Nebraska Department of Agriculture
Specialty Crop Block Grant Program
Final Performance Report (FY2008)

COVER PAGE

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Project Title

Are Crops Grown In Rotation with Dry Beans in Western Nebraska Serving as Alternate Hosts for the Bacterial Wilt Pathogen (Curtobacterium flaccumfaciens)? (Final Report)

Project Summary

Bacterial wilt of dry beans was a sporadic but often serious production problem in dry beans throughout the irrigated High Plains since first being reported from South Dakota in 1922. It was first observed in western Nebraska dry bean production fields in the early-mid 1950s, and continued to be economically important throughout the 1960s and early 1970s. The disease then only periodically appeared in seed, but has had little detectable effect on yields after the implementation of crop rotation and seed sanitation practices. The disease has now re-emerged and has been documented from more than 400 fields since 2004. It is not known why the disease has suddenly appeared again in dry bean production areas over the last four years to this extent, but it does warrant some concern.

Recently, soybean, corn and wheat plants have been identified in western Nebraska fields that were harboring bacterial isolates with the ability to cause disease on dry beans after artificial inoculations. Thus it is important to be able to document the distribution and incidence of the pathogen naturally occurring in production fields consisting of alternate crops grown in rotation with dry beans. Thus, a study was conducted in 2008 to survey fields in western Nebraska to address this concept.

Project Approach

Between early July and mid-September 2008, production fields were scouted for symptoms consistent with bacterial infections. The survey for the entire season consisted of 212 fields - scouted by myself (114) and several other consultants (98), and represented 11 counties in western Nebraska - Scotts Bluff, Morrill, Box Butte, Sheridan, Sioux, Banner, Kimball, Cheyenne, Keith, Perkins, and Duel.

From these survey fields, 270 symptomatic samples were observed, brought to the Panhandle Plant Pathology lab and processed for identification of potential bacterial infections. The total number of samples from each crop or plant type included: alfalfa (2), bromegrass (10), chicory (3), corn (59), dry beans (97), eggplant (1), unknown grass weeds (5), millet – proso and foxtail (15), forage peas (2), soybeans (5), sunflowers (43), sugar beets (6), triticale (2), and wheat (20).

All samples were either cultured on standard growth media or were incubated in a humidity chamber (or both). As bacterial growth emerged from symptomatic tissues in the humidity chambers or in culture, they were re-streaked on new media for separation and observed for colony growth characteristics and color. All recovered isolates were first tested by the Gram stain technique, which identifies the bacteria as either Gram positive or Gram negative. All Gram positive isolates (the bacterial wilt pathogen of dry beans is Gram +) were labeled and put into a -40 C freezer for later tests.

Testing for Pathogenicity

A total of 73 Gram positive samples were obtained over the course of the season, 38 of which were isolated from dry beans and identified as standard *Curtobacterium flaccumfaciens* isolates (39% of dry bean samples and 13.6% of all samples). However, 35 additional Gram positive samples were identified from the remaining crop and weed plants (19% of non-dry bean samples and 12% of all samples – Table 1).

These 35 isolates were tested once in growth chambers for pathogenicity on dry beans. Each isolate was inoculated on Great Northern, cv. “Orion” dry beans, utilizing 4 replicates per isolate. Inoculations consisted of dipping sterile needles into bacterial colonies from 48-hour cultures and inserting into stems just below the first fully expanded trifoliolate. Plants punctured with needles dipped in sterile water served as negative controls. We also included a bacterial wilt isolate known to be highly virulent as a positive control. Inoculated plants were incubated in lighted growth chambers with a 12-hour light/dark cycle and a temperature of 30 C (94 F).

Of the 35 Gram positive isolates collected in 2008, and tested for pathogenicity on beans, three proved to be pathogenic, including the two alfalfa isolates, and an additional one from wheat. Although fewer isolates were identified in 2008, we continued to document the presence of dry bean-pathogenic isolates with other crops grown in rotation with dry beans. A new host was identified in 2008 (alfalfa) that had not been previously observed. Without conducting this survey, it is doubtful that this crop would have ever been monitored and tested. As a result of this project, combined with previous work, we now have identified approximately 20 isolates found in other crops (wheat, soybean, corn, and alfalfa) since 2005.

Goals and Outcomes Achieved

The goals of this project were to:

1) Conduct a survey of Nebraska production fields to determine incidence and distribution of isolates causing wilt-type bacterial diseases;

2) Test the collected isolates for virulence and pathogenicity by inoculating dry beans and incubating under controlled environmental conditions; and

3) Test other legume species (chickpeas, lentils, snap beans, field peas, lupines) that may also be grown in rotation with dry beans for susceptibility to bacterial wilt isolated and potential pathogen carryover and survival.

Outcome #1: Conduct a survey of Nebraska production fields to determine incidence and distribution of isolates causing wilt-type bacterial diseases.

Between early July and mid-September 2008, production fields were scouted for symptoms consistent with bacterial infections. The survey for the entire season consisted of 212 fields - scouted by myself (114) and several other consultants (98), and represented 11 counties in western Nebraska - Scotts Bluff, Morrill, Box Butte, Sheridan, Sioux, Banner, Kimball, Cheyenne, Keith, Perkins, and Duel.

Outcome #2: Test the collected isolates for virulence and pathogenicity by inoculating dry beans and incubating under controlled environmental conditions.

From these survey fields, 270 symptomatic samples were observed, brought to the Panhandle Plant Pathology lab and processed for identification of potential bacterial infections. The total number of samples from each crop or plant type included: alfalfa (2), bromegrass (10), chicory (3), corn (59), dry beans (97), eggplant (1), unknown grass weeds (5), millet – proso and foxtail (15), forage peas (2), soybeans (5), sunflowers (43), sugar beets (6), triticale (2), and wheat (20).

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Outcome #3: Test other legume species (chickpeas, lentils, snap beans, field peas, lupines) that may also be grown in rotation with dry beans for susceptibility to bacterial wilt isolated and potential pathogen carryover and survival. It was important to identify additional isolates from other crops that possess biological and morphological characteristic of the bacterial wilt pathogen.

<u>Testing for Pathogenicity</u>
A total of 73 Gram positive samples were obtained over the course of the season, 38 of which were isolated from dry beans and identified as standard *Curtobacterium flaccumfaciens* isolates (39% of dry bean samples and 13.6% of all samples). However, 35 additional Gram positive samples were identified from the remaining crop and weed plants (19% of non-dry bean samples and 12% of all samples – Table 1).

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Of the 35 Gram positive isolates collected in 2008, and tested for pathogenicity on beans, three proved to be pathogenic, including the two alfalfa isolates, and an additional one from wheat. Although fewer isolates were identified in 2008, we continued to document the presence of dry bean-pathogenic isolates with other crops grown in rotation with dry beans. A new host was identified in 2008 (alfalfa) that had not been previously observed. Without conducting this survey, it is doubtful that this crop would have ever been monitored and tested. As a result of this project, combined with previous work, we now have identified approximately 20 isolates found in other crops (wheat, soybean, corn, and alfalfa) since 2005.

This characterization of the wilt pathogen's genetic population structure in the high plains includes a number of isolates from alternative crops collected during the course of this study, in addition to other bean isolates from all growing areas of Nebraska, Colorado, and southeast Wyoming.

Since 2008, the results of this project have been presented to a variety of different audiences. We have talked to the Nebraska Dry Bean Commission and Nebraska Dry Bean Growers Association. We have delivered presentations concerning the results of this project to various regional extension programs including the 2008 Colorado-Nebraska Crop Clinic, 2010 Colorado Crop Consultants Annual Meeting, 2009 Great Plains Diagnostic Network's Seminar Series, and the University of Nebraska's Crop Protection Clinics. We have also presented this material to peers and students who attended the 2008 Panhandle REC Seminar Series and the 2009 UNL Plant Pathology Department Seminar Series. This material has also been presented to international audiences via the American Phytopathological Society's national meeting in Portland, Oregon in 2009 and the Bean Improvement Cooperative's meeting in Fort Collins, Colorado in 2009. It is estimated that 750 – 800 industry experts were exposed to this information through the various oral presentation delivered to the aforementioned groups.

Some of the project's information is included in a new manuscript that will be submitted to the plant pathology journal entitled, *Phytopathology.* This journal is the premier source for peer-reviewed plant pathology research. The title of the manuscript containing this projects information will be found under the title of *Genetic Differentiation of Curtobacterium Flaccumfaciens pv. Flaccumfaciens Populations in the American High Plains,* authored by Irina V. Agarkova, Patricia A. Lambrecht, Robert M. Harveson, and Anne K. Vidaver

<u>Beneficiaries</u>

Dry bean growers, crop consultants and all other parties with an interest in producing dry beans will benefit from this project. Since this problem has reemerged under more modern farming practices such as crop rotation, we have a lot to learn about how to deal with the disease.

Lessons Learned

We were somewhat surprised at the high number of potential wilt isolates recovered from the alternative crops during the course of this study in 2008. However, after one evaluation, the only isolates that proved to be pathogenic on dry beans included the two alfalfa isolates, and an additional one from wheat. One of the delays we have experienced was in testing a second time for pathogenicity of all 35 isolates. We still need to confirm pathogenicity of all isolates by repeating inoculations a second time. This phase will be completed very shortly. Many of those isolates collected in 2008 could still be simply secondary contaminants associated with other diseases or stresses that were observed on plants.

Another factor to consider for 2008 is that the overall incidence of bacterial wilt in dry beans was lower than in the last 3-4 years. This is presumed to be due at least in part to the cooler and wetter conditions during August that was experienced in the western portion of the state in 2008. The lower and wetter temperatures would result in less stress on plants during and shortly after flowering than would normally be expected. High levels of stresses on plants, including water and heat stress has been shown to favor greater infection and disease development from the wilt pathogen.

Additionally, the winter of 2007-2008 was more severe than during the past 7-8 years. It could be argued that a more severe winter would result in lower levels of pathogen survival in crop residues left on the surface. We are therefore presuming that factors favoring wilt infection in dry beans would also correlate with the same pathogen being associated with other crops (in association with other bacterial diseases also favored by the same set of factors). Since overall wilt incidence and severity in dry beans was lower in 2008 than previous years, perhaps this could also explain fewer wilt isolates found in association with other crops.

Although fewer isolates were identified in 2008, we continued to document the presence of dry bean-pathogenic isolates with other crops grown in rotation with dry beans. A new host was identified in 2008 (alfalfa) that had not been previously observed. Without conducting this survey, it is doubtful that this crop would have ever been monitored and tested. We now have identified approximately 20 isolates found in other crops (wheat, soybean, corn, and alfalfa) since 2005.

Another positive benefit from this study is the development of a better method for screening the large numbers of samples that were obtained this summer. We have found that putting the symptomatic tissue in humidity chambers for 24-36 hours, results in high yields of numerous bacterial residents in tissues which are more easily separated on culture plates, rather than plating surface-sterilized tissues directly on media and waiting for growth to emerge from tissue pieces. The bacteria from plated material then still have to be re-streaked on additional media to properly purify and separate colonies for further identification. This new method saves one step in the procedure making our efforts more efficient and cost effective. This has now become our standard method of initial identification of any plant sample suspected as being infected with a bacterial pathogen that is submitted to the Panhandle REC Plant Disease Clinic.

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Additional Information

We have submitted a proposal for 2009 that will address the same concept. We have recently learned that it has been awarded. One of the reasons for our desire to repeat this study is that it is difficult to draw adequate conclusions from one field season. As mentioned earlier, there were fewer environmental stresses on the plants in 2008, particularly in August. Better conditions for plant growth tend to retard conditions for favorable pathogen growth and development, thus we may see different results in years with different environmental conditions. It is always difficult to understand why some diseases appear in one year, but not others; therefore relying on only one season's results will usually not provide an accurate picture of what is occurring in the field.

Secondly, the crop or disease history of fields we scouted this year was not always known for certain. Thus we did not have good preliminary data for the presence of the pathogen any time in the recent future for many of these fields. One of the reasons for also scouting dry bean fields during 2008 was we could easily go back to these fields in another year knowing disease incidence, and searching in those fields planted with another crop at a future date. Fields in 2008 found to have high levels of wilt, will then be specifically targeted for continuation of surveys for the pathogen in whatever crop they are planted to in 2009 or beyond.

Table 1. Gram + Bacterial Isolates Collected from Alternative Crops in Nebraska – 2009.

Crop	Description	Date	Storage
Millet	Harveson, Hwy 71 A, orange	7-9-08	B 61
Millet	Harveson, Hwy 71 B, yellow	7-9-08	B 62
Brome grass	Harveson, Box Butte Cty	7-2-08	C 2
Sunflower	Harveson, Box Butte Cty	7-2-08	C 4
Sunflower	Harveson, Box Butte Cty	7-2-08	C 5

Sunflower	Harveson, Box Butte Cty	7-2-08	C 6
Corn	Tony Schmidt	7-17-08	C 7
Wheat	Tony Schmidt	7-17-08	C 8
Corn	Clavibacter, Eitzman	7-17-08	C 10
Soybean	Harveson, Keith	7-25-08	C 12
Corn	Dean's Corn, SDI Field	7-8-08	C 13
Millet	Unknown, Booker, Friberger, #2	7-17-08	C 20
Corn	Eitzman, M Reuter	8-6-08	C 30
Corn	Harveson, Tony, Otoe Rd	8-6-08	C 39
Alfalfa	Harveson, orange	8-8-08	C 42
Alfalfa	Harveson	8-8-08	C 48
Corn	Curt. ?, Eitzman, Rod Adams	8-15-08	C 54
Corn	Jim Larson	8-18-08	C 55
Soil fungus	Harveson, SDI, Grant	8-22-08	C 56
Brome grass	Harveson, Hwy 30, Cheyenne Cty	7-9-08	C 59
Corn	D Schmer, Haun Bros	8-18-08	C 62
Corn	Eitzman, Schiff Farms	7-16-08	C 68
Corn	D Schmer, Haun, cream	8-20-08	C 81
Chicory	Unknown bacteria, Harveson, volunteer	7-16-08	D 24
Corn	Unknown bacteria	8-20-08	D 59
Soybean	Curt, ?, Harveson, Keith Cty, yellow	8-26-08	G 1
Corn	Butcher, yellow	8-28-08	G 2
Corn	D Schmer, T Carrier, orange	8-28-08	G 12
Corn	D Schmer, T Carrier, orange	8-28-08	G 13
Sunflower	Harveson, Jeff Rd, other field, white	9-5-08	G 25
Sugar Beet	Harveson, Young, #1	9-17-08	G 65
Millet	Harveson, Hwy 71 & CR 6, yellow	9-16-08	G 75
Millet	Harveson, Hwy 71 & Harrisburg, yellow	9-17-08	G 77
Sunflower	Harveson, petioles, #C, yellow	10-6-08	I 25
Corn	Eitzman, M Reuter, lt yellow	9-26-08	I 27

Project Title

Irrigation and Nitrogen Management of Potato under Reduced Water Availability (Final Report)

Project Summary

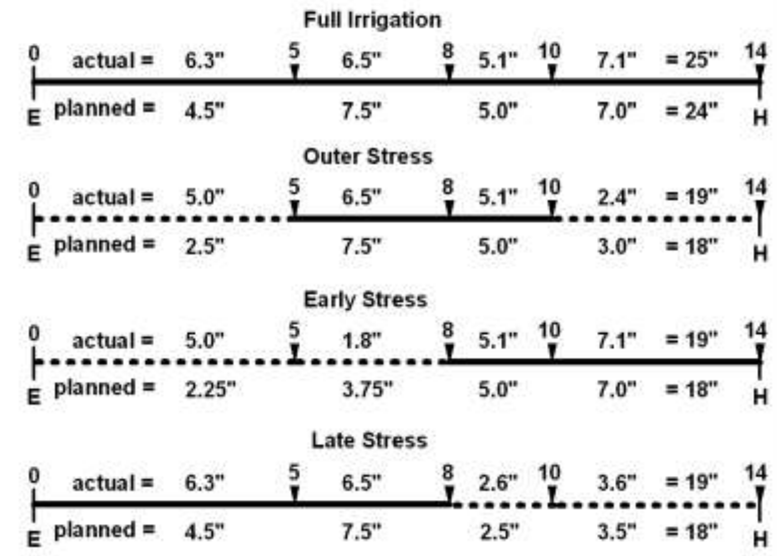
Drought is a continual problem in western Nebraska and has promoted a decline in water availability for agriculture. The objective of this proposal was to determine a period during potato production in which the negative impact of limited irrigation would be least detrimental to market yield. The drought of the past decade in western Nebraska has magnified the problem of declining ground and surface water. Legislation in Nebraska to manage groundwater is having an impact and changing water allocations. For potato growers in the Southwest and the Panhandle of Nebraska, it simply means less water and greater risk to yield and market quality. Under limited irrigation, less water is applied than is required to meet the optimum requirement. As a result, the crop is stressed. The goal is to manage irrigation timing and nitrogen fertilization such that the resulting water stress has less of a negative impact on marketable potato yield. In studies at North Platte; corn, soybean and wheat showed that proper limited irrigation management did not reduce yield as much as expected. Similar studies on potato have yet to be conducted. Potato is highly sensitive to soil moisture and nitrogen due to a shallow, fibrous root system. Although some studies have been conducted on a few varieties, none has been done on chipping varieties such as Atlantic, an important variety grown in Nebraska under chip contracts. Reduced irrigation or mild stress for extended periods also has not been studied. This project is intended to be the first year of a multi-year study.

Project Approach

Potato cultivar Atlantic was exposed to reduced irrigation during three periods (first eight weeks, first five weeks plus last four weeks, and last six weeks); see Figure 1. Irrigation during these periods will be reduced by half resulting in six inches less precipitation or 25% reduction from full irrigated plots (check). Controlled irrigation, adjusted for rain, was applied using a linear-move overhead (Lockwood) sprinkler irrigation system. Irrigation plots were divided into sub-plots based on nitrogen, as UAN, application which was applied at 90, 150 or 210 lb/a. Nitrogen application was pre-plant, plant emergence, and early post-emergence. All plots were randomized and replicated four times. Major plots were 16 rows by 40 ft. Morphological readings on vine growth were taken at each irrigation period change; also soil moisture and nitrogen, and plant nitrogen were determined at these times. Upon harvest, tubers were sorted by size and weighed. Premium sized tubers were scored for external and internal defects. Tubers were prepared and fried to determine cooking characteristics. Size, defects and cooking quality determined market compatibility.

Irrigation - A record-breaking rainfall in June (2009) that delayed differential irrigation to 26 June (Figure 1) resulted in the ‘outer stress’ schedule receiving more precipitation than planned and needed compensation at the end of the season. Rainfall variation was compensated by adjusting irrigation. Otherwise, irrigation went as planned.

Figure 1. Actual and planned irrigation scheduling, 2009



<u>Goals and Outcomes Achieved</u>

All activities were completed. The outcomes described here are based on one year and long-term outcomes cannot be measured without additional years of study. The accomplishments fulfilled the goals set for this project. The outcomes and their respective results of this project are listed below.

Outcome #1: Determine if the market yield in potatoes were adversely affected by limiting irrigation during the growing season.

The first year results indicated that limiting water availability was least harmful when occurring late in the growing season, but increasing the nitrogen application helped aid in the recovery of some of the lost yield. Regardless of timing, limiting irrigation decreased yield (Figure 8). Yield was partially increased by raising nitrogen fertility when water was limited. Yield was lower when irrigation was limited during the first several weeks ("early stress"), than when limited during the last weeks ("late stress") (Figure 8). At full irrigation, maximum yield was attained at 150 lb nitrogen/acre the recommended level for this variety. Yield of tubers size range of 2¼ -3¼ inch diameter was primarily affected by water availability accounting for ⅔ of the total marketable yield.

The timing of tuberization and flowering were not affected by limiting irrigation; however, 90 lb nitrogen/acre did delay flowering. By 8 WAE, flowering was 100% (full bloom) under all conditions (data not shown). Canopies weighed less and were smaller when water was limited (Figures 5 and 6). Limiting irrigation decreased weight regardless of N fertility. Upon the return of irrigation, canopy growth partially recovered. Stem length and number were affected by limiting irrigation or by N (data not shown). At 8 WAE, ground cover of fully irrigated plots was 100% but those experiencing limited irrigation during the early weeks were at 50% ground cover (data not shown). By 10 WAE, ground cover was complete under all conditions. At harvest, ground cover was half for late stressed plants compared to early stressed and fully irrigated plants and showed advanced ageing, senescence (Figure 7).

Outcome #2: Measure the market yield at the end of the season by harvesting total yield and then recording tuber size distribution, defects, and cooking characteristics.

Specific gravity, the accepted measure for dry matter content, was above 1.090 regardless of irrigation or nitrogen (data not shown). Tuber shape was not significantly affected (data not shown). Chip color was darker when irrigation was limited during early stress, but there was no difference between chips from fully irrigated plots, outer stress and late stress periods (Figure 9). Level of nitrogen fertility had no effect on chip color. Common scab (*S. scabies*) on harvested tubers was greatly increased when irrigation was limited in the middle of the season, approximately between 5 and 10 WAE (Figure 10). Black scurf (*R. solani*) incidence was much higher when irrigation was limited toward the end of the bulking, that is, from 8 to 10 WAE. The level of nitrogen had no effect on the incidence of common scab or black scurf. Frying quality was adversely affected when water availability was lifted between five and eight weeks after crop emergence. Water reduction then also resulted in a decrease in market value due to common scab infection. Dry matter and tuber shape were not affected.

Outcome #3: Determine water use, timing, soil water depletion, and nitrogen changes during water shortages.

Fully irrigated plots contained 16-20% soil moisture or about 90% saturation. Irrigation regiments directly affected soil moisture (Figure 2) and were not affected by nitrogen level.

Limiting irrigation and imposing stress on plants resulted in higher soil nitrogen compared to fully irrigated plots (Figure 3). This suggested a lower uptake of nitrogen by stressed plants. When fully irrigated, soil N is greater in 150 and 200 lb N/a fertilized plots than in those fertilized with 90 lb nitrogen/acre a and the soil nitrogen lasted longer (data not shown).

When irrigation was limited, petioles contained higher nitrogen levels compared to unstressed plants, fully irrigated plots (Figure 4). Fertilizing with N had little effect. Petiole nitrogen seemed to be much more affected by irrigation than by nitrogen fertilization.

Outcome #4: Perform an economic evaluation of the market yield price based on contracts, agronomic inputs, and savings in irrigation and fertilization costs.

This is scheduled to commence at the end of the multi-year project, which is still in progress.

Other Accomplishments

The potato cultivar, Atlantic, was exposed to reduced irrigation during three periods (first seven weeks, first four weeks and last four weeks, and last six weeks). Each plot was devided into three sub-plots based on nitrogen application. There were four limited irrigation treatments (full irrigation, early season stress, mid-season stress, and late season stress) and three nitrogen treatments (100, 150, and 200 lb/acre). Morphological readings on vine and tuber characteristic were taken every three weeks corresponding to each change in irrigation scheduling. When harvested, tubers were sorted by size.

Dissemination of Research

The results and findings of this study have been disseminated to the target audience and is ongoing as additional data is obtained from sequential years of project funding. The target audiences include potato growers and scientists, as further explained under the Beneficiaries section of this report. Presentations of preliminary data of the study were delivered to the following audiences. (The number of attendees exposed to this information are identified in parentheses.)

Nebraska Potato Development Committee in March 2010 in Kearney, NE. The target audience consisted of Nebraska potato growers and representatives of the Nebraska Department of Agriculture (20).

NCERA 211 ("Potato Research and Extension Program") in March, 2010 in Fargo, ND. The target audience consisted of North-Central Region Potato Growers, potato scientists and U.S. Department of Agriculture representatives (40).

Central Great Plains Working Group in August 2010 in Scottsbluff, NE. The target audience consisted of researchers interested in limited irrigation in crops in the Great Plains region. Those in attendance represented the universities of Nebraska, Colorado State, Kansas State, South Dakota State, and Wyoming (40).

Potato Education Guide Web Site. The target audience consists of potato growers, researchers and government representatives from around the world. The 2009 and 2010 data are currently being prepared to be uploaded onto the website. Completion is expected in December 2011 (8,000 people logged onto this web site).

Water Optimizer Program. The target audience consists of Nebraska and national potato growers. Incorporation of the study results will commence at the conclusion of study when the data has been combined, analyzed and interpreted. Commencement is expected in 2013. The Water Optimizer Program is a computer program, which will not be added until after the project is complete. The estimated completion date is 2013. The addition of the final data to the Water Optimizer Program is an add-on to the project that will help growers make decisions as to how to best allocate and utilize their water.

Beneficiaries

This work would directly affect the potato industry in Nebraska and especially that in western Nebraska west of Hwy. 83. Western Nebraska accounts for 14 of the 17 potato operations, and about half the State's acreage and chipping industry, most of which is contracted to Frito-Lay. These are the intended beneficiaries because drought conditions are not as major of a problem east of Hwy. 83. The economic impact has several aspects such as production costs, transportation costs, and environmental costs. It includes preservation of market yield with a reduction in water and nitrogen use, avoidance of the cost of rejected potato loads, and reduced nitrogen leaching. A second group of beneficiaries is the scientific community and Extension specialists in the USA especially in regions facing similar water limitations. These data will assist in agricultural planning as global climate change proceeds. To this end, as the results are verified by additional years of testing, data can be incorporated into the "Water Optimizer" program, a whole-farm, multi-cropping tool developed by Supalla and Martin (http://real.unl.edu/h20) used widely by Nebraska producers but does not include potato.

The quantitative data of this year’s study that concerns the potato community the most are related to yield, tuber quality, and cooking characteristics as these were affected by periods of limited irrigation (Figures 8, 9 and 10). Current policy of Frito-Lay and other chip manufacturers is an accept/reject criteria on loads of chipping potatoes. When tuber quality is below the accepted level then the entire potato load, a semi-truck, is refused. Therefore, a minimum quality is needed. The other quantitative data are critical to understanding soil water and nitrogen changes (Figures 2 and 3), and the health and growth of the plant (Figures 4 to 7).

This year’s data were presented already to Nebraska Potato Development Board (March 2010), at the “Potato Research and Extension Program” (NCERA211) meeting in Fargo, ND (March 2010), and at the meeting of the “Central Great Plains Working Group” (August 2010). The second year of this study will be the 2010 season.

Lessons Learned

Based on one-year data, the trend was that when limiting irrigation, it is least deleterious to withhold about ⅓ of the water early in the season and ⅔ of it at the end of the season (“outer stress”). Also, it appeared that applying more nitrogen would partially mitigate the deleterious effect of limiting water on yield (Figure 8). Based on yield, tuber quality and chip color, the worst case scenario was withholding water from the fourth to the eighth week after emergence (“early stress”), which is the period of tuber formation and early growth. Stress during this period not only lowered yield of premium sized chipping tubers (Figure 8) but also showed darker chips (Figure 9) and greater common scab (*Streptomyces scabies*) infection (Figure 10). The period of tuber bulking from the eighth week after emergence to harvest ("late stress") was more tolerant of reduced water than the period of early stress, and yield and chip color (Figures 8 and 9) were much like that of the period of outer stress. However, tubers from the late stress period showed a greater infection by black scurf (*Rhyzoctonia solani*) (Figure 10). Both late and outer stress periods showed premature senescence or dying (Figure 7).

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Figure 2. Soil Water (0-16") time course all N

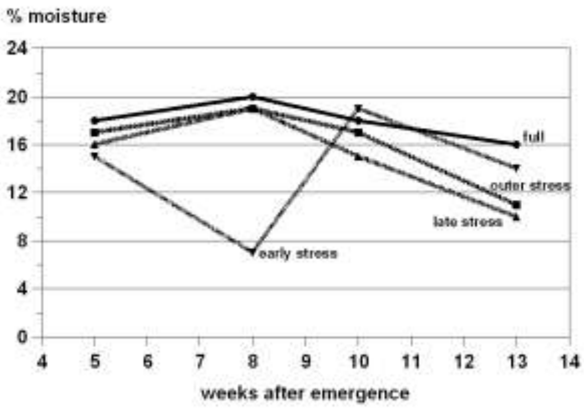


Figure 3. Soil N (0-8") time course at 150 lb N/a

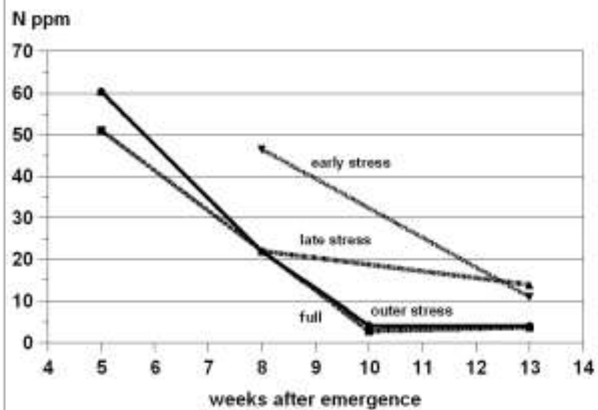


Figure 4. Petiole N time course at 150 lb N/a

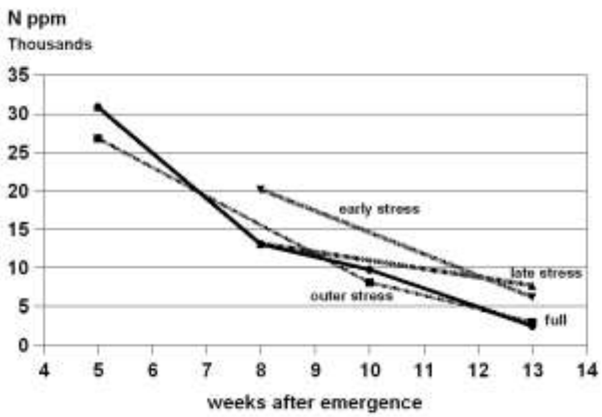


Figure 5. Vine Fresh Weight at 150 lb N/a

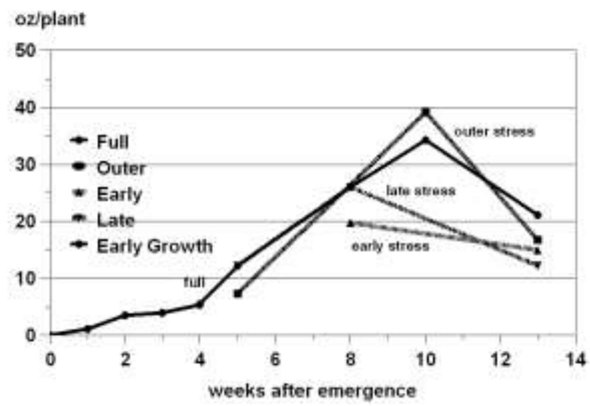


Figure 6. Canopy Area, all N levels combined

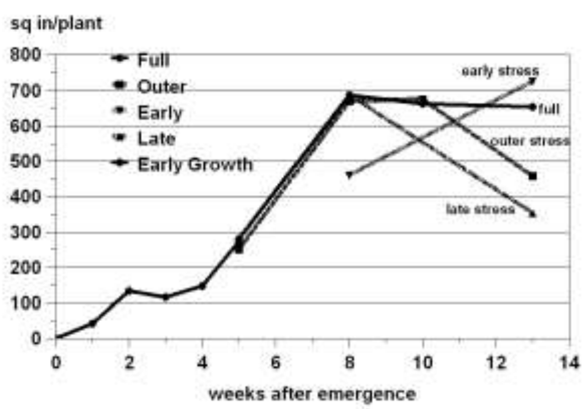


Figure 7. Ground Cover & Senescence

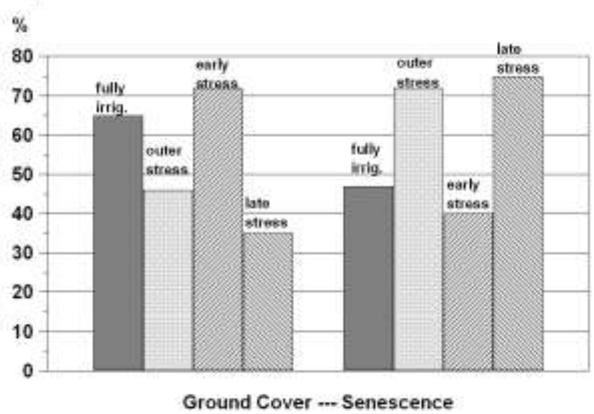


Figure 8. Yield (1.9-4.25 in) of Atlantic potato,2009

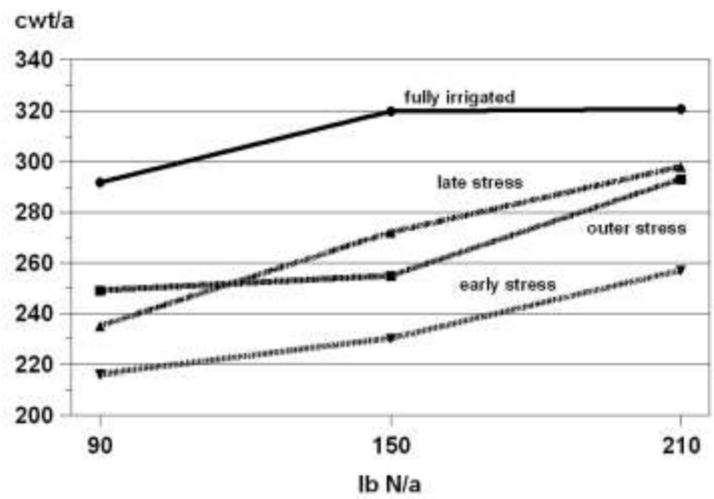


Figure 9. Tubers with light chip color, 1.0-1.5 on SFA scale

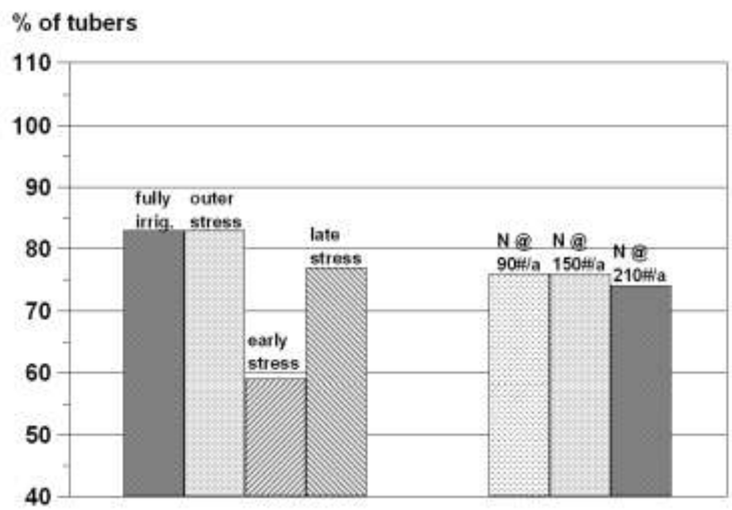
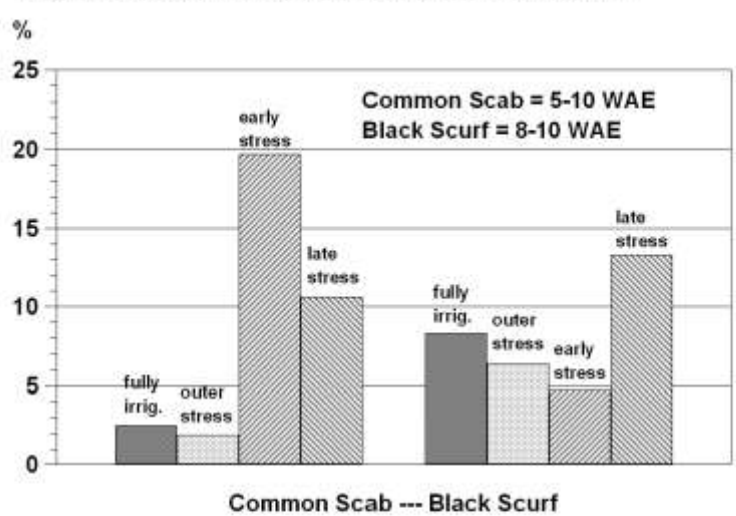


Figure 10. Common Scab & Black Scurf on chip tubers



Project Title

Characterization of Health Promoting Components, with an Emphasis on Natural Antioxidants, of Damaged (Split) Pinto Beans (Final Report)

Project Summary

According to the Economic Research Service of the United States Department of Agriculture, the pinto, navy, black, and great northern bean account for approximately 74% of the dry edible beans produced in the US, with Nebraska being No. 1 and 2 producer of the great northern and pinto bean, respectively. Studies have further shown that dry edible beans contain multiple health benefiting components (nutraceuticals) that been linked to multiple health benefits, including cardiovascular health and cancer prevention. Increased public awareness of the link between diet and health has propelled the intake of these dietary food systems containing nutraceuticals to unprecedented levels particularly in countries where the populations are aging and health care costs are rising. Nonetheless, the overall production trend of dry edible beans has decreased in Nebraska during this decade. In addition, dry edible beans are frequently damaged during the harvesting process or at post-harvest handling sites due to cracking or splitting of the seed coat. Despite the potential human health promoting components present, "split" beans are discarded from the human food supply and used for animal feed or disposed. *Therefore, the objective of this project is to characterize and compare "split" and "unsplit' PBs in terms of their compositional profiles and antioxidant capacities. As an outcome to this project, the feasibility of using"split" PBs, as a source for human health food ingredients or as a whole bean product will be determined.* Nebraska will benefit from this type of research as the rural economic sector will be promoted through the development of this specialty commodity for the niche, but fast growing, functional foods / nutraceutical market.

Project Approach

Summary of activities and tasks performed. The objective of this proposal was accomplished by completing the following specific aims listed below, as revised according to the interim report and discussed further in Section C.

- **Specific Aim 1:** To characterize and compare the lipid composition of "split" PBs and "unsplit" PBs, including total lipids, and their compositional profiles. (*Eighty percent accomplished while only two tests are outstanding (Vitamin E and sterols) and will be completed during Nov-Dec 2010).*
- **Specific Aim 2:** To characterize and compare the phenolic composition of "split" and "unsplit" PBs, including total phenolics compounds. *(Ninety percent accomplished. Only outstanding tests are anthocyanin analysis, which will be completed Nov-Dec 2010).*

- **<u>Specific Aim 3</u>:** To determine and compare the antioxidative capacity of the phenolic extracts of the “split” PBs and the “unsplit” PBs. *(100% accomplished).*
- **<u>Specific Aim 4</u>:** To disseminate information to Nebraskans, i.e., specifically growers and the industries through various presentations and development of a web site for this information. *(In-Progress, web site has been established, dissemination of some of the information through Newsletter, and one manuscript for peer-reviewed journal are in preparation with 1-2 additional papers anticipated).*
- **<u>Miscellaneous</u>:** *Additional tests (proximate, carbohydrate tests, and phytic acid analyses) were completed that was not described in the original proposal but was cited in the interim report.*

<u>Significant contributions and Role of Project Partners</u>: Dr. Carlos Urrea (UNL Panhandle Research and Extension Center). Dr. Susan Cuppett supervised the lipid analysis while Dr. Vicki Schlegel provided oversight of the remaining tests and development of the website, completion of Newsletter, etc., as well as overall supervision of the project.

<u>Goals and Outcomes Achieved</u>

<u>Summary of activities completed</u>: Pinto beans (split and unsplit) were received in-house after the 2009 harvest (Oct-Nov 2009). As such, the analysis of these samples, as described in this proposal started in Jan 2010 and has continued throughout the last 10 months with activities expected through Nov-Dec 2010. *A notable change to the proposal was that we analyzed three different cultivars of pinto beans using both their split and unsplit counterparts to determine whether potential health promoting components were affected by the damaged beans. Therefore, the number of samples (split + unsplit) analyses increased 2-3 fold.* It was also determined that the analysis of other major components was required in addition to those stated in the Specific Aims i.e., total proteins, total fat, ash, moisture and carbohydrate and various carbohydrate compositional characterization, and phytic acid levels.

<u>Summary of Outcomes</u>: Five different outcomes were listed in the original proposal and include the following. The cited outcomes are also listed to show the status of each expected outcome.

- Specific classes and amounts of lipids / phenolics groups that exhibit antioxidant properties will be identified in spilt beans. (Accomplished or in-progress refer to Sections B.1, C.1, and C.3).
- The phytochemical composition and the effects on the antioxidative properties due to a split as compared to unsplit pinto beans will be forthcoming. (Accomplished or in-progress refer to Sections B.1, C.1, and C.3).
- Two research papers published in peer-reviewed journal are anticipated with multiple presentations. (In progress with expected outcome to be accomplished 2011-2012).

- Data needed to leverage funds from federal sources for continuing work will be generated. (Accomplished, NIH grant is anticipated from this data and other on-going projects in our laboratories. Expected submission of these proposal 2011).
- Science-based results that will support and promote the consumption and production of pinto beans (Accomplished).

Comparison of actual accomplishments with the goals established in the reporting period.
Characterization analyses described in Specific Aim 1 (total lipids) and Specific Aim 2 (total phenols/total flavonoids for acid hydrolyzed and bound samples) have been completed for all the samples. Moreover, Specific Aim 3 have been completed (antioxidant capacity) for the acid hydrolyzed and bound samples. Additionally, proximates have been completed for all the samples. Items not completed include compositional analysis of the anthocyanins/tannins and (Specific Aim 2), antioxidant capacity of lipid (Specific Aim 3) as stated in the original proposal. Moreover, a target that was considered no longer realistic was the lipid analysis of hexane extracted beans, which is described in Specific Aim 1 of the proposal (Section C). Preliminary tests completed in our laboratory on other natural systems show little effect using hexane or diethyl ether in terms of compositional analysis. Total lipid yields are affected, however, with more lipids extracted using diethyl ether probably due to extraction of the complex lipids, which we are not currently analyzing within the scope of this project. In addition, based on the generated data (specifically the proximate) however, it was decided that instead of prioritizing further lipid characterization (total steryl esters, Vitamin E), compositional analysis of the carbohydrate fraction was warranted considering that fiber / prebiotics are relatively high in beans. (It must be noted that tests are in progress to complete the steryl ester and Vitamin E analyses in Nov-Dec 2010.) Moreover, total anthocyanins / tannins have not been analyzed as described in Specific Aim 2 but, in place of these tests, phytic acid tests were completed as beans contain high levels of this component, which in turn have been linked to health benefit as well as health impediments. In combination with the increased sample load, foregoing the cited tests was appropriate in favor of characterizing more pertinent traits in more types of bean cultivars. To summarize the following changes were made during the course of this project to strengthen the overall research objective.

- Two-three cultivars were evaluated instead of just one specified in the original grant, thereby increasing the overall number of samples analyzed and providing more information on the effects of cultivars on the health benefits on both split and whole beans.
- *Specific Aim 1*: Total fat, thin lay chromatography and fatty acid profiles, which are the major component of lipids, were obtained of the split and whole beans when extracted with diethyl ether.
- *Specific Aim 2*: Total phenols and flavonoids of the bound and unbound fractions were determined whereas phytic acid tests replaced anthocyanin / tannin test.
- *Specific Aim 3*: Only the antioxidant capacity of the bound and free phenolics fractions were obtained considering the higher number of samples tested and that these fractions exert much higher antioxidant levels compared to lipid extracts.

- *Miscellaneous Characterization*: Proximate values were obtained of all three cultivars to determine effects of split beans on their major components compared to the whole beans. More extensive carbohydrate tests were prioritized above the fat analyses (Specific Aim 1) considering the higher ratio of carbohydrate:fat ratio in pinto beans (refer to Miscellaneous Characterization, Section C.4) and the increasing health links of many carbohydrate based components, such as fructans, stachyose, raffinose, and resistant starch.
- *Specific Aim 4*: No changes were made.

Base Line Data: The following data is presented in terms of Specific Aims described in Section C3: *Comparison of actual accomplishments with the goals established in the reporting period.*

(C4.1) **Specific Aim 1**:

*Table 1***.** Total lipid levels for split / whole beans of three pinto bean cultivars.

Pinto Beans	**Lipid (%)**
LaPaz (S)	0.91 ± 0.01^{a}
LaPaz (W)	0.89 ± 0.01^{a}
Baja (S)	0.69 ± 0.13^{b}
Baja (W)	0.78 ± 0.02^{ab}
Poncho (S)	0.68 ± 0.13^{b}
Poncho (W)	0.93 ± 0.01^{a}
Average (S)	0.76 ± 0.15
Average (W)	0.86 ± 0.07

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3).
Values with different superscripts are significantly different ($p > 0.05$; Tukey HSD).

Figure 1. Thin layer chromatography showing major lipid compositional profiles of the split / whole bean for two cultivars (Baja and LaPaz).

Lipid Profiles of Pinto Beans

1. Standard mixture
2. Baja Whole
3. Baja Split
4. Lapaz Whole
5. Lapaz Split

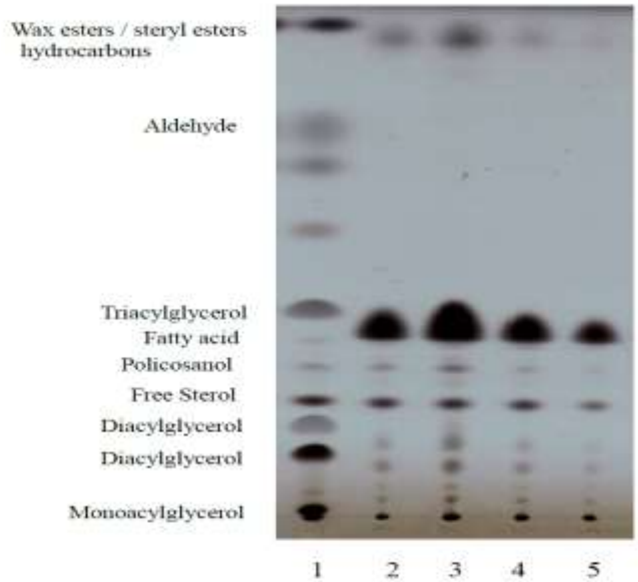


Table 2. Fatty acid profiles for split / whole beans of two pinto bean cultivars.

Pinto Bean	C14 (%)	C16 (%)	C16:1 (%)	C18:0 (%)	C18:1 (%)	C18:1 isomer (%)	C18:2 (%)	C18:3 (%)
LaPaz (S)	0.10 ± 0.04 ^{a}	9.69 ± 1.92 ^{a}	0.11 ± 0.02 ^{a}	1.50 ± 0.10 ^{a}	4.40 ± 0.36 ^{a}	1.39 ± 0.10 ^{a}	37.04 ± 2.87 ^{a}	45.77 ± 5.42 ^{a}
LaPaz (W)	0.29 ± 0.01 ^{b}	13.83 ± 1.56 ^{a}	0.19 ± 0.02 ^{a}	1.52 ± 0.02 ^{a}	3.96 ± 1.46 ^{a}	1.69 ± 0.44 ^{a}	26.94 ± 0.60 ^{b}	51.59 ± 0.08 ^{a}
Baja (S)	0.18 ± 0.00 ^{a}	12.96 ± 0.88 ^{a}	0.13 ± 0.10 ^{a}	1.39 ± 0.01 ^{a}	6.97 ± 0.10 ^{a}	1.55 ± 0.01 ^{a}	29.44 ± 0.41 ^{b}	47.37 ± 0.49 ^{a}
Baja (W)	0.34 ± 0.03 ^{b}	12.72 ± 0.46 ^{a}	0.17 ± 0.00 ^{a}	2.26 ± 0.12 ^{b}	5.61 ± 0.06 ^{a}	1.49 ± 0.04 ^{a}	27.83 ± 0.12 ^{b}	50.03 ± 0.22 ^{a}
Average (S)	0.14 ± 0.06^	11.33 ± 2.31	0.12 ± 0.01	1.44 ± 0.01	5.68 ± 1.81	1.47 ± 0.11	33.24 ± 5.37^	46.57 ± 1.31^
Average (W)	0.32 ± 0.04	13.28 ± 0.78	0.18 ± 0.01	1.89 ± 0.52	4.78 ± 1.17	1.59 ± 0.14	27.38 ± 0.63	50.81 ± 1.10

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3).
Values with different superscripts are significantly different ($p > 0.05$; Tukey HSD).
^ Average split value is statistically different from the whole bean ($p > 0.05$).

Specific Aim 2:

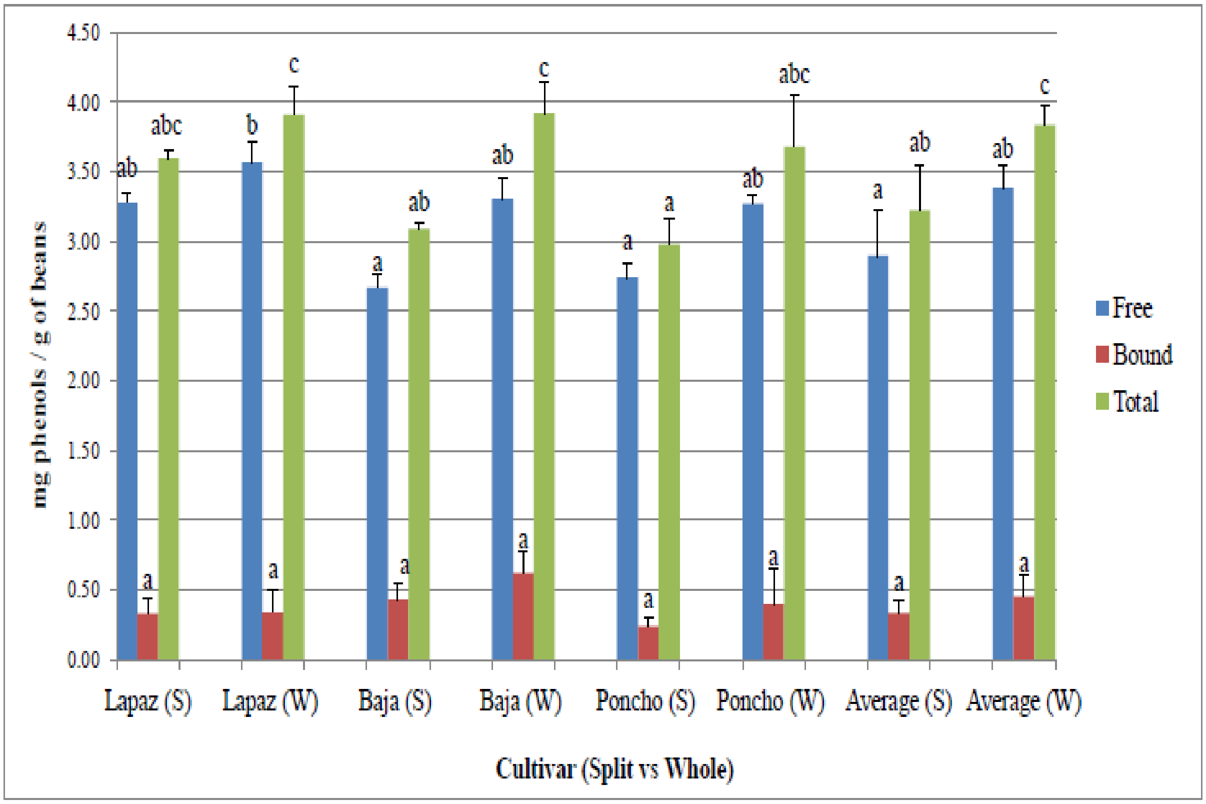


Figure 2: Free (blue), bound (red) and total (free + bound) (green) phenols in split and whole beans for each of three cultivars (mg phenols/g beans on a wet weight basis). Results are represented as the mean +/- standard deviation (n=3). Bars of the same color with different labels are significantly different at $p > 0.05$ (Tukey HSD).

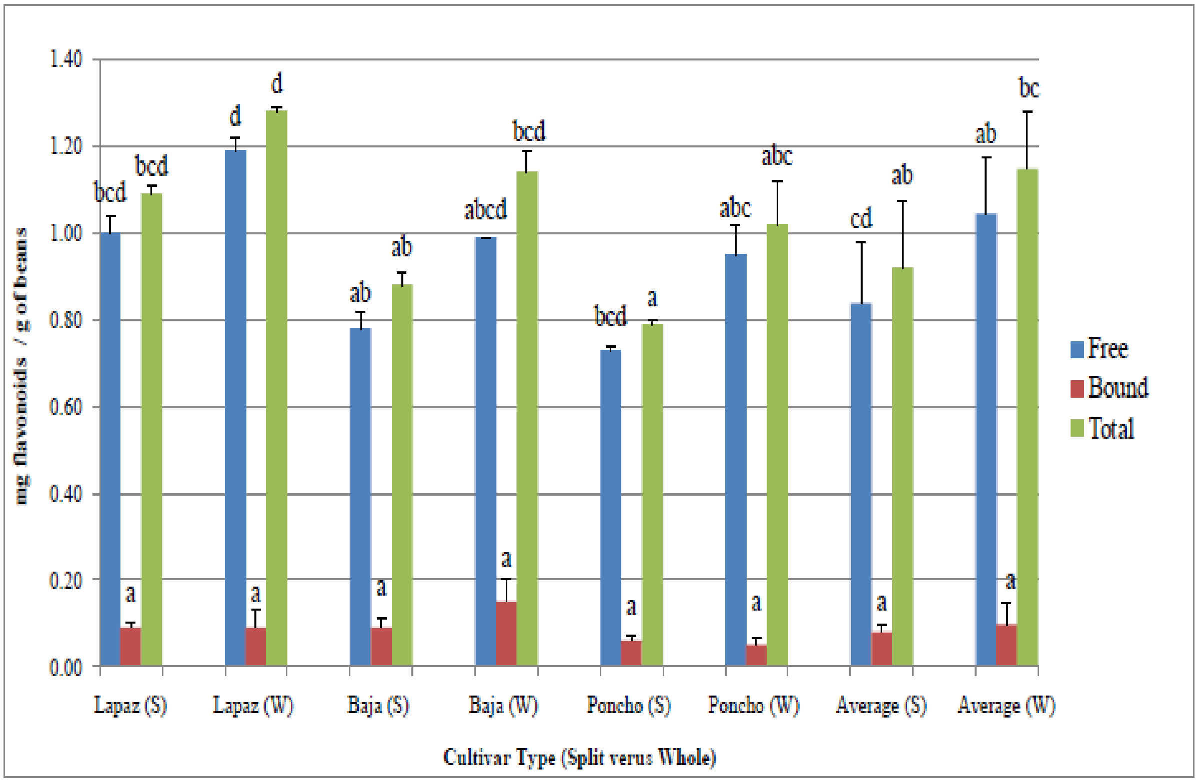


Figure 3: Free (blue), bound (red) and total (free + bound) (green) flavonoids in split (S) and whole (W) beans for each of three cultivars (mg phenols/g beans on a wet weight basis). Results are represented as the mean +/- standard deviation (n=3). Bars of the same color with different labels are significantly different at $p > 0.05$ (Tukey HSD).

Table 3. Phytic acid levels for split / whole beans of three pinto bean cultivars.

PB	Phytic Acid (mg/g)
LaPaz (S)	17.00 ± 0.70^{a}
LaPaz (W)	15.10 ± 1.51^{ab}
Baja (S)	13.54 ± 1.85^{b}
Baja (W)	12.85 ± 1.64^{b}
Poncho (S)	13.51 ± 0.40^{b}
Poncho (W)	13.07 ± 2.05^{b}
Average (S)	14.82 ± 2.09
Average (W)	13.84 ± 1.86

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3). Values with different superscripts are significantly different ($p > 0.05$; Tukey HSD).

Specific Aim 3:

Table 4. Antioxidant levels for split / whole beans of three pinto bean cultivars; free, bound, and total (free + bound) fractions.

Pinto Beans	Antioxidant Capacity (Free)	Antioxidant Capacity (Bound)	Antioxidant Capacity (Total)
LaPaz (S)	7971 ± 520[a]	373 ± 119[a]	8329 ± 745 [a]
LaPaz (W)	8861 ± 515[a]	441 ± 13[a]	9233 ± 634 [a]
Baja (S)	7142 ± 885[a]	515 ± 77[a]	7657 ± 1091 [a]
Baja (W)	8548 ± 1494[a]	617 ± 157[a]	9165 ± 1651 [a]
Poncho (S)	--	420 ± 87[a]	--
Poncho (W)	7960 ± 851[a]	478 ± 42[a]	8439 ± 1039 [a]
Average (S)	7651 ± 1644	461 ± 86	8112 ± 865
Average (W)	8160 ± 1099	485 ± 153	8645 ± 1252

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3). Values with different superscripts are significantly different (p > 0.05; Tukey HSD).

Miscellaneous Tests.

Table 5. Proximate levels for split / whole beans of three pinto bean cultivars.

Pinto Beans	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Carbohydrate (%)
LaPaz (S)	9.06 ± 0.04[a]	3.82 ± 0.02[a]	23.87 ± 0.49[a]	0.91 ± 0.01[a]	62.33 ± 0.54[a]
LaPaz (W)	9.08 ± 0.0[ab]	3.75 ± 0.07[ab]	24.39 ± 0.16[a]	0.89 ± 0.01[a]	61.86 ± 0.16[a]
Baja (S)	8.81 ± 0.12[c]	3.67 ± 0.04[bc]	18.83 ± 0.17[b]	0.69 ± 0.13[b]	67.99 ± 0.11[b]
Baja (W)	9.20 ± 0.09[bd]	2.96 ± 0.17[d]	18.46 ± 0.60[b]	0.78 ± 0.02[ab]	68.58 ± 0.61[b]
Poncho (S)	8.72 ± 0.08[c]	3.59 ± 0.04[c]	19.24 ± 0.53[b]	0.68 ± 0.13[b]	67.74 ± 0.60[b]
Poncho (W)	9.27 ± 0.01[d]	3.77 ± 0.03[ab]	18.50 ± 0.56[b]	0.93 ± 0.01[a]	67.82 ± 1.05[b]
Average (S)	8.87 ± 0.16^	3.70 ± 0.11	20.65 ± 2.45	0.76 ± 0.15	66.02 ± 2.80
Average (W)	9.18 ± 0.10	3.50 ± 0.41	20.45 ± 2.99	0.86 ± 0.07	66.09 ± 3.25

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3). Values with different superscripts are significantly different (p > 0.05; Tukey HSD).
^ Average split value is statistically different from the whole bean (p > 0.05).

Table 6. Total fructans, raffinose and stachyose levels of the split / whole bean of three pinto bean cultivars.

Pinto Bean	Resistant Starch (mg/g)	Fructans (mg/g)	Stachyose (mg/g)	Raffinose (mg/g)
LaPaz (S)	191.5 ± 14.8[b]	21.42 ± 1.9[a]	27.39 ± 5.08 [a]	6.72 ± 1.05 [a]
LaPaz (W)	180.0 ± 7.8[ab]	22.52 ± 1.0[ab]	26.44 ± 3.85 [a]	7.06 ± 0.72 [a]
Baja (S)	153.2 ± 11.4[a]	24.73 ± 1.1[ab]	26.92 ± 4.04 [a]	6.21 ± 0.68 [a]
Baja (W)	180.3 ± 2.7[ab]	24.59 ± 1.4[ab]	27.13 ± 4.52 [a]	7.00 ± 0.79 [a]
Poncho (S)	179.3 ± 11.4[ab]	24.54 ± 1.5[ab]	22.89 ± 1.26 [a]	5.16 ± 1.09 [a]
Poncho (W)	160.7 ± 20.4[ab]	25.40 ± 4.0[b]	24.48 ± 1.39 [a]	5.13 ± 0.08 [a]
Average (S)	174.70 ± 12.2	23.56 ± 1.22	25.73 ± 2.47	6.19 ± 0.35
Average (W)	174.66 ± 19.6	24.17 ± 1.96	26.02 ± 1.37	6.40 ± 1.08

W – Whole; S – Split. Results are shown as the mean ± standard deviation (n = 3). Values with different superscripts are significantly different (p > 0.05; Tukey HSD).

Specific Aim 4: To date this information has been disseminated to NE producers through Newsletter (Bean Bag, Dec issue). More articles are expected in this Newsletter as well as the Nebraska Farmer Newsletter to disseminate information. Lastly, a web site has been prepared in conjunction with Alice Henneman under food.unl.edu, which has currently received 250,000 hits since its launch in August 3. Within this web-site, I am building a page that will profile beans and thus this project. For example, refer to http://food.unl.edu/web/fnh/cooking-with-dry-beans and (http://liferaydemo.unl.edu/web/food /metabolomics). One manuscript is currently in preparation as well as 2-3 presentations, which will also be a means to disseminate the information.

Beneficiaries

(D.1) *Description of groups and other operations that benefitted from project*. Dry edible beans is an important Nebraska specialty crop with our state being the No. 1 and No. 2 US supplier of the great northern beans and pinto beans, respectively. A significant issue facing the US dry edible bean industry is the current price of competing field crops, such as corn, and the influx of dry edible beans from international sources. Nebraska regions most affected by this decline include several counties located throughout our state, but particularly those in the Panhandle area. As the number of acres of dry edible bean production declines, so too does their economic viability, which, in turn, adversely affects the rest of the economies in the region. It is expected that multiple beneficiaries will be impacted from this research particularly producers and distributors of dry edible beans in the Nebraska Panhandle. The companies with a presence in NE who will benefit from the development of FFN from dry edible beans will include large and small food based companies, such as Cargill, Archer Daniel Midlands, AGP, Abengoa, and Twin Valley Mills.

(D.2) *Quantitative data that concerns the beneficiaries.* Although split beans represent only a small portion of the overall bean production (~3%), development of new innovative uses, such as an ingredient for functional foods, will not only add value to the co-product but increase the reputation of a pulse that is now considered a "poor man's food". As this research represents the initial stages to develop a NE Dry Edible Bean program consisting of research, as a means to market, develop and produce safe and efficacious products for the fast growing FFN market, quantitative data that directly impacts our beneficiaries due to this specific project is difficult at this time. It was determined that in most cases the health promoting components were retained in the damaged beans (refer to Section C). *It is thus expected that damaged pinto bean can be directed into our human dietary supply allowing producers and distributors to minimally profit in the short term using their current production practices and dedicated acreage.* However, certain health promoting components should be evaluated for long-term impacts.

Lessons Learned

Conclusions for the project. Two primary conclusions were determined from this study 1.) in most cases, the health promoting components present in pinto beans were not impacted due to damage, but 2.) certain health promoting components were affected by cultivar type. Select components did change for the split compared to whole bean. Notably, the moisture content (Table 5) was less in split beans compared to the whole beans with lower, but mostly insignificant, trends occurring in the phenolic fraction (Figure 2 and 3) and antioxidant capacities (Table 4). Moreover, the fatty acids were also being affected by the split, as the overall levels of the omega 3 fatty acid (linolenic) decreased in the split while the omega 6 (linoleic acids) levels increased compared to the whole bean (Table 2). These results could become more significant as the bean ages or different cooking processes are applied. In terms of different cultivars, proximate levels (Table 5) significantly varied with LaPaz, which contained higher levels of protein but lower levels of carbohydrates compared to Baja and Poncho. Significantly lower levels of phenolics and flavonoids (Figure 2 and 3) were also present in the former cultivar with lower, but insignificant, trends in the overall antioxidant capacity (Table 4).

Unexpected outcomes of results. There were no unexpected outcomes, as this project was completed to obtain base line results, which was accomplished.

Share the lessons learned. Both cultivar type as well as damage imposed on the bean must be analyzed when testing for health promoting components. As these components can also be affected by farming practices and weather conditions, it is important to establish data bases to track the long-term impacts and correlate the possible effectors. This project has provided information to support this effort, as well as to provide base line information to our NE beneficiaries on the health promoting agents present in dry edible beans grown in our state.

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Project Title

Nutritional and Anti-Nutritional Compositions of Defatted Nebraska Hybrid Hazelnut Meals (Final Report)

Project Summary

The hybrid hazelnut shrub cultivars, which combine the superior qualities of the European hazelnut with disease resistance and cold hardiness of the American species, continue to show great potential as an oilseed crop in the Upper Midwest, and more specifically the state of Nebraska.
Unique fatty acid profile and physico-chemical properties, together with being rich in bioactive nutrients (phytosterol, tocopherol, and polyphenol) make hazelnut oil ideal for food and industrial applications. At the same time, it is of interest to identify uses for the defatted meal. The high protein content and balanced amino acid composition offer an opportunity to meet the needs for use as human food and animal feed supplements. However, like most plant protein sources, defatted hazelnut meal could contain anti-nutritional factors, such as phenolics, tannins, and phytates. Anti-nutritional factors generally refer to naturally occurring allelochemical substances of varied natures that can react with food ingredients to interfere with food intake, which eventually reduces growth. The presence of these anti-nutritional factors in the defatted meal could lead to lower nutritional value than otherwise expected. Therefore, in this project, we evaluated nutritional composition and the types and levels of anti-nutritional factors in defatted Nebraska hybrid hazelnut meals. The information obtained from this research is intended to serve as a key step for investigation of the potential of defatted hybrid hazelnut meal as food and feed supplements.

Project Approach

Following are summaries of the experiments conducted to address the specific objectives. (1) Evaluation of nutritional compositions, in terms of proximate composition, amino acid profile, and mineral elements of defatted hazelnut meals - The meals first were dried at 60 ˚C for 24 h prior to all analyses. Analyses of crude protein, oil, and ash were performed using standard methods. Crude protein content was measured by combustion method (AOAC 990.03) using a FP-528 Nitrogen/Protein Analyzer with DSP Control (Leco Corp., St. Joseph, MI).The oil content was measured using a Soxhlet apparatus according to AOAC 948.22. Ash content was determined according to AOAC 950.49. Carbohydrate content was determined by subtracting the total percentage of other components from 100. Neutral detergent fiber and acid detergent fiber of the meals were analyzed using reflux methods. The energy value was measured using a model 1108 adiabatic oxygen chamber (bomb) and the 1241 calorimeter (Parr Instrument Co., Moline, IL). The gross energy value of the sample was determined based on the change in temperature of the calorimeter system, the heat capacity of the calorimeter system, and the grams of sample used. The mineral elements, namely calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorous (P), potassium (K), sodium (Na), selenium (Se),

and zinc (Zn), were measured using a GV Instrument Platform XS inductively coupled plasma mass spectrometer, while the amino acid profile of hybrid hazelnut meal was determined using ion-exchange chromatography.
(2) Evaluation of types and levels of anti-nutritional factors in the defatted hazelnut meals - The levels of potential anti-nutritional factors, including total phenolic, tannins, condensed tannins, and phytates, in the defatted meals were measured. Total phenolics and tannins were determined by Folin-Ciocalteu method, while determination of condensed tannins was carried out by reacting with the butanol-HCl reagent and the ferric reagent. Phytate was analyzed using a rapid colorimetric procedure.

<u>Results and Conclusions</u>
Nebraska hybrid hazelnut defatted meals had average crude protein content of 48.2%, carbohydrate of 40.4%, energy value of 4369 cal/g, neutral detergent fiber (NDF) of 25.9% and acid detergent fiber (ADF) of 14.7% (Table 1)

Of tested mineral elements, K was the most abundant mineral element in the meals, with a mean value of 1954.1 mg/100g meal, followed by P (1230.4 mg/100g), Ca(758.8 mg/100g), Mg(538.7 mg/100g), Na (231.3 mg/100g), Mn (9.0 mg/100g), Fe (7.43 mg/100g), Cu (4.75 mg/100g), Zn (1.34 mg/100g), and Se (95.5 µg/100g). In general, the mineral composition patterns of Nebraska hybrid hazelnut defatted meals were similar with those of Turkish varieties (Table 2).

Sixteen amino acids were identified, and total amino acids contents were 62.5 g/100g crude protein. Seven essential amino acids accounted for approximately 27.8% of the total amino acids contents. Unfortunately, another essential amino acid, tryptophan, was not detected. All essential amino acid contents in the meals were significantly lower than the reference levels recommended for human and animal diets. Glutamic acid was present in the highest content, followed by arginine and asparic acid in the non-essential amino acids (Table 3).

Average total phenolics, tannins, condensed tannins, and phytate in the meals were 10.7 mg TA/g, 7.53 mg TA/g, 0.64% leucocyanidin equivalent, and 26.4 mg/g. The presence of high levels of these anti-nutritional factors reduced protein and mineral bioavailability. Some processing, such as soaking, cooking, toasting and extrusion were found to effectively reduce anti-nutritional levels (Table 4).
The data reported in this study suggest that Nebraska hybrid hazelnut defatted meal are a potential resource for human and animal consumption, along with supplement of some essential amino acids and processing to potentially decrease anti-nutritional levels. Further research on evaluation of processing methods to reduce anti-nutritional factors in the defatted meals will be conducted in future experiments.

Goals and Outcomes Achieved

The long-term goal of this project was to explore the value-added opportunities for food and industrial applications and to accelerate the development and commercialization of hybrid hazelnut production in Nebraska. In this project, our investigation of nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal were an integral part and play very critical and important roles in achieving long-term outcome measures for the project. With the information on nutritional compositions and anti-nutritional factors obtained from this project, developing strategies to reduce anti-nutritional levels and improve their nutritional values, and therefore, broadening the applications of Nebraska hybrid hazelnut during processing and storage, are underway.

Beneficiaries

First, over 100 Nebraska specialty nut crop producers, food processors, nut traders, and animal feeder will benefit from reading about the results through reports presented on the Industrial Agricultural Products Center website (agproducts.unl.edu) and poster presentation/handouts at events typically attended by the specialty nut industry. Further, a manuscript will be published in a peer-reviewed journal. It also will be presented at an international meeting. Therefore, the whole scientific community which works on tree nuts and hazelnuts will be impacted.

Lessons Learned

See data presented in tables 1 through 4.

Contact Person

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Additional Information

A manuscript has been prepared and is ready to submit for publication in the Journal of Food Science.

Other publications related to Nebraska hybrid hazelnuts are:

1. Xu, Y.X., Bianchini, A., and Hanna, M.A. 2010. Identification of mycoflora species and mycotoxin contaminations in Nebraska hybrid hazelnuts. (In preparation).
2. Xu, Y.X., Hanna, M.A. 2010. Hanna, M.A. 2010. Nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal (Ready to submit)
3. Xu, Y.X. Hanna, M.A. 2010. Nutritional quality and oxidative stability of oil extracted from hybrid hazelnuts. International of *Journal of Food Science and Technology* (In press)
4. Xu, Y.X., Hanna, M.A. 2010. Evaluation of Nebraska hybrid hazelnuts: nut and kernel characteristics, proximate, oil and protein compositions. *Industrial Crop sand Product* 31(1): 84-91.
5. Xu, Y.X., Hanna, M.A. 2009. Synthesis and characterization of hazelnut oil-based biodiesel. *Industrial Crops and Products* 29: 473-479.

6. Xu, Y.X., Hanna, M.A., and Josiah, S.J. 2007. Hybrid hazelnut oil characteristics and its potential oleochemcial application. *Industrial Crops and Products* 26: 69-76.

Table 1 Proximate composition of defatted hybrid hazelnut meals (dry basis)

Genotype	Crude oil (%)	Crude Protein (%)	Ash (%)	Total Carbohydrate (%)	Energy value (Cal/g)	NDF (%)	ADF (%)
1-20	3.26 ± 0.15^{c}	41.3 ± 0.55^{h}	8.02 ± 0.51^{ab}	47.5 ± 0.57^{a}	4349 ± 0.1^{c}	24.9 ± 0.89^{cde}	17.3 ± 0.67^{a}
10-50	4.34 ± 0.02^{a}	49.9 ± 0.97^{bc}	7.81 ± 0.44^{ab}	37.9 ± 0.26^{ef}	4468 ± 9.2^{a}	26.1 ± 0.33^{bcd}	17.0 ± 1.17^{a}
10-57	3.64 ± 0.41^{abc}	54.4 ± 0.32^{a}	7.03 ± 0.45^{b}	34.9 ± 0.27^{g}	4390 ± 13.4^{b}	21.9 ± 1.05^{e}	13.5 ± 0.30^{bc}
11-54	4.21 ± 0.05^{ab}	48.1 ± 0.41^{de}	7.57 ± 0.30^{ab}	40.1 ± 0.30^{d}	4341 ± 13.4^{c}	27.8 ± 1.84^{bc}	16.9 ± 0.37^{a}
13-34	3.40 ± 0.32^{bc}	46.7 ± 0.94^{ef}	8.62 ± 0.14^{ab}	42.2 ± 0.01^{c}	4243 ± 12.7^{e}	28.7 ± 1.84^{b}	10.4 ± 0.11^{d}
16-177	4.08 ± 0.31^{abc}	44.6 ± 0.87^{g}	8.46 ± 1.19^{ab}	43.0 ± 0.27^{b}	4367 ± 27.6^{bc}	23.4 ± 1.56^{de}	14.3 ± 0.49^{b}
18-12	3.87 ± 0.35^{abc}	50.6 ± 0.21^{b}	7.11 ± 1.10^{ab}	38.5 ± 0.27^{e}	4474 ± 23.3^{a}	22.0 ± 0.99^{e}	14.1 ± 0.03^{b}
25-60	3.89 ± 0.09^{abc}	45.3 ± 0.54^{gf}	8.64 ± 0.50^{a}	42.2 ± 0.04^{bc}	4372 ± 16.3^{bc}	27.5 ± 1.46^{bc}	17.4 ± 1.14^{a}
28-105	1.93 ± 0.02^{d}	48.7 ± 1.05^{cd}	7.92 ± 0.58^{ab}	41.5 ± 0.24^{cd}	4302 ± 0.7^{d}	23.1 ± 1.39^{de}	12.1 ± 1.22^{c}
29-142	2.55 ± 0.29^{d}	52.9 ± 0.85^{a}	7.50 ± 0.86^{ab}	37.0 ± 0.14^{f}	4390 ± 24.1^{b}	33.9 ± 0.41^{a}	13.5 ± 0.30^{bc}
Mean	3.52±0.02	48.2±0.42	7.86±0.45	40.4±0.03	4369±14.1	25.9±1.18	14.7±0.58
Range	1.93-4.34	41.3-54.4	7.03-8.64	34.9-47.5	4243-4474	21.9-33.9	10.4-17.4

Data are expressed as mean of three replications.

Means followed by the same letter within a column indicate no significant (p>0.05) difference by Ducan's multiple range test

Table 2 Mineral compositions of defatted hybrid hazelnut meals (dry basis)

Genotype	Ca (mg/100g)	Cu (mg/100g)	Fe (mg/100g)	Mg (mg/100g)	Mn (mg/100g)	P (mg/100g)	K (mg/100g)	Se (µg/100g)	Na (mg/100g)	Zn (mg/100g)
1-20	566.7±22.7^{d}	4.0±0.7^{d}	8.3±1.2^{ab}	490.5±47.1^{de}	9.2±0.9^{d}	1031.8±27.0^{g}	1849.7±136.0^{bc}	114.8±32.5^{ab}	223.9±35.6^{b}	0.0±0.0^{c}
10-50	753.1±71.7^{bc}	2.9±0.4^{d}	6.8±0.8^{b}	508.1±71.1^{cde}	3.3±0.1^{g}	1340.0±83.3^{ab}	1924.5±287.0^{bc}	100.2±18.8^{ab}	234.6±43.6^{b}	0.2±0.01^{c}
10-57	868.2±37.1^{ab}	6.0±0.9^{bc}	7.6±0.2^{ab}	466.2±23.6^{e}	5.6±0.1^{f}	1197.5±33.0^{de}	1563.1±162.8^{c}	99.5±52.6^{ab}	213.0±21.8^{b}	0.6±0.2^{c}
11-54	634.1±4.4^{dc}	7.1±1.0^{ab}	7.7±0.9^{ab}	510.9±38.8^{cde}	6.0±0.3^{ef}	1212.0±65.1^{cde}	1844.7±210.4^{bc}	74.4±1.6^{b}	219.4±39.5^{b}	2.2±0.0^{b}
13-34	848.9±35.3^{ab}	3.2±0.3^{d}	7.5±0.9^{ab}	575.4±52.4^{bcd}	10.0±0.2^{d}	1165.4±49.0^{ef}	2189.1±264.5^{ab}	93.9±1.8^{ab}	226.1±39.7^{b}	2.6±0.0^{b}
16-177	878.8±66.6^{ab}	4.4±0.7^{dc}	6.9±0.6^{b}	594.8±36.5^{abc}	6.8±0.1^{e}	1061.8±33.8^{fg}	2192.4±237.3^{ab}	88.7±21.1^{ab}	207.4±24.5^{b}	0.0±0.0^{c}
18-12	629.2±7.8^{dc}	4.5±0.7^{dc}	7.8±0.4^{ab}	483.3±12.1^{de}	12.7±0.7^{c}	1222.9±45.9^{bcde}	1724.0±85.2^{bc}	59.2±19.7^{b}	206.9±17.3^{b}	4.2±0.4^{a}
25-60	973.2±65.8^{a}	8.1±1.3^{a}	7.5±0.7^{ab}	683.2±44.4^{a}	13.7±0.2^{b}	1330.9±51.2^{abc}	2077.4±205.7^{b}	98.4±18.7^{ab}	315.2±33.4^{a}	3.6±0.8^{a}
28-105	553.2±82.6^{d}	4.5±0.4^{dc}	5.0±0.5^{c}	615.5±3.8^{ab}	15.4±0.4^{a}	1450.1±71.2^{a}	2577.6±59.1^{a}	140.1±8.8^{a}	239.9±26.7^{b}	0.0±0.0^{c}
29-142	882.3±79.4^{ab}	2.7±0.1^{d}	9.1±0.2^{a}	459.2±34.1^{e}	15.8±0.5^{a}	1291.6±5.4^{bcd}	1598.7±170.0^{c}	86.3±12.7^{ab}	227.1±17.7^{b}	0.0±0.0^{c}
Mean	758.8±151.8	4.75±1.82	7.43±1.1	538.7±74.5	9.9±4.4	1230.4±128.1	1954.1±311.2	95.5±21.9	231.3±31.4	1.34±1.66
Range	553.2-973.2	2.7-8.1	5.0-9.1	459.2-683.2	3.3-15.8	1031.8-1450.1	1563.1-2577.6	59.2-140.8	206.9-315.2	0.0-4.2

Data are expressed as mean of three replications.

Means followed by the same letter within a column indicate no significant (p>0.05) difference by Ducan's multiple range test

Table 3 Amino acid profile of one representative of hybrid hazelnut (genotype 16-177) defatted meal compared to that from Turkish varieties, defatted soybean meal, and recommended human and animal diets

Amino acid	Nebraska hazelnut defatted meal (g/100g protein)	Turkish defatted meal* (g/100g protein)	Defatted soybean meal# (g/100g protein)	FAO/WHO& (g/100 protein)	Requirement by European sea bass* (g/100g protein)

Alanine	3.10±0.06^{b}	5.51^{a}	5.93^{a}		
Arginine	8.37±0.10^{b}	10.6^{a}	7.08^{c}		4.1
Asparic acid	6.87±0.10^{c}	16.0^{a}	12.6^{b}		
Cystine	1.39±0.01^{a}	1.54^{a}	--		
Glutamic acid	15.6±0.39^{b}	15.9^{b}	22.3^{a}		
Glycine	2.99±0.11^{c}	5.52^{b}	5.77^{a}		
Histidine	1.69±0.01^{c}	2.10^{b}	2.58^{a}	1.9	
Isoleucine^{+}	2.15±0.04^{c}	3.95^{b}	5.26^{a}	2.8	
Leucine^{+}	4.56±0.15^{b}	9.11^{a}	8.93^{a}	6.6	
Lysine^{+}	2.06±0.01^{c}	3.90^{b}	5.77^{a}	5.8	4.8
Methionine^{+}	0.97±0.01^{b}	1.04^{b}	1.55^{a}		
Phenylalanine^{+}	2.92±0.01^{b}	5.99^{a}	5.19^{a}		
Serine	3.17±0.11^{b}	4.21^{a}	1.28^{c}		
Threonine^{+}	1.96±0.11^{b}	3.75^{a}	2.26^{b}		2.6
Tryptophan^{+}	---	---	---	1.1	
Tyrosine	1.90±0.01^{b}	4.13^{a}	1.72^{b}	3.4	
Valine^{+}	2.71±0.08^{c}	5.26^{b}	5.85^{a}	3.5	
Total essential amino acids	17.4	33.0	34.8		
Total amino acids	62.5	98.5	94.1		

$^{+}$ Essential amino acids
---indicated not detected
* Source: Emre et al., (2008)
$^{\#}$Source: Shiau et al., (1990)
$^{\&}$ Source: FAO/WHO/UNU (1985).
Mean ± SD followed by the same letter within a row and same unit indicate no significant (p>0.05) difference by Ducan's multiple range test

Table 4 Anti-nutritional factors of defatted hybrid hazelnut meals (dry basis)

Genotype	Total phenolics (mg TA/g)	Tannins (mg TA/g)	Condensed tannins (% leucocyanidin equivalent)	Phytates (mg/g)
1-20	12.3±1.13^{ab}	8.94±0.87^{a}	1.53±0.12^{a}	24.7±1.20^{cd}
10-50	9.30±0.56^{d}	6.50±0.63^{c}	0.32±0.11^{fg}	25.6±1.06^{c}
10-57	8.71±0.34^{d}	5.56±0.30^{d}	0.25±0.12^{g}	33.0±0.99^{a}
11-54	10.6±0.65^{c}	7.80±0.75^{b}	0.63±0.09^{d}	31.5±1.46^{a}
13-34	11.5±0.09^{bc}	6.78±0.18^{c}	0.26±0.05^{g}	18.5±1.24^{f}
16-177	12.9±0.40^{a}	9.12±0.39^{a}	0.83±0.04^{c}	28.7±0.86^{b}
18-12	9.17±0.33^{d}	6.54±0.30^{c}	0.51±0.02^{de}	21.5±1.38^{e}
25-60	9.51±0.09^{d}	6.83±0.13^{c}	0.41±0.07^{ef}	32.3±1.31^{a}
28-105	10.8±0.40^{c}	7.80±0.67^{b}	0.38±0.12^{efg}	25.2±0.96^{cd}
29-142	12.7±0.41^{a}	9.46±0.46^{a}	1.28±0.04^{b}	23.2±0.76^{de}
Mean	10.7±1.54	7.53±1.31	0.64±0.44	26.4±4.8
range	8.71-12.9	5.56-9.46	0.25-1.53	18.5-33.0

Data are expressed as mean of three replications.
Means followed by the same letter within a column indicate no significant (p>0.05) difference by Ducan's multiple range test

Project Title

Nebraska Grape Grower Education

Project Summary

Many Nebraska grape growers struggle with establishing and maintaining a successful, profitable, and healthy vineyard operation. Education focused on best management practices, grower self-assessments tools, and resource management is lacking. Therefore, the purpose of this project was to conduct an educational program that was based upon the information included within the VINEBALANCE Grower Self-Assessment Workbook. The information described in this workbook was delivered to Nebraska grape growers through educational seminars that provided guidance in evaluating and adopting best management practices that minimized environmental impacts, reduced economic risks, and protected worker health and safety. These practices included:

1. soil management to reduce erosion, runoff, and leaching;
2. use of integrated pest management practices for insect, disease, and weed management;
3. nutrient management, with a particular focus on nitrogen use;
4. pesticide management and spray technology; and
5. cultural practices used in viticulture.

The project, which consisted of classroom educational seminars and field tours, educated growers about sustainable options for accomplishing these tasks. By comparing current production practices with examples provided during the seminars, growers were able to both assess and discover ways to improve their sustainability.

Project Approach and Goals and Outcomes Achieved

A series of classroom educational seminars and field tours have been held to educate growers about sustainable options following the VineBalance Grower Self-Assessment Workbook. These activities have included::

Educational Seminar #1: **Pruning Seminar**
March 26 –held in Lincoln, NE – This is the first step in cultural practices used in viticulture and extremely important for canopy management.

Educational Seminar #2: **Worker Safety and Protection in the Vineyard; Identification of Diseases, Pests, and Weeds and use of Integrated Management Practices for their Control.**

April 30 (Lincoln) and June 4 (Cambridge, NE)

The following was used to describe this educational seminar:
Increase your awareness of what is being applied to your vineyard. Learn about the pesticide products used in your vineyards. Herbicides, insecticides and fungicides will be covered. Each state of vine development and the products used during those periods will be explained. The products' mode of action will be explained and how that mode of action affects the disease, insect or weed and potentially YOU as the applicator. Workers Safety Protection will also be covered. Sections 5, 6, and 7 of the VineBalance workbook will be gone through to evaluate where you are in the

VineBalance Assessment.
This topic should be extremely important to anyone who handles sprays in the vineyard. We have all attended seminars/field days that talk about diseases, insects, and weed control and we know what products to use to help control these problems. We can all read the warning labels but this seminar will take it one step further to explain what we may not easily find on label warnings. Vaughn Hammond's, UNL Extension Educator, Masters thesis researched similar information and he was asked to tailor a presentation that focuses on the vineyard and the most common products that are used. The information to be presented also covers the most common insects, diseases and weeds. This seminar will actually provide the #1 topic of concern to growers (insects, diseases, weeds) and your protection.

Educational Seminar #3: **Canopy Management Workshop**
May 20 (North Platte) and May 21 (Lincoln) – presented by Dr. Tim Martinson, Cornell University, lead author of the VineBalance Grower Self-Assessment Workbook.

Dr. Martinson sent the following description of his talks:
Canopy Management involves manipulation of vine growth to achieve production goals – whether they be optimizing light interception, managing or minimizing disease pressure, or maximizing fruit quality. Canopy management practices are one piece of a vineyard management program that starts with vineyard layout and vine spacing, choice of training system, pruning levels, and continues through to harvest decisions. They also have a huge impact on labor costs and profitability. In this workshop, I'll provide practical guideposts on what these practices are, what problems they are meant to address, when and how they are used, and their benefits and costs. I'll draw on my experience with over 30 native Labrusca, hybrid, and vinifera cultivars over the past 13 years in the Finger Lakes region of New York to cover:
· Vine balance, light interception, and canopy density
· Measures of vine balance: Crop load – leaf area to fruit ratio, shoot density
· Canopy density and fruit quality
· Managing vine balance, cropping levels, and light interception
- Shoot thinning

- Shoot tipping
- Shoot positioning
- Leaf removal
- Cluster thinning
· Applicability of these practices to different growth habits and training systems
· Balancing the costs and benefits
- time studies on shoot and cluster thinning
- cost per ton produced and per bottle of wine produced
- value: 'willingness to pay'

In the vineyard, we'll provide hands-on exercises in:

· Evaluating early-season canopies.
- Shoot counts and canopy density
- Techniques for cost-effective shoot thinning
- Shoot vigor
· Applying canopy management to different training systems
- VSP, High Cordon, and GDC
- Labor requirements, timing, evaluating results
· Crop estimation
- Yield components
- Cluster counts at 'first cut'
- Mid-season and harvest cluster weights

Participants gained a better understanding of how to evaluate their vineyard situation, select or modify appropriate training systems, and apply canopy management practices to achieve production and quality goals.

Beneficiaries

More than 100 growers attended the three educational seminars that were held in Lincoln and other locations in Nebraska. Some growers attended all three seminars. One of the major accomplishments is that these topics are what the growers have asked to be covered; the Worker Safety and Protection seminar was specifically developed for growers; and Dr. Martinson delivered a wealth of information that growers have been asking for. It should also be noted that growers want hands-on activities in the vineyards and this was done during the pruning seminar and the canopy management workshops. Dr. Martinson divided the participants into small groups and they actually counted shoots and grape clusters on a block of vines and then estimated the grape production. This was extremely beneficial to everyone in attendance.

Comparison of actual accomplishments with goals established for reporting period:

The only goal that has not been reached is nutrient management. This will be the topic of our final seminar. Dr. Read will cover petiole analysis in July for one of his field days and we are hoping to cover leaf analysis and micro-nutrients as our final education seminar. We are currently working on setting this up.

Contributions and role of project partners in the project:

The Growers Council Co-Chairs of the NWGGA conducted the initial surveys of what growers would like covered in the educational seminars; they made all arrangements for the seminars/field days; and they contacted all speakers to tailor their presentations to the topics that growers identified. They also kept track of the expenses incurred and submitted the bills for payment to the NWGGA Treasurer. The UNL Viticulture Program helped with the advertising of the activities and helped announce these activities at their March conference. Dr. Paul Read attended two of the three educational seminars and helped coordinate the visit of Dr. Tim Martinson.

Outcome #1: Provide Nebraska grape growers with education and hands-on field experiences to create and maintain healthy, productive, and sustainable vineyards.

We have achieved this outcome with the three seminars that we have held.

Outcome #2: Provide information to protect worker health and safety in the vineyard.

We have achieved this outcome with our April 30 and June 4 education seminars. This seminar was developed by Vaughn Hammond specifically for the grape growers of Nebraska.

Outcome #3: Increase the number of growers who are successfully utilizing the practices addressed in the VINEBALANCE Grower Self-Assessment Workbook.

Currently, about 25 percent or 20 NWGGA members are making use of the workbook's best management practices. Once the seminars are complete, it is projected that this number will increase to 75 percent or 120 NWGGA members.

Surveys were sent to all of our Nebraska Grape Growers to find out how many are following the VineBalance Grower Self-Assessment Workbook and ask if they feel it is helping establish and maintain healthy, profitable, and sustaining vineyards.

Lessons Learned

Our biggest challenge was in scheduling the seminars/field days – our speakers have very busy schedules and we also had to keep in mind where we were in the growing season. Pruning has to occur before bud break; canopy management including crop estimation must occur before the shoots are too big. This all becomes more complicated when you have to compete with other activities going on in the state, like the Kearney Wine and Jazz Festival which was taking place on May 20-22. But, Dr.

Martinson could only come to Nebraska that weekend. We had to move forward with our plans if we were to meet growers' needs, vineyard timing, and speaker availability. It was extremely important for us to bring in Dr. Martinson to bring to life the VineBalance concepts that we are trying to promote within the NWGGA.

Review Measurable Outcomes: It is extremely important that growers have a plan to help them maintain healthy, profitable, and sustaining vineyards. We have presented this to the NWGGA Board and mentioned that it may take the involvement of wineries to help instill the message to growers to follow VineBalance concepts in their vineyard. In the long run it is a win-win for both growers and wineries.

The final educational seminar focused on nutrient management. The UNL Viticulture Program held petiole analysis field days in July. The intent was to bring in a different approach to nutrient management that has not been done before – leaf analysis and micronutrient management. The best time to do this was while there were still leaves on the vines and before harvest. It was a challenge to find the availability of a speaker with this knowledge to come to Nebraska while the information can still be applied to the vineyard.

Contact Person

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Additional Information

None.

Project Title

Good Agricultural Practices Training for Specialty Crop Growers

Project Summary

After the recent E. coli outbreaks in spinach and other food-borne illness outbreaks in fresh produce, a thorough understanding of proper produce and crop handling is essential to the success of Nebraska's developing specialty crop industry. Mandates involving Good Agricultural Practices (GAPs) are likely on the way from the USDA and/or FDA to individual farming operations. Growers are becoming increasingly concerned with how this will affect their day-to-day operations. Farmers need guidance concerning the future of GAPs requirements and the implications this will have on individual operations. This project gave Nebraska specialty crops growers a perspective on GAPs from a region that is highly focused on specialty crops, an understanding of the mandates that may be coming, and provide a resource for developing farm-specific GAPs.

Part 1 provided *An Introduction to GAPs Seminar* that will brought in two speakers (Dr. Chris Gunter and Diane Ducharme) from North Carolina State University to discuss GAPs for specialty crop growers in Nebraska. Both speakers are currently working in NC with growers of all scales – from small road-side stands to major grower/shippers with hundreds of acres of specialty crops. The speakers are prepared to direct the training session towards "small" growers while remaining applicable to all growers.

Parts 2 and 3 involved developing a resource for growers to use when developing a farm-specific GAPs program. This involved collaboration between the Nebraska Fruit and Vegetable Growers Association, Nebraska Rural Initiative, and University of Nebraska - Extension. Attention was given to developing a document that can train growers for GAPs certification and an audit.

Part 3 Developing Farm-Specific GAPs programs was intended to provide a second, more in depth, GAPs training session for growers. This include a one session program that utilized speakers/instructors who were familiar with writing a GAPs farm food safety plan. A classroom was set-up so that growers were able develop a GAPs program specific to the activities and/or planned activities of the farm.

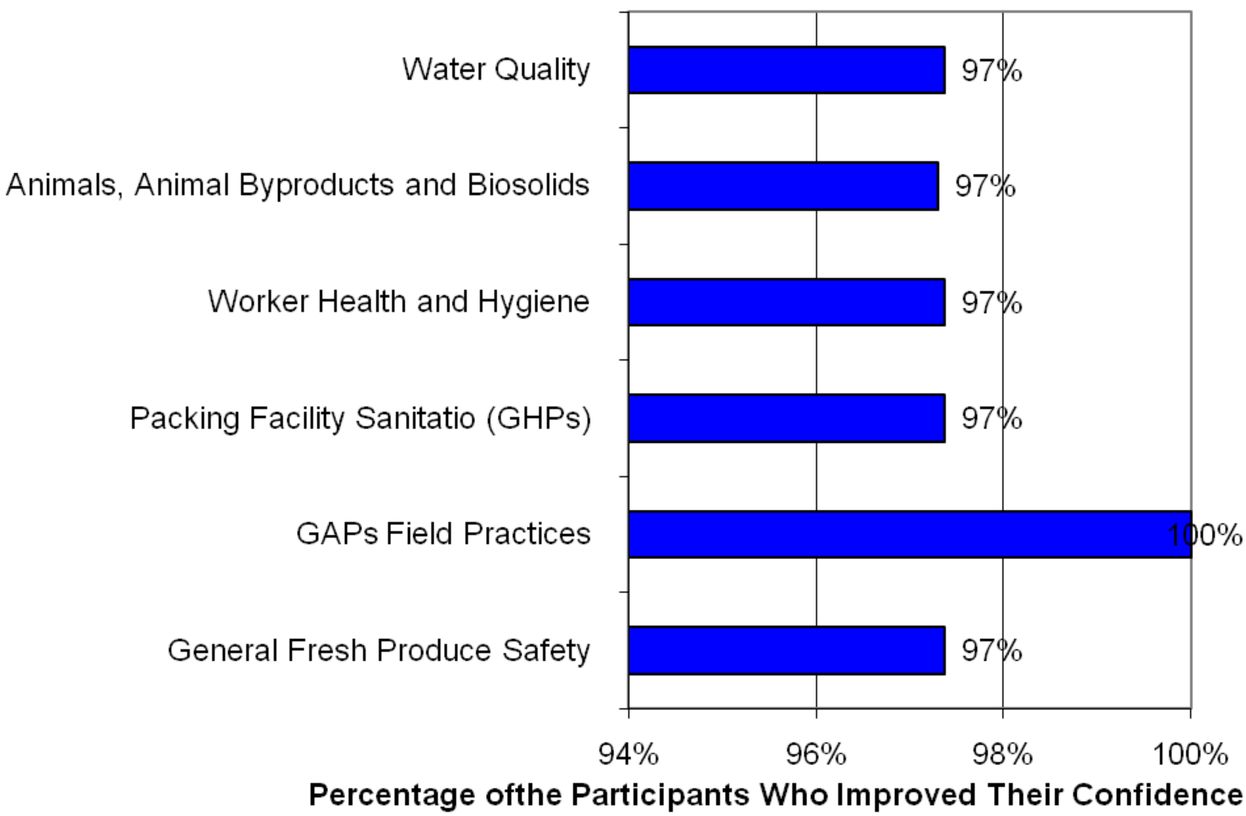
Project Approach and Goals and Outcomes Achieved

Part 1: An Introduction to GAPs Seminar

An *Introduction to GAPs Seminar* was held on the University of Nebraska-Lincoln East Campus on November 6, 2010. The seminar was hosted by the Nebraska Fruit and Vegetable Growers Association (NFVGA). Two speakers, Dr. Chris Gunter, and Diane Ducharme, from North Carolina State University presented information on the topic of Good Agriculture Practices (GAPs) for specialty crop growers in Nebraska.

The overall goal of this project was to prepare specialty crop growers of Nebraska for the future as it relates to GAPs. As such, the *Introduction to GAPs Seminar* was intended to reach a minimum of 40 attendees. Sixty producers, Extension Educators, Nebraska Department of Agriculture (NDA) personnel, and Nebraska Rural Initiative personnel attended this seminar. Additionally, the goal of this project is to increase knowledge and confidence of GAPs practices. Of those attending, 37 responded to an evaluation of the seminar. Eighty-Seven percent of those responding reported an improvement of their knowledge about GAPs as measured by a pre-test and post-test surveys. Ninety-seven percent reported improved confidence in the areas of Animals, Animal Byproducts and Biosolids, Worker Health and Hygiene, Packing Facility Sanitation, GAPs field practices, and general fresh produce safety.

Building Participants' Training Confidence



The NFVGA partnered with the NDA and Nebraska Rural Initiative to accomplish the goals set forth in Part 1 of the grant by setting up the *Introduction to GAPs Seminar.* The NDA contributed significant time for the planning of the seminar and in contacting individuals and farms that had shown interest in the subject in the past. The NDA further did the design for post cards advertising the seminar and mailing the post cards to potential participants. The Rural Initiative donated time to planning the seminar and tabulating evaluations following the seminar. The Rural Initiative also donated printing services such that each of the seminar participants received a set of GAPs handouts in their bag. The NFVGA contributed significant amounts of time to planning the seminar, reserving the room, and hosting the speakers. Electronics for the event, including a laptop, projector, and data storage were provided by the NFVGA. Directional signage for the event was donated by the NFVGA. Reimbursements to the speakers for rental cars, hotel rooms and meals were further made by the NFVGA. Finally, the NFVGA acted to setup the room for the event, speak at the event, direct persons, and moderate the speakers.

Part 2: Guidance Document Development

Collaboration between the NFVGA, Nebraska Rural Initiative, and the University of Nebraska –Lincoln Extension has occurred to develop GAPs guidance documents. An emphasis was placed on building upon guidance documents which have already been developed and creating new information. UNL-Extension lead the development of a website, online modules, and documents which will assist growers in the process of creating documentation for GAPs audits. The website will provide a central location for growers to access guidance documents. The online modules will provide a variety of information on GAPs, including basic information about what it is and why it should be done, how to create a farm food safety plan, how to adopt/modify documentation that can be used in a GAPs audit, and resources for additional guidance. The website address is http://food.unl.edu/web/localfoods/gaps and http://gaps.unl.edu will redirect you to the same website. All guidance documents will become live by December 31, 2011.

Part 3: Developing Farm-Specific GAPs Programs

Two Farm-Specifc GAPs programs were planned and scheduled for December 13 and December 15 in Grand Island and Lincoln, Nebraska, respectively. These programs were developed in collaboration with UNL-Extension and Rural Initiative. Three Extension Educators that are part of the UNL GAPs Team were scheduled to instruct the programs at each location.

Four growers registered in Grand Island, however, due to inclimate weather conditions, the program was cancelled. In light of this, the UNL Extension Educator in Grand Island has offered to work with these growers on an individual basis in 2012. Eight people participated in the half day Farm-Specific GAPs program in Lincoln. Three UNL GAPs Team Extension Educators worked with each of the participants on a case-by-case basis to develop farm specific information. As a result of this workshop, four farm-specific plans were developed.

One grower was quoted as saying, “I would never have sat down to write this if you didn’t have this work session [Farm-Specific GAPs program].” All of the growers present at this program were in agreement with the comment.

<u>Beneficiaries</u>

Attendees generally found the *Introduction to GAPs Seminar* beneficial. One grower commented that there was “great discussion and interaction with producers and speakers." The most common comments suggested providing more training and hands on development of farm safety plans and audits.

Development of a website, online modules, and documents will assist growers in the process of creating documentation for GAPs audits. The website will provide a central location for growers to access guidance documents. The online modules will provide a variety of information on GAPs, including basic information about what it is and why it should be done, how to create a farm food safety plan, how to adopt/modify documentation that can be used in a GAPs audit, and resources for additional guidance.

Eight people participated in the half day Farm-Specific GAPs program in Lincoln. Three UNL GAPs Team Extension Educators worked with each of the participants on a case-by-case basis to develop farm specific information. As a result of this workshop, four farm-specific plans were developed.

Lessons Learned

It was anticipated that Part 2 of the grant activities, which included development of a Guidance Document, would be completed in April 2011. However, as a result of collaboration with UNL Extension and the Nebraska Rural Initiative during Part 1 activities, it was decided that guidance document development would be most beneficial if collaboration with the same partners occurred. Due to scheduling issues with three partners and several individuals, this development is in process and will be completed by December 31, 2011. See *Part 2:Guidance Document Development* in the *Activities Performed* section for more information.

Due to inclimate weather, one Farm-Specific GAPs Program to be held in Grand Island, Nebraska was cancelled. The UNL Extension Educator in charge of the program at this location has offered to work with growers signed up for the program on an individual basis in 2012.

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Additional Information

None.

Project Title

Trial Community Garden to Farmers Market through Buy Fresh Buy Local (Final Report)

Project Summary

The specific issue addressed with this proposal was to develop and deliver training to Hispanic residents in Northeast NE on how to successfully produce and sell at farmers' markets. The focus area (Madison County, Nebraska) has experienced a 435% net change in their Hispanic population from 1990 – 2000. While the population has soared, there are few involved in selling at farmers' markets. Since many of these individuals have a farming or agriculture background the development of training could have a great impact on the number of Hispanics growing and selling products for local farmers' markets.

Project Approach

Two community information meetings were held in South Sioux City, NE where an average of 12 people attended. Those in attendance included community leadership and two leaders from the Hispanic/Latino community. These meeting covered a variety of topics including what are community gardens, what future trainings would cover, opportunities to sell at markets, and how to get involved.

A steering committee was organized consisting of about half Hispanic/Latino and half non-Hispanic residents in the South Sioux City area. This committee works with the Center for Rural Affairs to establish a community garden and provide training for those interested in gardening in the community plots. The committee met regularly, typically once a month to review their progress and set new goals for future projects.

A total of six trainings were held covering topics such as sustainable agricultural practices and what to grow in the garden with guest speakers from Extension, the Leopold Center and more presenting. Hands-on training in the garden has begun. An average of 8-13 people attended these trainings, and participants were half Hispanic/Latino and half non-Hispanic. Nine Hispanic/Latino gardeners/beginning farmers were involved in the project as gardeners half through this project. At the end there were seventeen involved.

A Guidebook for selling at Farmers' Markets was developed and translated into Spanish. This guidebook was well received by the Hispanic/Latino community and continues to be used in trainings that have occurred after this project was completed. The guidebook was very helpful during the trainings, as it allowed Spanish-speaking participants to follow along more easily and helped them to ask more specific questions regarding the materials and selling at market.

The Center for Rural Affairs assisted with coordinating trainings and meetings. NCDC/BFBL created and had the guidebook translated into Spanish.

Goals and Outcomes Achieved

The expected measurable outcomes were as follows:

1) At least 10 people will be trained to the point that they can successfully staff a booth containing their specialty crops at the Norfolk Farmer's Market. Of those who receive training we will track how many start marketing at local farmers' markets.

- There were a few who were ready to start at market, but unfortunately the market is full. Additional funding is being sought in order to start another market in the area, since the only one available is in Sioux City, IA and it's not accepting new vendors.

2) A pre and post training survey will be given to participants to gauge the effectiveness of training.

- Unfortunately the surveys were not conducted.

- There was a miscommunication and lack of translation. The original plan was to have a translator available for the surveys, but this fell through at the last minute and the surveys could not be conducted.

- Without the surveys, it was difficult to directly measure the effectiveness of the training. However, at the end of the second year (2011), two growers made expansion plans for preparation to sell at farmers markets. Therefore, it is believed that the training, which focused on this very topic, was successful. As a result of this evidence, it was decided that surveys not be sent to the training participants.

3) Documents and educational materials will be translated into Spanish so that this project can more easily be replicated in other areas of Nebraska. Areas targeted for future work include large Hispanic populations in and around Schuyler, Columbus, Dakota City, and West Point. We will be sure all materials are translated into Spanish with funding from this grant.

- There are future plans to replicate this project in other areas of the state, but at this time funding is limiting the expansion. It will be essential to have a translator lined up for all sessions and that the steering committee is fully engaged, because they are the best option for ensuring the work is sustainable.

The goal of this project was to provide training and technical assistance to the Hispanic community gardeners. The gardeners received training and assistance on how to grow specialty crops, and in early June 2010 they received training on how to sell at farmers markets in their community. Since then one family has expressed interest in larger scale farming but they are not quite ready to take the next step beyond gardening. They plan to garden for at least one more year and expand the number of plots they are growing crops in. All gardeners we told about opportunities to become famers, but no others have stepped forward to grow in this capacity.

Both grocery stores and one restaurant owner in the community expressed an interest in buying local foods from gardens, but the gardeners did not feel they were ready to commit to these businesses at the end of this project. This will most likely occur during the second growing season once the gardeners have more experience.

We began the project with some interest expressed from listening sessions held a year and a half back on possibilities for beginning farmers. To date we have gone from no one participating to 17 gardeners and key leadership involved and supportive of the project. Two garden sites have been donated by the city and we have accomplished successful outreach through use of Spanish-language media and more. The guidebook was developed and translated into Spanish. 18 gardeners and other Spanish speaking resident interested in selling their produce at area farmers markets attended the June training.

Beneficiaries

The beneficiaries of this project are the Spanish-speaking gardeners and others interested in selling at farmers' markets. We began the project with some interest expressed from listening sessions held a year and a half back on possibilities for beginning farmers. To date we have gone from no one participating to 9 gardeners and key leadership involved and supportive of the project. Two garden sites were donated by the city and we have accomplished successful outreach through use of Spanish-language media and more. These gardeners continue to receive on-going training through community meetings and workshops. As a result of this training two key leaders have stepped up and grown in their skills as leaders for the community.

Lessons Learned

1) Always have translators: One of the most important lessons learned in this project was how important translation and translators are. They're essential in identifying key people/leaders within the community and developing relationships with them in order to gain trust in working within the community. They were also key in helping workshop participants identify marketing skills and materials that would benefit them in selling their products and telling their story. As mentioned above in measurable outcomes, our surveys were not conducted due to a miscommunication that left us without the ability to deliver them. Communication comes to a halt without translation although it was possible to "communicate" when working side-by-side in the gardens. This transcended any language barrier both for the English-speaking gardeners and for the Spanish-speaking gardeners. People figured out a way to communicate because it was a collective effort.

2) It takes time: We expected to see economic impact much sooner, for instance, employment opportunities and money circulating in the community. It takes more than one growing season for people to feel confident enough in what they're doing to start selling to the community, especially when you're working with another culture and language. None of the gardeners felt comfortable selling what they grew during this project, but they were proud to donate the fruits of their labor to local churches and food banks. As the gardeners become more experienced we would expect them to begin selling to the community.

3) Community is important: This community is incredibly welcoming and happy to be a part of the project. That seems to be true across the board. The Center for Rural Affairs has been approached by two other Latino communities about the possibility of this kind of a project because of the success they've had with this project. The part of the project that was funded by this specialty crops grant ended but it's a two-year project funded by another source that will be completed this fall. The first year ended with abundant harvests and people growing more food than they could eat with every gardener who was signed up for year one coming back in year two with enough new additional gardeners to fill two full garden spots in South Sioux City.

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Additional Information

Copies of English and Spanish Guidebooks sent to NDA for reference.