialize in organic seed and plant breeding.

The second overarching goal of the project was to build the market for Montana-grown organic seed. To this end the project team surveyed organic vegetable producers statewide and released a report, *Montana Organic Seed Assessment: Vegetables, 2016*. The report includes findings on organic vegetable production in Montana which captured challenges growers face in sourcing organic seed and asked them to identify vegetable crops in need of improvement, including desirable traits. In the final year a promotional campaign for Montana grown seed highlighted the benefits of locally adapted and organically produced seed. To support promotion of Montana-grown specialty crop seed, OSA initiated communications and outreach activities that included a "Meet Your Seed Grower" blog series featuring Montana vegetable seed growers and a flier to distribute at farmers markets and other tabling events across the state. The blog series has been widely shared on social media and via Montana lists, and the flier includes the endorsement and support from other Montana organizations interested in advancing organic specialty crop seed, including the Alternative Energy Resources Organization, Montana Organic Association, and Garden City Harvest. The audience for this flier is mostly market growers and gardeners and the purpose is to go beyond "know your farmer" to "know your seed grower." The aim is to promote the benefits of regional seed systems and why growers might consider Montana-grown seed.

Benefits to other Commodities:

All variety trials, educational workshops, advisory services and other outreach activities focused solely on vegetable, herb, and flower seed production ensuring the target beneficiary is only specialty seed producers. The project team did not observe any non-specialty crop producers attending any events.

Significant Contributors:

OSA, with Triple Divide Seed Cooperative growers, advanced seed production skills to 136 producers at 5 workshops. Three of the workshops were held on organic seed production farms. Seed knowledge and networking opportunities were also shared with 300 participants at organic agriculture conferences and seed swaps. A primary group of beneficiaries of the project were producers in the seed cooperative, Triple Divide Seeds. OSA collaborated with Triple Divide in the educational events and on-farm trials and worked closely with this group of seed growers to identify key equipment needs for producers. Producers identified hand screens, a screen cleaning machine, and germination testing equipment as items needed to improve the efficiency and quality of seed grown among small to mid-size growers. These items are now housed by Triple Divide, but accessible to additional growers through requests to OSA.

Variety trials informed Triple Divide Seed Cooperative growers and others of best seed sources for seed saving in Montana. Triple Divide growers conducted on-farm trials of 9 carrots, 11 green beans, 12 peas, 9 onions, 10 cucumbers, and evaluated for market qualities. An "aha moment" for many growers was realizing that different sources of seed of the same variety performed differently in the region demonstrating the importance of quality management and stock seed production. OSA supported the trials by providing recommendations on trial entries, developing trial evaluation protocols, and processing the data into a digestible format. The results are still being dispersed through recent and upcoming field days in the region. Results also informed Triple Divide growers which varieties to produce for seed and the coop's seed offerings tripled during the project period from about 50 to 150 offerings.

This project was originally developed with strong input from the budding Triple Divide Seed Coop and a recognition of variability in skills and quality standards among grower members pointed to the need for education around seed quality and standardization of production and handling protocols. To this end OSA advised Triple Divide Coop throughout the project on development of their internal grower agreements and standardization of procedures for aspects such as isolation, germination standards, and routine quality checks in variety trials. Throughout the project OSA developed production protocols for 10 crop species. OSA also created a manual on quality assurance introducing topics of genetic quality, physical quality, and purity of seed. These resources are now available online and formed the basis of a quality assurance workshop held in November, 2017.

Market assessment and development was an additional aspect of the project goals. Growth in the market over the project period is evidenced in increased interest in organic seed production through attendance at seed events and growth in sales of Triple Divide Seed coop, which more than doubled during the project period. In the first year of the project, 2016, OSA developed a questionnaire for organic market growers regarding their seed and variety needs in Montana. This survey response rate was estimated to be close to 100% of the targeted MT stakeholder segment of vegetable growers. Respondents expressed the need for improved access to more diverse choices of regionally adapted seed. They also prioritize the need for quality seed of tomatoes, carrots, peppers, kale, and

onions. This information helped drive the prioritization of crops for the project variety trials and helped direct Triple Divide's expansion in variety offerings. The report of results, *Montana Organic Seed Assessment: Vegetables*, 2016, is available for free download online, see project attachments. In the final year of the project promotion of MT grown seed through a blog series highlighting MT vegetable seed farmers and a flier highlighting benefits of MT grown seed.

Goals and Outcomes Achieved

Activities Completed:

OUTREACH AND NETWORKING EVENTS:

This project delivered 10 events and reached 436 people at in-person educational trainings and events.

12/3/2015: Seed intensive pre-Montana Organic Association Annual Conference, Bozeman, MT, 30 participants

12/3/15-12/5/15: Montana Organic Association Annual Conference -- State of Organic Seed presentation, Bozeman, MT, 15 participants

12/3/15-12/5/15: Montana Organic Association Annual Conference -- closing keynote on coexistence, Bozeman, MT, 100 participants

12/3/15-12/5/15: Montana Organic Association Annual Conference -- seed production intensive, Bozeman, MT, 16 participants

9/11/2016: On-farm Seed Saving Workshop, Whitefish, MT, 15 participants

12/1/16-12/3/16: Montana Organic Association Conference, Kalispell, MT, 15 participants

11/11/2017: Seed Quality 101 workshop, Missoula, MT, 12 participants

11/12/2017: On-farm Seed cleaning workshop and Triple Divide Grower Quality Assurance Training, Ronan, MT, 18

12/7/17 - 12/9/17: Montana Organic Association annual conference, Seed workshop, Great Falls, MT, 150

1/27/2018: Livingston Seed Extravaganza, Livingston, MT, 20

PUBLICATIONS

Seed Quality: Best Practices for Vegetable Seed Handling in Montana

- Published on July 23, 2018
- Url: **https://seedalliance.org/publications/seed-quality-best-practices-for-vegetable-seed-handling-in-montana/**

- Traditional press release sent July 23, 2018 to 36 media and agricultural organizations in Montana
- Url: **https://seedalliance.org/press/understanding-best-practices-for-seed-production-and-handling-in-montana/**
- Seed Broadcast blogpost: **https://seedalliance.org/2018/new-resources-best-practices-for-vegetable-seed-handling-in-montana/**
- Number of downloads since release: 12

We've made the 10 crop specific seed handling reports available for quick reference on our website. Each of these were also released on July 23, 2018 and are included as links in the traditional press release and blogpost listed above. We aren't tracking individual downloads on these, but rather pageviews via Google Analytics. Details to date:

- *Beet Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/beet-seed-production-quick-reference/**
  - Number of pageviews since release: 12
- *Broccoli Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/broccoli-seed-production-quick-reference/**
  - Pageviews: 10
- *Carrot Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/carrot-seed-production-quick-reference/**
  - Pageviews: 7
- *Cucumber Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/cucumber-seed-production-quick-reference/**
  - Pageviews: 7
- *Kale Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/kale-seed-production-quick-reference/**
  - Pageviews: 11
- *Onion Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/onion-seed-production-quick-reference/**
  - Pageviews: 7
- *Snap Bean Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/snap-bean-seed-production-quick-reference/**
  - Pageviews: 7
- *Sweet Corn Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/sweet-corn-seed-production-quick-reference/**
  - Pageviews: 6
- *Tomato Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/tomato-seed-production-quick-reference/**
  - Pageviews: 8
- *Winter Squash Seed Production: Quick Reference*
  - **https://seedalliance.org/publications/winter-squash-seed-production-quick-reference/**
  - Pageviews: 7

MARKET ASSESSMENT: *Montana Organic Seed Assessment: Vegetables*

- https://seedalliance.org/publications/montana-organic-seed-assessment-vegetables/

In 2016, Organic Seed Alliance conducted its first organic seed needs assessment in Montana as part of a long-term project to identify crop improvement needs, train more farmers in organic seed production and plant breeding skills, and foster other collaborative organic seed research, education, and outreach. Our survey included responses from 39 stakeholders. A review of organic producer data shows that our response rate of certified organic vegetable farmers in Montana was nearly 100%.1 Survey respondents report a number of organic vegetable seed challenges, from a lack of regionally adapted options to limited choice and quantities in organic varieties. Respondents identified the following five crops as priorities for crop improvement projects: tomatoes, carrots, peppers, kale, and onions. Fortunately, the majority of respondents want to participate in research to help address these and other organic seed needs, as more than 80% of respondents say they're interested in on-farm variety trials. This response shows there's much opportunity in training more Montana vegetable farmers in organic plant breeding and seed production to efficiently fill organic vegetable seed supply gaps.

PROMOTION OF MONTANA GROWN SEED:

In the final year this project promoted Montana grown seed through a blog series featuring Montana seed producers and distribution of a one page flier to be used in stores and farmers markets to promote MT organic seed. A sample of the blog post featuring farmer Judy Osowitz, Terrapin Farm can be viewed here: https://seedalliance.org/2018/meet-your-seed-grower-judy-owsowitz/

Long Term Outcomes:

Developing robust regional seed systems is certainly long-term work requiring ongoing efforts. One of the most promising outcomes of this project has been witnessing the rapid growth in interest in seed among the broader organic farming community. More vegetable and specialty crop growers are not only recognizing the need to engage in seed systems, but enthusiastic to participate in some way on their own farm. More than 80% of the organic vegetable farmers surveyed in our assessment responded that they are interested in conducting on-farm trials and 60% are interested in conducting plant breeding on their farms. We've also seen a dramatic increase in interest in seed education evidenced in attendance rates at recent on-farm field days of seed farms.

Plant breeding is long term work due to the nature of annual seed production and the need for more skillful breeders. While this project did not produce new varieties it did advance the skills in plant breeding and an appreciation of the need for ongoing variety selection to improve adaptation to regional growing conditions over time. This project trained over 100 participants in basics of selection and variety improvement. In the long term this investment in seed skills will result in more farmers and gardeners stewarding varieties in Montana creating a more diverse set of regionally selected varieties and breeding pools for future variety development

Major successful outcomes in quantifiable terms:

Over 400 participants gained access to seed knowledge and several new online resources to guide seed production in Montana including publications that inform the market needs, specific crop production practices, and how to improve seed quality.

While the number of downloads is still relatively low given the late release during the project period, these resources will live on beyond the life of the project. The information in the publications formed the foundation of trainings throughout the project and will serve as resources to those who were not able to attend in person during prior workshops. Based on the farmers who collaborated on the project research and outreach it is evident that seed production is expanding with Triple Divide Seed Coop's business doubled in sales; the number of varieties they sell tripled, and more producers now contracting with national seed companies for larger scale production.

The farmers who engaged in on-farm trials and viewed the trials first hand through workshops gained a great appreciation for the importance of seed quality. Not only did they better understand that different varieties perform differently under different environments even within regions of Montana, they could often see firsthand that different seed sources of the same variety varied in quality. This underscored the importance of routinely conducting trials, selecting stock seed for seed production, and following best practices to ensure the highest quality seed is produced. Prior to the project there was a more casual sense among the producers in the Triple Divide Coop that they could each just source seed to plant or use their own saved seed. The group now has a more rigorous process for tracking and identifying the best lot of seed available for seed production ensuring a higher quality crop is produced.

Beneficiaries

Description:

Organic farmers who produce seed as part of their farm economy were the primary beneficiaries of the project. They gained new skills and relationships that supported their operations. The ability of Montana seed producers to produce higher quality, more diverse regionally adapted seed provided the secondary benefit to organic farmers who rely on seed for their vegetable and specialty crop operations. The broader organic community of stakeholders including food industry and eaters also benefit from a more robust regional food system bolstered by a regional seed system.

Number of Beneficiaries:

Over 400 participants gained knowledge about seed through project outreach events. Over 100 gained skills through in person trainings. Participants at these trainings also learned about the new seed processing equipment purchase through this project. Access to diverse seed options expanded through this project as Triple Divide Coop now offers over 150 varieties, 100 more than prior to the start of the project. As these producers gained knowledge of which varieties grow best in Montana the new offerings also have a higher likelihood of performing well for Montana seed buyers.

Lessons Learned

Insights:

This project initially aimed to deliver a quality assurance manual and trainings within the first year of the project. This would have allowed easier process of implementing quality protocols by the Triple Divide Coop over the later 2 yrs of the project. It took longer to complete in part due to the extensive scope of this topic and in part due to seasonal busyness of the farmers involved and desire to engage

the farmers along the way for input on QA priorities. The crops selected for developing crop-specific protocols were prioritized by the market assessment and farmer input, but these 10 crops also required extensive gleaning of information to ensure they address farmers' need for knowledge and reflect MT climatic considerations. It is hoped the manual will serve growers into the future beyond the project participants.

The project originally also projected releasing new varieties by the end of the project. Once the team started assessing the priorities to meet the goal of expanding access to regionally adapted varieties it became clear that variety trials and variety improvement were a needed first step prior to launching new breeding work. To this end the project focused on skills in assessing germplasm, selecting for regional adaptation and identifying breeding needs. This allowed the growers to focus in on their choice of varieties to produce for seed and undoubtedly has resulted in selecting better performing varieties for the regional growing conditions.

Another aspect that took more development than originally anticipated was coordination of the on-farm variety trials. There was a need for more education on how to manage on-farm trials in a scientific perspective, development of trial evaluation protocols that addressed the key performance needs for Montana, and ability to compile and analyze the results. The success of the trials and usefulness of the results improved over the course of the project due to OSA supporting through training and setting up systems for data collection, tracking and analysis.

Unexpected Outcomes:

While the project's intent and success was to reach growers beyond the Triple Divide Farmers Coop this core group collaborated closely with the project team in variety trials, education, and prioritization of activities. Over the project period OSA served a coordination role and facilitated several discussion and decision making process among the members including prioritizing crops, coordinating variety trials, and implementing quality assurance protocols. Over the course of the project it became clear that this newly formed group (founded in 2014) was learning how to work together, communicating about individual expectations, sorting out leadership roles, and gaining an identity as a new business. We believe the presence of OSA as an external facilitator asking questions about operations, growth expectations, and educational needs, helped the farmers better understand their own strengths and differences and gain clarity in the direction of the business. This was not an original primary goal of the project, but a ripple effect of our efforts to support the economic and production success of the growers individually and as a cooperative business.

Outcomes Not Achieved:

As discussed in the insights and lessons learned above - the quality assurance educational materials took much longer to complete than originally projected, but were ultimately delivered, and the project focused on building the skills and access to diverse seed resources necessary prior to initiating truly new breeding work. The take home lesson is to remember each year is only one growing season and the lessons from last season must be played out with iterative improvements in planning with each successive year.

Contact

Micaela Colley

PO Box 772
Port Townsend, WA 98368
info@seedalliance.org
360-385-7192

Additional Information

Links to project online resources:
PUBLICATIONS
Seed Quality: Best Practices for Vegetable Seed Handling in Montana
Published on July 23, 2018
Url: https://seedalliance.org/publications/seed-quality-best-practices-for-vegetable-seed-handling-in-montana/
Traditional press release sent July 23, 2018 to 36 media and agricultural organizations in Montana
Url: https://seedalliance.org/press/understanding-best-practices-for-seed-production-and-handling-in-montana/
Seed Broadcast blogpost: https://seedalliance.org/2018/new-resources-best-practices-for-vegetable-seed-handling-in-montana/
Number of downloads since release: 12

Improving the Competitiveness of Specialty Crop Producers Through Packaging, Marketing, and Food Safety

Project Summary

Packaging can be a barrier for smaller fruit and vegetable growers to access larger wholesale markets. Each package must meet food safety, operational, and marketing needs of the retailer. The Western Montana Growers Cooperative worked to improve access for Montana fruit and vegetable producers to supermarkets through improved packaging of a range of products that span numerous farms. Packaging and item identification was themed to promote awareness of local specialty crops among consumers and coded with UPC's and PLU's to facilitate operations.

In addition, WMGC piloted the distribution of produce in cleaned and sanitized Reusable Plastic Containers (RPC's) that are food safety compliant and resource efficient.

We monitored sales increases through supermarkets and tabulate volumes and costs for the RPC's used. This project will position Montana fruit and vegetable growers to better compete in the large grocery market.

Project Approach

Objectives

1) **Increase farmer access to supermarkets by rolling out themed packaging for a group of produce items such as blueberries and cherry tomatoes and by developing specialty crop point of sale materials to ease the merchandizing needs of supermarkets.**

We developed artwork to use for themed packaging and labeling for fruits and vegetables. The artwork was used in the design of packaging for 6 different frozen fruits and vegetables and a variety of point of purchase signs (6 or more) and package labels for different varieties of apples and pears. We created PLU stickers for apples and varieties of winter squash.

These marketing materials are incorporated into our discussions with produce managers and packaging and promotion of fruits and vegetables.

2) **The creation of 8 different washing and sanitizing facilities to meet the needs of farmers, and an analysis of the resources required to get boxes returned to producers and sanitized for reuse.**

Three of the farms operating wash stations served as collection sites for neighboring farms. The neighbors observed the facilities, the processes, and the shipped products in RPC's regularly.

3) **WMGC will produce a report documenting challenges and successes implementing the RPC pilot program as well as costs and number of uses of RPC's and distribute the report and track the number of recipients.**

We purchased 550 large size and 160 smaller reusable packing containers (RPC's) for use in the 2016 growing season. Harlequin Produce and Lifeline Farm were the largest user of the containers, but several other farmers participated as well. Harlequin established protocols for use, washing and reuse.

The host farmers spoke to the all the issues of practicality, food safety, work flow and costs related to the use of RPCs. Because these farms took the lead in food safety, with most obtaining GAP/GHP certification, discussions about RPC's lead to discussions about larger issues of food safety. These discussions helped to foster the culture of awareness and continual improvement.

We also purchased plastic liners for use with some produce items and to reduce the labor of washing. The plastic liners can also be used with used wax boxes as an alternative. We have experimented with a range of packaging scenarios for a range of crops and will evaluate the program this winter.

Many farmer to farmer discussions begin with personal visits that lead to observation and discussion. In addition, WMGC hosts annual tours of farms and facilities. Most growers are members of the Montana Sustainable Farmers Union (Montana Homegrown) which includes annual peer-to –peer visits to each farm.

The WMGC shares information with members about RPC's and food safety through a number of ways. The WMGC maintains a permanent Food Safety Committee that reports to the WMGC board monthly. Discussions of the RPC program in the board meeting minutes are emailed to the membership. At the WMGC annual membership meeting in February, staff and the participating

farmers will review the RPC program. In early spring, food safety plans and requirements for the coming season will be sent to each member.

Benefits to other Commodities:

N/A

Significant Contributors:

WMGC general manager, Dave Prather

The WMGC Food Safety Coordinator, Jim Sugarek

Goals and Outcomes Achieved

Activities Completed:

Goal	Benchmark	Target	Actual
Expand market access for Montana fruit and vegetable producers by improving consumer awareness within supermarkets and increasing purchases of locally grown, sustainably raised products in these locations.	Fruit and vegetable sales to conventional groceries in 2014 was $79,400.	The target is to double sales by 2017 to $160,000 annually.	$80,000 in 2014 to $180,000 in 2017 (project ended 1/31/2018)

Project Activity (1000 Characters max)	End Month:	End Year:	Actual completion
G1A1: Coordinate selection of fruits, herbs, and vegetables for labeling design. Approve designs for each item.	July	2016	July 2016
G1A2: Create artwork for the range of fruits and vegetables.	July	2016	March 2016
G1A3: Produce package labels, bags, item labels and produce ties.	August	2016	September 2017
G1A4: Label products and distribute to stores	December	2017	ongoing
G1A5: Promote products in stores and evaluate effectiveness	December	2017	December 2017
G1A6: Track sales of specialty crops to grocery stores on an annual basis. Explore details as needed by store or by item.	January	2018	January 2018
G2A1: Construct southern wash/sanitize facility	April	2016	July 2016
G2A2: Construct northern wash/sanitize facility	April	2016	July 2016
G2A3: Write and implement Standard Operating Procedures for wash/sanitize facilities and distribution system	December	2017	April 2016
G2A4: Purchase appropriate reusable plastic containers for specified crops.	June	2016	July 2016 part 1
G2A6: Operate wash/sanitize facilities, coordinate, evaluate, and modify	December	2017	December 2017
G2A7: Communicate at least annually in January with LCCDC, Wallace GAP Community of Practice group, and the NGFNetwork.	January	2018	December 2017
G3 Analyze results of RPC pilot project and disperse among other Food Hubs and producer groups	October	2017	December 2017

G2A5 - Set up 6 additional RPC wash/sanitize facilities on different farms to expand RPC usage	July	2017	December 2017

Long Term Outcomes:

WMGC staff is available to answer questions, consult on Food safety issues, or make referrals to farmers.

We work with the producer cooperative LINC Foods in Spokane on food safety issues and have shared information about our program with them. In March of 2018 we will share information about our project with food hubs and the biannual conference, which is in Albuquerque this year.

So far in 2018, WMGC has sold $95,130 worth of specialty crop products to institutions.

Major successful outcomes in quantifiable terms:

We met our goal of doubling sales to supermarkets from $80,000 in 2014 to $180,000 in 2017. While we have a core group of items for stores, we feel there is more potential for growth in both the number of items and the volume of sales of each.

So far in 2018, WMGC has sold $95,130 worth of specialty crop products to institutions.

Beneficiaries

Description:

The WMGC shares information with members about RPC's and food safety through a number of ways. The WMGC maintains a permanent Food Safety Committee that reports to the WMGC board monthly. Discussions of the RPC program in the board meeting minutes are emailed to the membership. At the WMGC annual membership meeting in February, staff and the participating farmers will review the RPC program. In early spring, food safety plans and requirements for the coming season will be sent to each member.
In addition WMGC staff is available to answer questions, consult on Food safety issues, or make referrals to farmers.

We work with the producer cooperative LINC Foods in Spokane on food safety issues and have shared information about our program with them. In March of 2018 we will share information about our project with food hubs and the biannual conference, which is in Albuquerque this year.

Number of Beneficiaries:

50 farmer members of the Western Montana Growers Coop

Lessons Learned

Insights:

For retail packaging, each product requires custom design and artwork, implementation and marketing. We underestimated the time and personnel needed for each new item.

Unexpected Outcomes:

N/A

Outcomes Not Achieved:

N/A

Contact

Jim Sugarek, Accountant
Western Montana Growers' Coop
1500 Burns St Suite C
Missoula MT 59802
(406) 493-0859
grower@wmgcoop.com

Additional Information

N/A

Promoting Pulse Crops for 2016 International Year of the Pulses

Final Report – Accepted 2017

Project Summary

Background:

Pulse crops play a significant role in enhancing global food and nutrition security, environmental protection and enhancing the livelihoods of smallholder farmers. They provide an affordable source of protein, are high in fiber, contain no gluten and may help with blood glucose management. In addition to the health benefits, pulses return nitrogen into soils and when rotated with other crops will reduce farmers' need for chemical fertilizer saving farmers money and reducing overall greenhouse impact.

However, there is a lack of consumer awareness of where pulse crops come from, what their benefits are and, for those who are aware of pulses, how to integrate them into their diet. With the United Nations proclaiming 2016 *International Year of Pulses*, this is the single largest opportunity to increase awareness of pulses. This project will develop and air a television spot targeted to raise

consumer awareness of Montana grown pulse crops. The ad will make consumers aware of Montana grown peas, lentils and chickpeas, and direct them to resources to find more information on purchasing and preparation of pulses.

The objective of this project is to increase the sales of Montana grown pulse crops through the airing of a public awareness campaign.

Timeliness:

The General Assembly of the United Nations has voted to declare 2016 as the "International Year of Pulses." Because there will be lots of attention on Pulses in 2016, this may be the single largest opportunity to increase awareness of pulses.

Previous Funding:

Not Applicable

Project Approach

Activities:

The RFP for production companies was sent out in August of 2015. From the production companies that submitted a proposal, Spur Studios was selected. Spur worked with Montana Department of Ag to develop the story board and visual design for the TV spot. The script was drafted by September 1st. With the developed advertisement, we worked with cable and local TV stations to select a mix of air times and stations targeted to maximize reach and to target household decision makers on food purchases. The commercial aired on cable for 3 months and on local channels for 7 weeks throughout the year with the last airing in November, 2016. The cable and TV stations we worked with provided us a non-profit rate where the number of airings were doubled for the same quoted price. The TV spot also had some limited run on the Hulu website. Though informally surveyed, many individuals reported having seen the commercial throughout the state.

Reception of the TV spot, though not formally measured, was broadly positive. While it is not possible to draw a connection between total pulse sales and the airing of the spot, there was a significant increase in pulses grown and sold in Montana. We believe that this ad was an effective tool to raise the aware in Montana's non-agricultural economy based communities of the significance of the pulse industry in the state.

Benefits to other Commodities:

Not applicable.

Significant Contributors:

Spur Studios was great to work with and did a great job on the commercial. Our local TV stations were also easy to work with and matched all of our air times so instead 4 times a day for 7 weeks, we got 8 times a day for 7 weeks.

Goals and Outcomes Achieved

Activities Completed:

The TV spot was contracted developed and ran on television 8 times per day for 7 weeks.

Goal	Performance Measure	Target	Actual
Increase consumer awareness of grown in Montana pulse crops, their availability and health benefits	Our goal is to increase sales of Montana Grown Peas, Lentils and chickpeas by 5%.	In 2014, $153,907,573 of pulses were purchased.	Pulse sales increased 30% adding $46,172,271

Project Activity	Who will do the work?	Start Month:	Start Year:	End Month:	End Year:	Actual completion
Create content and script for commercial.	Marty Earnheart	September	2015	September	2015	September 2015
Send out RFP to video companies for production of commercial.	Marty Earnheart	September	2015	October	2015	August 2015
Begin production of commercial.	Marty Earnheart/Selected Production Company	October	2015	November	2015	November 2015
Send out RFP to TV stations for airing of commercial.	Marty Earnheart	September	2015	September	2015	September 2015
Begin airing commercial.	TV Stations	June	2016	December	2016	January 2016
Study pulse Checkoff to evaluate results of Ad campaign.	Marty Earnheart	December	2016	December	2016	January 2017

Long Term Outcomes:

Not Applicable

Major successful outcomes in quantifiable terms:

Pulse sales increased 30% adding $46,172,271

Beneficiaries

Description:

Montana Pulse Crop Growers

Number of Beneficiaries:

Approximately 1,000 pulse growers in the state.

Lessons Learned

Insights:

We were able to gain significant exposure through television stations matching ad buys.

Unexpected Outcomes: None

Outcomes Not Achieved:

All outcomes were achieved.

Contact

Marty Earnheart
Montana Department of Agriculture
Box 200201, Helena Montana, 59620
406-444-9126
mearnheart@mt.gov

Additional Information

The video spot can be viewed at https://www.youtube.com/watch?v=HoHQBVX8Npo

Providing Education to Montana Grape Growers and Wine Makers

Project Summary

This project brought expert speakers to present to members of the Montana Grape and Winery Association (MGWA) at their annual meetings in 2017 and 2018. Expert speakers will provided education to grape growers and wine makers on a wide range of topics pertinent to members of this emerging industry. Success for the project will be measured in the self-reported increase in knowledge from participants.

Funds were additionally used to update the website of the Montana Grape and Wine Association to raise public awareness of Montana grown and produced wine.

Project Approach

Activities:

Three speakers were funded to attend the 2017 Montana Wine and Grape Growers Association (MWGA) meeting. Speakers focused on cultivar selection, wine grape production and wine branding/marketing. Approximately 80 individuals were in attendance at the conference.

For the 2018 MWGA conference, funds were used to support the attendance of speakers:

- Matt Clark, University of Minnesota – *Cold Climate Grape Varieties*
- Markus Keller, Washington State University – *Vineyard Practices for Crop Yield and Quality*

- Greg Cook, NDST & 4e Winery – *The Chemistry of Wine*

Funds were additionally used to contract developers to update the MWGA website.

Benefits to other Commodities:

The 2018 MWGA Conference also included a number of apple cider makers from across the state.

Significant Contributors:

Rich Torquemada, President, MWGA

Goals and Outcomes Achieved

Activities Completed:

Project Activity	Actual completion month and year	# of attendees- If applicable
MGWA Conference 2017	April 2017	Approx. 80
MGWA Conference 2018	April 2018	Approx. 80
Update MWGA Website	June 2018	June 2018

Long Term Outcomes:

N/A

Major successful outcomes in quantifiable terms:

In both 2017 and 2018 approximately 80 Montana grape growers and wine makers benefited from knowledge shared by expert speakers at the MWGA annual conference.

Beneficiaries

Description:

Montana grape growers, and wine and cider makers.

Number of Beneficiaries:

Approximately 100 given some large level of overlap between the two years of the conference.

Lessons Learned

Insights:

Although technically and legally there are large areas of overlap between wine and cider makers, combining the groups is still in its experimental phase. The level of overlap in the branding and marketing of the respective groups does not seem to have a large degree of overlap.

Unexpected Outcomes:

N/A

Outcomes Not Achieved:

All objectives of the project were achieved.

Contact

Jim Auer, Grants Manager
Montana Department of Agriculture
Box 200201
Helena, MT 59601
406-444-5424
jauer@mt.gov

Additional Information

MGWA Website: https://www.montanagrapeandwine.com/