Specialty Crop Block Grant

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12-25-B-0934

Final Performance Report

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Dry Pea and Bean Crop Research

Project Summary:

Although Montana is considered as the second largest dry pea and lentil producer in the USA, variety development and agronomic research are inadequate, especially for Chickpea and marrowfat pea. Due to the lack of *Ascochyta* blight disease resistant chickpea cultivars and less knowledge in marrowfat peas, chickpea and marrowfat pea production acres remain low, even though the crops have high market prices.

The PI at the Central Agricultural Research Center (CARC), Montana State University (MSU) worked with breeders from Pacific Northwest, Canada, and Europe to evaluate chickpea and marrowfat varieties and breeding lines for potential adaptation to Montana environment and produce good yield and quality. Five breeding lines were selected from Marrowfat breeding materials for further evaluation. In addition, four commercial varieties and three advanced breeding lines of marrowfat peas were tested for yield potential and seed size in replicated trials in 2011 and 2012. Two commercial varieties and one advanced breeding line show very promising, which will be recommended to producers.

Similar to chickpeas, twenty-seven breeding lines were selected from breeding materials for further evaluations. In addition, seven commercial varieties and four advanced breeding lines were tested in replicated trials at multiple locations for yield potential, disease resistance and quality. Results indicated that newly developed varieties and breeding lines have high disease resistance and higher yields. These varieties will be recommended to producers to grow. This is a multi-year continuous project, and we have made good progress. The continuous work after 2012 is supported by the **Specialty Crop Block Grant #12-25-B-1079.**

Project Approach:

Plant breeding and cultivar development takes many years before a suitable cultivar is developed and accepted by producers. In this project, the PI and research team adopted two approaches: 1) single plant and breeding lines were selected from breeding materials obtained from breeders; 2) commercial varieties were obtained from seed dealers and advanced breeding lines were requested from breeders to test their adaptation and yield potential in Montana.

One each of marrowfat pea and chickpea nurseries of segregating breeding populations was planted at CARC in the spring 2009, and individual plants that demonstrate good agronomic characteristic and seed quality were selected from the segregating breeding populations. The breeding material included in those nurseries was specifically selected to address the problems of Montana. Specifically, chickpea breeding populations for inclusion in the nurseries included those with genes for resistance to the prevailing pathotypes of *Ascochyta rabiei* that cause *Ascochyta* blight, large seed size and high yields. Those selected individual plants were threshed separately in the laboratory by hand. Seeds collected from each plant were planted in a single row trial using a single row planter in spring 2010 at CARC. Plants from each single row were harvested and threshed by hand. Seeds from those single rows were examined and screened for quality and potential end users.

The PI in this project realized the breeding and cultivar development is a multi-year effort. To meet the producer's immediate needs, commercial cultivars and advanced breeding lines were requested from seed dealers and plant breeders to test at multiple locations in Montana in 2011 and 2012. The experiment was a randomized complete block design with 4 replications, and the plot dimensions were 6 ft. x 20ft. Crop tours and field days were organized at several of the testing sites to give producers a visual comparison of cultivar performances in 2011 and 2012. Montana Pulse Day was organized by Northern Pulse Growers and Montana Department of Agriculture in Great Falls, MT once a year in 2009, 2010, 2011, and 2012.

More than 200 people attended the event each year and the PI presented some of the research results from this project at these events.

Goals and Outcomes Achieved:
The ultimate goal of this project is to select and develop suitable cultivars of marrowfat pea and chickpea that adapted well to Montana's climate and soil conditions with disease resistance, high yield, and good quality.

Marrowfat pea line selection and testing:
Genetic improvement and cultivar development requires multi-year efforts. We have made good progress and achieved good results. We'll continue this project. So far we have selected five marrowfat lines (PS0877MT663, PS0877MT621, PS0877MT625, PS0877MT624, and PS0877MT833). In addition, three commercial varieties (Big Daddy, Guido, Supra) and three advanced breeding lines (PS99101364, PS99101365, and PS02100740) were tested in replicated trials at Moccasin, MT in 2011 and 2012. The yields and seed sizes are presented in Table 1.

Table 1. Marrow fat pea yield, test weight, and seed weight at Moccasin, MT in 2011 and 2012.

	2011		**2012**	
Variety	**Yield (lb./a)**	**Seed wt. (g/100seeds)**	**Yield (lb./a)**	**Seed wt. (g/100seeds)**
PS02100740	954	32.4	1029	28.36
PS99101365	686	34.2	841	25.84
PS99101364	673	34.2	930	27.18
Supra	806	34.9	1038	30.20
Guido	679	37.6	955	40.14
Big Daddy	705	36.3	947	30.84

Another commercial variety, Orka, was tested at two locations at Moccasin and Richland in 2012, and yielded 1404 lb. /a at Moccasin and 2427 lb. /a at Richland, respectively. The seed size of Orka is similar to PS02100740 at Moccasin (28.60 g/100 seeds), but the seed weight reach 34.76 g/100 seeds at Richland, where there was more moisture in the growing season. Therefore, Orka, Supra, and PS02100740 have potential to receive higher yields in Montana, but Guido has the biggest seed.

Chickpea line selection and testing:
So far, we have selected 27 breeding lines from the breeding materials for further evaluation. In addition, we tested commercial chickpea varieties CDC Frontier, Dwelley, Dylan, Myles, Sawyer, and Sierra in 2011 (Table 2) and tested CDC Frontier, Dwelley, Myles, Sawyer, Sierra, CDC Alma, and CDC Orion in 2012 (Table 3) at multiple locations. Several advanced breeding lines from USDA-ARS Pullman were also included in the multi-location trials in Montana.

Table 2. Chickpea yields at Bozeman, Conrad, Corvallis, Huntley, Moccasin, and Richland 2011.

Variety	Conrad	Havre	Moccasin	Richland
CA0390B007C		366	964	1241
CA04900421C	---	269	1029	1593
CA04900843C	---	97	1105	987
CA0690B0250C	---	461	994	755
CA0690B0409C		545	1045	1082

IS-14		381	919	687
CDC Frontier	3422	1005	824	1606
Dwelley	2474	249	817	467
Dylan	2872	49	1047	574
Myles	2749	1237	996	1096
Sawyer	2906	763	1062	1328
Sierra	2739	439	990	710
Trial Analysis:				
Trial Means	796	1750	830	1175
P-Value	<0.0001	0.0521	0.0143	<0.0001
LSD (0.05)	136	575	304	577
CV (%)	9.62	18.28	19.18	29

With irrigation, chickpeas yielded 1200 to 1900 lb. /a at Corvallis, and 1900 to 3100 lb. /a at Huntley, respectively. With very high disease pressure, new chickpea varieties with good disease resistance yielded more than 2500 lb. /a (CA0469C025C), but old varieties that are susceptible disease were severely damaged by *Ascochyta* leaf blight and yielded little.

In summary, the marrowfat pea and chickpea cultivar selection and testing project had made good progress. Some breeding lines show higher yield potential compared to check varieties in the trials. A few advanced chickpea breeding lines showed higher disease resistance and yields. Due to the large production area in Montana, a small yield increase and good disease resistance in new varieties can make a big difference to the industry.

Table 3. Chickpea yields at Bozeman, Conrad, Corvallis, Huntley, Moccasin, and Richland 2012.

Variety	Bozeman	Conrad	Corvallis	Huntley	Moccasin	Richland
			(Irrigated)	(Irrigated)		
CA0469C025C	---	---	1963	---	905	2589
CA04900421C	---	---	1870	---	1223	910
CA0690B0427C	---	---	1746	---	659	759
CA0790B0042C	---	---	1801	---	981	201
CDC Alma	828	1946	1771	3056	919	1467
CDC Frontier	875	2103	1971	2745	605	2488
CDC Orion	852	2090	---	3167	1619	1907
Dwelley	---	---	1189	2052	570	58
Myles	994	1626	1693	2668	964	1588
Sawyer	777	1493	1308	2544	786	782
Sierra	450	1311	1477	1935	657	180
Trial Analysis:						
Trial Means	796	1750	1678	2595	830	1175
P-Value	<0.0001	0.0521	0.1749	0.0012	0.0143	<0.0001
LSD (0.05)	136	575	NS	526	304	577
CV (%)	9.62	18.28	21.74	11.58	19.18	29

Beneficiaries:
As of 2011, dry pea planting acres have reached 190,000 acres in Montana, and chickpea planting acres increased from 6,300 acres in 2010 to 9,000 acres in 2011. Although the expansion of the production is mainly determined by the economic returns and rotation benefits of those crops, the multi-location variety trial has provided visual demonstration to farmers about pea and chickpea adaptation to climate and soil conditions across Montana.

Field days organized at each of MSU research centers, and the Montana Pulse Days organized by Northern Pulse Growers and Montana Department of Agriculture each year have provided more comprehensive information to producers on pea and chickpea variety performance, production technology, and economical returns etc.

Every year we host a field day at our research center (CARC) with approximately 100 people attending the field day each year. Since 2009, we have had an annual Montana Pulse Day organized by Northern Pulse Growers and Montana Department of agriculture. I am one of the major speakers in this venue and about 250 people from Montana and neighboring states attended the meeting each year. In addition, we held a field crop tour at the testing site in northeastern Montana (the major pulse crop production area) each year since 2009, about 60 farmers attended the tour each year.

All these activities have helped Montana farmers to understand and adopt these specialty crops. The expansion of pea and chickpea planting areas from northeastern Montana to central and north central Montana may reflect a portion of the beneficiaries of this research project. Because of the expansion of production areas, several pea and chickpea buyers have set up buying and processing facilities at several locations in Montana.

Lessons Learned:
Chickpea is most susceptible to Ascochyta blight. Several chickpea cultivars performed well at central Montana were severely damaged by the disease at northeastern Montana. Cultivar development for Ascochyta resistance will be a multi-year effort. But newly developed commercial varieties and advanced breeding lines have showed promises. The integrated pest management (IPM) strategies (including disease resistant cultivars, fungicide applications, and cultural practices) will be needed for chickpea production.

Environment specific cultivar selection had to start from single plant selection, and seed increase takes several years. Due to the limited amount seed available, multi-location testing for the breeding lines selected in Montana is slightly delayed in this project.

Herbicide management and record keeping is very important for pea and chickpea production. In 2012, the chickpea breeding line evaluation trial at Moccasin was damaged by residual herbicide in soil, but we collected seeds from survival plants for 2013 trial.

Furthermore, apparently deer and disease are problems for chickpea trials. Due to the deer damage, one trial at Creston, MT failed. There was a huge *Ascochyta* disease pressure at Richland site in 2012. However, with this disease pressure we were able to select disease resistant varieties.

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Additional Information:
The funding from this Specialty Crop Block Grant only supported the planting, selection, harvesting, and sample processing of marrowfat pea and chickpea plant population and single row nurseries. The multi-location pea and chickpea variety trials across Montana were supported by the Montana Agricultural Experiment Station and the USA Dry Pea and Lentil Council grant. The PI's salary is paid by Montana State University. This is a multi-year continuous project, and the continuous work after 2002 is supported by the **Specialty Crop Block Grant #12-25-B-1079.**

Potato Disease Prevention Research

Project Summary:
The purpose of this proposal was to enhance the routine virus testing capabilities of the Potato Laboratory at Montana State University, and to determine if varietal resistance could be used to manage incidence of the virus PVA. The MSU potato lab employs the most rigorous testing program for potato viruses of any certification program in the United States. Most states rely solely on visual inspection for potato diseases and laboratory testing as a backup for visual assessment. Montana conducts 100% testing of all nuclear and generation 1 potatoes, and representative sampling of the later generation fields. All of the routine testing is done using ELISA, which has a sensitivity of ~100,000 virus particles per gram of plant tissue. PCR is 100-1000 times more sensitive, is valuable for early detection, and for detection of latent infections that do not display visible symptoms.

PVA testing was initiated in the Montana crop in 2007. This disease is very difficult to visually detect in the field, so serotesting or PCR are vital for identification in the early generations, so that specific nuclear generation plants or infected families can be removed. Through information gathered from leaf sampling conducted by the Potato Lab, there are significant differences in susceptibility of different potato varieties. There is no data in the literature on varietal resistance to PVA. For this project, we tested the 10 potato varieties with the highest acreage in replicated, PVA inoculated greenhouse trials. The data gathered on susceptibility to PVA is of high value to growers for managing PVA, especially in seed plots where more resistant varieties can be grown as buffers for more susceptible varieties. This is important because in 2007, Idaho and Oregon included PVA in their tolerances for total mosaic virus, of which PVA is a component.

In 2008, the USDA specialty grants program provided funding to upgrade the MSU Potato Lab's testing equipment. One of the upgraded instruments was for Polymerase Chain Reaction (PCR), which is a method that can detect minute amounts of DNA. During the winter of 2009, the potato lab personnel validated the methodology and the specific primers used to detect various strains of PVY, PVX, and PVA. This project built on that base by refining the techniques used for virus detection, and by also using PCR to quantify the amount of virus was in various cultivars inoculated with PVA. We built on this project above and beyond the original objectives by performing Quantitative PCR (using a borrowed instrument) on the samples from the PVA experiment.

Project Approach:

Experiments were conducted to determine the relative sensitivity of ELISA and PCR for the detection of PVA, PVX and PVY in potato tubers, sprouts and leaves. The first experiment tested different dilutions of virus infected leaves that had been combined with different ratios of healthy leaves. This experiment was designed to both determine thresholds for virus detection, and also address the potential for detection in bulk sampling methods. For this experiment, a 1cm diameter cork borer was used to cut disks of virus infected or healthy leaf tissue. Dilutions were performed with 1:10, 1:50, 1:100, 1:200, 1:400 and 1:1000 ratios of infected to healthy leaf disks. Leaf disks were placed in plastic extraction bags with extraction buffer. Leaves samples were extracted using protocols specific to ELISA and RT PCR, then analyzed using the respective techniques. For all three viruses, PCR detected virus from the higher dilution (lower titer). For PVX, PCR was 10X more sensitive than ELISA. For PVY and PVA, PCR was 20 more times sensitive than ELISA (Table 1). From the experiment, we learned that by using PCR for PVX and PVY, we could bulk up to 1000 leaf samples together, and still detect 1 positive leaf out of the entire sample.

Table 1. Highest dilution with positive test results for ELISA vs. PCR where 1 virus positive leaf disk was combined with healthy leaf disks.

Virus	ELISA	PCR
PVX	1:100	1:1000
PVY	1:50	1:1000
PVA	1:10	1:200

In a second experiment, potato tubers were tested for detection threshold using PCR. For PVX (which is known to have high virus titers in tuber tissue), the virus was detected in a 1:200 dilution of diseased to healthy tuber core tissue. For PVA, the virus was detected in non-diluted tuber cores. We have not performed this experiment yet with PVY, but will in the future.

A third experiment was performed to determine if detection of potato viruses in tuber cores using PCR was sensitive enough to be used in place of ELISA for analysis of sprout or leaf tissue. The purpose of this experiment was to determine if we could obtain similar results using tuber core samples analyzed using PCR, to what are obtained using sprout and leaf tissue analyzed with ELISA. Leaf tissue analyzed using ELISA is the typical method for summer and winter testing, and sprout testing is used as a back-up test for winter testing if a valid result is not obtained from samples grown in Hawaii. If we could utilize PCR for analysis of tuber cores, we could analyze tubers immediately without waiting 3-4 weeks for the tubers to sprout. For PCR assays, tuber cores were removed from the stem end of the tuber. Sprouts were removed from the tubers when they were ~1/2” long. Leaf samples were collected from the apical to the inoculated leaf. For PVA, PCR detected 2% less virus in tuber tissue than ELISA in leaf tissue, and 6.8% more sensitive than ELISA for detection of PVA in sprouts (Table 2). Since this work was done on un-diluted tuber cores, it still may not be sensitive enough to use for a post-harvest test considering the previous data where PVA was not detected in 1:10 dilutions of tuber tissue. For PVX, virus detected in tuber cores using PCR and sprouts using ELISA were very similar, and either technique only underestimated the total virus by 5-6% compared to leaves. Taking this in combination with the prior data that PVX can be detected in dilutions of up to 1:200 in tuber tissue, this illustrates that PCR can definitely replace the sprout/ELISA test on tubers when a quick test result is required. For PVY, the percentage of positive plants was highest for leaves using ELISA followed by sprouts with ELISA and tuber cores using PCR. While the percentage of infected tubers detected by PCR and tuber cores was

significantly less than for both leaves and sprouts with ELISA, it may still be high enough to warrant use when a quick result is needed, and there is insufficient time to sprout tubers or grow plants.

In 2012, the tuber core analysis was expanded on by testing dilutions of virus positive tuber tissue with healthy tuber tissue. Since we have recently adopted real-time PCR through our 2010 SCBG funding, we chose to use that technique rather than conventional PCR. For PVA and PVX, tubers were diluted as much as 1:400, and for PVY, diluted to 1:32. All of the dilutions were analyzed using ELISA and real-time PCR. For PVA, ELISA detected virus at the 1:2 dilution and real-time PCR detected as low as 1:32. Since lower dilutions were not tested, it is plausible to predict that tuber tissue could be diluted even further. For PVX and PVY, ELISA detected virus at 1:10 and real-time PCR detected 1:400. These detection limits indicate that real-time PCR will be extremely reliable for testing tubers, and that the detection threshold is low enough that more tubers could be combined in one test. These results actually expand beyond the original objective of comparing the sensitivity of PCR to ELISA by testing the detection threshold using an even more sensitive technique, real-time PCR.

Table 2. Percent virus (PVA, PVX, PVY) detected in tubers using tuber cores analyzed with PCR, and sprouts and leaves analyzed with ELISA.

	Percent Virus Detected		
	PVA	PVX	PVY
Tuber Cores - PCR	16.8	29.5	26.3
Sprouts - ELISA	10.0	30.6	30.5
Leaves - ELISA	18.8	35.8	35.2

In a fourth set of experiments testing the relative effectiveness of PCR vs. ELISA for detection of potato viruses, 2 lots of potatoes, one that was harvested from plants known to be infected with PVA and one harvested from plants infected with PVY were tested using both detection methods. Individual tubers from each lot had two cores removed from the stem end. One core was extracted and analyzed using PCR and the other was tested for presence of virus using ELISA. These same tubers were then sprouted and one sprout was removed, cut in half lengthwise, and each half analyzed using ELISA and PCR respectively. These same tubers were then planted, and 3 weeks after emergence one leaf was removed from each plant, cut in half and tested using the respective methods. The results of this experiment indicate the relative detection limits of each method, and the probability of detecting virus in tuber vs. sprout vs. leaf samples for each method. For the PVY tuber lot, PCR detected more than twice as many PVY+ tubers in core samples than ELISA, 6% more PVY+ sprouts, and a similar amount of PVY in leaves (Table 3). These results verify that ELISA is as effective PCR for detecting PVY in leaf samples. These results demonstrate that while PCR is more likely to detect virus in sprout and tuber cores, virus infected tubers may be missed due to titers that are below the detection limit. For the PVA lot, ELISA and PCR detected a similar number of positive tuber cores (Table 4). This is an unexpected result, because virus titer of PVA is generally thought to be low in tuber tissue, and in previous experiments, we were not able to detect PVA in tuber tissue using PCR. For the sprout tissue, PCR was detected 6% more

tubers than ELISA. For leaf tissue, both methods detected the same number of infected plants. A useful aspect of this data is the information that using PCR for core or sprout tissues should result in an accurate assessment of infection comparable to leaf sampling.

Table 3. Detection of PVY using ELISA and PCR for tuber cores, sprouts and leaves derived from tubers harvested from infected plants

	Total # of Tubers Tested	Number of Tubers Testing Positive		% Infection Detected	
		ELISA +	PCR+	ELISA	PCR
Tuber Cores	206	21	56	10.1	27.2
Sprouts	213	65	78	30.5	36.6
Leaf Tissue	214	75	76	35.0	35.5

Table 4. Detection of PVA using ELISA and PCR for tuber cores, sprouts and leaves derived from tubers harvested from infected plants

	Total # of Tubers Tested	Number of Tubers Testing Positive		% Infection Detected	
		ELISA +	PCR+	ELISA	PCR
Tuber Cores	213	33	35	15.5	16.4
Sprouts	207	21	36	10.1	17.4
Leaf Tissue	214	39	39	18.2	18.2

In greenhouse experiments, the relative susceptibility of 10 potato varieties was tested using mechanical inoculation with PVA infected plant sap. The varieties tested were Norkotah Colorado 3, Russet Burbank, Yukon Gold, Classic, Dark Red Norland, Norkotah, Alturas, Umatilla, Ranger, and Amisk. There were 20 replicate plants for each variety. Plants were started from plantlets which had been produced in-vitro. Plants were inoculated 1 month after transplanting when they had 3-4 true leaves. PVA inoculum was prepared by grinding a PVA positive tobacco leaf in buffer. Three leaves of each plant were sprayed with a puff of carborundum, and then PVA inoculum was applied to the leaves with a cotton swab. Non-inoculated leaves basipetal to the inoculated leaves were removed. The experiment was repeated twice. In the first run of the experiment, 22 and 23 days after inoculation, only the varieties Norkotah and Dark Red Norland tested positive for PVA using ELISA and PCR. Using PCR, 44% of plants tested positive and ELISA detected 11%. For Norkota, PCR detected 75% infected plants and ELISA detected 65%. At 45 days, plants were tested with ELISA only and 56% and 80% of the Dark Red Norland and Norkota plants were infected respectively. These data indicate that in the first sampling, PCR detected 4X more infection in the Dark Red Norland than ELISA. The difference was not as great as with Norkotah. What this may indicate is that virus titers are not as high in Dark Red Norland as in Norkotah, and the virus titer rose above the detection level more quickly in Norkotah than in Dark Red Norland.

Table 5. Percent PVA Positive Plants Detected using ELISA at 22 and 45 Days and PCR at 23 days

	% PVA Infected Plants		
	ELISA 22 days	PCR 23 days	ELISA 45 days
Norkotah Co3	0	0	0
Russet Burbank	0	0	0
Yukon Gold	0	0	0
Classic	0	0	0
Dark Red Norland	11	44	56
Norkotah	65	75	80
Alturas	0	0	0
Umatilla	0	0	0
Ranger	0	0	0
Amisk	0	0	0

In a repeat of this experiment, plants were inoculated using the same method and were tested using ELISA at 17 and 36 days after inoculation. Leaf samples were also tested using PCR, but results were inconsistent and are not reported below. In this experiment, 4 varieties in addition to Dark Red Norland and Norkotah were infected with PVA as detected by ELISA, and the percent detected increased in all varieties from 17 to 36 days. Russet Burbank and Yukon Gold appear to be less susceptible to infection than Norkotah Co3, Classic, Dark Red Norland, and Norkotah. Norkotah Co3, Dark Red Norland and Norkotah were infected at very high levels at only 17 days (Table 6).

Table 6. Percent PVA positive plants detected using ELISA at 17 and 36 days

	%PVA Infected Plants	
	17 days	36 days
Norkotah Co3	75	90
Russet Burbank	10	50
Yukon Gold	20	40
Classic	45	85
Dark Red Norland	70	80
Norkotah	65	85
Alturas	0	0
Umatilla	0	0
Ranger	0	0
Amisk	0	0

In 2011, this experiment was repeated using real-time PCR. To determine the relative virus titers of Potato Virus A (PVA) in different varieties of potato, and the relative sensitivity of the ELISA and real-time PCR methods, 10 plants each of 10 different potato varieties were inoculated with PVA by rubbing sap from an infected plant on a lower leaf of 1-month-old plants. After 1 week, the leaf acropetal to the inoculated leaf was sampled and extracted for analysis by real-time PCR and ELISA. Presence of virus was determined using both 30 and 35 PCR cycles. 1 week after inoculation, no samples had detectable virus using ELISA and across all varieties, 15 plants were positive for PVA using the 30 cycle threshold and 50 plants were positive for PVA using the 35 cycle threshold (Table 7). At week 4, ELISA detected similar amounts of virus to real-time PCR, demonstrating that it is still a very viable technique for detecting virus in plants that have had sufficient time to build up virus titer. The real-time technique is much more sensitive and better for detecting early infections. One interesting observation is that at 35 cycles, there were significantly more positive plants detected across all varieties at 1 week verses 4 weeks. This may indicate that while the PVA virus is initially able to infect the plant tissue, varieties that are more resistant tend to eliminate the virus over time. This has significant implications for PVA management in the field. At 30 cycles, this was not demonstrated, but for varieties such as Amisk and Umatilla which have demonstrated resistance to PVA in previous trials, the PVA was detectable at week 1 using real-time PCR and not at week 4. This may indicate that these varieties actually suppress the replication of the virus within the plant.

Table 7. Number of positive PVA detections using ELISA and real-time PCR (RT-PCR) 1 weeks and 4 weeks after leaf inoculation.

Cutoff at 30 cycles

	Week 1		Week 4	
	RT-PCR	ELISA	RT-PCR	ELISA
ALTURAS	0	0	0	0
AMISK	3	0	0	0
CLASSIC	1	0	1	0
DK RED NOR	0	0	3	3
NORK CO3	6	0	8	7
NORKOTAH	3	0	7	7
RANGER	0	0	0	0
RB	0	0	7	7
UMATILLA	2	0	0	0
YUKON GOLD	0	0	0	1
Grand Total	15	0	26	25

Cutoff at 35 cycles

	Week 1		Week 4	
ELISA	RT-PCR	ELISA	RT-PCR	ELISA
ALTURAS	3	0	0	0
AMISK	6	0	2	0
CLASSIC	5	0	1	0
DK RED NOR	5	0	5	3
NORK CO3	9	0	8	7
NORKOTAH	7	0	8	7
RANGER	4	0	0	0
RB	5	0	7	7
UMATILLA	2	0	1	0
YUKON GOLD	4	0	0	1
Grand Total	**50**	**0**	**32**	**25**

This project specifically benefitted Montana Seed Potato Growers and seed potato researchers and certification personnel. Information on detection of viruses using different methods and varietal differences in susceptibility to PVA were presented to potato growers at grower meetings and workshops, and to other potato researches and seed potato certification personnel at the USDA special working group WERA 89 “Virus and virus-like pathogens of potato”.

This work was conducted solely by staff of the MSU Seed Potato Certification Program.

Goals and Outcomes Achieved:

Goals and Outcomes by Objectives -

Objective 1. Compare the sensitivity of PCR to the ELISA technique, which has been used extensively in the Potato Lab for the last 20 years.

We quantified the detection limits for three viruses when using PCR vs. ELISA. For all three viruses, PCR detected virus from the higher dilution (lower titer). For PVX, PCR was 10X more sensitive than ELISA. For PVY and PVA, PCR was 20 more times sensitive than ELISA (Table 1). From the experiment, we learned that by using PCR for PVX and PVY, we could bulk up to 1000 leaf samples together, and still detect 1 positive leaf out of the entire sample. For tuber cores, samples could be diluted 1:400 and still detect virus. This information has been extremely useful because it has given us confidence that we can use PCR for testing tuber tissue to satisfy Post Harvest Test requirements. We are also using PCR bulked samples for testing meristem cultures for a wide range of viruses and bacterial samples. This saves our program at least $5,000 per year in testing costs that we used to contract out. Information on the

technique was presented to the board members of the Montana Potato Improvement Association and to Montana Potato Growers at their annual meetings in 2010, 2011 and 2012. The availability and pricing of the PCR test was described in the Potato Lab Newsletter in March 2013.

Objective 2. Develop bulk-sampling and processing methods for detection of PVX using PCR

We demonstrated that we can use PCR in highly diluted samples (1:1000) and still detect pathogens. This is especially useful for determining the presence of a zero-tolerance pathogen. Bulking numerous samples which make the technique much more cost effective. We are also using this technique for testing our mother stock for an array of viral and bacterial pathogens.

Objective 3. Adapt the hydraulic plant sap extraction presses currently used for ELISA for DNA extraction.

We were not able to fulfill this objective due to the high volatility of the extraction materials used for DNA extraction. The reagents posed a safety risk when used in the open vessels that are used in our hydraulic press. Extraction reagents used for ELISA were evaluated but were not effective for DNA extraction and no viruses were detected when those reagents were used.

Objective 4. Determine susceptibility of different potato varieties to the virus PVA.

Through inoculated greenhouse trials, we showed that 6 of the 10 varieties tested were resistant to PVA. This matches the data from summer testing very closely where 3 varieties (Russet Burbank, Russet Norkotah and Russet Norkotah CO3) are more heavily impacted by PVA and 1 additional variety (Dark Red Norland) is occasionally infected with PVA. This information is valuable to the seed growers because they can use the resistant varieties to surround their seed plot and reduce exposure to PVA. These results were presented to Montana Potato Growers in progress reports at annual grower meetings and at a grower workshop on Integrated Pest Management Plans for Seed Potato Growers. In March 2013, the PVA data was also presented at the meeting on "Potato Virus and Virus-Like Disease Management" and a summary of results will be included as an impact in the final report for that USDA working group. This data has not been published in a peer reviewed journal, but the information has been disseminated to the key researchers and certification individuals with the potato working group.

Beneficiaries:

The beneficiaries of this project are the 52 Seed Potato Growers in Montana and also growers in other states. The information on the methodology and the PVA varietal resistance has been shared with seed 30 potato researchers and certification personnel in other states at the national meeting on "Potato virus and virus-like disease management". Montana seed potato producers have benefited from enhanced testing services available through the MSU Potato Lab. As a result of this and subsequent SCBG projects, we now offer PCR as a routine service.

Lessons Learned:

We have demonstrated that we can routinely use PCR in our lab for rapid disease identification and in situations where the virus titer may be very low. The extraction protocols are much more time consuming than ELISA and the reagents are also much more expensive. For general testing, especially summer leaf testing and for the Post Harvest Test; ELISA is still the most efficient and cost effective technique. PCR is most suitable when you need the extreme sensitivity or if you need to test tuber tissue which has lower

virus titers than sprout or leaf tissue. We demonstrated that the varietal resistance that we observed in summer leaf testing was similar in inoculated greenhouse trials. This is an important observation because very often, differences may be observed in natural infections in the field and artificial conditions in the greenhouse.

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Movable Grow Tunnel Vegetable Project

Background:
High tunnel production systems are relatively new to Montana and the northern Great Plains. Increased production and more profitable timing of sales result from investing in high tunnel technology. The Glendive area has very favorable growing degree days (2,662 - 50° F Base). Vegetable growing regions in neighboring states with similar growing degree days include Twin Falls, ID (2,552), Quincy, WA (2,681), and Yakima, WA (2,381). The growing region between Miles City (2,726) and Glendive may be best in Montana for growing annual vegetable crops. Hot summers provide the heat units needed for growing and ripening and cold winters reduce bug and disease pressure.

This 3-year project provided funding to design and construct two movable high tunnels in conjunction with a large-scale, commercial vegetable plot. Non-traditional vegetable row crops such as roasting peppers, hot peppers, sweet peppers, tomatoes, sweet potatoes, onions, and cucumbers were grown inside and outside the tunnels systems to determine possible commercial production and market acceptability of these crops in the region. Fingerling potatoes; summer and winter squash; red, white, and yellow onions; and sweet corn will be grown outside in deer-proof fields.

Motivation:
Original motivation included the sugar market being in transition. Irrigated producers were looking for alternative, high-value crops to replace or add to their crop rotation to maintain the sustainability and viability of their operations. When examining alternative crops, whether for dryland or irrigated production, the logical first choices are those that require the least changes in equipment and production practices. For most current irrigated farmers in the region, row crop vegetables could be produced under the current furrow irrigation system and would not require substantial changes in equipment or production practices.

Because the climatic and soil conditions in the lower Yellowstone Valley make this area ideal for commercial vegetable production, these crops have the potential of becoming a high value rotation crop for the Yellowstone Valley region from Billings and Hardin to Fairview and, thus, a major source of income to the state.

High tunnels are an additional means of risk management that do not require a large amount of capital input or a major change in farming operations or equipment.

This specialty crop project should:

- Increase innovation
- Improve the efficiency of specialty crop production
- Reduce food distribution costs
- Increase the marketing of local specialty crops
- Provide the research necessary to determine the adaptability of this production system to Montana
- Promote the production of specialty crops
- Improve food nutrition by providing more fresh, local foods year-round
- Promote "buy local"
- Address environmental concerns as high tunnels typically use less herbicides and insecticides

Project Approach:
High tunnels have been attracting a lot of attention in the past few years, as more and more producers have come to consider high tunnels essential tools in their operations. A high tunnel is basically an arched or hoop-shaped frame covered with clear plastic and high enough to stand in or drive a tractor through. Traditional high tunnels are completely solar heated, without electricity for automated ventilation or heating systems. Crops are grown in the ground, usually with drip irrigation. Compared to greenhouses, high tunnels are relatively inexpensive, ranging in price from $1.50 to $3.00 per square foot.

High tunnels are used extensively in Europe, Asia, and the Middle East. Although high tunnels are not used as much in the United States as in other parts of the world, interest in the United States is growing rapidly.

High tunnels have the potential for:

- Earlier crop production (7 to 21 days earlier)
- Higher yields per acre (2 to 3 times higher)
- Cleaner, higher-quality produce
- More efficient use of water resources
- More efficient use of fertilizers
- Reduced soil and wind erosion
- Potential decrease in disease
- Better management of certain insect pests
- Fewer weeds
- Reduced soil compaction and elimination of root pruning
- The opportunity for efficient double or triple cropping
- High tunnels allow certain crops to be grown throughout the winter, providing a continuous supply to markets (and tables) the entire year.

To increase the utilization and vegetable production while using high tunnel production systems, a few producers have started using movable high tunnel designs. To design and implement a similar system in Montana will require some trial-and-error, practical hands-on development, and research. This proposal funded the development of two movable, high tunnel systems (one on tracks and one on skids) and research into what vegetable production system may be best adapted to our region and, possibly, other parts of Montana.

Three field days were held in relation to the High Tunnel Project. Each Field Day was held at a different time of year so participants could see the variety of activities that happen throughout the year in high tunnels. In 2010, 19 people attended. Eight were growers. The workshop concentrated on introducing agency and private producers to the concept of high tunnels, movable high tunnels, and construction options.

Two field days were held in 2012, one in March and the other in October. The March workshop concentrated on how to operate a high tunnel and what to plant in high tunnels. The workshop featured a two-hour DVD presentation by Eliot Coleman, the author of Four-Season Harvest and The Winter Harvest Handbook .

Eliot Coleman's rotation plan for movable high tunnels was discussed. Six of the nine attendees were growers.

The October 13th workshop allowed participants hands-on experience in building a high tunnel from scratch using locally source materials. A 12' x 40' high tunnel was constructed. Twelve of the 13 attendees were growers.

Climatic, Soil, and Water Implications

The historic climatic data for Glendive indicates that from April 13 to October 27 each year the minimum daily temperature is 32° F, or above, and covers a period of 197 days. The typical "growing season" runs from May 15 to September 15 (the time between the last killing frost in the spring and the first killing frost in the fall) and is 123 days long. Adding a layer of plastic between the environment and the plant population not only allows the grower to mitigate killing frosts but adds 10° F of protection to the daily minimum temperature. Adding 10°F to the minimum daily temperature gives an above 32°F time period from March 17 to November 16, or 244 days. Putting all this data together, high tunnels should allow his should allow for production from March 17 to November 16 or a 121 day increase over the typical 123 day growing season, essentially doubling the growing period.

Plant selection for the early and late cool/cold periods in the high tunnel is critical for full season use. Spinach has been successfully over-wintered at the Glendive site. Bak Choi, pak choi, and kale produced late crops when planted, or transplanted, in the high tunnels.

Soils in eastern Montana tend to be saline, 7.6 pH to 8.1 pH. The water, if drawn from typical well, in the Glendive area, is not suitable for irrigation. Choosing commercial field crops that can tolerate the higher pHs, such as asparagus, beets, potatoes, and tomatoes, will go a long way towards creating viable and sustainable commercial production ventures.

Plant Varieties

It became apparent throughout the life of the project that just about any variety annual crop can be grown in this region. The growing season is sufficiently long for most vegetables to fulfill their production cycle. Timing of sales and consumer acceptance is a bigger consideration for profitable vegetable production in this area. In an attempt to accustom local consumers to new and different foods and food

items, we prepared and gave many samples to market-goers so that they could try items that were unfamiliar to them. In many cases recipes were also made available.

As this project was “sponsored”, there was hesitancy on our part to compete with other local producers. If another local vendor was offering a similar item at the Farmers Market, we would not promote our product until they had sold out or offer our products only through the FTT Store. Another marketing strategy employed was to offer free samples of our produce and then send the market-goer to the other vendors for purchase.

Varieties of squash and cucumbers that are bush-type were favored over vining varieties to maximize space and allow for mechanical cultivation. The preference for bush varieties did not seem to limit our ability to select from a plethora of seed sources.

- Asparagus: Two-year old crowns of two male-female varieties (Martha Washington and Purple Passion), and two hybrid, all-male varieties (Jersey Giant and Jersey Knight) were planted in the spring of 2011. The first year’s production produced a few sprue asparagus. Sprue asparagus are the first pickings or "thinnings" and have has thin stems. Too early to tell. There was limited, but promising production in 2012 with the Jersey Knight and Jersey Giant producing larger stems. Although the Martha Washington’s stem were not as large, it made up for its lack of size by producing more volume. The Purple Passion seemed to be a novelty to consumers and was mixed in with the green asparagus stems when marketed. All the plants are vigorous and strong and seem to do well in the saline soil. We should see ever increasing production over the next 5 years.

  The asparagus season is usually over by the time the farmers markets begin and the plants require daily hand-harvesting. To be a viable crop for area producers, an easier and more ergonomic way to get close to the plants to harvest and control weeds will need to be devised.
- Cucumbers: Cucumbers are a common farmer’s market item in Glendive. Production was limited so as to not compete with other market vendors. The two main varieties trialed were Marketmore 76 and German bush pickle. Both pickling and slicing cucumbers were produced. One exception was a melon that tasted like cucumber. The seed was donated by a local gardener who said it was an heirloom, Italian variety that they didn’t know the name of. The vines were prolific producers, but we have not been able to locate a seed source. The melon was a big hit at the Saturday Farmers Market in a cucumber salsa recipe.

- Dill: The timing of dill production will need to be fine-tuned. As the dill was self-seeding, little was done to cultivate the herb. The problem is that the dill has finished production before the pickling cucumbers are ready to be pickled. We had several requests for dill at the farmer’s market that we were not able to fulfill because the production period for the dill had past. Future efforts will include new plantings timed to coincide with the peak of the pickling cucumber season.

- Garlic, Shallots, and Chives: Five varieties of garlic (Spanish Roja, Purple Glazer, German Red, Mitichi, and elephant), one variety of shallots, and two varieties of chives (garlic and regular) were trialed. The German red and Spanish Roja were the most prolific. These two varieties showed little damage from frost heaving and speculation is that the producer would benefit little from planting them in a tunnel. During the duration of this project winters have been relatively

mild and snow cover fair. Producers north of our area wishing to grow garlic, which must be planted in the fall, may find it advantageous to plant in a high tunnel, but may be just as well off by planting in a low tunnel. Low tunnels are about 1/5 the cost of a typical high tunnel. The shallots did well, but had a limited market and may have suffered from a lack of water.

- Horseradish: Prolific but a little goes a long way. Needs a certified, commercial processing facility.

- Jerusalem Artichokes: A small patch of Jerusalem artichokes, or sunchokes, has been cultivated the last two years. The tubers tend to do well on their own, but attract voles. We were contacted by a commercial grower who was looking for a large plot in Montana to grow some seedstock. He hasn't been in contact since May 2012.

- Leafy Greens: Curled leaf and flat leaf kale, Pok Choi, Bak Choi, Swiss Chard, and a variety of leaf lettuce were produced. The leaf lettuce in the high tunnel came on a little earlier than that grown outside, but tended to bolt due to the spiking of high temperatures on sunny days. A better way of controlling temperature automatically will need to be installed. Most producers in the region would probably use high tunnels as a way to diversify farm financial risk, but would not have the time or inclination to do so unless automatic venting or temperature alarm systems could be installed.

  Three varieties of Swiss chard was successfully grown, Fordhook Giant, Bright Lights, and Red Rhubarb. The people that tried it like it. People, who weren't used to it, didn't buy it. All three varieties produced prolifically over a long period of time. To market it "indirectly" it was included in salad green mixes with great success. A Swiss chard kimchi was also manufactured with limited success.

- Onions: Both seed and sets were used. When using seeds, the rows were planted thickly to determine whether the thinnings would be a viable crop that could bring in extra income early in the season. The thinnings were harvested during the course of normal field work and weed control. They were readily accepted by the consumer but it was apparent that the market could be easily flooded if larger acreages of the crop were planted. A commercial or institutional outlet will need to be developed.

- Pepper production: Sweet bell and hot peppers for fresh market and roasting were produced. The sweet bells sell well at the farmers markets and at the FTT Local Foods Store. A few hot peppers go a long way. A commercial outlet for their production appears to be necessary. Two varieties of roasting pepper, NuMex Big Jim and pablano, were test grown. Both would benefit from being started in low tunnels to give them the head start they need to complete their production cycle. While we have the heat degree days needed to produce hot peppers, having them come to the market earlier in the season should be financially advantageous. Value can be added to this crop by roasting the peppers and making them available to the consumer.

- Specialty Potatoes: French fingerlings, German butterball, Yukon Gold, LaRatte, Rose Finn, and Austrian crescent have been grown. The small potatoes presented a special problem as they could not be successfully dug with a potato digger with standard chain spacings. The extra cost and time of digging them by hand was not offset by higher prices at the market. "New potatoes" were

more popular and commanded a higher price much in part due to the consumer's desire to relive past events where they remember their mother or grandmother serving "new potatoes" which were young, undersized forms of potatoes, usually red. The production volume, except for Yukon Gold, does not appear to match production volumes attained by more conventional varieties of potato. They are a nice novelty potato and taste good, but the extra labor and low volume did not make them a viable alternative to more traditional varieties.

- Radishes: A variety of radishes were grown. The French breakfast radishes and small round radishes were popular, but local sales were limited and the market was quickly flooded. The daikons (long white) were a harder sell. People would taste them but did not know what they would do with such big radishes. Two kinds of kimchi were manufactured. One recipe used daikon radishes and other root crops and another utilized Swiss chard. The kimchi was "acceptable" to those who tired it, but would probably remain a "hard sell" to the typical eastern Montana customer. One variety of radish was a big hit at the Saturday Farmers Market. The rattail, or podding, radish grown strictly for its pods were grown and free samples distributed at the farmer market. It makes a great appetizer when dipped in sea salt a consumer with beer. It is consumed fresh and requires not preparation.

- Raspberries: Autumn Bliss, Caroline, Polana, Royalty, Nova, Joan, and Polka were planted in 2011. At this point in time, it is too early to gain significant production data to determine their adaptability and profitability in high tunnel production systems. One potential issue with hoop house production of fall-earing raspberries is that they need to be pollinated by bees, which will require the introduction of bees into the high tunnel. People not used to being around bees, or those that are allergic to them, will probably find this a definite drawback.

- Rhubarb: The beginnings of a commercial production plot of rhubarb for fruit and wine production was initiated in 2012. The plot will be expanded until it reaches approximately 1 acre in size. Several area residents make good dessert wine using rhubarb and rhubarb sells for about $2.00/lb. at the local farmers markets. Rhubarb has some commercial potential and is used in many spring desserts and rhubarb pie.

- Spinach: Three smooth leaf varieties (Emu, Red Cardinal and Space) and two curled leaf varieties (Space and Spargo) were trialed. The Red Cardinal bolted early. The Emu bolted last. Production of all spinach, which went dormant in late November and began growing again in March, outpaced demand. The plants were tilled under in April to make way for new production.

- Strawberry Production: Albion and Tristar were planted. The plants from the Tristar supplier arrived in considerably better condition than the Albion. The Albion plot was virtually a 100% loss. The Tristar strawberries are still producing but have suffered from grasshoppers, dry conditions, and weed pressure. The plants received a heavy layer of mulch in 2012 to help retain soil moisture and reduce weed pressure. The production of strawberries has proved to be very labor intense and culturally difficult.

- Winter Squash: Acorn, delicata, and buttercup squash can be grown in abundance, but will produce more than local markets will bear. A methodology to process this abundance into sales later in the season needs to be developed. The acorn and buttercup squashes keep well into the

fall but require a storage unit to keep them at about $50^{O}F$ to $60^{O}F$. Root cellars work well but can be too dry to maintain proper moisture content. The delicata do not keep as well as the acorn and buttercup squash but make up for the short storage time with a soft rind which allows the consumer to bake the squash in slices without peeling.

Other winter squash varieties such as hubbards, banana, kabocha, spaghetti, and butternut have all been grown successfully within the region. They produce in such great abundance that they are hard to sell. The typical family would have trouble utilizing one of these larger-type squashes. Processing them into squash butter or providing a proportioned, smaller piece of the vegetable should help make these vegetables more marketable. As cut squash is considered "processed", the use of a certified, commercial kitchen with the proper equipment would ensure the ability of producers to market their products in a safe and efficient manner.

- Summer Squash: Every gardener within the area produces summer squash, mainly zucchini. We produced the standard and round varieties of zucchini, patty pan, yellow straight neck, and yellow crookneck summer squash. It is an item everyone starts looking for early but quickly tires of as the season progresses. A small acreage of summer squash would be able to feed a large regional population. As the summer progresses, it is a local food item that is available for free from most gardeners. The market potential may be from producing non-traditional summer squash varieties (patty pan and round zucchini) as interest in "something different" yet familiar tended to keep market sales consistent, at least at the beginning of the season. We were able to create a "zucchini chip" in the dehydrator that was popular at the farmers market and a several food events.

- Sweet potatoes: We grew the crop in 2010 and 2011 using Georgia Jet and Beauregard, but had such poor production (small tubers and low volume) that we did not plant in 2012. Because of the long growing season needed, they had to be grown inside the tunnels. Cooperators who grew the crop in 2012 did well with good volume and large tubers. Commercial viability may be limited. North Dakota is working on a commercial variety that can be grown in the north.

- Sweet Corn: We had limited sweet corn production as it is a commercial crop already grown by many local producers. The year that we did grow sweet corn, 48% of the crop was destroyed by raccoons.

- Tomato Production: Six 300' rows of tomatoes were grown outside the high tunnels in 2012. Two were supported with the Florida weave method, two without any support but weeded; two rows not provided support and not weeded. A variety of tomatoes were grown, both hybrid and heirloom. The two rows supported by steel fence posts and the Florida weave method, produced well. The tomatoes left to their own devices also produced well, but produced more tomatoes that would not be acceptable in the marketplace due to defects and damage. The tomatoes that were not supported and not weeded were supported by the weeds, but production volume was lower than the other two methods. The real difference came in deer damage. Deer, like humans, found the Florida weave supported tomatoes easier to see and harvest. They then moved to the unsupported, but weeded tomatoes. The surprise was that they tended to leave the tomatoes in the unweeded rows alone.

The portion of cherry tomatoes that were not sold at the farmers market, were picked and froze whole for later use.

Goals and Outcomes Achieved:

- **Increased innovation:**

  - ✓ After the inception of this project, three local producers purchased high tunnels of their own through an NRCS program. All were attendees at the first high tunnel workshop in 2010 and all three have been successful at their endeavors and regularly sell at farmers markets and through the FTT Local Foods Store. A story about one of those local cooperators was featured in the September-October 2012 issue of Furrow Magazine, which has 80,000 potential readers.
  - ✓ Introduced producers and agency personnel to moveable high tunnel production systems
  - ✓ Demonstrated the different types of equipment that should help growers successfully produce new crops like the set trans planter, the six-row mini planter, and the 5 gallon salad spinner.

  - ✓ 31 new specialty crops and/or varieties of specialty crop vegetables were introduced through this project

- **Electric Deer Fence :**

- The fence effectiveness of the deer fence was not able to be tested at this site. The landowner installed a center pivot the cut across the west side of the property being rented. This prevented construction of the fence on the west side. Additionally, the irrigation district scheduled burying of the lateral on the north side of the property that prevented construction of the fence along that border. The property being rented has a pipeline easement running through it. Scheduled pipeline repairs would have required removal of the fence on the south side. As the fence is high tensile wire and has long stretches between anchored ends, the construction of the fence was not feasible.

- The electric fence system planned for was effective against deer at a previous site, but had little effect on raccoons and grasshoppers. Adding three wires to the 7-wire design should help eliminate raccoon damage. Future plans are to include poultry (ducks and chickens) into the mix to curb grasshopper damage. The 10-wire fence will help to keep land-borne predators from attacking the poultry at this unmanned site

- **Improve the efficiency of specialty crop production:**

  - ✓ Made specialized specialty crop production equipment available for use by local producers
  - ✓ Promoted the use of high tunnels to increase yearly yields of vegetables by extending the season and promoting bed- versus row-production within the tunnels
  - ✓ Introduced new, more compact-growth varieties of standard vegetable crops
  - ✓ The season, barring unforeseen cold snaps, will run from March 17 to November 16. Varieties of spinach and kale will be able to be harvested throughout the winter between November 16 and March 17, but only when unfrozen and with an additional floating row cover.
  - ✓ The volume of local foods produced and purchased locally over the last three years of the project, as indicated by sales at the Saturday Farmers Market and the FTT Local Foods Store, increased by approximately 30% each of the three years with approximately 4,200 lbs of produce being sold in 2012. This does not include vegetables sold at the Glendive Friday

Farmers Market, vegetables sold at other area markets, and/or vegetables consumed by the growers themselves.

- **Reduce food distribution costs:**

  ✓ Increased the volume of local foods produced and consumed

- **Provide the research necessary to determine the adaptability of this production system to Montana**

  ✓ Mechanical and operational issues with high tunnel production have been noted, cataloged, and passed on to producers and workshop attendees
  ✓ Production data on several different types and varieties of vegetables has been gathered

- **Promote the production of specialty crops**

  ✓ Demonstrated the variety of different crops that can be produced inside high tunnels and through more traditional methods
  ✓ Introduced both consumers and producers to new vegetable varieties

- **Address environmental concerns as high tunnels typically use less herbicides and insecticides**

  ✓ The minimal use of herbicides has been maintained on this project. Glyphosate is the only chemical that has been used for weed control in this project
  ✓ Natural insect control has been demonstrated though the use of large bat houses, bluebird and wren birdhouses
  ✓ The use of chicken tractors to control weeds and insects has been promoted

Beneficiaries:

- All attendees at the 24 presentations were introduced to movable high tunnels (approximately 1,266). Additionally, producers and agency personnel who called the office or inquired at other meetings about movable high tunnels would add an additional 240 individuals to that total.

- Local producers have begun to produce higher volumes of non-traditional farm products that in the past were only produced for personal consumption. The volume of products being sold at the two local farmers markets, the Farm-to-Table Local Foods Store, and directly to restaurants has increased in the last two years. Asparagus, usually only foraged locally, has become a very popular item at the local foods store and negotiations have begun to make them available at a local restaurant in 2013.

- Local producers have had the opportunity to see a variety of non-traditional vegetables grown inside and outside of high tunnels. The 2012 season saw the first, large-scale attempt at the commercial production of tomatoes in Dawson since WWII. Chinese vegetables such as pak choi, bak choi, and daikon radish, which withstand cold spring and fall temperatures, were grown

as demonstration ventures. Five varieties of spinach were successfully over-wintered in one of the tunnels.

- As a result of one of the workshops, a local producer had a 12'x40' high tunnel built on their property. The high tunnel was constructed from materials sourced locally in an October 2012 workshop. Attendees were able to get hands-on experience in constructing a high tunnel from scratch. Many producers interested in high tunnel production balk at the cost of a kit. Area producers now have access to the jigs necessary to construct their own high tunnel. High tunnels constructed using locally sourced materials cost about 1/3 the cost of a similar size structure purchased in kit form. The homemade tunnel's materials do not appear to be structurally as strong, so the long term viability of the homemade tunnels will need to be studied.

- Producer and agency attendees gained additional knowledge at any one of the three workshops held over the life of the project. They acquired a hands-on familiarity with the different types of high tunnels, high tunnel construction techniques, the local foods movement, and marketing training and experience.

- Approximately 880 consumers and producers were introduced to new vegetable varieties.

- Consumers now have access to a wider range of fresh locally grown vegetables.

- Glendive School District students: In 2010 and 2012, local foods were featured for one week at all levels in the Glendive School system. Squash, local beans, and fresh greens were featured.

Lessons Learned:

- Pest Control: Electric fences don't keep grasshoppers out. The incorporation of poultry into the plot may help alleviate some of the problem, but may create new problems of their own. A demonstration 4'x10' chicken tractor was built from recycled lumber and displayed at 2012 Harvest Fest.

- Deer-proof fence: The landowner who we are renting from installed a center pivot irrigation system that cut into part of the 8 acres we were renting. As a result, we left part of the fence uninstalled. This was an opportunity to determine what damage wildlife may have on tomato production. As the property is about 100 yards from Yellowstone River, deer pressure was a big problem. The deer first appeared to be weary, starting to work on the ends of the tomato rows furthest from the bulk of human activity. However their wariness soon past and they began working on the whole patch.

- Water: A year-round source of water would greatly enhance the potential successful outcome of a high tunnel project. The project was designed to demonstrate the feasibility of erecting and using a high tunnel on any piece of irrigated ground. The availability of water before the regular irrigating season, which starts May 1 here, and after the normal irrigation season, which ends October1 here, would greatly enhance the potential success. The high tunnel system tends to trap any water put into the tunnel in its own continuous water cycle. No matter how much water is put

in, eventually it needs to be replenished due to workers going in and out of the tunnel and leakage, as the tunnels are never completely air-tight.

- Dehydration: Dehydrating the crops produced will be an important production and marketing tool for future food crops produced in the region. Extending the market season for some perishable crops is not feasible, even with proper storage and handling.

- Crops like tomatoes and summer squash are prolific producers but typically have a short production window meaning that prices fall when the glut hits. The high tunnels are meant to alleviate some of that market risk by bringing in production two to four weeks earlier than local crops grown outside. Still, the vegetables in the high tunnels will continue to produce right through the peak growing period. Being able to convert the produce into a marketable food item for later consumption should be a profitable alternative to abandoning the plants for more profitable fresh market items. A variety of crops were dehydrated.

- Freezing Product: While the best way, nutritionally, to consume produce, after eating it fresh, is freezing. Freezing requires the use of specialized equipment, specialized storage that requires a constant supply of energy, and specialized handling. The capital requirements of establishing a frozen food business may be prohibitive. The one item that seemed to fit well with local production and consumption of fruits and vegetables were cherry tomatoes. The cherry tomatoes were frozen whole on cookie sheets and then stored in plastic bags for later use.

- Temperature Control: Controlling the temperature in the high tunnels is critical for many crops. The leaf lettuce and on variety of spinach bolted early due to spiking high temperatures early in the season. In the case of spinach, all varieties overwintered well, but bolted earlier than the other four varieties.

- Labor: A lot more on-site labor is needed to make a project of this type and scope easier to manage and operate.

- Equipment: Older, small tractors without roll bars allow you to get closer to the inside edges of the high tunnels and make tilling the ground within the tunnels easier and more efficient. Specialized equipment to set up and retrieve the drip irrigation system and the floating row covers would be useful. Specialized, ergonomically-correct equipment to allow workers to get closer to the plants would allow for more efficient weeding and harvesting.

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Specialty Crop Market Expansion

Project Summary:
Since the 1980s Montana's Alternative Energy Resources Organization (AERO) has been working to enhance the competitiveness of specialty crops in Montana. Through a variety of publications and

programs AERO has helped many Montana farmers transition to specialty crops. AERO has also played a central role in helping to develop marketing systems for specialty crops, including institutional procurement, farmers markets, and "Buy Fresh, Buy Local" programs. Based on our ongoing institutional knowledge of these trends in Montana, we see specialty crop farmers as having hit a production ceiling. The market and demand for Montana-grown specialty crops is developing faster than the farmers can fill it.

One of the major barriers to increasing the supply and competitiveness of Montana-grown specialty crops is providing information about the many aspects of growing and marketing specialty crops, including production, handling, processing, marketing and distribution. This information is needed among farmers in hands-on, field-based learning environments with other growers.

The goal of this project has been to coordinate a broad group of stakeholders in a statewide educational effort that will increase specialty crop competiveness, production and business development. This project provides three venues for current or prospective specialty crop farmers to learn about everything from on-farm production techniques to marketing and distribution that will help them transition to specialty crops and/or increase their competitiveness. This will be accomplished through a conference, three tours, and an online source of information related to growing and marketing specialty crops.

Project Approach:
There were three principle outcomes of this project: a conference, tours, and a website. The overall project approach has been to rely on direct feedback from stakeholders to help guide the development of these outcomes. In late 2010 a statewide steering committee was formed to help develop a theme and general framework for the conference. This steering committee included representatives from the Montana Dept. of Agriculture, Montana State University, a regional economic development organization, and the National Center for Appropriate Technology (NCAT).

The committee identified key topic areas for the conference work sessions that include but are not limited to production issues, farm business management, value added processing, food and farm safety, beginning farmer issues, distribution, and marketing.

AERO has a core group of members called the Ag Task Force that use their on-the-ground experiences to guide our Sustainable Food & Agriculture program. We also used Ag Task Force meetings in May and September of 2011 to provide ideas for the tours and the conference. One Ag Task Force member, Pam Gerwe of Purple Frog Gardens in Whitefish, Montana, emerged as a leader in helping the group decide on farm tour sites that would be especially interesting and useful for specialty crops producers and consumers. One of these tours was done in partnership with Montana State University Northern's (MSU N) Bio-energy Center. $1,500 was used as matching funds for this project, as this tour highlighted on farm production and processing of oilseeds, but also went in depth into experimentations with dry-land vegetable production; include plant variety selection and production practices unique to non-irrigated sandy soil and crop storage techniques.

Another Ag Task Force member, Becky Weed of Thirteen Mile Lamb & Wool in Belgrade, Montana emerged as a leader in conference planning, and helped to recruit speakers that had extensive and unique knowledge about growing and marketing specialty crops on varying scales.

Another key approach to this project has been to use the conference itself as a way to identify the issues of primary concern to specialty crops producers, in order to identify content to put on the website. The conference brought together specialty crops farmers with many different levels of experience, and effectively illustrated the spectrum of issues, and key resources needed, among Montana's different types

of specialty crops producers. This website must be fluid and have new content added. The website can be viewed at *www.aeromt.org/food-ag/specialty-crops-conference*.

The content provided on the website is based on topics discussed at the Specialty Crops Conference. The conference attendees were exclusively specialty crop producers. The presentation on Full Belly Farm and the presentation titled "A Journey Toward Food & Farm Diversity" pertain exclusively to specialty crops. Since the presentation on greenhouse was attended solely by Montana specialty crop growers, the information provided was applied solely to the competitiveness of specialty crops. The same was true of presentations on seed availability, marketing strategies, season extending techniques, cover cropping and soil management, and distribution models. Again, all of the presenters as well as conference attendees were specialty crops producers, and applied the information in each session solely to their specialty crops operations.

Other materials on the site include documents titled *Composting: The Basics, Equipment & Tools for Small Scale Intensive Crop Production,* and *Sustainable Season Extension.* These resources are provided based on needs identified by specialty crops producers at the conference. We included a section on the website relating to policy, and highlighted the National Sustainable Agriculture Coalition (NSAC) as a resource. We provided information on programs that directly relate to specialty crops producers, including the Specialty Crops Block Grant and the Specialty Crops Research Initiative.

Goals and Outcomes Achieved:
A total of over 140 individuals, including county Extension Agents, state and federal agency staff, farmers, and interested citizens, attended three tours of Specialty Crops operations in Montana.

In July we toured the Quinn Farm in Big Sandy, and in addition to production and processing of oilseeds, our host shared experimentations and successes in using appropriate varieties for raising dry-land vegetables.

In August we visited Groundworks Farm in Great Falls and learned about their extensive efforts raising myriad vegetables using season extending techniques and selling through a Community Supported Agriculture program.
Finally in September we visited both Fialky Farm and PloughShare Farm in Dixon and Moiese, and explored these highly diversified fruit and vegetable operations that are selling primarily to local markets.

These tours engaged a broad array of stakeholders by using the on-the-ground experiences of our hosts to analyze the many issues relating to Specialty Crop production, marketing, processing, and distribution in three very different regions of Montana. Evaluation surveys from these tours illustrate that attendees found them interesting, and informative. Our expected measurable outcome for tours was 300 attendees total, please see the *Lessons Learned* section for an explanation of this discrepancy.

In November of 2011, farmers and other stakeholders from across Montana braved winter weather to travel to Great Falls and participate in AERO's Specialty Crops Conference titled *Diversifying Montana's Food and Farming Profile*. Based on guidance from the conference planning committee as well as AERO's Ag Task Force, we recruited two primary speakers, Judith Redmond of California's Full Belly Farm and Helen Atthowe, a former Missoula County Extension Agent, operator of Biodesign Farm, and current farm consultant. Both speakers told the story of their respective farm businesses and shared insights based on their experiences growing fruits and vegetables primarily for local markets.

Breakout sessions included presentations and facilitated discussions from thirteen of Montana's key Specialty Crops stakeholders, including farmers from around the state, and representatives from the Montana Department of Agriculture, the Natural Resources Conservation Service (NRCS), the National Center for Appropriate Technology, and the Organic Seed Alliance. Presenters shared their perspectives on a range of current issues, such as entrepreneurs sharing lessons learned developing value-added food

products, beginning farmers reflecting on their experiences accessing land, as well as sessions on state food safety regulations and crop insurance options for Specialty Crops producers.

Conference participants also had a chance to dive into the specifics of soil management and season extending techniques, as well as issues of production scale and diversified marketing. Survey-based feedback provided at this event provided especially pointed direction for the current and future needs of Specialty Crops farmers in Montana. The conference was attended by approximately seventy people who took advantage of the significant time built into the agenda for networking, sharing best practices, and brainstorming through common challenges.

We have used the conference as the basis for a webpage highlighting the issues that were discussed and the people who participated in order to provide information to specialty crops stakeholders that were not able to attend. We have posted a brief description of the conference and photograph, the conference agenda and contact information for the presenters, some of the presentations themselves, as well as information on the USDA definition of Specialty Crops and the Specialty Crops Block Grant program. We will continue to build on this website as we identify relevant resources to share, such as additional presentations, research, or links to other informational sources. To date we have only had 17 visits to our webpage.

Income from the conference was substantially less than forecasted. AERO received $2,935 from conference registrations, but we did not earn anything from this project as it all went back into staff time on this specific project.

Another outcome was a map of Montana's specialty crop components, which we intend to post on the website.

Beneficiaries:
This project directly engaged 210 specialty crops stakeholders in Montana through tours and a conference. The majority of tour and conference participants were specialty crop farmers, though they both attracted participation by community food systems advocates. The conference engaged stakeholders from partnering organizations, such as the Organic Seed Alliance, the National Center for Appropriate Technology (NCAT) and the Montana Department of Agriculture. In addition, value added food processing businesses with an interest in specialty crops shared their expertise, including a representative from the Orchard at Flathead Lake. Overall, the main beneficiaries of this project have been the myriad specialty crops farmers in Montana, who have gained information relevant to their production and marketing practices.

Lessons Learned:
There were a few factors that contributed to the unanticipated extended timeline for this project. AERO was only able to hire a Food and Agriculture Program Manager in July of 2010; fully seven months after the project funds were awarded. This was too late to organize tours for the 2010 growing season, and pushed that outcome to summer 2011. We had hoped to have the conference in spring of 2011, but due to a staff lay-off, it required more time to organize the conference and we had to push it to fall of 2011. It was the timing of these staffing factors that influenced the delay of this project.

In addition, attendance at our three farm tours fell short of our goal by 60 participants. Although we had strong representation among different stakeholders at the tours, such as farmers, food consumers, agricultural educators, and state agency staff, shortcomings in our recruitment outreach proved ineffective in reaching our tour attendance goals. For future tours, we will focus on less broad outreach, and more on targeting specific stakeholders with in-person outreach as an alternative approach.

Attendance at the Specialty Crops Conference fell short of our goal by 130 attendees. Multiple groups of people that had registered for the conference were unable to come at the last minute due to a statewide occurrence of severe winter weather limiting travel from many parts of the state. But also, due to the scheduling of this event, it fell at a time of year when many other food and agriculture organizations are hosting their annual meetings and other events, and it became clear that recruitment for a specialty crops conference would be a severe challenge during "conference season." This timing issue was a clear learning experience in scheduling similar events in the future.

AERO also encountered a significant challenge in working with the main project partner, the Montana Food Systems Council. This council formed as an outcome to the 2007 Governor's Summit on Food & Agriculture, and is a forum for information exchange, coordination, and policy development in four key areas: farm viability, processing and distribution infrastructure development, food access and security, and public awareness. All of these areas are of significance to Montana's specialty crops producers. By 2010 it became clear that the Montana Food System Council was not functioning effectively, and the council has ceased communications during 2011. This project partner's role was to be a communications hub for specialty crops, and it became clear that AERO would have to assume extra responsibilities in order to identify and recruit relevant stakeholders, and effectively disseminate outreach information to the public.

There are two other project partners that were unable to participate effectively on this project. One was slated to provide a website contractor to host and monitor the web-based specialty crops clearinghouse. While they were unable to provide this service to the project, they did participate in other aspects. As a result, AERO is developing and maintaining the website. Moreover, another project partner was unable to provide personnel that could develop and disseminate pre and post surveys to be given at each session to aid the program in ascertaining if the participants are gaining knowledge from the information provided. Instead, with limited capacity, AERO was able to distribute post surveys to participants of the farm tours and conference, gaining valuable feedback about specific content in those programs that was especially valuable to different types of stakeholders, helping to identify the types of resources specialty crops stakeholders need from online and other sources. It became clear while executing this project that our original proposal to coordinate these groups in this project was overly ambitious as a result of unanticipated logistical hurdles.

We are currently unable to create a map of Montana's specialty crop components and post it on the website because that information is contingent on a statewide food mapping project that we are currently working on with the Montana Department of Agriculture. This project has collected vast data sets of food systems establishments, such as grocery stores and restaurants that buy locally from farmers, processors, distributors, and of course, fruit and vegetable growers as well. Many, but not all, of these data points will provide the foundation for a map specific to Montana's specialty crop components, and will provide a statewide perspective for various stakeholders. The expected completion date for this food mapping project is August 2012, though much of the data that could be imported into a Google Map format and embedded into the specialty crops website will be ready in the next few months.

Finally, it is important to note that the Specialty Crop Block Grant (SCBG) funds committed to this project; there was an additional $5,000 from the Natural Resources Conservation Service (NRCS) committed as well. Due to the delay of the conference and FY12 budget uncertainties and constraints for NRCS, these funds were not received.

Contact Information:

The contact person for this project is:

☐ Kevin Moore, Sustainable Food & Agriculture Program Manager, AERO
☐ (406) 443-7272, kmoore@aeromt.org

Additional Information:

Although this is a final report and there are no additional performance goals to be achieved in an upcoming reporting period, we do plan to build off of the momentum from the conference in three key ways:
1: We will leverage information provided by producers at the Specialty Crops Conference to identify additional specialty crops tour sites for the 2012 growing season.
2: We will use the conference attendee contact list to recruit participation into additional networking opportunities for specialty crops producers and other stakeholders to continue a dialogue and resource-sharing. In addition to tours, these opportunities could include AERO Ag Task Force Meetings, the AERO Annual Meeting, and other events organized by AERO's statewide food system partners.
3: We will continue to add content to the specialty crops information webpage, which is based on the AERO website. These include additional and related presentations by conference speakers, new research, funding opportunities, or policy changes related to specialty crops, and announcements for events to continue networking specialty crops stakeholders in Montana.

AERO	**Amount Budgeted MDA**	**Amount Spent to date (12/31/11)**	**Total Remaining**
Expenses			
Salary	$15,000	$19,0461	
Benefits	$4,200	$7,5221	
Travel	$2,500	$2,587	
Speaker Honorarium	$4,000	$1,800	
Printing	$1,650	$1,416	
Postage	$850	$661	
Contractor (Graphics & Communications)	$680	$297	
Telephone	$600	$568	
Conference Meeting Space	$3,000	$2,039	
Conference Food	$5,000	$1,544	
Indirect Expenses	$4,040	$4,040	
$41,520	$41,520	$0	

Montana Locally Grown Promotions

Project Summary:
Farmers markets are traditionally the first outlet through which Montana specialty crop producers (SCPs) market their products. As more consumers become aware of Montana farmers markets and attend them, the more SCP are purchased. Ancillary to the promotion of markets is research to help SCPs determine necessary levels of weed eradication from their farms, allowing more time spent on marketing, rather than weeding. Additionally, we wanted to help Montana restaurants and grocery stores access more Montana SCPs, so we hosted face-to-face events at which SCPs and buyers could make contracts.

Project Approach:
Below is a summary of the activities performed:

- Montana Farm to Table Connection 2010 (Missoula): We hosted this event in Missoula with 10 chefs and 31 growers attending. The Chef & Distributor educational panel discussion hosted 3 chefs and 3 distributors, each explaining how they successfully buy from local producers. During lunch, presentations were made about grant and training programs available to growers. The event was a success and came in under budget. Therefore, growers and chefs requested an additional Connection event, and we were able to accommodate in Helena, March 2011. For the growers who were not specialty crop, we used matching funds to cover their expenses.
- Montana Farm to Table Connection 2011 (Helena): We hosted this event in Helena with 25 chefs and 19 growers. This event coincided with the Montana Agriculture Showcase for Montana legislators and the public, offering additional public relations for the growers. This event was a supplement to the annual connection held each Fall. If we find at the Fall Connection that attendance is not affected by the secondary Connection, we may plan to host two annually. For the growers who were not specialty crop, we used matching funds to cover their expenses.

- Montana Farmers Market Promotion 2011: We published 1,000 hard copies of a directory of 54 farmers markets in 2011, as well as on our Department, USDA, VisitMT websites. We distributed the directories to Visitor Information Centers for sharing with locals and tourists, encouraging their purchase of Montana specialty crops.
- Montana Farmers Market Promotion 2012: We published 1,000 hard copies of a directory of 54 farmers markets in 2011, as well as on our Department, USDA, VisitMT websites. We distributed the directories to Visitor Information Centers for sharing with locals and tourists, encouraging their purchase of Montana specialty crops.
- Sustainability of Market Gardens In Montana: Project director – Bruce Maxwell, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT

  A major challenge to the sustainability of market gardens attempting to follow organic standards is weed management. An informal survey of farmers selling produce at farmers markets, CSAs and roadside stands in the northwest indicated that their greatest challenge was keeping up with weed control. Our study sought to identify ecologically based weed management approaches that would minimize the labor requirements for weed management and maintain high quality produce from market gardens in Montana.

  Three graduate students, Charles Holt, Ana Difendorpher and Tim Reauch were funded over the period of 2011 and 2012 to conduct the research and teach/manage student interns associated with the Townes Harvest Garden (THG) at MSU. THG produces fresh vegetables for a student run CSA, local Farmer's Markets and the Gallatin Valley Food Bank. We created an experiment with three treatments on 3 different classes of vegetables and the students maintained the treatments and were able to observe firsthand the crop response to the treatments. The weed management treatments were: 1) complete removal of weeds once per week throughout the growing season, 2) minimum removal at critical points in time over the growing season, and 3) no weed management.

  The preliminary results of the experiment indicated that vegetable production was significantly reduced with every species where no weed control was conducted. In addition, the weedy (non-weeded) plots were difficult to harvest as the weeds were hiding the produce. Intermittent weed removal was almost always as effective for producing marketable produce as the complete weed

control plots. We concluded that in most cases strategically timed weeding can be just as effective as complete weed removal. The exact time and subsequent economic benefit of reducing weeding was not quantified, but any reduction in time spent weeding is apt to increase the sustainability of the Market Garden. The exact crop stages or weather conditions that would likely be the mechanism to drive intermittent weeding will likely be crop specific and site specific and may also vary with the dominant weeds in the garden.

The grower training portion was all hands-on training: the 5 student interns worked the garden and ran the CSA and farmers market booth alongside the graduate students. The 5 student interns, as well as the 3 graduate students, will become specialty crop growers upon graduation and implement their training, for a total of at least 8 SC growers affected. Graduate students and undergraduate interns were all integral to the success of this project. As many of these students will go on to work on Market Gardens in Montana and elsewhere, the experience gained in this project should contribute to innovative approaches designed by the farmers to better understand the limitations to market garden sustainability. We are in the process of identifying the appropriate information pamphlets to release on our findings. We plan to release this information items by May 2013.

Goals And Outcomes Achieved:

- 8 of 8 of the farmers market gardeners will implement what they learned during the Grower Training.
- The contractor did not complete pre- and post-tests associated with the training. However, since the training and experiments resulted in not-previously-known information, we can assume at least a 20% increase in farmers market gardeners' knowledge.
- Specialty crop growers, 60 restaurants, and 10 distributors participated in the connection events.
- We did not opt to host the farm to restaurant tour due to high cost and lack of interest.
- It was difficult to conduct a survey in a way that would collect information on increases in production and purchases of Montana-grown products for Montana restaurants. However, based on the surveys, we were able to ascertain that 21 restaurants would begin buying Montana specialty crops after attending our events; while the other 39 would continue to buy Montana specialty crops as they had before.
- A total of 555 specialty crop growers were reported as farmers market vendors in 2010, accounting for 35% of total vendors.
- The number of reported farmers markets increased from 53 to 54 in 2011, and up to 78 in 2012.
- The research was completed. Information pamphlets will be provided in paper form to SCPs and on MSU's and the Department's websites by May 2013.
- The Montana Farmers Market Association did not come to fruition. After several attempts to secure meetings to formalize the structure of the organization, our contractors reported back the lack of interest in the formation of the association. However, we will continue to host the farmer's market website.

Beneficiaries:

The groups that benefited from this project are as follows:

- A total of 577 specialty crop growers benefitted from this project from grower training, increase marketing of their products, and increased marketing of farmers markets – a venue through which they sell their products.

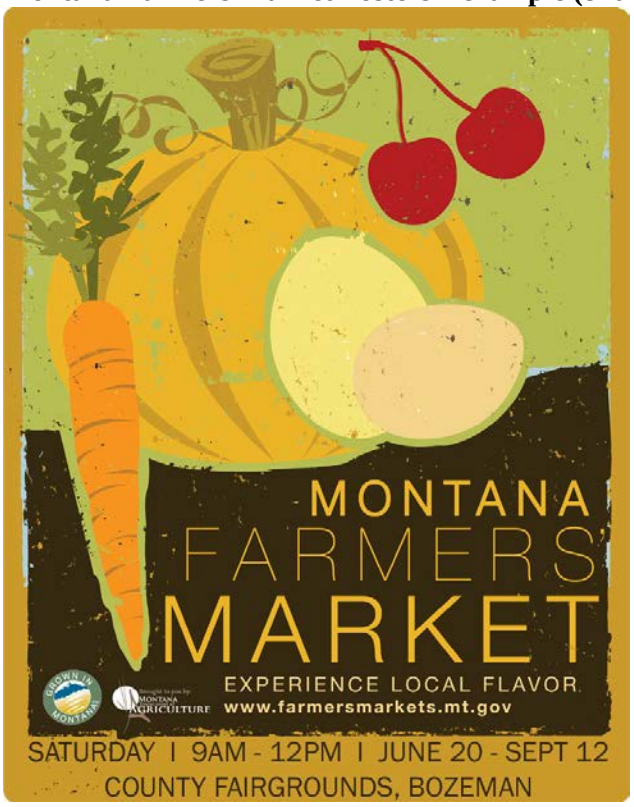
Lessons Learned:

- For the Montana Farm to Table Connection 2010 (Missoula), we had hoped to host tours of farms and restaurants. However, as we began planning for this, it was too difficult to get farms and restaurants to sign up as tour spots, plus, we found it difficult to get chefs or growers to commit to extra time away from their jobs in order to attend the tours. In the end, we decided that the Connection was the most important part, so we cancelled the tours.
- For the Montana Farm to Table Connection 2011 (Helena), we were limited by space, so we were only able to accommodate 19 growers.
- For the Montana Farmers Market Promotion and Training, we were limited by the ability of our contractor to complete the projects. After several meetings with potential Montana Farmers Market Association members, it was determined that an association was not a high priority for Montana farmers markets at this time. In 2010, only 50 farmers markets were in the entire state of Montana; not a critical mass for a successful statewide farmers market. Also, our contractor found that it was impossible to develop a guide for direct marketing because Montana's laws were conflicting or difficult to interpret.
- For Sustainability of Market Gardens In Montana: It was more difficult than we thought to provide timely, specific data.

Budget:

Balance		**$ 35,017.00**
Montana Farm to Table Connections 2011	$ (3,171.73)	$ 31,845.27
Farmers Market Promotion 2011	$ (1,864.87)	$ 29,980.40
Farmers Market Training 2011	$ (1,231.51)	$ 28,748.89
Specialty Crop Grower Research	$ (21,593.33)	$ 7,155.56
Farmers Market Promotion 2012	$ (954.98)	$ 6,200.58
Returned balance	$ (6,200.58)	$ -

Montana Farmers Market Posters – example (820 distributed)



Specialty Crop Safety Education

Project Summary:
Mission Mountain Food Enterprise Center (The Center) is a program founded by Lake County Community Development Corp. (LCCDC) in 1999. The Center provides expertise in food business development and incubation to individual enterprises, cooperatives, and specialty crop producers. From planting to consumption, there are many opportunities for bacteria, viruses, and parasites to contaminate our food. Because of this the food industry and the new Food Safety Act regulators such as FDA and USDA have established regulatory requirements that affect specialty crop producers who direct market or are adding value to their production. Value added food product development can be confusing to producers and entrepreneurs due to regulations, licensing and labeling requirements. This project delivered a focused educational program in food safety that assisted specialty crops producers in gaining a better understanding of food safety regulations and how they can meet them. This project is very timely in regard to proposed release of the Food Modernization Act in early 2012. Through this project specialty crop producers and processors enhanced their competitiveness in local markets. This program was accomplished by delivering the following goals and objectives.

Goal 1 – Increase the capacity of specialty crop producers in understanding on-farm food safety and upcoming FDA food safety regulations.

- Deliver educational programs that assist specialty crop producers in meeting food safety regulations for direct farm marketing of specialty crop market produce
- Assist producers in understanding new regulatory requirements as adopted by FDA and the Montana Department of Health and Human Services.

Goal 2- Build capacity and understanding of food regulation in value added food processing

- Deliver educational programs that will assist specialty crop producers who are value adding to their production in understanding and meeting food regulation for the wholesale/retail marketplace

Project Approach:
Lake County Community Development Corporation (LCCDC) worked with the Montana Department of Agriculture Food and Agriculture Development Center Program in determining a suitable curriculum for GAP training. The program centers assisted in outreach and communication for the GAP trainings held.

Several cooperatives, Western Montana Growers Cooperative and Flathead Cherry Growers Cooperative were contacted to access their needs in gaining more information and understanding of food safety and GAP. LCCDC staff built the centers capacity by participating in training opportunities to gain more understanding of the upcoming Food Modernization Act and GFSI (Global Food Safety Initiative) audit requirements. The center held trainings in HACCP and Better Process Control Authority through Washington State University Food Science Dept.

Upon an approved budget amendment the center contracted DDB Technical Services to conduct and assessment of the center's food safety program and assisted the center in developing a full food safety program that will address GFSI third audit requirements. The following is the outcomes of the projects approved goals and objectives.

This project was also funded by the MT Food and Agriculture Center Program (Montana Department of Agriculture) and in reference to Pasta Montana- the company funded all the work that was conducted for them through a contract with Montana Manufacturing Extension Center.

Matching funds referenced in our proposal from state and private sources and those funds were used to support non-specialty crop clients.

Goals and Outcomes Achieved

Goal 1- Objectives and Tasks	Activities	Outcomes	Partners
1. Deliver educational programs that assist specialty crop producers in meeting food safety regulations for off farm marketing of produce **1A**- Hold two educational workshop "Food Safety Begins on the Farm", from Cornell Good Agricultural Practices Program **1B-** Attend Western Montana Growers Coop annual meeting and provide information on on-farm planning to meet food safety requirements.	- Nov 2011 LCCDC staff attended the NW Food Safety Conference and received professional development in National GAP Program, Global Food Safety Requirements and the upcoming Food Modernization Act. - Worked with the Flathead Cherry Growers Association outreach and communication with producer members to attending GAP training conducted by Monson Packing. - Held 2 GAP Workshops in Missoula and Bozeman. The workshops educated the attendees on the requirements and procedures to obtain GAP certification. - Staff attended the Western Montana Growers Cooperative Annual meeting and presented on the Food Modernization Act. - Staff participated in a teleconference with Senator Tester and the Western Montana Growers Cooperative to discuss the concerns producers had in the implementation of the Food Modernization Act. - Staff attended the Global Food Safety Initiative Conference in Boise Idaho. The conference reviewed third party audit systems and their requirements	Staff Jan Tusick and Yvette Rodriquez received certification of participation from Washington State University. This training provides our staff the expertise to work directly with our clients in understanding food safety regulation. - 42 of the 77 cherry growers have gone through GAP training - 38 Western Montana Grower Cooperative members (all specialty crop producers) have received GAP training materials. - The Missoula workshop had 34 attendees of which 21 were specialty crop producers. The Bozeman workshop had 46 attendees of which 29 were specialty crop producers. -38 specialty crop producers attended annual meeting. - 2 staff and 4 specialty crop producers participated in discussing the Food Modernization Act with Senator Tester. -2 Staff received professional development in Global Food Safety Audit requirements	Washington State University continues to hold training our staff can attend to stay informed on food safety issues and regulations. Flathead Cherry Growers Cooperative Montana Department of Ag

2. Provide technical assistance to producers in understanding new regulatory requirements as adopted by FDA and the Montana Department of Health and Human Services. **2A**- Develop technical resources and update MMFEC library/website on food safety regulations. **2B-** Participate in the annual meetings of existing specialty crop producers (AERO, MOA, MFU, Western Montana Growers Cooperative) and provide information on food safety regulations	- Purchased GAP training materials for the resource library. -Provided technical assistance in the development of HACCP plans - WMGC was assisted in completing HACCP plans and labeling for processing of pitted frozen cherries, sliced fresh carrots, beets, and apples, cubed and frozen butternut squash and pureed and frozen pumpkin - Staff attended the annual meetings of AERO, MOA, MFU and Western Montana Growers Cooperative. A booth was operated at each meeting and information on food safety and GFSI audits was provided. Jan Tusick presented on food safety at the MOA annual meeting.	- Resource library available to all MMFEC clients. MMFEC website was updated and will host resources for GAP. 3 processing business successfully completed HACCP plans and now operate under HACCP Pasta Montana successfully passed a BRC third party audit. Western Montana Growers Cooperative is preparing a group plan utilizing the model which will be audited this fall. - HACCP for seven specialty crops was completed. Annual meetings had the following attendance- AERO- 75, MFU- 230, MOA- 100, WMGC- 38	Alternative Energy Resource Organization (AERO), Montana Farmers Union (MFU), Montana Organic Association (MOA), and the Western Montana Growers Cooperative (WMGC)
Goal 2- Objective and Tasks	Activities	Outcomes	Partners
1. Deliver educational programs that will assist specialty crop producers who are value adding to their production in understanding and meeting food regulation for the wholesale/retail ma	- Held a HACCP (Hazardous Analytical Control Point and Process Control Authority Trainings for food processors. - Held a Process Control Authority and Retort Processing trainings - Held a Food Processing Training with Sarah Masoni, OSU Food Product Development Specialist.	- Attended by 30 food processors of which 14 were specialty crop value added producers. - Attended by 8 food processors of which 3 were specialty crop value added processors -12 Food processors attended of which 2 were specialty crop value added processors	Montana Dept of Agriculture provided funding for all trainings.

1A- Hold a Hazard Analysis Critical Control Point training in general food processing for the retail/wholesale marketplace. **1B**-Hold a process control school training for acidified food processing			
Goal 3- Objective and Tasks	Activities	Outcomes	Partners
1- Assess the Mission Mountain Food Enterprise Center's Food Safety Program to determine deficiencies that need to be addressed to fully meet GFSI standards. 1A- Hire a consultant to conduct an assessment of MMFEC food safety program 1B- Address deficiencies and develop prerequisite programs needed to pass a GFSI standard audit	DDB Technical Services contracted to assess MMFEC Food Safety Program DDB Technical Services was contracted to develop and design the necessary policies and procedures needed.	Consultant found MMFEC compliant with USDA and FDA guidelines in Good Manufacturing Practices (GMP's) and Sanitary Standard Operating Procedures (SSOP's) . However the center needed to develop and adopt new policies and procedures to meet GFSI standards. - MMFEC adopted new prerequisites and a complete Food Safety Management Program. The program will be developed into a toolkit so MMFEC clients and specialty crop processors can develop their own food safety management programs.	DDB Technical Services Washington State University- Dr. Dougherty provided technical expertise.

Goals and Outcomes Achieved:

Goal 1- The activities completed fully met the goals objectives and several of the project outcomes. Producers were very resistant to the GAP trainings and openly objected to the basis of the regulations. The trainer was industry trained and many of the producers were small scale producers conducting direct market sales therefore the instruction was not well received. The Montana Department of Agriculture and the Center conducted an evaluation and interviews on how the training could be improved. The consensus was the trainer should have farm experience and be able to communicate with farmers effectively.

MMFEC staff has built strong partnerships by attending Alternative Energy Resources Organization, Montana Farmers Union and Montana Organic Association annual meetings. Future speaking arrangements will be developed for annual meetings to further communicate and provide information on food safety regulations.

Goal 2- The Hazardous Analysis Critical Control Plan (HACCP) and Better Process Control School Training were attended by 38 food processors which fully met the outcome of the goal. The evaluations of the trainings were excellent and all attendees were certified. MMFEC will continue to work with the Montana Department of Agriculture in the delivery of these trainings as HACCP will be mandated for most food processors in the Food Modernization Act and FDA mandates process control authority on all acidified foods.

Goal 3- The project was amended to allow the center to conduct a full analysis of our food safety program. DDB Technical Services was contracted and a full assessment conducted. A workout plan to address deficiencies was completed and a full food safety management program was adopted. The contractor worked with staff to conduct an internal audit and all verification records were being documented. In the future project a toolkit of the plan will be developed for processors and will be delivered in training.

Western Montana Growers Cooperative- 41 members- (80% specialty crop producer members) benefited from the GAP training and HACCP plan development. There have been 3 HACCP plans developed: fresh cut vegetables, blanched frozen vegetables and the lentil burger for the cooperative.

The training sessions were attended by 30 food processors of which 14 were specialty crop value added producers. To date there have been 5 HACCP plans completed. 8 processors attended the process control training. Three of these attendees are specialty crop value added processors. All attendees were certified.

A model GFSI standard audit program is in place at the Mission Mountain Food Enterprise Center. The program has undergone two internal audits by a third party and has successfully upheld the program. A tool kit for the program has been finalized in March 2013 and trainings will be delivered in April and October 2013.

Three processing businesses have successfully completed HACCP plans and now operate under HACCP - Pasta Montana successfully passed a BRC third party audit.

Western Montana Growers Cooperative is preparing a group plan utilizing the model which will be audited this fall.

Training will be held utilizing the model and tool kit that has been developed. Twelve companies have enrolled in this training to be held in April 2013. The toolkit will provide templates to complete their own program for their processing company.

The Food Safety Program Toolkit was completed and the first training held which was attended by 10 food processing businesses of which 5 were specialty crop food processors. A follow up survey will be held the fall of 2013 to determine how many have had a third party audit.

Of the five food safety plans systems we had hoped to achieve we were only successful in getting two food safety plan systems in place and both have been audited.

We will continue to offer training utilizing the Food Safety Program Toolkit and will conduct follow up surveys on third party audits.

Beneficiaries:
The beneficiaries of this project were specialty crop producers and value added processors.(Flathead Cherry Growers Coop-77 members, WMGC- 38 members) In particular the Western Montana Growers Cooperative (80% specialty crop producer members) benefited from the GAP training and HACCP plan development. The cooperative is pursuing value added processing of their members crops to sell at institutional markets. These markets demand HACCP and this enabled the cooperative to fully develop a product line for sale. This development has pushed the cooperative to a $700,000 per annum in sales and now they are year round with their value added season extension products. The cooperative also learned the importance of food safety and GAP and will be pursuing a group GAP project in the future.

The Mission Mountain Food Enterprise Center is a model for food processing facilities nationally. Acting as a Food Hub, the center now operates under a GFSI based Food Safety Management System and will be able to provide technical expertise and model that can be used in other facilities. A toolkit will be developed in a new project funded by USDA Specialty Crop Program.

Lessons Learned:
This project had an important lesson learned and that is how you deliver trainings to producers. We learned you must have a trainer that understands the needs of the small farmer and has the skill and experience to fully communicate with them. We are working with Family Farms Org and will be exploring delivering a training program that will provide on farm safety training by experience farmers.

The development of a comprehensive food safety management program instilled in the MMFEC staff a deep understanding of food safety and how to effectively communicate and verify a facility system. The staff now has the professional capacity to provide technical assistance in this area and fully deliver HACCP development services and GFSI audit preparation services. This has built the capacity of MMFEC tremendously.

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Outline of Food Safety Management Program

Table of Contents

Section 1: Management Program

1.1 Management Commitment

1.1.1: Food Safety Policy Statement

DOC 1.1.1: Our Company Organizational Chart

1.1.2: Management Responsibility and Annual Assessment

SOP 1.1.2 : Annual Assessment

DOC 1.1.2 Annual Assessment Report

1.1.3: Client Complaint Management

SOP 1.1.3: Client Complaint Response

DOC 1.1.3: Client Complaint Form

1.2 Document Control

1.2.1: Document Control

DOC 1.2.1: Food Safety DOC Register

1.2.2: Records

DOC 1.2.2: Master Signature Log

1.3 Specification Program

DOC 1.3.1 Product Specification Form

1.4 Regulatory Inspection Program

1.5 Non-conforming product Program

1.6 Recall and Traceability Program

1.6.1: Recall Program

DOC 1.6.1: HOLD Form

DOC 1.6.2: Emergency Recall Notification List

1.6.2: Traceability Program

1.7 Site Security/Emergency Preparedness Program

Section 2: Good Manufacturing Practices (GMP'S)

A: Premises

A1: Building Exterior

DOC 2.1.1: Monthly Exterior Inspection

A2: Building Interior

DOC 2.2.1: Monthly Interior Inspection

A3: Sanitary Facilities

A4: Water/Steam/Ice Quality and Supply

B: Transportation and Storage

B1: Transportation

B2: Storage

SOP 2.B.2: Storage of Raw Materials

C: Equipment and Maintenance

C1: General Equipment

D: Personnel

D1: Employee Training

E: Sanitation and Pest Control

E1: Plant Sanitation

E2: Pest Control

F: Recall and Product Identification

F1: Recall Program

F2: Product Identification

Section 3: Prerequisite Programs

3.1.1: Personnel Practices

3.1.2: Clothing

3.1.3: Jewelry and other Personal Effects

3.1.4: Visitors

DOC 3.1.4: Visitor Log

3.2.1: Staff Engaged in Food Handling

DOC3.2.1: Processing Practices

3.3.1: Training Requirements

3.3.2: Training Program

DOC 3.3.2: Training Skills Register

3.4.1: Calibration Program

SOP 3.4.1: Calibration methods

3.4.2: Calibration Records

DOC 3.4.2.1: Thermometer Calibration

DOC 3.4.2.2: Water Activity Meter Calibration

DOC 3.4.2.3: pH Meter Calibration

3.5.1: Pest Control Program

SOP 3.5.1.1: Pest Control Assessment

SOP 3.5.1.2: Pesticide Control

DOC 3.5.1.1: Pest Activity Log

DOC 3.5.1.2: Pest Control Map

3.5.1.2: Pest Control Contractors

3.6.1: Maintenance Program

SOP 3.6.1: Equipment Operation template

DOC 3.6.1: Equipment Maintenance Schedules template

DOC 3.6.2: Repair Work Order

3.7.1: Cleaning and Sanitation program

SOP 3.7.1.1: Sanitizing Procedure (SSOP)

SOP 3.7.1.2: Sanitizer Concentration Verification

DOC 3.7.1.1: Master Sanitation Schedule DAILY

DOC 3.7.1.2: Master Sanitation Schedule WEEKLY

DOC 3.7.1.3: Master Sanitation Schedule MONTHLY

DOC 3.7.1.4: Classification Table for Cleaning Equipment and Tools

DOC 3.7.1.5: Master Cleaning Review

3.7.2: Microbial Control Program

3.7.2A: Listeria Program

SOP 3.7.2 Microbial Testing Procedure

DOC 3.7.2: Microbial Test Log

3.7.3: Sanitizer and Detergent Control

SOP 3.7.3.1: Sanitizers and Detergents Approval and Purchasing

SOP 3.7.3.2: Sanitizer and Detergent Storage, Handling and Disposal

SOP 3.7.3.3: Sanitizer and Detergent Inventory Control

3.8: Chemical Control Program

SOP 3.8.1: Chemical Approval and Purchasing

SOP 3.8.2: Chemical Storage, Handling and Disposal

SOP 3.8.3: Chemical Inventory Control

DOC 3.8.1: Chemical Inventory Log

3.9: Water Quality Program

SOP 3.9.1: Water Portability Testing

3.10: Glass and Foreign Matter Control Program

SOP 3.10.1: Glass Control

SOP 3.10.2: Foreign Matter Control

DOC 3.10.1: Glass Inventory Log

3.11: Approved Supplier Program

DOC 3.11.1: Approved Supplier Database

3.12: Receiving and Shipping Program

SOP 3.12.1: Inspection of Incoming Products

SOP 3.12.2: Loading and Shipping Procedure

DOC 3.12.1: Product Receiving Log

DOC 3.12.2: Product Shipping Log

3.13: Allergen Control Program

SOP 3.13.1: Allergen Control Procedure

3.14: Weight Control

Program

SOP 3.14.1: Weight Scale Calibration

DOC 3.14.1: Weight Scale Log

Section 4: HACCP

4.1: HACCP Policy

SOP 4.1: HACCP Plan Development

HACCP Development Forms

Misc. Forms