Nebraska Department of Agriculture Specialty Crop Block Grant Program Final Performance Reports (FY 2010 – Farm Bill)

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Project Title

Feasibility of Split Beans (Great Northern and Pinto) to Protect against Cellular Oxidation

Project Summary

Dry edible beans are an important Nebraska specialty crop with our state being the No. 1 and No. 2 US supplier of the great northern beans (GNB) and pinto beans (PB), respectively. Studies have further shown that dry edible beans contain natural antioxidative agents greater than or comparable to many types of fruits, vegetables, and cereals. These natural antioxidative agents (e.g., polyphenols, phenolics acids) have in turn been linked to multiple health benefits, including cardiovascular health and cancer prevention. Split dry edible beans may also be a valuable source of natural antioxidants as many of these compounds have already been quantified in our laboratories resulting in antioxidant capacities comparable to the whole beans. However, the latter analyses were completed based solely upon the ability of the beans to scavenge a single type of free radical. Therefore, a significant gap in knowledge exists on the ability of damaged beans to protect a biological system against oxidative stress. *The objective of this project was to determine the antioxidative properties of split beans (both GNB and PB) compared to their whole bean counterparts using a model cellular system (e.g., human hepatic cancer lines) and a novel biochemical approach (Fourier mid-infrared spectroscopy).* The hypothesis was that split beans will protect against oxidative stress at the cellular level comparable to their whole bean counterpart. The objective of this project was completed by performing the specific aims shown below.

- **Specific Aim 1***: To characterize the phenolic content of the damaged and whole GNB / PB that will be used for Specific Aim 2-3.*

- **Specific Aim 2:** *To determine suitable levels of H2O2 and beans (split and whole GNB / PB) needed respectively to affect and/or protect cells against oxidation but that did not cause catastrophic toxicity.*

- **Specific Aim 3:** *To determine the oxidative protective properties of the phenolic-rich PT and GNB bean extracts (split and whole) using FTIR spectroscopy.*

As an outcome, information was generated that directly linked split dry edible beans to a biologically significant health benefit thereby potentially adding value to crop, as splits are typically disposed. This research thus supports Nebraska Specialty Crops program by promoting the consumption of and adding value to dry edible beans.

Importance and Timeliness

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, i.e., particularly GNB. As a result, the number of acres dedicated to dry edible bean has been declining in most US states. Nebraska regions most affected by this decline include several counties located throughout our state, but particularly those in the Panhandle area. This geographic region has a clear need for higher paying jobs as 100% of these Nebraska counties have a median household income 22% below the state average. Additionally, population growth in these regions has been flat between 2000 and 2006 with the participating counties experiencing a 6% population decline in Nebraska. 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. Adding value to dry edible beans both by recapturing the value lost in the damaged dry edible beans and by promoting beans as a healthy dietary food system will help to stabilize the dry edible bean industry in our state. This project is therefore *important and timely* as the first to determine the antioxidative properties in damaged GNB in an in vitro model system thereby directly linking split beans to a health benefit compared to their whole bean counterpart.

Previously Funded SCBGP Projects

This project builds on the research study that was funded through the Nebraska Department of Agriculture via a Specialty Block Grant in 2008. The latter studies focused on characterizing potential health-promoting components in damaged GNB and PB. This information provided the foundation to proceed with the project described herein.

Project Approach

(C.1.1.) *Qualitative and Quantitative*: The objective of this proposal was accomplished by completing the following specific aims. Qualitative and quantitative measurements are provided concurrently with each Specific Aim.

***Specific Aim 1*: To characterize the phenolics content of the damaged and whole GNB / PB that will be used for Specific Aim 2-3.** This specific aim was completed by determining the compositional profiles of the GNB (Gemini line) and PB (LaPaz) in terms of their phenolic / flavonoid content and a bench top antioxidative method (oxygen radical absorbance capacity (ORAC)), i.e., a method that is routinely used to determine the oxidative protective capabilities of natural systems (Table 1 and 2). Similar to previous studies, the data show no significant differences between total phenols, flavonoids, and antioxidative capacity for either the split GNB or PB compared to the whole beans in terms of total amounts of phenols/flavonoids or anti-oxidative capacities (AOX), albeit the PB had higher values for all the parameters tested compared to the GNB. It must

be noted that extracts that targeted only the free fraction were prepared for Specific Aim 2 and 3 considering the low amounts present in the bound fraction.

	GNB (Whole)	GNB (Split)
Free Phenols	2.34 +/- 0.29	2.27 +/- 0.08
Bound Phenols	0.07 +/- 0.01	0.08 +/- 0.01
Total Phenols	**2.41 +/- 0.30** mg/g	**2.35 +/- 0.09** mg/g
Free Flavonoids	0.37 +/- 0.02	0.36 +/- 0.02
Bound Flavonoids	0.009 +/- 0.007	0.006 +/- 0.002
Total Flavonoids	**0.38 +/- 0.03** mg/g	**0.42 +/- 0.02** mg/g
Free AOX*	1581 +/- 348	1621 +/- 331
Bound AOX	235 +/- 27	151 +/- 62
Total AOX	**1816 +/- 409**	**1772 +/- 393**
	□mole Trolox /100 g	□mole Trolox /100 g

Table 2: Pinto Beans (LaPaz) -- Total Phenolics, Flavonoids, Antioxidant Capacity (Free and Bound). * AOX—Antoxidative Capacity.

	PB (Whole)	PB (Split)
Free Phenols	4.03 +/- 0.17	3.68 +/- 3.60
Bound Phenols	0.34 +/- 0.16	0.33 +/- 0.11
Total Phenols	**4.34 +/- 0.23** mg/g	**4.01 +/- 3.71** mg/g
Free Flavonoids	1.19 +/- 0.03	1.01 +/- 0.03
Bound Flavonoids	0.09 +/- 0.04	0.09 +/- 0.01
Total Flavonoids	**1.28 +/- 0.07** mg/g	**1.10 +/- 0.04** mg/g
Free AOX*	7971 +/- 519	8048 +/- 858
Bound AOX	373 +/- 119	441 +/- 13
Total AOX	**8329+/- 745**	**9233 +/- 871**
	□mole Trolox /100 g	□mole Trolox /100 g

Specific Aim 2: **To determine suitable levels of H2O2 and beans (split and whole GNB / PB) needed to respectively either affect or protect cells against oxidation but that did not cause catastrophic toxicity.** This specific aim was completed by first determining an appropriate oxidizing dosage (H202) that did not promote significant cytotoxicity (catastrophic cell death) but did affect the biochemical phenotype of the cell (via Fourier transform mid-infrared spectroscopy). Different concentrations of H202 was applied to a human colon cancer cells lines ($HepG_2$) and monitored for cell viability and cell necrosis. Comparison of these results (Table 3) indicates that 0.5-1 mM H202 concentration did not seriously affect viability or cause significant cell necrosis.4

Fourier transform spectroscopy (FTIR) was then used to analyze the cells treated with oxidizing levels as cited in Table 3. As shown in Figure 1, the samples cannot be differentiated using the zero order FTIR spectra at any of the windows of biological relevance (W1-W5). As this is usually the case, the spectra are typically deconvaluted by subtraction of the control, or converting each to the first or second derivative. For example, upon subtraction of the control spectrum (-H_2O_2) from each spectrum of the treated cells, major spectral shifts are apparent in all the windows of interest, especially for the 1 mM-10 mM of H_2O_2 treatments (Figure 2). Moreover, hierarchical cluster analysis (a multivariate test) of the zero order data showed clustering of the 1 mM–0 mM samples separating into a distinct branch, and the 0.05 mM treated cells clustering into another branch (Figure 3). These results confirm that H202 did produce FTIR spectral shifts in a dose dependant manner. Moreover, these data support the cell viability / necrotic data indicating that 1 mM concentrations of H_20_2 should be used for subsequent experiments (Specific Aim 3), as the corresponding spectrum clustered away from the control but was also separated from the treatments that did affect cell viability (0.5-10.0 mM) (Table 3).

Table 3: Variable and Necrotic Cells in response to H_2O_2 concentration treated for 4 hrs.

H_2O_2 Concentration (mM)	Total Cells	% Necrotic
0.5	90 +/- 10	1.89 +/- 0.20
1.0	92 +/- 12	7.02 +/- 4.79
5.0	48 +/- 9	2.79 +/- 4.61
10.0	44 +/- 3	5.03 +/- 8.31

- MTT assay. ** Trypan blue assay.
- Results are shown as the mean =/- std dev or n=3 biological replicates.

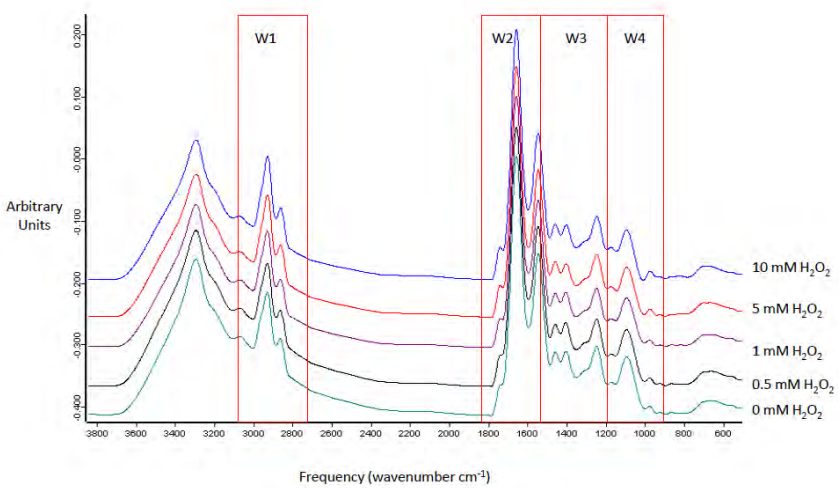

Figure 1: FTIR zero order pre-preprocessed data (baseline corrected, smoothed normalized to the amide 1 peak (1650 cm^{-1}) exhibited by $HepG_2$ cells treated with 0, 0.5, 1, 5, 10 mM hydrogen peroxide. W1-- Lipid region (3100-2750 cm^{-1}); W2 – protein region (1750-1500 cm^{-1}); W3 – protein / lipid / phospho-containing region

(1500-1200 cm^{-1}) W4 – carbohydrate and phospho-containing region (1200-900 cm^{-1}).

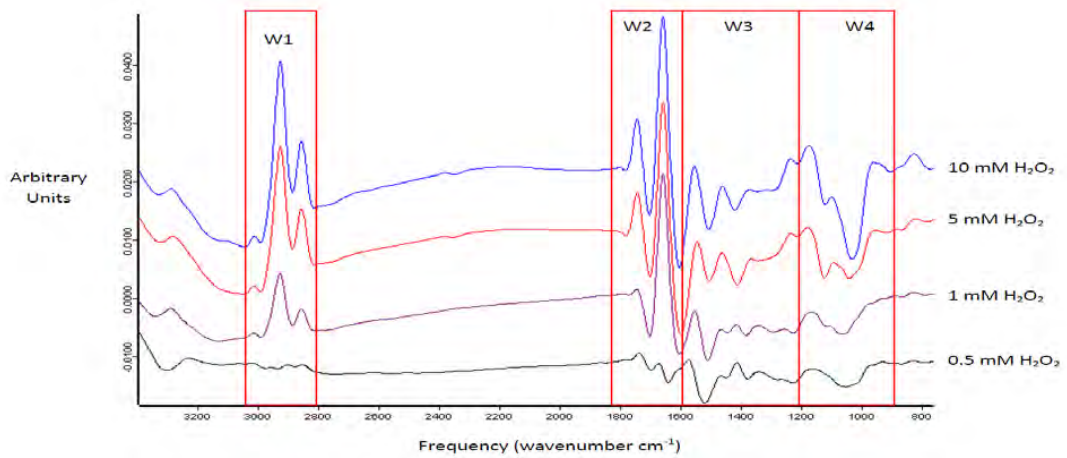

Figure 3: Subtraction spectra (H2O2 treated spectrum – control) of FTIR zero order pre-preprocessed data normalized to the amide 1 peak (1650 cm-1) exhibited by $HepG_2$ cells treated with 0, 0.5, 1, 5, 10 mM hydrogen peroxide. W1-- lipid region (3100-2750 cm^{-1}); W2 – protein region (1750-1500 cm-1); W3 – protein / lipid / phospho-containing region (1500-1200 cm^{-1}) W4 – carbohydrate and phospho-containing region (1200-900 cm^{-1}). 2. W1-- Lipid region (CH2, CH3) 3100-2750 cm^{-1}; W2 – Protein region (amide 1 and 2) 1750-1500 cm^{-1}; W3 – protein / lipid / phospho-containing region, 1500-1200 cm^{-1}; W4 – carbohydrate and phospho-containing region, 1200-900 cm^{-1}.

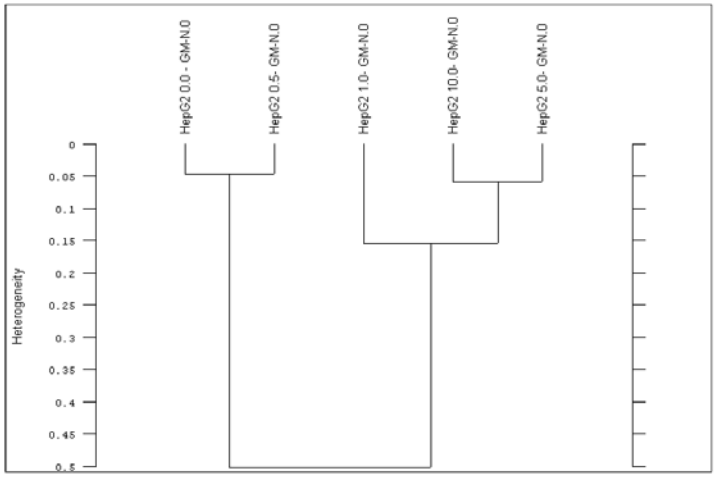

Figure 4: Dendrogram of zero order spectra obtained from H_2O_2 treated $HepG_2$ cells (0, 0.5, 1, 5, 10 mM). The dendrogram was prepared by applying Ward's algorithm to spectral regions of 3200-2800 cm^{-1} and 1750-900 cm^{-1} to the mean of 9 spectra (3 biological replicates analyzed three times.)

The second stage of Specific Aim 2 was to determine levels of phenolic rich bean extracts that were not cytotoxic to the cells. Therefore, the same tests as cited for H2O2 tests were applied to the $HepG_2$ system treated with different dosages of PB and GNB (whole and split) (Tables 4 and 5). Based upon these results, treatments of 100 µg/ml and 250 µg/ml were selected for Specific Aim 3 as both show non-toxic effects for both market classes of beans (split and whole).

Similar to the H_20_2 experiments, the bean treated cells were analyzed by FTIR and the data were interpreted via hierarchical cluster analysis (Ward's algorithm). As shown in Figure 5a (whole) and Figure 5b (split), the GNB whole cells clustered in a dose dependant manner with lower treatments forming separate clusters relative to the higher treatments. However, the split beans generated a cluster where the control separated from all the treatment groups. These results indicate that beans affect the biochemical fingerprint of the cells not only with respect to amounts but also relative to whole vs split beans. The biochemical fingerprints of the PB treated cells were less affected by the whole (Figure 6a) and split beans (Figure 6b), but were again affected in a dose dependant manner. Comparison of the GNB and PB clusters shows significant differences between biochemical fingerprints as affected by bean market classes suggesting that the type of beans target different cellular pathways. Nonetheless, based on these data, bean concentrations of 100 µg/ml and 250 µg/ml were used for subsequent experiments (Specific Aim 3) as spectra of $HepG_2$ cells treated with both levels typically clustered with the control, and also show the least impact on cell viability / necrosis (Tables 4 and 5).

Specific Aim 3: **To determine the oxidative protective properties of the phenolic-rich PT and GNB bean extracts (split and whole) using FTIR spectroscopy.** Specific Aim 3 was satisfied by treating the $HepG_2$ cells for 24 hours with either split and whole GNB or PB extract (100 µg/ml and 250 µg/ml) followed by 4 hours of the oxidizer (1.0 mM). As shown in Figure 7, the spectra of cells treated with only split and whole clustered together, which formed a separate clade with the control (or blank; -bean extract, - H_20_2). However, the cells treated with only the H_20_2 separated from the former cluster for both the whole and split beans, but grouped with the +GNB+ H_20_2 cells for only the whole cells (Figure 7a). Alternatively, the H_20_2 treated cells separated into a single branch for the split beans (Figure 7b). Again, these results indicate that the whole and split GNB beans act differently on the $HepG_2$ cells. As there was a clear separation of the H_20_2 cells from the other branches, the split beans may actually be protecting the cells better than the whole cells. Comparable dendrograms were again obtained for the whole and split PB treated cells (Figure 8). Despite the similarity, the +PB+H_20_2cells either clustered with the H_20_2 only cells (+100 µg/ml) former and distinct branch (250 µg/ml) cells. These results indicate that PB provided little protection in the presence of the oxidizer compared to the GNB beans.

Table 4: Viable and necrotic cells in response to whole and split Gemini great northern beans (GNB) concentrations treated for 24 hours.

Whole GNB (µg/ml)	**Viable Cells (%)***	**Necrotic Cells (%)****
Control	100 +/- 0	10.0 +/- 3.0
100	104 +/- 4	16.7 +/- 8.9
250	99 +/- 9	25.5 +/- 1.6
500	96 +/- 4	40.2 +/- 14.9
1000	64 +/- 4	99.1 +/- 1.5
Split GNB (µg/ml)		
Control	100 +/- 0	5.1 +/- 1.7
100	112 +/- 5	24.0 +/- 0.3
250	114 +/- 9	24.9 +/- 3.7
500	135 +/- 7	54.8 +/- 6.4
1000	61 +/- 7	98.8 +/- 2.0

* MTT assay. ** Trypan blue assay.
Results are shown as the mean +/- std dev or n=3 biological replicates.

Table 5: Viable and necrotic cells in response to whole and split LaPaz pinto beans (PB) concentrations treated for 24 hours.

Whole PB (µg/ml)	**Viable Cells (%)***	**Necrotic Cells (%)****
Control	98 +/- 11	4.6 +/- 2.6
100	115 +/- 10	12.5 +/- 3.7
250	135 +/- 25	11.2 +/- 5.6
500	114 +/- 16	45.2 +/- 11.6
1000	63 +/- 5	93.2 +/- 4.79
Split PB (µg/ml)		
Control	102 +/- 2	2.9 +/- 1.3
100	111 +/- 17	14.1 +/- 1.7
250	127 +/- 7	13.7 +/- 3.7
500	101 +/- 14	51.8 +/- 1.6
1000	77 +/- 9	88.0 +/- 1.9

* MTT assay. ** Trypan blue assay.
Results are shown as the mean +/- std dev or n=3 biological replicates.

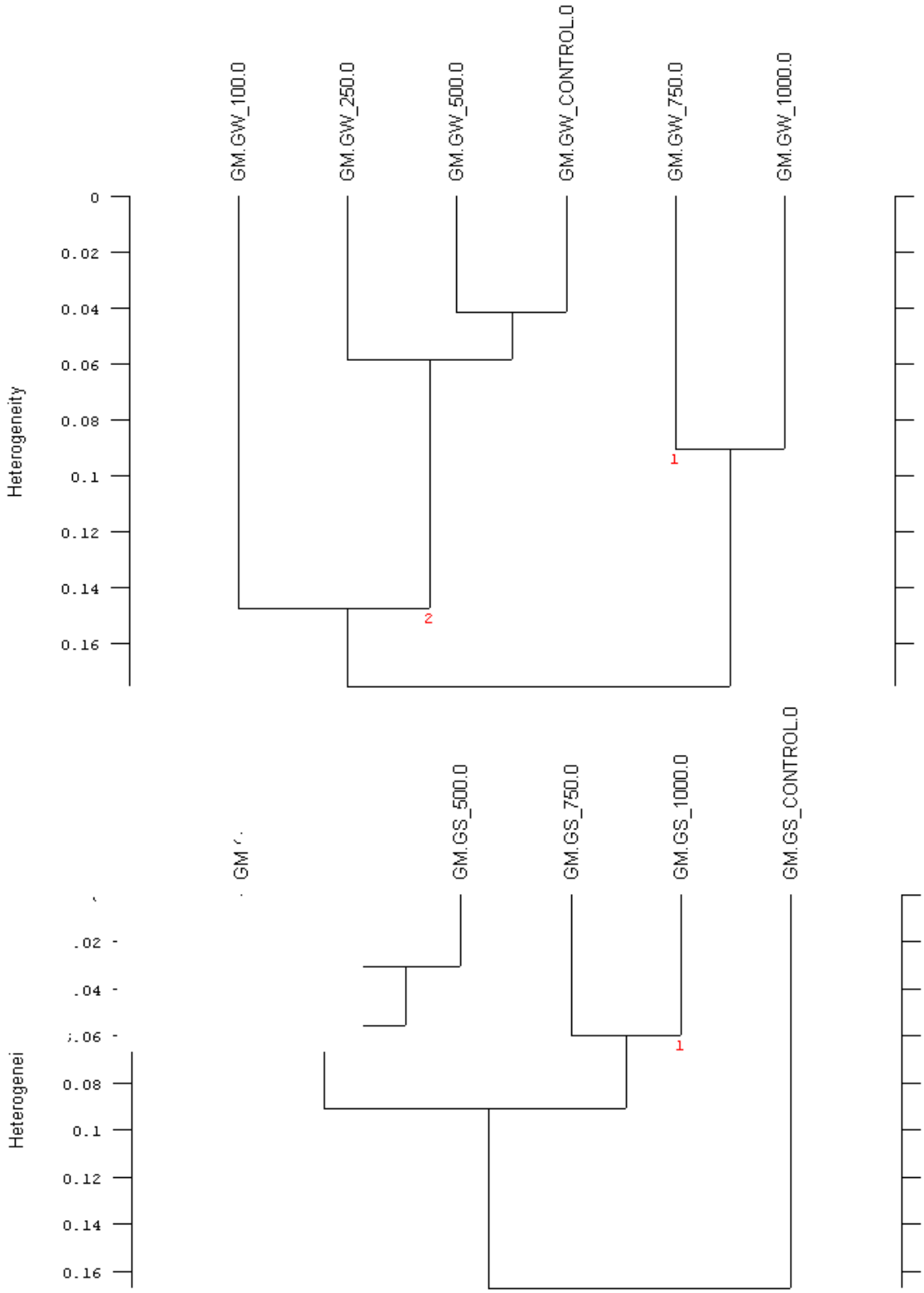

Figure 5: Dendrogram of the first derivative spectra obtained from GNB treated $HepG_2$ cells (0, 100, 250, 500, 750, 1000 µg/ml); A.) whole B.) split. The dendrograms were prepared by applying Ward's algorithm to spectral regions of

3000-2800 cm^{-1} and 1800-900 cm^{-1} to the mean of 9 spectra (3 biological replicates analyzed three times.)

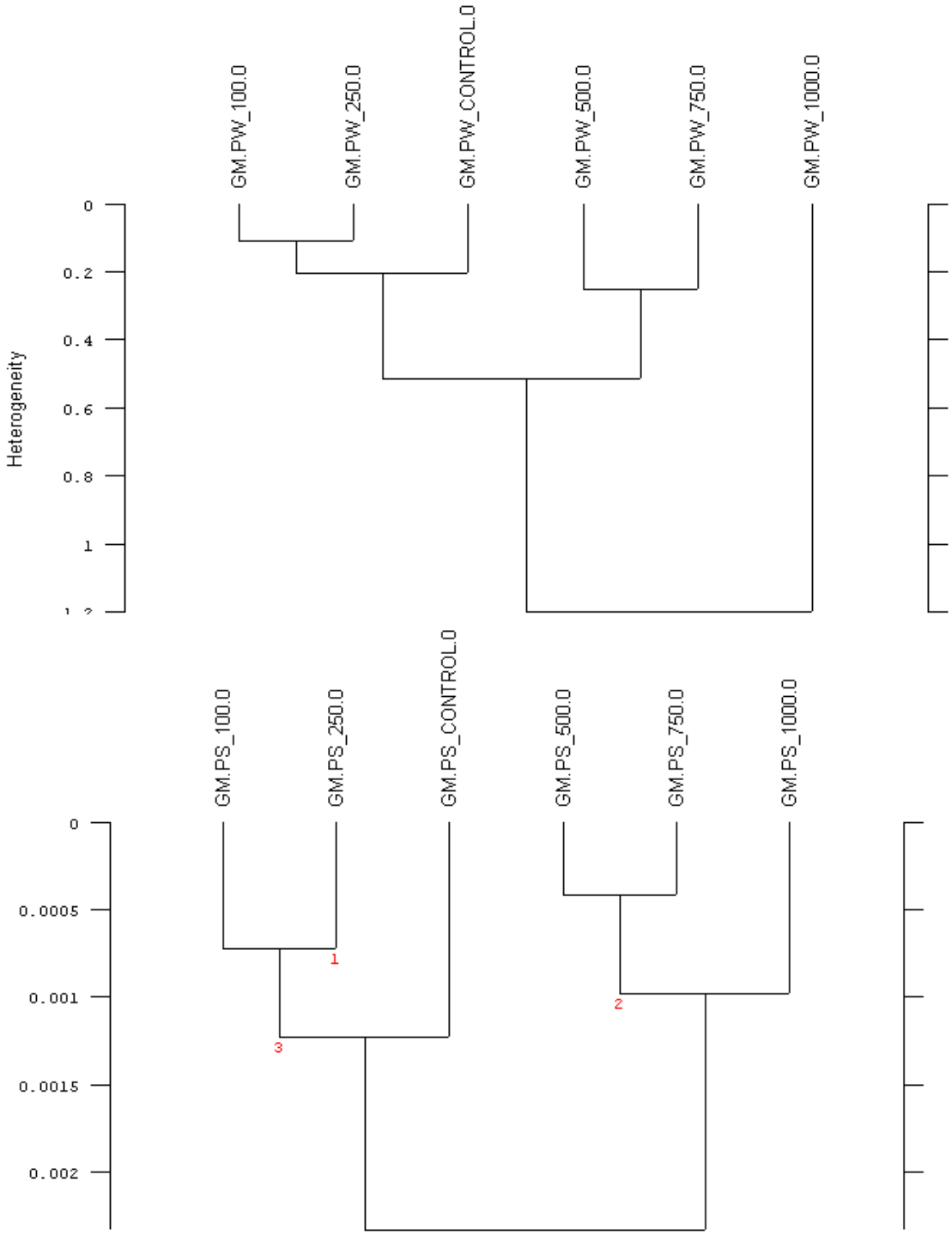

Figure 6: Dendrogram of the second derivative spectra obtained from PB treated $HepG_2$ cells (0, 100, 250, 500, 750, 1000 µg/ml), A.) whole B.) split. The dendrograms were prepared by applying Ward's algorithm to spectral regions of

3000-2800 cm^{-1} and 1800-900 cm^{-1} to the mean of 9 spectra (3 biological replicates analyzed three times.)

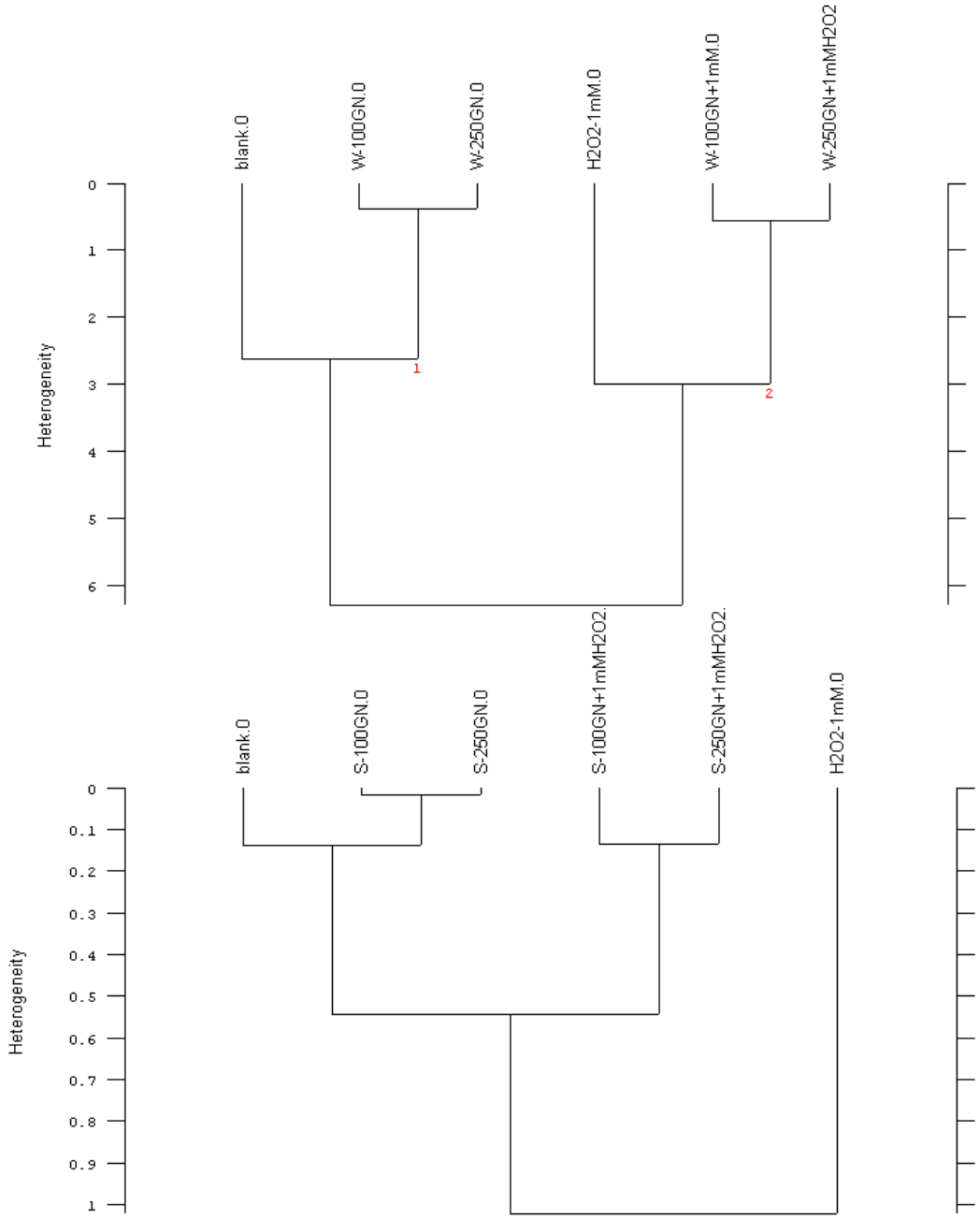

Figure 7: Dendrogram of the first derivative spectra obtained from GNB treated $HepG_2$ cells (0, 100, 250, µg/ml); A.) followed by 1 mM H_2O_2. A.) Whole, B.) Split. The dendrograms were prepared by applying Ward's algorithm to spectral regions of 3000-2800 cm-1 and 1800-900 cm^{-1} to the mean of 9 spectra (3 biological replicates analyzed three times.)

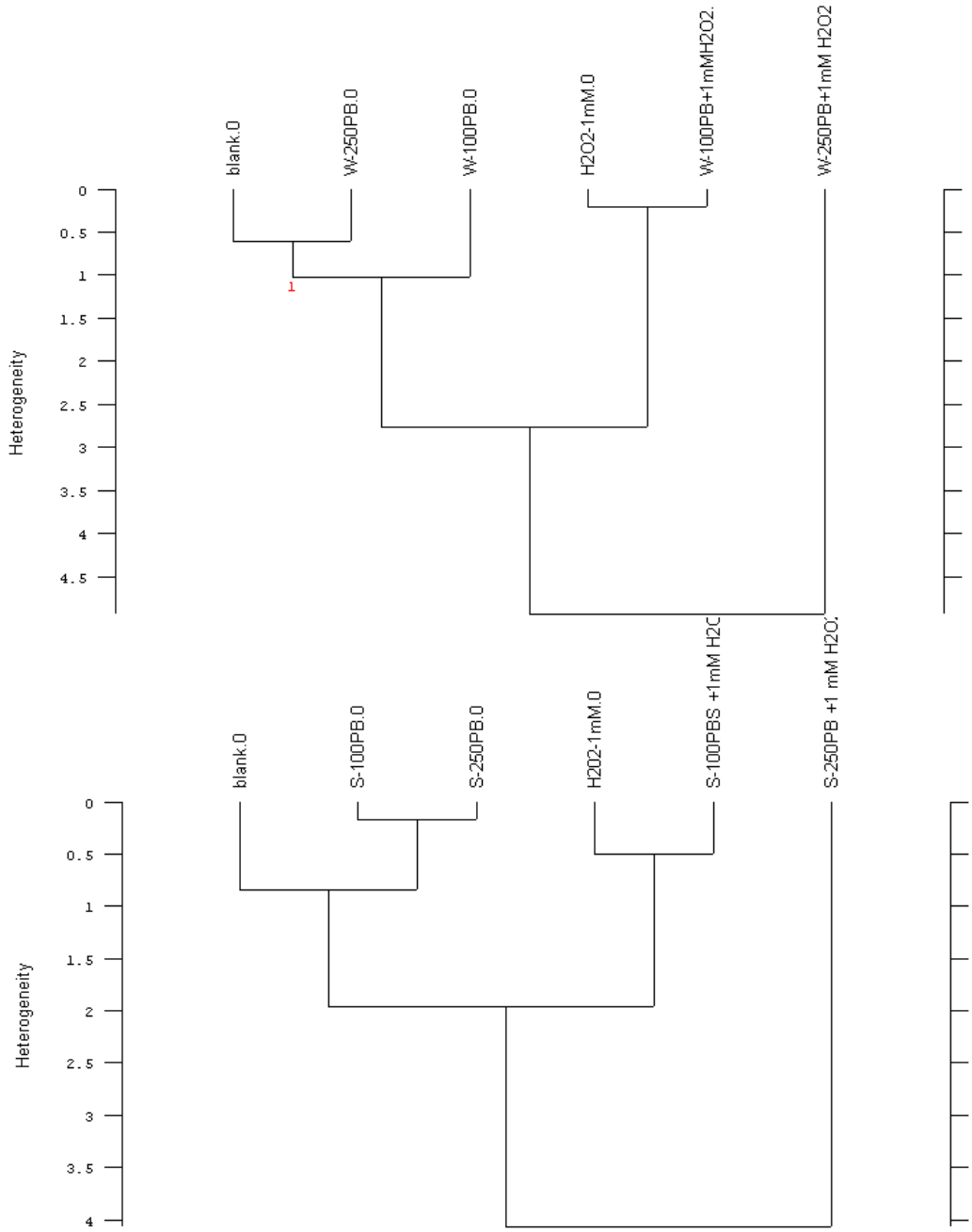

Figure 8: Dendrogram of the second derivative spectra obtained from $HepG_2$ cells (0, 100, 250, µg/ml); A.) followed by 1 mM H_2O_2. A.) Whole, B.) Split The dendrograms were prepared by applying Ward's algorithm to spectral regions of 3000-2800 cm^{-1} and 1800-900 cm^{-1} to the mean of 9 spectra (3 biological replicates analyzed three times.)

<u>Significant Results, Accomplishments</u>

The hypothesis of this project was that split beans will protect against oxidative stress at the cellular level comparable to their whole bean counterpart. This

hypothesis tested true for the GNB at both dosages levels used. In fact, the split beans appear to provide better protection than the whole beans as these treatments clustered with the blank, and the GMB only. Although the PB split and whole showed similar effects, the clustering of the lower dose PB bean application (100 µg/ml + H_20_2) suggest that this dose did not provide oxidative protection. More significantly, the combined higher PB doses (250 µg/ml + H_20_2) significnatly impacted the biochemical structure as suggested by a complete separation of this treatment group from the blank or other treatments. It is not apparent whether this is a positive of negative impact, but the results indicate that the PB + H_20_2 treatment resulted in a response that is higher in combination than as separate treatments. The data is currently under evaluation to determine the biological significance of these shifts. In conclusion, they hypothesis tested true for the GNB, but false for the PB although both the split and whole bean + H_20_2 profiles were similar. This is an interesting outcome considering the higher levels of phenolics present in the PB. Comparison of the GNB and PB clusters show significant differences between the FTIR biochemical fingerprints as affected by bean market classes suggesting that the type of beans target different cellular pathways, which in turn could reflect how each protects the cells from oxidation. More studies are needed to test this hypothesis. The data is still being studied in combination with a statistician to understand the large amounts of multivariate data generated from this project. For example, certain regions could have be more protected relative to than others for each type of bean. The most significant result is that the split beans, at least relative to the GNB, are linked to a direct health benefit.

Favorable or unusual developments

Favorable or unexpected developments resulted from the activities performed for Specific Aim 2. More specifically, the FTIR data showed that the phenotype of the cancer cells was different for each bean market. These results suggest that the phenolic rich extract from of the different market classes have different targets to remediate the growth of cancer and FTIR is an effective approach to monitor such biochemical changes. These results have significant implications in developing specific types of beans for various cancer targets. As such, we intend to pursue this new development as it applies to other bean market classes and cancer cells again using FTIR and other analytical methods to understand the biological significance.

Significant contributions and role of project partners in the project

Dr. Carlos Urrea (UNL Panhandle Research and Extension Center) grew and provided the beans for this project. Dr. Vicki Schlegel has been providing continual oversight of the project to date.

Goals and Outcomes Achieved

Activities completed to achieve performance goals and measurable outcomes for the project

All experiment related activities were completed for this project, but more data analysis is needed to disseminate the information to our producers, distributors, etc. Two-three manuscripts are expected from this work, 1 poster is already in preparation to present at a national conference with 2-3 more poster – oral presentation expected. Dissemination of the information is also expected via newsletters and websites.

Long-term outcome measures and progress

Although these activities were not intended to be long term, they do have long term implications. For example, information was generated that directly linked split dry edible beans, particularly the GNB, to a biologically significant health benefit thereby adding value to this bean market class. The data suggest that there is little difference between the effects of the whole and split on cellular metabolism albeit there are differences when it pertains to as given market classes, thereby affecting the ability of both beans to protect against oxidation. To produce longer term outcomes, the next step of the project is to disseminate this information to Nebraska bean producers, distributors, and food companies, so as to better position promote, develop, and ultimately market damaged dry edible beans as a source for oxidative protective components as well as providing the fundamental information to develop FFN products and other bean based products for human consumption (1-5 years). This research has in part, provided, the foundation for starting the cited activities and for leveraging funds from other agencies to promote the consumption of beans and to continue to study the health benefits of a currently under-utilized specialty crop in terms of its functional food and nutraceutical attributes.

(D.1.3) *Project baseline comparison with final end point of the project*. Each specific aim has been completed within the time frame shown in the Table 6. However, analysis of data is still underway using other statistical approaches, (specifically as it applies to Specific Aim 3) and further dissemination of the data through conferences, papers, newsletters, etc., is anticipated.

Table 6: Time Line for Project Jan 2011-Dec 2011

Jan 2011-Dec 2011	1st Quarter (Winter 2011)	2nd Quarter (Summer 2011)	3rd Quarter (Fall 2011)
· Specific Aim 1 · Specific Aim 2 · Specific Aim 3	Identification of Student	Training of Student Completed	Completed (Oxidizer)

Jan2012-Nov 2012	1st Quarter (Winter 2012)	2nd Quarter (Summer 2012)	3rd Quarter (Sept 2011)
· Specific Aim 1 · Specific Aim 2 · Specific Aim 3	In Progress(GNB - PB)	Completed (GNB - PB) In Progress (GNB-PB)	Completed (GNB PB)

Beneficiaries

Groups, operations, and other industry stakeholders that benefitted from the project

It is anticipated that multiple beneficiaries will be impacted from this research particularly producers and distributors of dry edible beans in the Nebraska Panhandle and other counties as the split beans can be used for other health based purposes than merely disposed or sent to animal feed. The companies with a presence in Nebraska who will benefit from the development of dry edible beans as a health promoting food system include large and small food based companies, such as Cargill, Archer Daniel Midlands, AGP, Abengoa, and Twin Valley Mills. In addition to the long-range potential for private investment in the region by food and pharmaceutical manufacturers is the retention of dry edible bean dependent suppliers and service providers.

Outreach Activities

A presentation on virtues of consuming dry edible bean to remediate oxidative stress was presented to a group of nurses and dietitians (approximately 40-50 individuals) on Nov 2, 2012, in Scottsbluff, NE. It is further expected that the results generated from this project will be presented in next several issues of The Bean Bag*, which has a circulation of approximately 3000 readers located in* 24 states and Canada. Recipients include growers, landowners, politicians, other dry bean organizations, processors, advertisers, University personnel, et cetera. Other presentations, via poster or oral, at regional or national conferences are also anticipated.

Lessons Learned

In general, the project progressed smoothly after a graduate student was identified and trained. However, a statistician knowledgeable in bioinformatics is also essential considering that the data will require further analysis to determine the biological significances of the bean treatments. Such collaboration is currently being established.

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Additional Information

None.

Project Title

Identification and Introgression of Sources for Bacterial Brown Spot Resistance in Dry Edible Beans

Project Summary

Bacterial brown spot, caused by *Pseudomonas syringae* pv. *syringae,* was first observed in western Nebraska dry bean fields on a limited basis throughout the late 1960s. Epidemics still occur sporadically, but the pathogen's presence has been increasing in incidence and damage during the past 20 years in the Central High Plains. When there is a disease outbreak, it can be very damaging due to the lack of resistance in modern commercial varieties. Due to a high incidence of brown spot in Nebraska production during 2009 (almost 15% of the samples from a survey), there is a renewed interest and need for developing new varieties with resistance to brown spot. Bacterial brown spot is subject to phytosanitary regulations for some countries. Besides affecting the seed movement between countries and even within states in the U.S., some health concerns may be raised and cause problems for the Nebraska dry bean industry.

The main goal was to identify sources of bacterial brown resistance in both U.S. and CIAT's (International Center for Tropical Agriculture) dry bean core collections and transfer those sources of resistance into Nebraska dry bean lines.

Project Approach and Goals and Outcomes Achieved

The protocol and activities for this project was shared with colleagues from U.S. and South Africa. The team worked with and trained 3 undergraduate students in developing the screening technique

A protocol to screen bacterial brown spot was developed. Six bacterial brown spot isolates (GN2, 82 JL, 9907, PS 10, PSM 5, and PS 18) were screened in concentrations of 1.5 and 3.0 x 10^8 cfu ml^{-1} using Neb. Sel.1 # 27 and Orion as resistant and susceptible checks, respectively. One leaflet of the first expanded trifoliolate leaf of each plant was inoculated using the multiple needle method (Andrus, 1948 and Zapata et al., 1985). Two plants per accessions were planted and inoculated. The plants were evaluated 7 and 14 days after inoculation using a 1-9 scale, where 1= immune and 9= highly susceptible (CIAT, 1987). Reactions from 1to 4 were considered resistant and from 5 to 9 were susceptible. This experiment was replicated twice.

The isolate PSM 5 was utilized in a concentration of 1.5 x 10^8 cfu ml^{-1} caused infection enabling us to differentiate between the resistant and the susceptible parents. This isolate was selected to screen both US and CIAT's Core Collections.

The entire US Dry Bean Core Collection (424 accessions) was screened with the PSM 5 Bacterial Brown Spot isolate.

About 1,353 accessions from CIAT's Core Collection were screened with the PSM 5 Bacterial Brown Spot isolate.
Koch's postulates were verified by re-isolation of the pathogen from symptomatic plants.

Due to high incidence of thrips in summer 2012 and high volume of bean harvest, the planting has being delayed of the resistant accessions. A total of (178) accessions showing resistance (disease ratings from 1 to 3) from both core collections are going to be inoculated on December 2012 with the PSM 5 isolate, and the resistant accessions will be inoculated to the other five bacterial brown isolates GN2, 82 JL, 9907, PS 10, and PS 18 in a concentration of 1.5×10^8 cfu ml^{-1}.

Resistant accession to all 6 isolates will be crossed with elite Nebraska germplasm in the crossing block, which will to be planted in January 2013.

Below are the outreach activities conducted for this project:

1. Reviewed protocol and activities with colleagues from U.S. and South Africa.

2. Worked with and trained 3 undergraduate students in developing the screening technique.

3. Reported results during the High Plains Advanced Cropping School: Dry Beans at the Panhandle Research & Extension Center, Scottsbluff, Nebraska.

4. Four reports were published in the local newspaper (*StarHerald*) and the Nebraska Dry Bean Growers Association's *Bean Bag* publication.

Listed below are the significant contributions and role of partners

1. The National Plant Germplasm System (NPGS) provided seed of 424 accessions.

2. The International Center for tropical Agriculture (CIAT) provided seed of 1,700 accessions.

3. Robert Harveson and Kathy Nielsen provided the inoculum, helped with the inoculation, and verified Koch's postulates.

4. Carlos Urrea and John Thomas planted the accessions, helped with the inoculations, scored the plants, and summarized the data.

Beneficiaries

The identification of resistant germplasm sources and the development of new resistant cultivars will benefit any individual involved with the dry bean industry, directly or indirectly. This disease can affect the producer's profits by reducing both yield and quality parameters. This will potentially impact 1,300 producers. This, in turn, affects the processor and general economy of the communities where the dry beans are produced. Thus, it was particularly prudent to be attempting to produce new brown spot-resistant cultivars. Release of bean cultivars with disease resistance will lower production costs and pesticide use and will likely increase bean yield.

This project will directly benefit the dry bean growers in western Nebraska. There were approximately 3,500 grower representing 130,000 acres of dry beans in 2009. The dry bean industry, as a whole, will benefit indirectly with the identification of such sources of resistance.

The results of this project were reported at the following events.

1. High Plains Advanced Cropping School: Dry Beans at the Panhandle Research & Extension Center, Scottsbluff, NE from August 16-18, 2011. Approximately 124 crop adjusters, including bean growers, attended.

2. Global Crop Diversity Trust meeting held at the International Center for Tropical Agriculture (CIAT) from March 28-30, 2012. Thirty scientists were present from different countries including Australia, Canada, Italy, Mexico, and the U.S.

3. Phaseolus Crop Germplasm meeting at Niagara Falls on November 5, 2012. Twenty dry bean scientists were present.

4. Nebraska Dry Bean Commission on November 15, 2012.

5. Eight reports were published in the local newspaper (*Star Herald*) and the Nebraska Dry Bean Growers Association Bean Bag publication.

The results of this project will also be presented to Nebraska dry bean growers during their annual meeting on January 8, 2013. Approximately 200 growers will attend this conference.

The results of this project were also published in the following reports.

1. Harveson, R.M., C.A. Urrea, and C.D. Yonts. 2011. Summarizing eight years of bacterial wilt research in Nebraska. The StarHerald, Scottsbluff, NE. Page 1. June 5, 2011.

2. Harveson, R.M., C.D. Yonts, and C.A. Urrea. 2011. Evaluating cooper applications for managing bacterial wilt infections in dry beans. The Bean Bag. 29(2):9 & 20.

3. Harveson, R.M., and C.A. Urrea. 2011. A two-year survey to determine the prevalence and distribution of bacterial diseases in Nebraska dry bean production fields. The StarHerald, Scottsbluff, NE. Pages 1 & 2. January 16, 2011.

4. Harveson, R.M., and C.A. Urrea 2011. Conducting a field survey for determining the prevalence and distribution of bacterial diseases in Nebraska dry bean production fields. The Bean Bag. 29(2): 5-6.

5. Harveson, R.M., and C.A Urrea. 2011. Developing dry bean cultivars with resistance to bacterial brown spot. The BeanBag. 28(5): 10.

6. Harveson, R. M., and Urrea, C. A. 2011. Developing new dry Bean cultivars with resistance to bacterial brown spot, Bean Bag, Winter Issue.

7. Harveson, R. M., and Urrea, C. A. 2012. Bacterial brown spot of dry beans in Nebraska. Bean Bag, Summer Issue, 2012.

8. Urrea, C.A., and Harveson, R. M. 2012. Identifying sources and mapping genes for bacterial brown spot in dry browns. Bean Bag, Summer Issue, 2012.

Lessons Learned

The project was slightly delayed because of the development of the inoculation protocol. As described above, a protocol was successfully produced and implemented. Six isolates and two concentrations were used to determine a working isolate and concentration.

A protocol to screen bacterial brown spot was developed. Due to high incidence of thrips in the greenhouse in 2012, the final screening of the resistant accessions from both collections is still in progress.

Resistant accessions to the isolate PSM 5 will be inoculated to other five bacterial brown spot isolates (GN2, 82 JL, 9907, PS 10, and PS 18) in

concentrations of 1.5 and 3.0 x 10^8 cfu ml^{-1} using Neb. Sel.1 # 27 and Orion as resistant and susceptible checks, respectively. Resistant accession will be crossed to elite Nebraska germplasm in order to introduce resistance to bacterial brown spot.

It will take at least 5 years to develop dry beans with bacterial brown spot resistance. Studying the genetics of bacterial brown spot resistance will be initiated in the near future. Resistant accessions identified in the study will be crossed to susceptible accession and mapping populations. The F1 of resistant by susceptible accessions will be backcrossed to both parental lines. The six generations (parental lines, F1, F2, and the 2 backcrosses) will be inoculated to bacterial brown spot and the genetics will be elucidated.

Mapping the genes of bacterial brown spot resistance will be elaborated from the genetic studies developing recombinant inbred lines (RILs).

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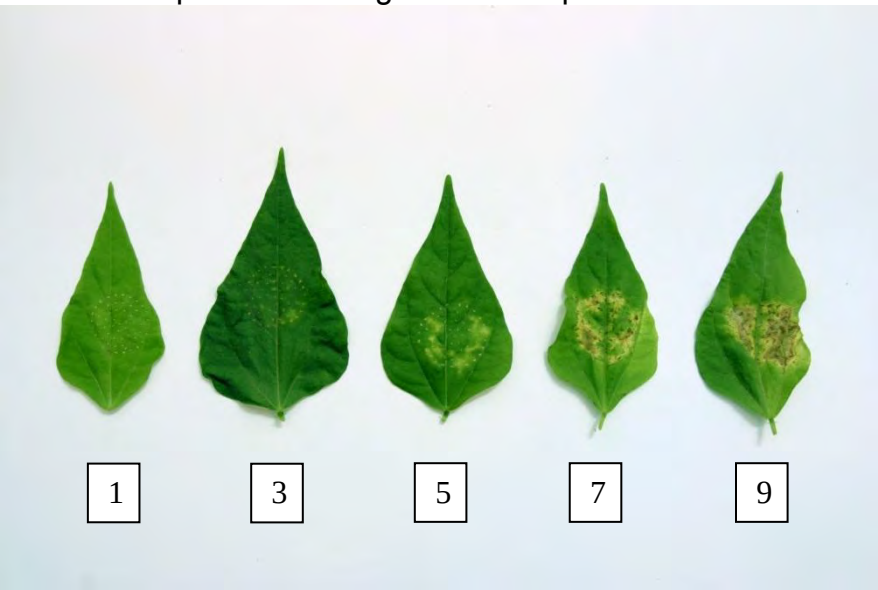
Additional Information

A bacterial brown spot scale rating was developed as follows:



Reactions from 1to 3 were considered resistant, from 4 to 6 intermediate, and from 5 to 9 were susceptible.

Project Title

Irrigation and Nitrogen Management of Potatoes Under Reduced Water Availability

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. 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. The effects of reduced irrigation or mild stress for extended periods has not been studied previously. This project is the third year of a four-year study that began in the 2009 season (FY2008 Funds) and provides verification data. New measured data were also added, i.e., leaf area index.

Project Approach

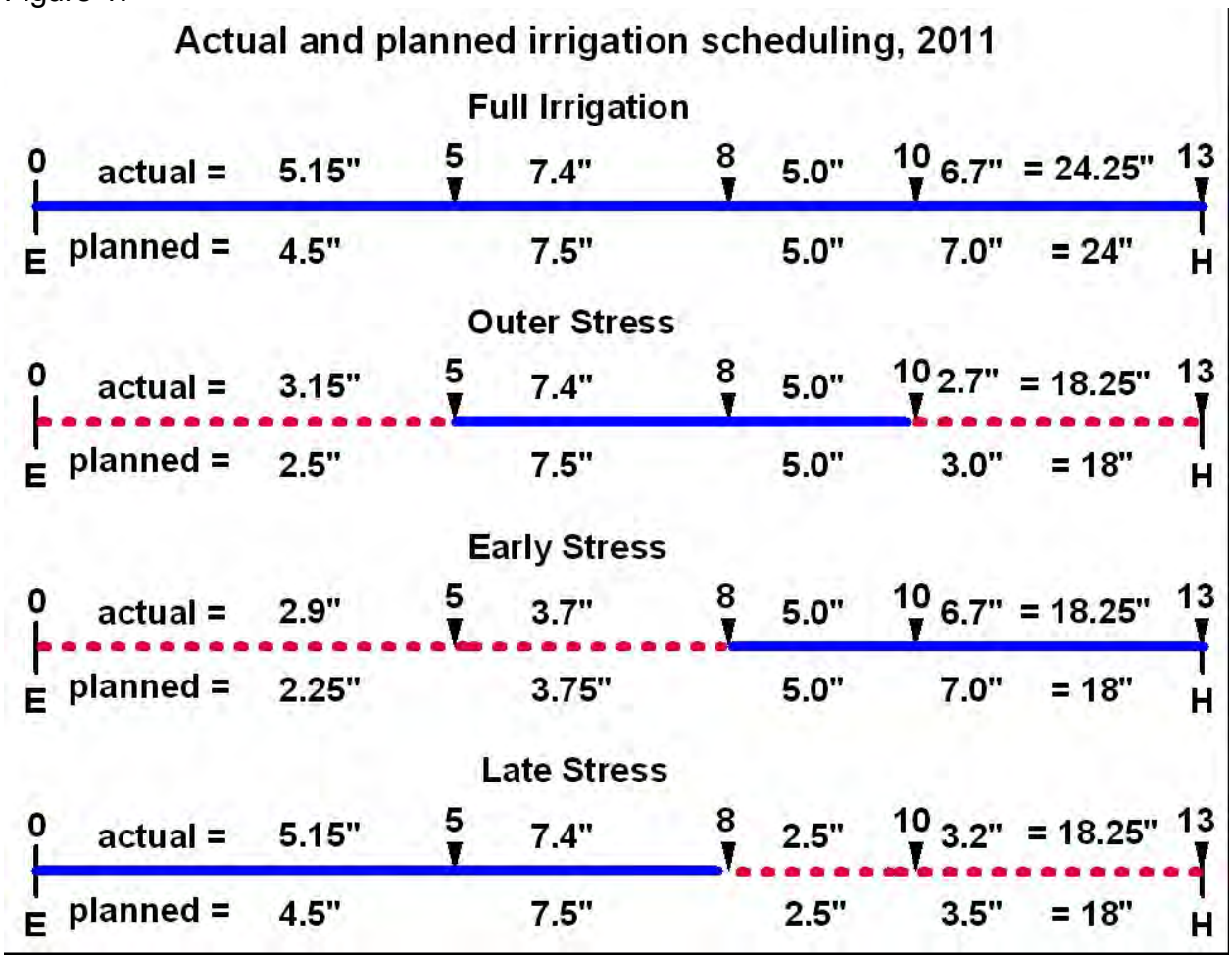
Potato cultivar Atlantic was exposed to reduced irrigation during three periods (first weeks after emergence, first five weeks plus last four weeks, and last six weeks; see Figure 1). Irrigation during these periods was reduced by half resulting in six inches less precipitation or 25% reduction from 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. Main 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. The 2011-season trial was conducted exactly according to the Work Plan as stated and all measurements were taken. All activities were completed. The outcomes described below are for the third season of the study. The accomplishments fulfilled the goals set for this project.

Significant results and accomplishments are listed below in the Goals and Outcomes Achieved section of this report so the conclusions and recommendations are summarized here. Yields were severely depressed when

water was only partially applied during the onset of tuber growth (5-8 weeks after emergence, WAE). A water shortage during this period also caused a darkening of potato chips fried from these tubers and increased tuber infection by common scab. The tentative recommendation is that the worst period to deprive potato from full irrigation is during the onset of tuber growth, 5-8 WAE.

Irrigation - Over an inch of rain fell in the second half of June, so the first irrigation began on 1 July (2011) (Figure 1) resulting in 0.5 inches more precipitation than planned during the first three weeks after emergence. Rainfall variation was compensated by adjusting irrigation. Irrigation went as planned.

Figure 1.



Goals and Outcomes Achieved

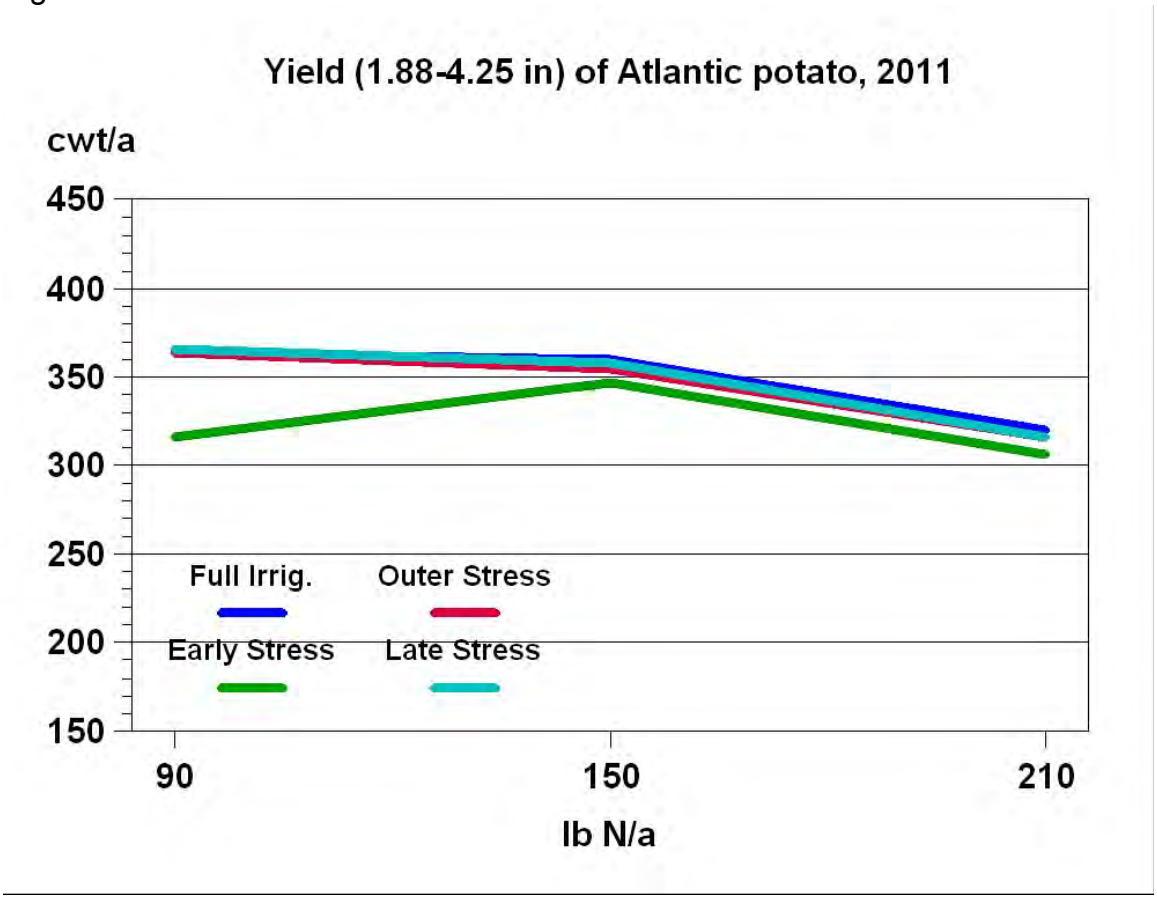
The following summarizes the results and conclusions following the format of Expected Measurable Outcomes as original stated in the project proposal.

Expected Measurable Outcome #1: The most distinctive outcome from the study will be to identify a specific seasonal period in which limiting irrigation will not adversely affect market yield of potato.

Actual Accomplishment

Yield was reduced by limiting water availability to potato plants for the first 8 WAE (July) in 2011 (Figure 2). In 2011 unlike the previous two years, withholding half the water during mid to late tuber growth (last five weeks, 8-13 WAE) showed no yield difference from fully irrigated plants. Increasing nitrogen application may partially worsen the yield loss.

Figure 2. Yield



Expected Measurable Outcome #2: Market yield will be measured at the end of the season by harvesting total yield and then recording tuber size distribution, external and internal defects, and cooking characteristics.

Actual Accomplishments

Yield was determined based on tuber size distribution. Tubers were evaluated as to quality for frying. Chip color was negatively and significantly affected when

water was reduced between 5 and 8 WAE (Figure 3). Infection by common scab, a defect that eliminates market value of tubers, was significantly increased when plants were deprived of water between 5 and 10 WAE (Figure 4). Several quality aspects, notably dry matter content and tuber shape were assessed and were not adversely affected by limiting water availability.

Figure 3. Chip Color

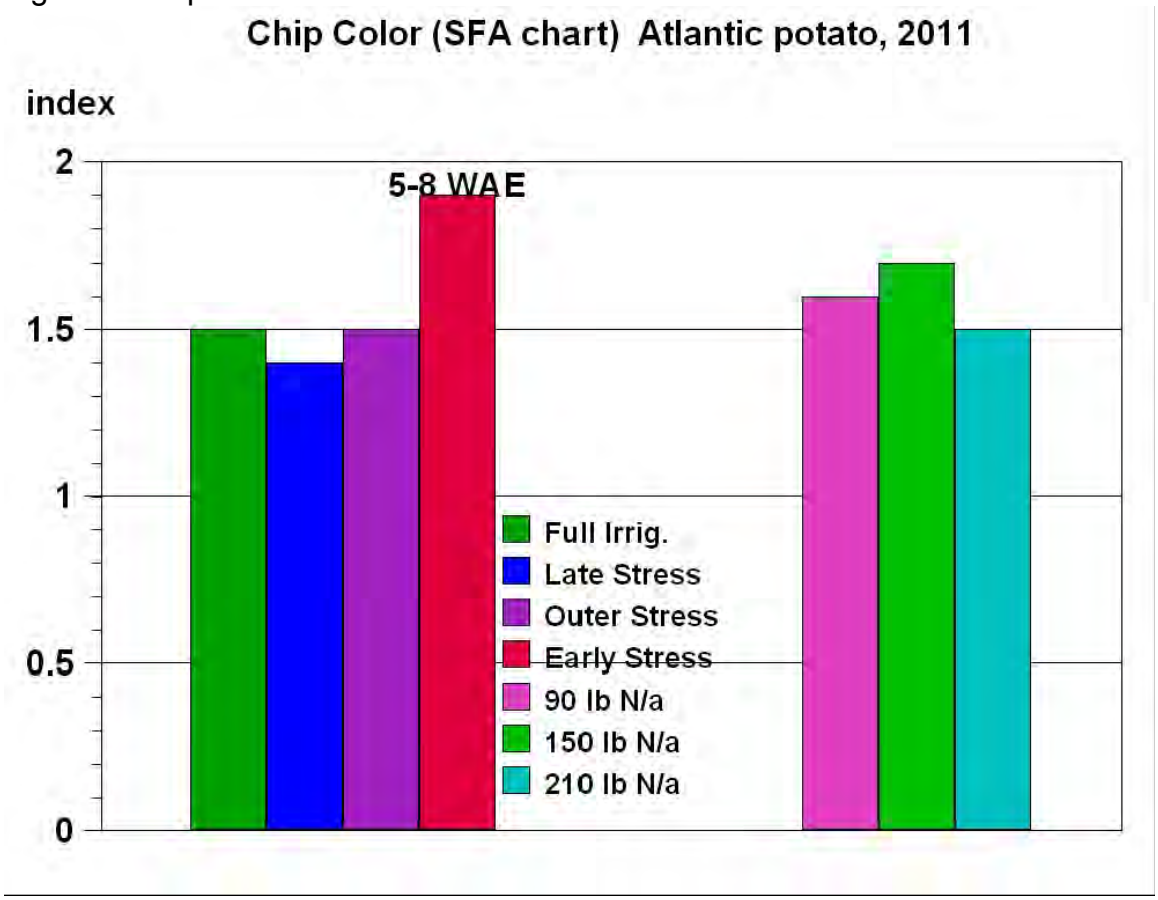
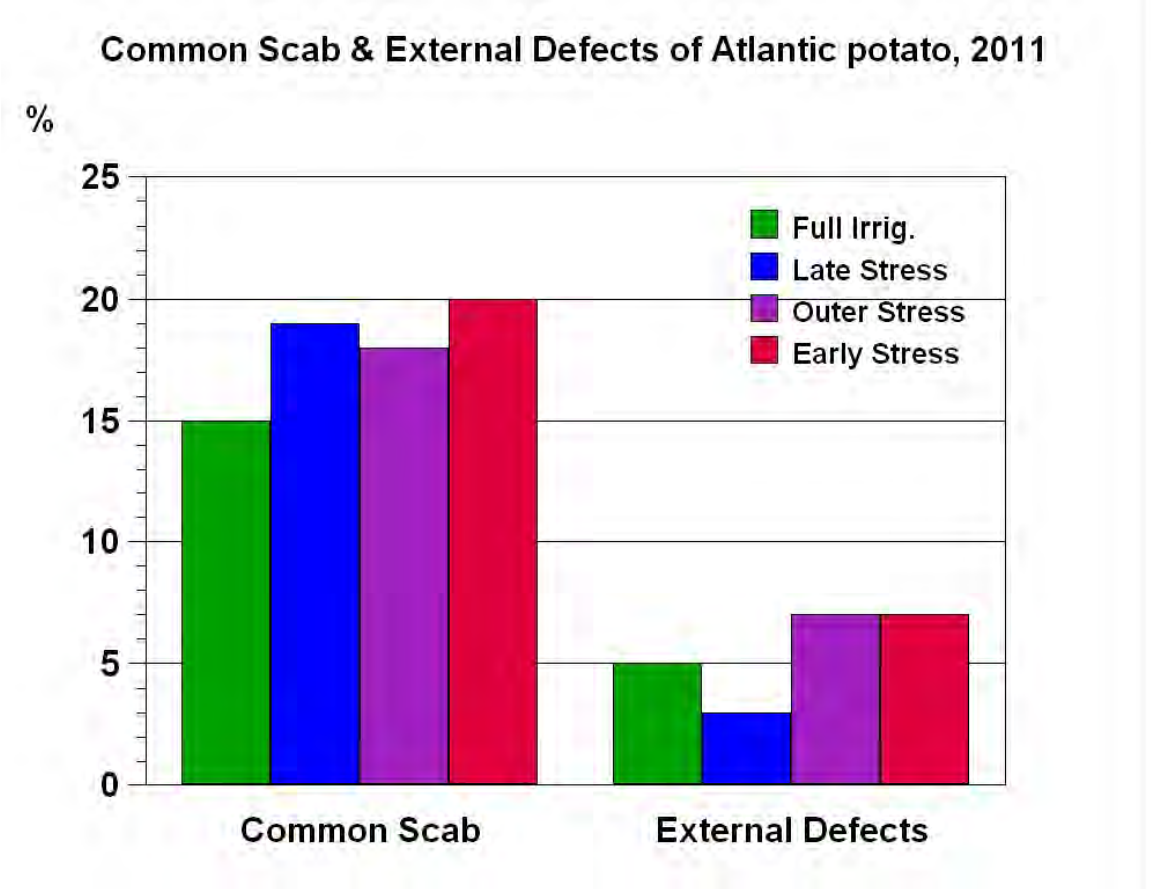


Figure 4. Common Scab and External Defects



Expected Measurable Outcome #3: Additional clear and measurable outcomes will be the determination of water use and timing, soil water depletion, nitrogen requirement and interaction during water shortages, and soil nitrogen changes. Changes in soil water and nitrogen, and petiole (in plant) nitrogen will be tracked at the start and end of water limitation periods throughout the season.

Actual Accomplishments

The following were already reported in the Annual Report and only summarized here. Fully irrigated plots contained 16-20% soil moisture or about 90% saturation during tuber bulking. Irrigation regiments directly affected soil moisture, and N uptake and utilization. The timing of tuberization and flowering were not affected by limiting irrigation. Canopies were smaller, weighed less and had reduced leaf area when water was limited.

Expected Measurable Outcome #4: Rainfall and evapotranspiration will be monitored weekly throughout the season.

Actual Accomplishments

See “Irrigation” under “Project Approach” above.

Expected Measurable Outcome #5: An economic evaluation of the market yield price based on Frito-Lay contracts, agronomic inputs, and savings in irrigation and fertilization costs will be tabulated at the end of the project.

Actual Accomplishments

This is a long-term outcome to be done at the conclusion of study in 2013.

Beneficiaries

The results and findings of this study were disseminated to the target audiences. This study is ongoing and dissemination of information will continue as additional data are obtained. This State plan covered the third year of a four-year project. The target audiences are potato growers and scientists. A list of presentations of the third year (2011) of the study, were:

1. To Nebraska Potato Development Committee in February, 2012 in Kearney, NE - target audience = 20, Nebraska potato growers and representatives of the Nebraska Department of Agriculture.

2. To the American Society of Horticultural Sciences in July 2012 in Miami, FL - target audience = 1000, US and international horticulturists, teachers, researchers, and government representatives.

3. To the Potato Association of America in August 2012 in Denver, CO - target audience = 300, USA and Canadian potato growers, University, USDA-ARS and Ag-Canada researchers, and representatives from potato-producing countries such as the UK, Netherlands, and Mexico.

4. To NCERA 211 (“Potato Research and Extension Program”) in August, 2012 in Denver, CO – target audience = 60, north-central region potato growers, potato scientists and USDA representatives.

5. To the Internet - target audience = 8,000. all potato growers, researchers and government representatives world-wide. The 2009 and 2010 data has been prepared for uploading onto the PI’s website “Potato Education Guide” under “Nebraska Research” for international dissemination. The quantitative data, that concerns the potato community the most, concern yield, tuber quality, and cooking characteristics as these were affected by periods of limited irrigation (Figures 2, 3 and 4). 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 load, a semi-truck, is refused; a minimum quality is needed. The other quantitative data are critical to understanding soil water and nitrogen interactions, and the health and growth of the plant to withstand biotic stress.

Lessons Learned

The third year's data verified most of the tentative conclusions of the previous two years. When limiting water supply, it is least deleterious to withhold water toward the end of the season, from mid bulking (8 WAE) to harvest, and worst when withheld during early tuber growth, 5-8 WAE.

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Additional Information

None.

Project Title

Increasing the Availability of Nebraska's Specialty Crops Through High Tunnels

Project Summary

This project was designed to increase the number of producers in Nebraska using high tunnel technologies. This project was accomplished by conducting a series of workshops, webinars, and trainings that provided interested participants with the knowledge and education to own and operate their own high tunnel or hoop house. The initial trainings during the first year of the project were geared towards beginning or novice levels of expertise and progressed to the second year into intermediate and advanced levels. Conducting this project in stages allowed participants to see preparation for, utilization of, and practical application for high tunnels. This project included preparation and implementation of the use of high tunnel technology during the growing season.

Project Approach

The typical growing seasons in Nebraska run from May through October. Some farmers have been able to expand their season from April through November with the use of hoop houses or high tunnels. The Nebraska Sustainable Agriculture Society (NSAS), in partnership with Buy Fresh Buy Local Nebraska (BFBLN), conducted a series of workshops for direct marketing sustainable, organic and transitioning famers on the techniques and skills require to expand the growing season in Nebraska for specialty crops. The objectives of this project were to:

1. Increase awareness about high tunnels and how they can be used to extend specialty crop production in Nebraska; and

2. Increase the technical skill level among specialty crop farmers growing, or starting to grow, crops in high tunnels.

To accomplish the project objectives, we completed the following tasks:

1. Conducted in class trainings and webinars

2. Delivered hands-on training sessions/tours;

3. Developed trainings and confirmed teachers;

4. Coordinated tours and hands-on training sessions;

5. Evaluated all trainings;

6. Recruited participants for training (small farmers/beginning farmers); and

7. Reported and shared information via websites, NSAS bimonthly newsletter, NSAS Annual Meeting, and social media.

Elaine Cranford (UNL) and William Powers (NSA) planned and coordinated all of the tasks. Assisting was Amanda Bergstrom (UNL). For the trainings and workshops, they utilized local and regional consultants from the UNL Horticultural Department who were experts in high tunnel construction, use, and maintenance. They also had 2 – 3 farmers who currently utilized high tunnel technology on their operations. The farmers provided first-hand knowledge to the participants. Direct market trainings, during the project, were conducted by Billene Nemec (BFBLN). Project presentations were conducted by William Powers and Elaine Cranford at NSAS's Annual Meeting and the Western Nebraska Sustainable Agriculture Conference. Below is the breakout of each event and the number of people who attended each.

NSAS Annual Meeting 2011	45
NSAS Annual Meeting 2012	85
Western NSAS Conference 2011	35
Western NSAS Conference 2012	50

Information on the project, including outreach and evaluations, were conducted by Powers and Cranford, with assistance from Bergstrom. The development of the trainings and webinars began begin in the fall of 2010. In February 2011, participant recruitment began. Recruitment concluded in March. The initial trainings and webinars started in April and concluded in June. They were progressive in nature, beginning with the basics and going toward a general understanding and knowledge that enabled participants to own and operate their own high tunnels or hoop houses. A total four classroom workshops and four webinars were held over the course of this project. Approximately 200 and 90 people participated in these events, respectively. Farm tours were held shortly after the initial trainings. Tours were held on farms where high tunnels were in use, and included participation and expertise from the respective farmers. A total of four farm tours were held over the course of this project. During the first year of the project, approximately 65 people attended the farm tours. During the second year, approximately 70 people attended. Cumulatively, 135 people attended the farm tours.

Goals and Outcomes Achieved

The goal of this project was to increase the availability of specialty crops in Nebraska by increasing the number of small farmers/beginning farmers using high tunnels in order to extend their growing season of specialty crops. Two objectives, each with its own tasks, were conducted to achieve this goal.

The first objective (Objective 1) was to increase the awareness about high tunnels and how they can be used to extend specialty crop production in Nebraska. A total of four classroom workshops and four webinar trainings were held, each of which featured high tunnel experts. Two workshops and two webinars were held during each year of the project. Below are the titles of the webinars, when they were recorded, where they can be found on the internet, and how many people participated.

Webinar 1: ***High Tunnels & Cold Frames: Tools to Extend the Growing Season, Presented by Stacy Adams*** UNL Extension (Recorded April 20, 2011) http://connect.extension.iastate.edu/p26096626/?launcher=false&fcsContent=true&pbMode=normal. A total of 33 attended the in-class live webinar and 194 viewed the online recording.

Webinar 2: ***Choosing the Right High Tunnel- Components and Design, presented by Stacy Adams*** UNL Extension (Recorded May 18, 2011) http://connect.extension.iastate.edu/p40393250/?launcher=false&fcsContent=true&pbMode=normal. A total of 12 attended the in-class live webinar and 83 viewed the online recording.

Webinar 3: **Rainwater Catchment from a High Tunnel for Irrigation Use** (Recorded January 2012). http://www.leopold.iastate.edu/pubs-and-papers/2012-01-rainwater-catchment-high-tunnel-irrigation-use. A total of 20 attended the live webinar.

Webinar 4: **Hoop Houses for Extending Your Growing Season, Presented by Tammy Hinman and Andy Pressman** (Recorded 2012). http://www.youtube.com/watch?v=VZ-JAGKcup8 A total of 25 attended the live webinar.

The second objective (Objective 2) was to increase the technical skill level among specialty crop farmers growing, or starting to grow, crops in high tunnels. Two hands-on workshops and one farm tour was held in the first year of the project. .

The first workshop was held at UNL on June 28, 2011. A total of 31 people attended the workshop and farm tour. The second was held at the West Central Research and Extension Center in North Platte, Nebraska, on September 26' 2011. A total of 39 people attended.

Two workshops and three farm tours were held in the second year of the project.

Several outreach activities were accomplished. Regular updates on the project have been printed in NSAS's newsletter. The webinars are archived on the NSAS's website at http://www.nebsusag.org/resources/res_hightunnels.htm.

Approximately 392 people participated in the farm tours, workshops, and/or webinars associated with this project. Below is a breakdown of these numbers.

1. 4 farm tours/field days were conducted. Cumulatively, approximately 135 people attended these events.

2. 4 classroom workshops were held. Approximately 200 people attended these events (70 in the first year; 130 in the second year).

3. 4 webinars. Approximately 90 people participated. These webinars, which are archived on the Internet, have been viewed over 500 times.

Surveys were conducted to gauge the knowledge and application of high tunnel use at the workshops. Questions in the surveys included knowledge of high tunnels and current specialty crop use. Surveys were used to determine if there was an increase in using high tunnels and if production actually increased.

At the 2011 North Platte Workshop, the evaluations results were impressive. On a scale of 1 through 5, 1 representing “strongly disagree” and 5 “strongly agree,” the cumulative scores for the following questions were as follows.

Question: I know more about High Tunnels than I did prior to attending this workshop?
Score: 4.32

Question: I will be able to use what I learned in this workshop?
Score: 4.41

A cumulative score of 4.27 was achieved when asked if this workshop was relevant to the attendees. The audience consisted of several participants, including 11 farmers/ranchers and 5 growers.

Also, 11 respondents agreed to the statement that learning and participating in the workshop enabled them to expand their farm/business plan to incorporate items they otherwise would not have been able to grow. Sixteen respondents said the workshop provided more detailed information than they would have previously found online or in a textbook. Seven participants viewed or attended the webinars offered prior to this workshop.

The 2011 Lincoln Workshop scored equally as well. Below are the scores from the same set of questions.

Question: I know more about High Tunnels than I did prior to attending this workshop?

Score: 4.76

Question: I will be able to use what I learned in this workshop?
Score: 4.81

A cumulative score of 4.81 was achieved when asked if the workshop was relevant to the attendees. The audience consisted of several participants, including 1 grower and 6 farmers/ranchers.

Also, 12 respondents agreed to the statement that learning and participating in the workshop enabled them to expand their farm/business plan to incorporate items they otherwise would not have been able to grow. Two of the 12 said the workshop gave them the confidence to consider starting their own garden business. Thirteen respondents said the workshop provided more detailed information than they would have previously found online or in a textbook. Seven participants viewed or attended the webinars offered prior to the workshop.

The scores for the other two workshops were combined. Below are the 2012 workshop scores.

Question: I know more about High Tunnels than I did prior to attending this workshop?
Score: 4.41

Question: I will be able to use what I learned in this workshop?
Score: 4.41

A cumulative score of 4.25 was achieved when asked if the workshop was relevant to the attendees. The audiences consisted of several participants, including 4 growers and 21 farmers/ranchers.

Also, 18 respondents agreed to the statement that learning and participating in the workshop enabled them to expand their farm/business plan to incorporate items they otherwise would not have been able to grow. Twenty respondents said the workshop provided more detailed information than they would have previously found online or in a textbook. Eighteen participants viewed or attended the webinars offered prior to the workshops.

Beneficiaries

The beneficiaries of this project included fruit and vegetable producers throughout the state of Nebraska, as well as some producers from Kansas, Iowa and Missouri. Over 80 producers attended the initial workshops and this number increased in the second year.

Outreach activities included regular updates on the project in the NSAS newsletter and in other regional publications. Webinars were archived on the NSAS website, and presentations on the project and high tunnels were scheduled for western and eastern Nebraska conferences.

Lessons Learned

Lessons learned included coordinating the training and workshop with the industry experts. We initially coordinated our efforts with Stacy Adams for the eastern Nebraska workshops; we worked with a different set of trainers for the western Nebraska workshops. Coordinating the efforts would have made the planning more efficient.

We also had technical difficulties with 2 of the webinars, most of which were tied to connectivity issues. There were some technical difficulties experienced, especially with the second webinar. It is believed this is why the attendance was lower than hoped. The webinar started several minutes later than initially planned, and many may have chosen not to participate because they were unable to login.

After the first webinar, we did a “walk through” to fix any issues that might arise during the second webinar.

Significant contributions and project partners included the following:

> Stacy Adams, Assistant Professor of Practice Horticulture Greenhouse Production & Management
>
> Laurie Hodges, Associate Professor and Extension Specialist Commercial Vegetable, Herb, and Specialty Cut Flower Production Plant Physiology and Production
>
> Elaine Cranford, Cooperative Development Specialist at the Nebraska Cooperative Development Center,
>
> Billene Nemec, Coordinator, Buy Fresh Buy Local Nebraska

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Additional Information

None.

Project Title

Young Urban Farmers

Project Summary

Community CROPS added the new Young Urban Farmers project two years ago, which expanded on our current programs by giving youth opportunities to learn the skills involved with planning, growing, and selling their own produce.

This project addressed two needs in the community. First, many young people do not know the origins of their food or what it takes to produce this food. Giving them the skills to grow their own food will make them better consumers, gardeners, and possibly farmers in the future. Second, this project addresses the rising rates of obesity among young people by helping them eat healthy foods and get exercise through farming.

Young Urban Farmers gave participants first-hand experience in observing working farms around Lincoln and designing their own farm at the school. The students produced their own vegetables in newly created spaces at their school. Working through an after-school program on site and during the school day, CROPS staff interacted with youth and taught them skills in crop production, management, and marketing, in addition to making healthy, sustainable lifestyles more accessible to all.

Project Approach

Community CROPS erected fourteen by thirty-six foot hoop house at Mickle Middle School in Lincoln, Nebraska, which was used to grow crops. Some of these crops include beets, two varieties of salad greens, kale, swiss chard, cilantro, kohlrabi, and spinach. The students built three raised beds, two cold frames, and a compost bin.

Over the course of the grant period the Young Urban Farmers Program brought hands on experience and knowledge of specialty crop production and environmental stewardship to the students and participants in the Mickle Middle School district. This was administered through two groups at the school and one outside group. Youth were educated, provided an outdoor learning/gardening space, and participated in physical outdoor activities.

The first group was the after-school Urban Farmers Club that was partially directed through the local YMCA CLC program. This group met twice weekly on Tuesday and Thursday afternoons from 3:00-5:00 p.m. for the duration of the 2011 – 2012 school year. It consisted of 25 students who were in grades 6th through 8th. Some students in this group volunteered through the summer and joined again in the fall of 2012. We also had two active volunteers who came

weekly and were vital to the success of the program, as the project grew too large for one person to manage. From group, we had three families who actively volunteered to be a part of the project. They expressed how much their children loved the program and now are growing produce at home.

The second group involved the students in the 8th grade FCS class in the spring semester of 2012. The class consisted of approximately 80 8th grade students. They were involved in the entire growing process, from seed planting to harvest. They received lessons on where their food originates, and studied various food production systems. The larger focus was on the idea of how local agriculture processes affect the community as a whole. This question led to many discussions about the local economy, health of communities, and environmental ethics. The theme of the year really became the production practices in local agriculture.

There was a group of high school students who came to volunteer and observe this project and what was being accomplished. In addition, there were two students from UNL who volunteered on a weekly basis.

The last group was an outside organization that was interested in getting their youth involved during their summer program. The Bethany Day Camp, organized through Lincoln Parks and Recreation, brought approximately 40 youth from the ages of 6 – 13 to the Mickle Urban Farm site twice weekly throughout the summer. These students were taught the various concepts of organic gardening and participated in hands-on farming activities. The interaction of this group not only got the youth excited about gardening, but it also engaged the involvement of the staff, all of whom reported to have started a garden at home during the course of the summer. There was one 7 year old who begged to do some garden "weeding" every week.

Goals and Outcomes Achieved

During the grant period the groups extensively explored small scale agriculture and participants performed various tasks. such as preparing the beds, planting, weeding, watering, harvesting, selling, and building various planter beds for exploration. Produce grown amounted to approximately 350 pounds of produce including over 70 lbs of tomatoes, 30 lbs of cucumbers, 40 lbs of squash, 15 lbs of gourds, 25 lbs of eggplants, 10 lbs of peppers, along with varying amounts of onions, garlic, lettuce, carrots, herbs, kale, radishes, beets, and other produce. The youth participated in over 250 hours of gardening. In the classroom, the tasks and topics discussed involved growing over 30 varieties of produce. This provided students, families, participants, and the local community with fresh, local vegetables which were sold in on-site at mini markets and at the local University Place Community Farmers Market during the summer.

Our actual outcomes achieved exceeded our expected measurable outcomes as described in the original application. First, we managed to grow a recorded 350 pounds of produce during the program period. There was a significant amount of produce that went unrecorded that far exceeded our original goal. Second, we intended to reach at least 50 students over the course of the 2 year project and we were able to engage approximately 150 students directly with several other students in the school and local community being indirectly impacted through the program. Third, our outreach to the local community was intended to be around 200, which was met with an article in the *Lincoln Journal Star* and a report on the Channel 8 Eye Witness news. The number of community members reached through these media outlets is immeasurable but we know that we impacted the students, their families, and the teachers. Last, we set out hoping to create a best practices model and curriculum base to be used in other school districts. This goal was achieved as there is interest from Dawes Middle School who intends to learn from Mickle Middle School in hopes of administering a similar project in their school district.

The students conducted two small grower's markets at the school and learned about commerce and marketing. The urban farmers attended a field trip to a local vegetarian restaurant where met with the owner and discussed different aspects of the program. This particular restaurant owner had previously purchased food from Community CROPS.

The table below provides a comparison.

Expected Outcomes	**Actual Outcomes**
300 lbs produce	350+ lbs produce
Outreach to 50 students	Engaged 150 students
Outreach to 200 community members	Over 200 reached, Journal Star article and Channel 8 News report
Best Practices Model created	Interest from Dawes Middle School

The Mickle Middle School and local YMCA was a great foundation for transmitting this program to the students and youth in the area. It engaged approximately 150 local youth and many local community members. It will serve as a model for administering school gardens in other districts in the Lincoln community. What started as an empty lot behind the school was transformed into an interactive learning space capable of producing hundreds of pounds of healthy, locally-grown produce. We were able to provide education to over 80 Mickle students and over 40 youth from other programs. And with that we provided locally-grown produce to the members of the surrounding community.

The table below lists the program income generated during the grant period. All of the revue was used to pay for salaries, supplies, and the market booth fees at the University Place Farmers' Market.

Mickle Market Sales
2011 – 2012

#	Date	Market	Revenue
1	9/13/11	Mickle On-Site Urban Farmers	$15.00
2	9/14/11	Mickle On-Site Urban Farmers	$10.00
3	10/12/11	Mickle On-Site Urban Farmers	$10.00
4	7/11/12	University Place Community Market	$55.75
5	7/25/12	University Place Community Market	$38.00
6	8/8/12	University Place Community Market	$20.00
7	9/6/12	Mickle On-Site Urban Farmers	$13.00
		Total Market Revenue	**$161.75**

Beneficiaries

The main groups benefiting from the administration of this program were the students of Mickle Middle School, their families, school staff, and local neighborhood. Also impacted was the Bethany Day Camp staff and youth, the University Place Farmers' Market, and the local YMCA. Garden tours and market days were hosted by the students during the year.

The project was featured in the *Lincoln Journal Star* newspaper in October 2011 (http://journalstar.com/news/local/education/article_d1aa1be0-083f-510a-b7ef-8bf3f753812c.html). Several of the students were photographed working on site and many were interviewed. Because of the article, Community CROPS received numerous e-mails and phone calls from individuals in the community expressing their desire to help with and encourage the program. The project was also featured on the CROPS website http://www.communitycrops.org/youth, the CROPS Facebook page, and on the Channel 8 Eye Witness News on March 22, 2012.

Lessons Learned

There were some difficulties that were not originally anticipated. The first was vandalism. Lincoln Public Schools erected a chain link fence to deter vandalism. However, the problem is was the chain link fence is only four feet high, which is not tall enough to prevent vandals from entering the field. The hoop house plastic has been sliced on two separate occasions. The first was minor as there were only two slices. However, the second was more severe and problematic; there were a total of ten slices in the plastic. The plastic has been repaired with a special UV resistant tape. The police were contacted after both incidents and reports have been filed. Two meetings with Community CROPS and Mickle Middle School were held to discuss these incidents and to find a solution to this

problem. It was decided to install sensor lights and a sign stating that the area is now being monitored by video surveillance.

In the beginning, when the youth were first introduced to the idea of growing food, we discovered that there was a huge disconnect in their understanding of where their food originates. Most had no idea how, where, or when food was grown and harvested. This project enabled us to bridge that gap by teaching and involving the students in food production. We were amazed to discover the interest it generated in the children and in the families. However, even though there was a tremendous amount of support for the program, we found it difficult to sell the produce. Also, once the produce was picked, storing the food for the market was challenging. We discovered that there is a need for on-site storage to preserve the produce. Unfortunately, the needed storage was not available. We often let the children take food home to their families to ensure that the produce was being utilized.

Another issue we encountered was the amount of management and time it took to keep the garden in order. It was more than one person could handle. The help of several volunteers was needed to ensure that the proper best garden management practices were followed.

The student /coordinator blog was difficult to use. This was discussed with the principal and CROPS is still waiting on approval from the district. There proved to be more “red tape” involved than originally anticipated. The alternative to a blog was a small space on the school’s web site called “The CROPS Corner.” This allowed students to regularly post happenings at the Urban Farm and to provide growing tips. There was also a small space currently designated to the project on the Mickle Middle School website.

Overall, we learned that a gardening program of this size requires an enormous amount of time and monitoring. The lack of student knowledge in growing produce resulted in their excitement in the program. It is believed that student and teacher involvement in gardening education and experience will result in healthier lifestyles for those involved.

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Additional Information

Mickle Middle School wrote a letter to Community CROPS that was forwarded to NDA expressing the value of this program and the positive impact it had on their students.

Over the course of the project, Mickle students earned $25.00 from the produce sales, all of which were reinvested in the project to cover expenses not included in the grant award.

Project Title

The Farmer's Alternate Crop: Winter Production of Greenhouse Strawberries

Project Summary

The overall goal of this project is to enhance Nebraska's economy by growing high 'value' horticultural crops during the winter months.

To accomplish the project, the University of Nebraska – Lincoln (UNL) developed and tested methods for:

1) Optimizing the system by determining the strawberry cultivars best suited for sustainable crop production;

2) Quantify the crop value not just in terms of profitability, but also in terms of contributions to human health;

3) Reduce fixed and variable costs for structures, water, fertilizer and especially, energy inputs

Nebraska, the heartland of America, is well known, nationally and internationally, for its abundant and profitable agricultural field crop production during the spring, summer, and fall seasons. This is due to sunshine, warm temperatures and plentiful moisture. However, what is not well known is that some of the sunniest days, but coldest days of the year occur during the winter months. Winter time solar energy can be utilized for controlled environment agriculture (CEA), in this case, greenhouses. Greenhouse food production has yet to be fully explored and developed in Nebraska. With increasing transportation costs, concerns about imported food safety, human health/obesity issues, and the need to improve local economies, increasing local production of fresh fruits and vegetables is a logical step for CEA in Nebraska. Additionally, growing food using CEA allows Nebraska farmers an additional source of income outside of the usual field season. Research by Hoagland et al., 2008 found that the average corn/soybean farmer has labor and/or time available from December through March, which could be utilized to grow alternate crops.

This one year allocation of funds for this project was used to pay partial technical support and some operating expenses such as supplies and nutraceutical analysis.

Project Approach

UNL modified a typical Quonset, double polyethylene commercial style production greenhouse located on UNL's East Campus by installing a gas meter and rerouting the heat tubes to under the benches (2). They also assembled an

automatic water/fertilizing system, again with a water meter, in order to utilize capillary mat technology for growing the strawberry plants. A wireless system was installed to monitor the production environment in greenhouse – specifically temperature, humidity, light quality, quantity and energy, soil moisture and heating/cooling events. This instrumentation was supported by funds from the USDA/CSREES NE 1035 Commercial Greenhouse Production: Component and System Development (Dr. George Meyer, PI.

Thirteen cultivars of strawberry plants were purchased, potted up and grown on the capillary mats from October through April 2011. Berry harvest began late November/early December. Berries were harvested, counted, and weighed weekly. In March, UNL selected berries from each cultivar and Dr. Vicki Schlegel's lab analyzed them for health-promoting phytochemicals (total phenols, flavonoids and antioxidant capacity) as well as sugars. The nutraceutical and sugar content of the strawberries will provide feedback for determining which cultivars will be selected for commercial production. Berries were frozen in liquid nitrogen immediately after harvest and stored at −80°C prior to further analysis. The samples were then be extracted with 1.2 N HCl in 50:50 water:methanol. After centrifugation, the Folin-Ciocalteu method will be used to determine total phenol levels in the sample supernatants as described by Singleton and Rossi (1965). To quantify total flavonoids and antioxidant capacity, the sample supernatant will be prepared as cited above and measured according to Adom and Liu (2002) and Cao et al. (year), respectively. Moreover, simple sugar analyses will be performed to determine sweetness of the different sample as described by Keutgen and Pawelzik (2007).

Goals and Outcomes Achieved

The goals for this one year were to:

1) Determine which cultivars of strawberries will produce the greatest yield (mass and number) during the whole growing season;

2) Determine which cultivars have the best health-promoting phytochemicals;

3) Select/recommend 6 – 9 cultivars for final trial during the 2011-2012 growing season;

4) Determine water and gas usage with a goal of sustainable, cost effective greenhouse production during the winter; and

5) Address pest issues such as algae on the mats.

Outcomes:

Goal #1. The cultivars that gave the highest yield (number of berries) were Chandler, Albion, Seascape; Cavendish, Evie-2 (Figure 1). The cultivars that produced the most weight (mass) were the same as those that produced the highest number of berries (Table 2). However, not all the cultivars flowered and fruited during the target period of November and December.

Goal #2. Nutraceutical or healthy chemicals in strawberries . There was no difference in the total phenol concentration among cultivars (Sweet Charlie 1.839 -- AC Wendy 1.06 mg gallic acid equiv g^{-1}). Flavonoid concentration was significantly higher in Dar Select, Seascape, Chandler, KRS-10, Cavendish , Evie-2 , Albion and Sweet Charlie compared to Strawberry Festival, Tribute , Honeoye and AC Wendy (Table 3). The top yield performers were among the highest in flavonoid concentration. This was not the case for antioxidant capacity as Albion and Evie-2 had significantly less antioxidants than all other cultivars except KRS-10, Tribute and AC Wendy. In terms of sweetness or sugars in the berries, there was quite a bit of overlap among the cultivars depending on the sugar type. However, of the high yielding cultivars, Albion and Seascape, have significantly more sugar concentration than Evie-2 and Chandler. Cavendish falls somewhere in between. This year UNL also plans to add another measure of sugar concentration (Brix).

Goal #3. UNL selected and recommended 6 cultivars for final trial during the 2011-2012 growing season. They are Albion, Chandler, Cavendish, Seascape, Portola, and Evie-2.

Goal #4. Gas usage – from September 21, 2010 through April 16, 2011, the greenhouse used 3659 cu. ft of natural gas. The commercial rate (average) for natural gas (Black Hills at http://www.neo.ne.gov/statshtml/118.htm) is $8.59 per 1000 cu ft. Thus, the total usage cost for 6 months was $31.43. For water, a total of only 66 gallons was used during the 6 months of growing strawberries. Water is sold by the unit with1 unit =748 gallons ($1.28 per unit). There is a monthly service charge of $3.26 so we estimate the total cost to be $20.84. UNL added this information to their water and gas usage to their start-up costs model.

Goal #5. In growing the plants, UNL reduced algae by using 'panda' plastic (white top/black plastic bottom). Pests were controlled with sprays and bio-controls. However, UNL is looking further into other pesticides and biocontrols with an aim toward using mainly organic methods.

Beneficiaries

UNL's UCARE student, Han Do, and Dr. Ellen Paparozzi, started appearing in the *Scarlet, Omaha World Herald*, *At Work for Nebraska* and several other newspapers. Two main things resulted from the articles. First, the web site hits

increased dramatically (Table 3) and second, individuals/groups started contacting Dr. Paparozzi. Four main groups/individuals have kept in contact, which include potential fresh market growers and wine makers. The most promising is Mr. Doug Garwood of Cardinal Farms, South Sioux City. He visited the UNL model greenhouse and hosted Dr. Paparozzi and 3 other team experts (Drs. Meyer, Adams and Lambe) at his hydroponic tomato operation in South Sioux City. Next year, depending on the outcome of the current 6 cultivar trial, Doug plans on adding a greenhouse for growing strawberries during the winter under the Cardinal Farms brand. He and his son, Scott, plan to visit when strawberry production is peaking (late November – early December).

UNL presented a poster at the Great Plains Growers Conference 2011 (formerly the Annual Missouri Small Fruit and Vegetable Growers conference). There were 466 attendees, 92 exhibitors, and 78 speakers/organizers from Iowa, Indiana, Kansas, Missouri, Nebraska, Ohio, Oklahoma, Texas, South Dakota and Arizona.

In September, Dr. Paparozzi gave an oral presentation on the information contained in this report at the National American Society for Horticultural Sciences. There were 900 attendees at this meeting. Her presentation was one of only nine that were podcasted and posted on the ASHS web site (http://ashs.org/db/horttalks/detail.lasso?id=116120). From the two meetings, Dr. Paparozzi has been contacted by two consultants in the U.S. and one in Macedonia who are interested in more information on the sustainable practice of growing of strawberries.

Lessons Learned

The most significant result from this one year's work is the selection of the cultivars for the final trial year. As anticipated, one variety was not able to be the sweetest, the healthiest as well as produce the greatest number and mass of strawberries. The cultivars selected for the current trial were: Albion, Chandler, Cavendish, Evie-2, Seascape and Portola. See next section for how this was determined.

Overall, UNL is making excellent progress towards providing farmers and growers a cost effective way to produce strawberries during the winter. UNL ran oversight for all facets of the project. The technologist and hourly student were responsible for all data collection. Dr. Blankenship and I analyzed and interpreted all data received. Dr. Schlegel's lab ran all the analyses on the nutraceutical and sugar properties of the strawberries. Assistant Professor Adams provided expertise in the design and installation of the capillary mat system and overall benching, heating and greenhouse structure. Dr. Meyer and his team installed the computer, web cam, sensors for measuring light and mix water holding capacity as well as the recording software for the data associated

with the sensors. Assistant Professor Lambe compiles start-up and production costs.

Publication: Ellen T. Paparozzi, George E. Meyer, M. Elizabeth Conley, Stacy A. Adams, Erin E. Blankenship, Paul E. Read and Vicki L. Schlegel. 2011. Cultivar Choice Affects Quality and Production of Winter-grown Strawberries. HortScience 46(9): S112 (Abstr.)

It was discovered that stolon/crown production is possible during the winter. One of the concerns of strawberry plant crown producers is that if Nebraska were to start significant winter production, who would supply the plants? In a phone conference with Nate Nourse of Nourse Farms, Massachusetts, he indicated that most plant producers are already close to capacity in terms of meeting spring orders for strawberry crowns. In UNL's research, due to continual nitrogen fertilization and short days photoperiods, many stolons (runners) with one or more small strawberry plant crowns were produced by all cultivars. There is nothing in the literature to indicate that stolon production inhibits berry production so UNL let them grow and in mid-December, gathered six scientists, harvested all the stolons and recorded this data. UNL plans to review this information over the next year to determine if this could be cost effective.

The cultivar Strawberry Festival performed well in most of our trials. However, this cultivar peaked in March rather than during November/December. Also it is not readily available in the fall. Consequently UNL did not include it in their final trials.

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Additional Information

Selected References:

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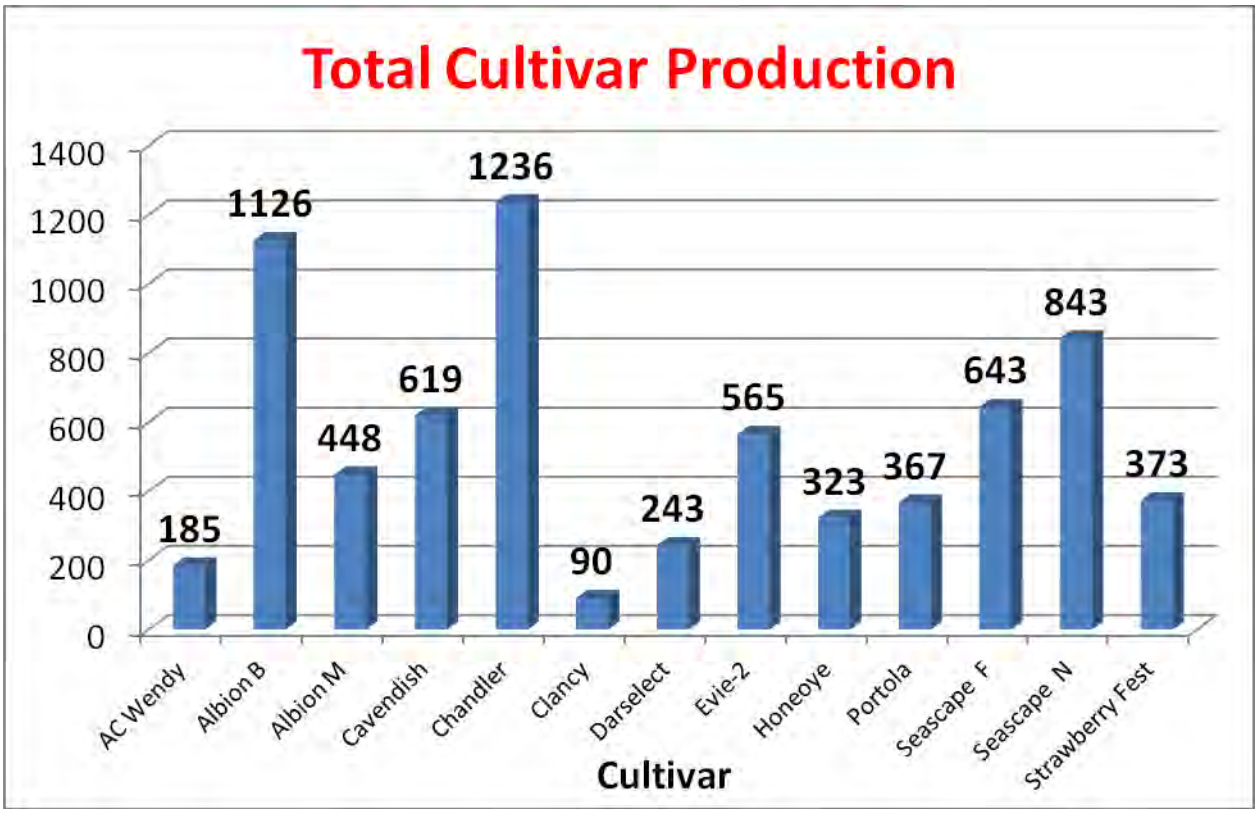

Figure 1. Total number of berries produced for 2010-2011 growing season.

Table 1. The total mass (weight) of strawberries, by cultivar.

Cultivar	Sb Type	Flowered by	1st Harvest	Peak Times	Total (g)
AC Wendy	Jb	10/05/10 3 plants 01/18/11 24 Total	10/22/10	March	2512.51
Albion B	d-n	10/26/10 1 plant 12/07/10 24 Total	11/16/10	March/ April	10,112.37
Albion M	d-n	10/05/10 2 plants 01/28/11 24 Total	11/03/10	December March	5,046.76
Cavendish	Jb	10/05/10 6 plants	10/30/10	March	7,838.93

		01/28/11 24 Total			
Chandler	Jb	10/05/10 1 plant 11/17/10 24 Total	11/04/10	December	10,954.92
Clancy	Jb	10/05/10 1 plant 04/01/11 19 Total	11/01/11	November	584.52
Darselect	Jb	10/05/10 7 plants 04/01/11 24 Total	10/28/10	November April	2,238.34
Evie-2	d-n	10/05/10 3 plants 02/28/11 13 Total	10/30/10	March/April	6,410.78
Honeoye	Jb	10/05/10 8 plants 03/25/11 24 Total	10/23/10	March/April	2,638.94
Portola	d-n	10/05/10 1 plant 01/28/11 10 Total	11/05/10	December March/April	5,782.70
Seascape F	d-n	10/05/10 8 plants 10/26/10 24 Total	11/02/10	December March/April	5,512.63
Seascape N	d-n	10/05/10 3 plants 02/11/11 22 Total	10/29/10	December March/April	7,530.11
Strawberry Festival	Jb	12/07/10 4 plants 01/28/11 10 Total	12/29/10	March/April	3,897.89

Table 2. Nutraceutical properties of strawberries listed, by cultivar. Cultivars noted with an asterisk (*) also yielded well.

	Flavon mg catechin equiv g^{-1}	Cultivar	ORAC uM trolox equiv. g^{-1}
Darselect	0.63	Sweet Charlie	1.83

Seascape*	0.58	Darselect	1.76
Chandler*	0.58	Chandler*	1.67
KRS-10	0.58	Straw Fest J	1.59
Cavendish*	0.54	Straw Fest A	1.54
Evie-2*	0.45	Seascape*	1.54
Albion*	0.44	Cavendish*	1.46
Sweet Charlie	0.41	Honeoye	1.42
Straw Fest A	0.38	KRS – 10	1.35
Tribute	0.37	Evie-2*	1.26
Straw Fest J	0.36	Albion*	1.25
Honeoye	0.35	Tribute	1.07
AC Wendy	0.28	AC Wendy	1.06

Table 3. Simple sugars found in strawberries (glucose, fructose, sucrose) that contribute to the total concentration of carbohydrates in the fruit.

CV	Gluc mg g^{-1}						Fruc	Suc	TOT CARB
ALB*	9.33				A		5.67	1.18	16.15
ACW	6.76		B		A		4.33	0.82	11.90
SBFJ	6.24		B		A	C	3.94	0.80	11.03
HON	5.75		B			C	3.47	0.75	9.96
SEA*	5.47		B		D	C	2.57	0.74	8.82
SBFA	4.94		B	E	D	C	2.42	0.57	7.90
DAR	4.80		B	E	D	C	2.65	0.77	8.18

CAV*	4.35	F	B	E	D	C	2.82	0.46	7.61
K10	4.18	F	B	E	D	C	1.66	0.35	6.17
Evie*	3.38	F		E	D	C	1.73	0.52	5.60
CH*	2.24	F		E	D		1.46	0.52	4.25
SWC	2.00	F		E			2.74	0.52	5.28
TRI	1.23	F					0.72	0.28	2.18

Table 4. Visits to UNL's web site (http://agronomy.unl.edu/cea)

Month	Number of visits to website	Comments
March	2	
April	39	Information appears in UNL and rural newspapers
May	26	Information continues to appear in other publications
June	22	Most visitors enter through the research port
July	28	Article appears on Omaha paper
August	29	Homeowners start finding the site
September	12	
TOTAL	158	

Project Title

Hybrid Hazelnut: Propagation Research for Future Demonstrations in Nebraska

Project Summary

The long range goal of the hybrid hazelnut research program at the University of Nebraska (UNL) Industrial Agricultural Products Center (IAPC) was to explore the value-added opportunities for food and industrial applications and to accelerate the development and commercialization of hybrid hazelnut (hybrid hazelnut) production in Nebraska. The overall goal of this research project was to evaluate the success of large scale hybrid hazelnut propagation techniques and to prepare for future field scale research that will further evaluate adaptability and hardiness of hybrid hazelnut cultivars in large field demonstrations across Nebraska. If hybrid hazelnuts are to be produced at a commercial scale in Nebraska, the evaluation of these improved propagation techniques on a relatively large scale will need to begin years before the identification of the most desirable cultivars.

Project Approach

Specific research objectives were to:

1. Evaluate and enhance tissue culture propagation techniques for hybrid hazelnut selections suitable for production in Nebraska;

2. Propagate select cultivars for future field demonstration; and

3. Monitor survival and growth rates of propagated plants in the laboratory, greenhouse, and nursery.

This project has advanced hazelnut propagation efforts in Nebraska, but propagation of hybrid hazelnut proved extremely difficult. Micro propagation of dormant buds and leaf material were unsuccessful as were root layering and chip bud grafting. The few explants that were initially established from forced buds as reported in the annual report (September 2011) were infected with fungi and molds soon after. Explants that were not initially infected were cleaned and transferred to new sterile containers, but were similarly infected in the following weeks. Initial efforts to incorporate a fungicide with the media were not successful, but were only approached on a limited basis. Considering the unsuccessful results of micro propagation techniques with hybrid hazelnut (*C. avellana* x *C. americana*), a control propagation study was conducted with non-hybrid material (C. avellana) from the National Colonal Germplasm Repository of Corvallis, Oregon (Repository). Propagation of the *C. avellana* material from the Repository has been successful for 5 of the 6 cultivars. Jefferson, Yamhill, Santium, Epsilon, and Theta cultivars were successfully propagated over the

course of the project, but Gama never developed enough plant vigor to establish roots. Successful propagation of these non-hybrid cultivars provides a comparison of propagation techniques with both hybrid and non-hybrid varieties. Only limited numbers of the *C. avellana* (non-hybrid) varieties became contaminated during tissue culture transfer, while all efforts to propagate hybrid hazelnut have been unsuccessful, primarily due to fungal infestation. The C. avellana plants resulting from this propagation effort were grown in the green/shade house environment in the summer of 2011, over wintered in cold storage, and used to establish in-field test plots at 4 locations across Nebraska (SE, NE, SC and SW). A total of 135 hazelnut trees were established and supplemental irrigation allowed 108 of the trees to continue growth through fall defoliation. A key evaluation will be the overwinter survival rate, which will be evaluated in the spring of 2013 when additional trees will be used to replace those that have died out at that time.

Macro-propagation efforts were conducted throughout the summer of 2010 but as of September 30, 2012 only one hybrid hazelnut plant was successfully propagated and that was by the more traditional in-field mounded root layering method. It grew in the greenhouse and shade house during 2011 and was planted in 2012 at the University of Nebraska hazelnut research plot adjacent to the tree it was propagated from. It continued to grow well with supplemental irrigation during the extremely hot and dry summer of 2012. The Nebraska Forest Service conducted additional in-field mound layering efforts with the Grand Traverse cultivar at the UNL research plot in the summer of 2012 with much higher success rates. Nine trees were cutback in 2011 and were mounded for layering in 2012. As a result, 165 Grand Traverse layers were rooted in the fall of 2012. These plants will grow in a shade house during the summer of 2013 and will be available for planting in the spring of 2014. It should be noted the Grand Travers cultivar is reported to be a *C. avellana* x *C. colurna* hybrid, not a *C. avellana* x *C. americana* hybrid. However, Grand Traverse does have cold hardiness characteristics and does show resistance to Eastern Filbert Blight (EFB) as it has been producing suitable size and quantities of nuts in the UNL research plot since 2006.

This project was built on a previously funded Specialty Crop Block Grant project to conduct hybrid hazelnut propagation research from October 2009 through September 30, 2010 and extended through September 30, 2011. In addition, this project was built on previously funded projects on general nut/kernel characteristics, nutritional quality of extracted oil and defatted meal, and nut/kernel mold contamination. The results from the previous research projects were promising and supported IAPC's initiative to identify propagation techniques suitable for large scale multiplication of hybrid hazelnut cultivars.

Goals and Outcomes Achieved

Objective #1: Evaluate and enhance tissue culture propagation techniques for hybrid hazelnut selections suitable for production in Nebraska.

In addition to the propagation efforts from previous research, tissue culture from hybrid hazelnut buds and hazelnut leaves, chip bud grafting, and mounded root layering in the field propagation of the embryo axis of hybrid hazelnut was evaluated. The technique was designed to limit unsterile material that could contaminate the tissue culture plant material or media. Embryo axis germination uses cold stratified embryo axes immediately before they emerge from the hybrid hazelnut seeds. The seeds for this research were selected from 2010 seed production of undetermined crosses. A total of 40 kernels from two trees were evaluated for seed quality and 22 axes were selected for germination on growth media, of which 7 immediately became contaminated with fungus. Initially 12 of the 15 remaining axes appeared to survive, but within 3 weeks only 9 showed signs of growth. These 9 plants grew slightly over the following months but eventually 4 became contaminated with fungal growth. As of September 30, 2011, 5 plants were alive but 3 have very low plant vigor.

A preliminary trial evaluated the potential to include a fungicide in the media formulation to control fungal contamination in the micro propagation environment. This trial used a very small number of alternative media formulations.

Propagation techniques evaluated included propagation from dormant buds, leaf material, embryo axis material, chip bud grafting, root layering, and in-field mound layering. Specific evaluations included selections from multiple hybrid hazelnut cultivars (NADF plants) and growth media formulations. Of these, only in-field mound layering showed any success and which was limited to establishment of one hybrid hazelnut plant from a *C. americana* cross and 160 hazelnut plants (Grand Traverse) from a *C. colurna* cross, both were crossed with *C. avellana*. No micro propagation techniques were successful using tissue culture methods, which are typically much more prolific if the proper methods are identified.

Objective #2: Propagate select cultivars for future field demonstrations.

Considering the repetitive contamination associated with the multiple micro propagation efforts of hybrid hazelnut plant materials, non-hybrid hazelnut plant material was obtained to evaluate propagation techniques and methods. Non-hybrid hazelnut plant material, *C. avellana,* was provided by the National Colonal Germplasm Repository of Corvallis, Oregon (Repository). The cultivars included Jefferson, Yamhill, Santium, Epsilon, Theta and Gamma. Propagation of the *C. avellana* material was successful with various growth rates for the 6 specific cultivars evaluated. Jefferson and Yamhill cultivars initially showed more vigor than other cultivars. The Theta cultivar has acclimated to the laboratory

environment as well and each of these 3 cultivars have been readily propagated, transferred to fresh media, rooted and transferred to soil. The Epsilon and Santium cultivars are acclimating to the laboratory environment as well but with less vigor. The Gamma cultivar had very low vigor. As of September 30, 2011, 160 *C. avellana* plants from 3 varieties resulted in successful propagation. Propagation efforts with this material continued in 2012 to produce 90 additional plants representing 5 of the 6 varieties evaluated.

Successful propagation of these non-hybrid cultivars provides a comparison of the propagation techniques with both hybrid and non-hybrid varieties. Only limited numbers of the non-hybrid varieties became contaminated during transfer, while all efforts to micro propagate hybrid hazelnut have consistently resulted in fungal contamination.

Objective #3: Monitor survival and growth rates of propagated plant in the laboratory, green house, and nursery.

Unfortunately, there has been very little success propagating hybrid hazelnuts. Only one plant from the in-field mounded root layering method established a limited root system. This plant was transplanted into potting soil and transferred to the greenhouse in October, 2010 to continue root development before entering winter dormancy. This plant survived winter dormancy and continued to grow in the nursery environment throughout 2011 at rates similar to other hybrid hazelnut plants established from seed.

Successfully propagated plants developed very well in the laboratory, green house, and nursery environment with a survival rate above 90%. However, the Yamhill and Theta varieties did not develop root systems as quickly. As a result, the Yamhill and Theta varieties had a low in field survival rate (less than 20%) over the very hot summer, even with supplemental irrigation. Observations indicated these plant varieties had lower plant vigor in the laboratory and green house environment, which limited their ability to establish suitable root systems prior to placement in cold storage over the winter months. It is anticipated that field survival rates could be improved with extended time in the nursery environment or by eliminating plants with low vigor and under developed root systems prior to planting. Some of the Yamhill plants with well-developed root systems survived and grew equivalent to the more successful Jefferson and Epsilon varieties, which had in field survival rates above 80%.

Beneficiaries

The research performed will benefit the hazelnut industry with further documentation of the challenges associated with propagating h. hazelnut (*C. avellana* x *C. americana* crosses). More specifically, project staff has gained a broader perspective of the challenges associated with large scale propagation efforts for hybrid hazelnuts. This will indirectly benefit Nebraska specialty nut

crop producers, food processors, and nut traders as they also understand the challenges associated with large scale commercial production of hazelnut in Nebraska.

Troy Pabst of the Nebraska Forest Service provided an update of efforts to commercialize hybrid hazelnuts in Nebraska at the Upper Midwest Hazelnut Growers Conference. His presentation primarily focused on the Nebraska Forest Service's efforts, but also included IAPC's research efforts to identify propagation techniques suitable for large scale commercial development. This Conference reached approximately 60 nut producers from the Iowa, Minnesota, Nebraska, and Wisconsin area and was held in West Saint Paul, MN on March 4 and 5, 2011.

IAPC staff participated in the Hybrid Hazelnut Consortium each of the past 3 years and reported project progress and results to this collaborative research group. The Consortium includes hazelnut researchers from Oregon State University, Rutgers University, the National Arbor Day Foundation, and the University of Nebraska (Nebraska Forest Service and IAPC). The results will be shared at the Consortium meeting scheduled for December 2012.

Lessons Learned

The research project has continued to progress and was built on previous research efforts. However, hybrid hazelnut propagation has continued to be extremely difficult, especially using micro propagation techniques like tissue culture, which would be most beneficial for large-scale multiplication. To date, only one hybrid hazelnut plant has been successfully propagated from our research efforts and that was by the more traditional in-field mounded root layering method. The Nebraska Forest Service has had additional success with this propagation technique but on a single cultivar, Grand Traverse, which is not a cross with *C. americana*. However, Grand Traverse has cold hardiness and EFB resistance which makes it a desirable plant for establishment in Nebraska.

Using cultivars of *C. avellana* to validate the micro propagation techniques that were unsuccessful with *C. americana* crosses served a dual purpose as the control verified our laboratory procedures were suitable to effectively propagate *C. avellana*, and the propagated cultivars were available for use in establishing greenhouse, nursery and field plot production methods. These cultivars will continue to provide useful information as they demonstrate growth rates and future hazelnut productivity of *C. avellana* at 4 locations in Nebraska. It is anticipated growth, survival and hazelnut productivity will be limited by cold and variable winter air temperatures that are common in the Midwest and can injure woody tissues and staminate flowers of *C. avellana*, which lack cold hardiness.

The research team is disappointed current research efforts have not resulted in successful propagation techniques for hybrid hazelnut thus far, but the research

has been very beneficial in providing additional knowledge to support the future identification of large scale reproduction methods for hybrid hazelnut cultivars. This research is an important key to identifying alternative propagation techniques and addressing the overall goal of developing and commercializing hybrid hazelnut production as an alternative oilseed crop for Nebraska.

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Additional Information

Collaborative efforts continue to develop between UNL's IAPC and the Hybrid Hazelnut Consortium, specifically the Nebraska Forest Service and the National Arbor Day Foundation. The research team conducting propagation efforts for this project participated in the 2010 Hybrid Hazelnut Consortium visit to Corvallis, Oregon to visit Oregon State University research orchards and facilities, three commercial hazelnut orchards, two nurseries specializing in hazelnut propagation, the National Clonal Germplasm Repository, and a hazelnut processing facility that supplies confectionary grade hazelnuts. This visit expanded our research team's understanding of the industry, but more specifically, it allowed us to evaluate propagation techniques currently utilized for the European hazelnut species (*C. avellana*), which may be adaptable to hybrid hazelnut. Members of our team also participated in the 2011 Consortium meeting at Rutgers University to gain a broader understanding of hazelnut susceptibility to eastern filbert blight (EFB), which is caused by the fungal parasite *Anisogramma anomala* and is common in the wild American hazelnut, *C. americana.* Members of our team will also participate in the 2012 Consortium meeting scheduled for December 2012 which will be hosted by the National Arbor Day Foundation in Nebraska City, Nebraska.

Associated publications related to the potential for h. hazelnut production in Nebraska:

1. Yixiang Xu, Edward Sismour, John Parry, Milford Hanna, Haiwen Li (2011) Chemical composition and antioxidant activity in hazelnut shells from US-grown cultivars. *International Journal of Food Science and Technology*, under reviewed.
2. Yixiang Xu, Andreia Bianchini, Milford A. Hanna. (2011). Evaluation of Mold and Mycotoxin Contaminations in Hybrid Hazelnuts Grown in Nebraska. *Journal of Food Processing and Technology*, 2, 5.
3. Yixiang Xu, Milford A. Hanna (2011) Nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal. *International Journal of Food Science and Technology*, 46, 2022-2029.

4. Yixiang Xu, Milford A. Hanna (2010) Nutritional quality and oxidative stability of oil extracted from hybrid hazelnuts. *International Journal of Food Science and Technology*, 45 (11), 2329-2336.
5. Yixiang Xu, Milford A. Hanna (2010) Evaluation of Nebraska hybrid hazelnuts: nut and kernel characteristics, proximate, oil and protein compositions. *Industrial Crops and Products*, 31 (1), 84-91.
6. Yixiang Xu, Milford A. Hanna (2009) Synthesis and characterization of hazelnut oil-based biodiesel. *Industrial Crops and Products*, 29 (2-3), 473-479.
7. Yixiang Xu, Milford A. Hanna, Scott J. Josiah (2007) Hybrid hazelnut oil characteristics and its potential oleochemcial application. *Industrial Crops and Products*, 26, 69-76.

Selection of project photo's

Figure 2. 64 hazelnut trees planted near Holdrege, NE

Figure 1. Hazelnut trees protected from pests and sun

Figure 3. Hazelnut leaves damaged by sun and wind

Figure 44. Hazelnut tree - fall foliage

Project Title

Evaluating the Potential for Reduced-Input Grape Production in Nebraska

Project Summary

Over 1.2 million grapevines existed on farms in Nebraska's eleven eastern counties in the late 1800s and early 1900s. A variety of factors, including the U.S. Constitutional Amendment known as Prohibition, extreme temperature events, diseases and other factors led to the demise of this once flourishing industry, an industry that was essentially defunct by the middle of the 20th Century. With the repeal of Prohibition in 1933, recent availability of new, more adapted cultivars (varieties), and the enactment of the Nebraska Farm Wineries Act in the mid-1980s, a renewed grape and wine industry emerged.

The most important constraint to successful grape production is disease pressure, necessitating as many as 6 to 10 fungicide applications per year in eastern Nebraska. Such sprays are costly to the grower and represent a significant pesticide load for the environment. Generally, dryer conditions such as those found in western Nebraska are more conducive to a reduced need for fungicide sprays, thus providing an excellent opportunity for reduced-input grape production. A further opportunity for organic grape production was also potentially anticipated as a result of new disease-tolerant cultivars and lines being developed by grape breeding programs in several northern states. Therefore, the focus was on developing an understanding of disease incidence and management and their impact on resulting grape yield and fruit quality.

Project Approach

Nationwide, there is an increased interest in organic wine consumption with major producers such as Gallo and Fetzer actively engaged in their production. Two cultivars, each of tolerant, intermediate, and disease-susceptible grapes, were tested by UNL's Viticulture Program (UNVP) at two sites -- one in eastern Nebraska and one in western Nebraska. No fungicides were applied and subsequent disease incidence, yield, and fruit quality were monitored for at least two years.

As a result of this research, it was anticipated that reduced fungicide use, and possibly fully organic practices, may be adopted by current and new grape growers resulting in less pesticide pressure on the environment and increased economic benefits to Nebraska and other Midwest communities.

The objectives of this proposal were to:

1. Identify disease pressure at two sites, one in eastern (humid) and one in western (semi-arid) Nebraska;

2. Determine if purportedly disease-tolerant genotypes can be successfully grown with reduced or no fungicide application; and

3. Influence growers to reduce pesticide use, especially fungicides, and to consider the feasibility of organic grape production in Nebraska (Technology Transfer via Field Days, Workshops and Extension Communications).

Goals and Outcomes Achieved

Objective #1: Identify disease pressure at two sites, one in eastern (humid) and one in western (semi-arid) Nebraska.

Below are the observations from the eastern and western Nebraska evaluations.

Eastern Nebraska Research site. All six cultivars evaluated (Frontenac, St. Croix, Valiant, Prairie Star, Lacrosse and Marechal Foch) exhibited varying degrees of susceptibility to Black Rot (*Guignardia bidwellii*), with Lacrosse, and Valiant the most severely affected. Marechal Foch exhibited modest Black Rot and Frontenac also showed slight symptoms. The most extreme cases of Black Rot symptoms resulted in berries turning black and hard and eventually falling off of the cluster. Downy Mildew (*Plasmopara viticola*) was of no consequence for Frontenac and St. Croix, while moderate symptoms were exhibited by Valiant and Prairie Star, with debilitating infections appearing on Lacrosse and Marechal Foch by late season (at *Veraison*, the onset of ripening). Phomopsis (*Phomopsis viticola*) was not exhibited by any of the six cultivars being tested, but Powdery Mildew (*Uncinula necator*) was slightly damaging to St. Croix, Valiant, Prairie Star, Lacrosse and Marechal Foch.

Cooperating Commercial Grower Vineyards (eastern Nebraska). Infection by Black Rot and Downy Mildew were not observed on Frontenac, St. Croix and Marechal Foch, but Black Rot infections of Lacrosse and Valiant were significant, with Prairie Star showing intermediate symptoms. Moderate symptoms of Downy Mildew occurred on Valiant and Prairie Star. Again, Phomopsis was not a problem on any of the six cultivars being evaluated, but Powdery Mildew symptoms developed late in the season on Lacrosse, Valiant and Marechal Foch.

Preliminary evaluation of results. Table 1 gives a snapshot of the results of 2011 grape disease severity evaluations. Based upon such preliminary observations, it is not recommended to grow these grapes in eastern Nebraska without spraying for fungal disease control. However, it appears that Frontenac could be grown with a reduced spray program, employing only Black Rot spray(s). St. Croix might also be practical to consider for a reduced spray program, since it only showed slight susceptibility to Black Rot and Powdery

Mildew. Additional observations were taken in the 2012 growing season to determine the feasibility of a reduced spray program in eastern Nebraska for Frontenac and perhaps one or more of the cultivars being tested. This relates to the second objective of this project, which was to determine if purportedly disease-tolerant genotypes can be successfully grown with reduced or no fungicide application.

Because extreme drought and above-average temperatures were experienced during the 2012 growing season, minimal to no disease symptoms occurred in the test vineyards in both eastern and western Nebraska. As a result, no conclusions could be drawn based upon 2012 disease observations (data not shown).

Table 1. Eastern Nebraska Grape Disease Severity – 2011

Cultivar	Black Rot	Downy Mildew	Powdery Mildew
Frontenac	X	0	0
St. Croix	X	0	X
Valiant	XX	X	X
Prairie Star	X	X	X
Marechal Foch	X	XX	X
Lacrosse	XX	XX	X

Rating Scale: XX = severe; X = moderate; 0 = absent or of no commercial concern. Phomopsis (*Phomopsis viticola*) was not a problem in the 2011 growing season.

Field Day. Disease problems were discussed as part of a Field Day held at Prairie Creek Vineyards, near Central City, Nebraska on July 30, 2011. Twenty-five people attended this event.

Grower Workshops. A grower workshop was held in Lincoln, Nebraska on December 3, 2011. Disease problems and their management were discussed as part of this workshop featuring Dr. R. Keith Striegler, University of Missouri Viticulture Specialist. Twenty-seven people attended this event. In 2012, a grower workshop on Pesticide Drift problems was held, cooperatively hosted by the UNL Viticulture Program, the NWGGA and the Northern Grapes Project. This workshop took place at the Southeast Community College (Lincoln Campus) and attracted 45 attendees, with an additional estimated 50 connected by webinar.

Western Nebraska Evaluations. Because of budget cuts, the research site at the Panhandle Research and Extension Center could not be used as a site for evaluating reduced input grape production. However, observations on cooperating commercial vineyards were pursued to compensate for loss of the PREC site, thus providing useful preliminary observations noted as follows.

Objective #2: Determine if purportedly disease-tolerant genotypes can be successfully grown with reduced or no fungicide application.

Fungicide Spraying. No sprays were employed on the two cooperating commercial vineyards reported in this section. Frontenac, Marechal Foch, St. Croix and Lacrosse are cultivars that are found on cooperating commercial vineyards. It was possible to obtain data from the PREC site prior to its termination on Frontenac, St. Croix, Marechal Foch, Prairie Star, Valiant and Lacrosse. Additional cultivars will be evaluated in 2012. Results from 2011 strongly suggest that it is possible to produce Frontenac, St. Croix, Prairie Star, Marechal Foch and possibly Lacrosse with few to no fungicide sprays. (Consideration of Valiant will not be continued because wineries have indicated no demand for this grape for winemaking purposes.) Data from the 2012 growing season were limited because of the drought conditions, but it can be concluded that based upon the 2011 results, growers may consider minimal spray programs on a preliminary basis.

Partner Contributions.

- Steve Gamet has been instrumental in management of eastern Nebraska vineyards and data acquisition.

- Mr. Ed Swanson has continued to provide advice on cultivar susceptibility, cultural practices and disease management. His experience with Lacrosse and Marechal Foch has been especially valuable.

- Mr. Peter Hemstad (University of Minnesota) and Dr. Bruce Reisch (Cornell University) have been helpful in evaluating cultivar performance, with Mr. Hemstad being especially helpful with regard to Frontenac.

- Mr. James Schild, Extension Educator, Scottsbluff County/PREC has assisted with the final observations and assessment of the grape planting at the PREC.

Objective #3: Influence growers to reduce pesticide use, especially fungicides, and to consider the feasibility of organic grape production in Nebraska (Technology Transfer via Field Days, Workshops, and Extension Communications).

Conclusions regarding reduced fungicide input and technology transfer to influence growers was addressed via the above noted 2012 Field Day and Workshop. The following conclusions can be drawn as a result of this research project:

1. A broad conclusion is that growers in western Nebraska can consider zero to minimal pesticide use for winegrape production in Nebraska.

2. In eastern Nebraska vineyards, reduced pesticide inputs can be considered on a trial basis.

3. Selection of cultivars exhibiting significant disease tolerance are a powerful aid in reducing pesticide use in both eastern and western Nebraska (e.g. 'Frontenac', 'Frontenac Gris', 'Norton' and to a slightly lesser extent, 'Edelweiss' and 'Saint Croix').

Beneficiaries

The immediate beneficiaries of this project are the more than 150 commercial grape growers in Nebraska who will gain a better understanding of sustainable and organic viticulture practices. Reduced pesticide use will result, thus making their enterprises more profitable while enabling them to deliver higher quality grapes to Nebraska's more than 25 wineries. Although the specific economic impact is difficult to measure in the short term, it has been well established that an "economic multiplier" effect occurs in communities where winery enterprises are developed. In addition, reduced pesticide use will have a positive impact on the environment.

Lessons Learned

Budgetary decisions at the Panhandle Research and Extension Center (PREC) at Scottsbluff determined that Extension Educator J. Schild could no longer be involved with the University of Nebraska Viticulture Program (UNVP) and that the land allocated to the UNVP research vineyard would no longer be made available.

These decisions necessitated that the western Nebraska component of this research program be conducted entirely on cooperating commercial vineyards, with no research to be conducted at the PREC. Fortunately, owners of three commercial vineyards have graciously offered their vineyards as sites on which appropriate observations and data could be collected. Modest preliminary data were collected on two of these vineyards in 2011, and additional disease ratings were obtained on all three in 2012.

The results obtained in the 2012 growing season-will further the objectives of this project. A Field Day to showcase the results of this research and to provide growers with hands-on opportunities to evaluate disease symptoms on the tested cultivars was held in western Nebraska during the summer of 2012. The 2012 results and a summary of recommendations was also presented at the 2012 Fall Viticulture Workshop. A summary of the results of this project will also be discussed at the 16th Annual Grape and Wine Forum and Trade Show in Kearney, Nebraska, on Saturday afternoon, March 2, 2013. A "Reduced Input Grape Production" Round Table will be held beginning at 3:00 p.m. Both University of Nebraska – Lincoln Viticulture Program personnel and Nebraska commercial grape growers will participate in the Round Table discussion.

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Additional Information

As new purportedly disease-resistant cultivars become available (i.e. from the "no-spray" Cornell University Program), reduced pesticide inputs will continue to be an important part of the UNVP's research and outreach thrusts.

A summary of results and recommendations will be posted on the UNL Viticulture Program web site and also presented in one or more issues of the *Nebraska VineLines*, which is a UNL Extension publication that is sent to Nebraska and Midwest region grape growers.

Project Title

Increasing Commercial Value of Byproducts from Hybrid Hazelnuts Grown in Nebraska-Recovery of Natural Antioxidants and Anti-Cancer Ingredients

Project Summary

A large amount of byproducts, including hard shell, green leafy husks, and leaves, are produced during hazelnut harvesting and industrial processing. Currently, these byproducts are disposed of as low-value heat sources or as an organic soil amendment. Commercial value from these byproducts has been rarely explored. Hazelnut byproducts are rich in natural antioxidants, anti-cancer, and phenolic compounds, and are a reliable source of new and efficient natural antioxidants. These high-value antioxidants can be used as nutraceuticals, dietary supplements, and pharmaceuticals. They render beneficial biological activities and health benefits by reducing the risk of age-related diseases, such as cardiovascular disease and cancer.

However, research on these antioxidants is lacking. In addition, the use of hazelnut byproducts, as potential sources of nutraceuticals and functional food ingredients, could provide new revenue streams for the hazelnut industry to increase the overall commercial value of hazelnuts. Hence, the objectives of this project was to investigate the antioxidant constituents and their concentrations in different Nebraska hybrid hazelnut byproducts using different extraction processes and to assess their antioxidant and antiradical activities for potential opportunities to increase their commercial value.

This project builds on a series of previously funded projects on general nut/kernel characteristics, nutritional quality of extracted oil and defatted meal, and nut/kernel mold contamination. The results from the previously approved projects are important, and supported the University of Nebraska – Lincoln's (UNL's) Industrial Agricultural Products Center (IAPC) initiative to extend research to address improving commercial values of the byproducts.

Project Approach

Following are summaries of the experiments conducted to address the specific objectives.

Nebraska hybrid hazelnuts, cultivated at UNL's East Campus research plot, were hand-harvested only in the Fall 2010. The nuts were de-hulled mechanically, sorted by size, and cracked mechanically. Following separation of the kernels, the shells were packaged and stored under frozen conditions until analyzed. Dried shells were frozen using liquid nitrogen and ground using a micro-mill grinder (Bell-Art Mini Mill) to pass a 20 mesh size of the sieve for fiber analysis. The screened material was further ground to pass through a 40 mesh size of the

sieve for all other analyses. Commercial hazelnut cultivars grown in Oregon were used as a comparison.

Chemical composition

Analyses of crude protein, crude lipid, ash, and crude fiber were performed using the methods as described by Association of Official Analytical Chemists (AOAC, 2000). Crude protein content was measured using the combustion method (AOAC 990.03) with a *Vario MAX CN* (Elementar Americas, Inc, NJ). Oil was extracted from dried, ground samples using 50 mL of hexane in a Soxhlet apparatus for 8 h (AOAC method 948.22). Ash was determined using dried samples following AOAC method 950.49. Carbohydrate content was determined by subtracting the total percentage of other components from 100. Crude fiber was measured by digesting the samples with 1.25% (w/v) H_2SO_4 followed by NaOH (AOAC method 962.09).

Antioxidant composition and activity

Natural antioxidant was extracted using an aqueous acetone 80% (v/v). Ground sample (250 mg) was mixed with 10 mL of aqueous acetone, subjected to ultrasonic treatment for 20 min at room temperature, and then centrifuged for 10 min at ~4000 rpm and 4 °C. The supernatant was collected, blown under nitrogen and stored at 4 °C prior to analysis. For phenolic compounds, total and simple phenolic compound concentrations were determined by the Folin-Ciocalteu method (Makkar *et al.*, 1993). Both total phenolics and tannins were expressed as tannic acid equivalent (TAE) on a dry matter basis. Condensed tannins were measured according to Porter *et al.* (1986) and were expressed as leucocyanidin equivalent (% in dry matter). Antioxidant activity of hazelnut shell extracts was analyzed using 2, 2-Diphenyl-1-picrylhydrazyl ($DPPH^{\bullet}$) and 2, 2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) ($ABTS^{\bullet+}$) radical scavenging capacity assays (Bloom 2009).

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, the chemical composition, phenolic compounds (total phenolics, tannins, and condensed tannins), antioxidant activity ($DPPH^{\cdot}$ and $ABTS^{+\cdot}$ assays), and the relationships between phenolic compounds and antioxidant activities of the hazelnut shells from Nebraska hybrid hazelnuts were investigated for potential commercial development. The work is an integral part and plays very critical and important roles in achieving long-term term outcome measures for the project. With the information on hazelnut kernel quality and nutritional traits plus food safety issues completed in the previous works, extracting natural antioxidants from the waste will promote the commercial values of Nebraska hybrid hazelnuts.

Beneficiaries

First, over 100 Nebraska specialty nut crop producers, food processors, nut traders will benefit from reading about the results through internet reports on the IAPC web site (http://www.agproducts.unl.edu) and poster presentation/handouts at events typically attended by specialty nut crop producers.

Further, the 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

Total carbohydrate was the predominate component in all hazelnut shells with crude fiber accounting for over 85%. Protein was the second major component in the shells, followed by ash and oil. There were no clear distinctions between compositions of Oregon cultivars and Nebraska hybrid cultivars.

The Oregon cultivars presented significantly higher total phenolic content, tannins, and condensed tannins, while average concentrations in Nebraska hybrid hazelnuts were 2- to 5-fold lower than their Oregon counterparts. Variation in phenolic compound levels between Oregon and Nebraska cultivars could be attributed to many factors, including cultivar, climate, environment, and agronomical management. Since hybrid cultivars are not planted in Oregon and European cultivars cannot survive in Nebraska, it is difficult to determine which factors make significant contributions to the observed variability.

All extracts exhibited strong antioxidant activity. $DPPH^{\bullet}$ radical scavenging activity ranged from 65.9% to 74.8% reduction in $DPPH^{\bullet}$ percent concentration after 20 min. $ABTS^{\bullet+}$ antioxidant activity was two to three times higher in the Oregon cultivars compared to the Nebraska hybrids.

In conclusion, the hard shells hazelnut cultivars were found to be rich in carbohydrate, especially crude fiber. No clear distinction existed in chemical compositions between Oregon cultivars and Nebraska hybrid cultivars. However, the Oregon cultivars had significantly higher concentrations of phenolic compounds compared to their Nebraska counterparts. The results suggest that hazelnut hard shell may serve as a potential source of natural antioxidants for food applications.

The respective procedures are effective at evaluating the potential value of hazelnuts.

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Additional Information

The manuscript was submitted for publication on International Journal of Food Science and Technology.

Publications related to Nebraska hazelnuts:

8. Yixiang Xu, Edward Sismour, John Parry, Milford Hanna, Haiwen Li (2011) Chemical composition and antioxidant activity in hazelnut shells from US-grown cultivars. *International Journal of Food Science and Technology*, under reviewed.

9. Yixiang Xu, Andreia Bianchini, Milford A. Hanna. (2011). Evaluation of Mold and Mycotoxin Contaminations in Hybrid Hazelnuts Grown in Nebraska. *Journal of Food Processing and Technology*, 2, 5.

10. Yixiang Xu, Milford A. Hanna (2011) Nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal. *International Journal of Food Science and Technology*, 46, 2022-2029.

11. Yixiang Xu, Milford A. Hanna (2010) Nutritional quality and oxidative stability of oil extracted from hybrid hazelnuts. *International Journal of Food Science and Technology*, 45 (11), 2329-2336.

12. Yixiang Xu, Milford A. Hanna (2010) Evaluation of Nebraska hybrid hazelnuts: nut and kernel characteristics, proximate, oil and protein compositions. *Industrial Crops and Products*, 31 (1), 84-91.

13. Yixiang Xu, Milford A. Hanna (2009) Synthesis and characterization of hazelnut oil-based biodiesel. *Industrial Crops and Products*, 29 (2-3), 473-479.

14. Yixiang Xu, Milford A Hanna, Scott J Josiah (2007) Hybrid hazelnut oil characteristics and its potential oleochemcial application. *Industrial Crops and Products*, 26, 69-76.

Project Title

Japanese Beetle Survey

Project Summary

The goal of this project was to conduct a comprehensive survey of Nebraska nursery dealers and growers, to determine the presence or absence of Japanese beetle (*Popillia japonica*) populations at those facilities. This information was then used to certify Nebraska grown nursery stock for international and interstate movement, to areas that have enacted quarantines to prevent the introduction of Japanese beetle.

Project Approach

In 2011, Nebraska Department of Agriculture field staff set, monitored, and retrieved 291 traps, in 39 counties, at nurseries, focusing on high-volume importers, and firms shipping interstate and internationally. Traps were required to remain in place until at least October 1. A total of 17,990 beetles were trapped statewide, with 15 counties having positive traps. Positive traps were found in the following counties: Adams, Buffalo, Cass, Dakota, Douglas, Gage, Hall, Lancaster, Lincoln, Red Willow, Saline, Sarpy, Saunders, Thayer and Washington.

Soil sampling was conducted March through May, 2011, at select firms in known infested counties, where Japanese beetle (JB) populations had previously been confirmed via trapping. Firms were selected based on several factors, including level of infestation and nursery production methods. A total of 481 soil samples were collected over 354 acres, for 14 firms in seven counties. No Japanese beetle grubs were found.

Firms in known infested areas that wished to ship interstate or internationally may request to certify their nursery stock, based on application of specific chemicals. While this was an option available to nursery stock shippers, none exercised this option, and as a result, NDA inspection staff witnessed zero chemical treatments for JB certification in 2011.

A radio public service announcement informing the public on the purpose of and need for this survey ran from June 13-19, 2011. It was available on the NDA web site, and carried by various radio stations statewide. The Department also has over 2,600 individuals that have subscribed to receive these reports directly.

Goals and Outcomes Achieved

The goal of this project was to conduct a comprehensive survey of Nebraska nursery dealers and growers, to determine the presence or absence of Japanese

beetle (*Popillia japonica*) populations at those facilities. This information is then used to certify Nebraska grown nursery stock for international and interstate movement, to areas that have enacted quarantines to prevent the introduction of Japanese beetle.

Measurable outcomes for this project included:

1. Disseminating survey information in the NDA Entomology Program Annual Report;

2. Direct mailing of JB certification requirements to licensees;

3. Incorporating project results on the NDA web site;

4. Inclusion of survey results on the NDA Entomology Program display booth at Nebraska Green Expo; and

5. Submission of relevant articles to the NNLA newsletter.

Each of these objectives either have been met, or is on track to be met. The supporting documentation for this is listed below.

Information on NDA Japanese Beetle Survey Activities was disseminated at the Nebraska Green Expo Conference in Council Bluffs, January 10 – 12, 2011. This included information on the 2010 survey results, historical finds, and upcoming survey plans for 2011. Information on how to request a site to be surveyed was available at this event, along with information on interstate and international shipping and receiving requirements. This event had 723 registered attendees from the nursery, landscape and turfgrass industries. A verbal presentation was also given as part of the Nebraska Nursery and Landscape Association (NNLA) Annual Business Meeting, on January 11, 2011, with approximately 75 nursery representatives in attendance. Additional outreach was conducted at the Nebraska Arborists Association (NAA) Annual Winter Meeting, held February 28, 2011, with approximately 200 attendees; the Governor's Ag Conference, held March 1-2, 2011, with 200 attendees; NNLA/NAA Summer Field Day, August 12, 2011, with approximate attendance of 75 individuals from the nursery and arborist industries.; and the Nebraska State Fair, August 26 – September 5, 2011, with attendance of 333,043 individuals. This outreach included display boards and informational handouts with specific information on Japanese beetle, the NDA Entomology Program Annual Report, survey and trapping work, and interstate and international shipping and receiving requirements.

Additionally, NDA staff wrote newsletter articles for the November 2010 NNLA Newsletter, addressing Japanese Beetle concerns for the state, and encouraging

firms interested in participating in the survey to contact the Department. This newsletter is sent to all NNLA members, and is also available on their web site.

Since the beginning of this project, NDA issued 47 state and federal phytos to facilitate the movement of nursery stock interstate and internationally, certifying 13,200 individual plants as meeting the Japanese Beetle requirements of the receiving state or country. NDA has also entered into three compliance agreements with firms that regularly ship nursery stock interstate. These firms generally have a strong track record of interstate shipping, and have demonstrated their willingness and ability to understand and follow requirements under the Nebraska Plant Protection and Plant Pest Act, and those of the receiving state. Firms under a compliance agreement must sign an agreement with NDA, attesting that they will meet certain standards. They are then able to certify their own shipments as meeting a specific state's JB entry requirements. Without a compliance agreement, a firm would have to obtain a state phyto for each shipment. Firms under a compliance agreement can ship with proof of compliance in lieu of a state phtyo. NDA updated those agreements for 2012 so there was a reporting requirement for the number of shipments and number of plants certified using this process. NDA staff continues to survey, inspect and oversee the firms, and will terminate the agreements if used improperly.

Phytosanitary certificate issuance numbers from 2009 were used as a benchmark against which to compare 2011 data. The total number of certificates issued and the total number of plants shipped were compared with 2009 data to determine if there was an increase in either the number or volume of material shipped. From the recorded data listed below, there was an increase on the number of phytosanitary certificates issued and the total amount shipped in 2011 compared to 2009. The expected target goal was an increase in the total amount of nursery stock shipped. This goal was achieved. For the sake of comparison, also listed is the data from 2010 and 2012.

2009 OR – 2 certificates, 596 plants
Canada – 9 certificates, 15,263 plants

2010 CO – 5 certificates, 4,853 plants
IA – 2 certificates, 87 plants
OR – 2 certificates, 130 plants
Canada – 21 certificates, 28,606 plants
Compliance agreements – 1 for CA, number of plants are not available

2011 CO – 23 certificates, 4,447 plants
OR – 2 certificates, 396 plants
WA – 2 certificates, 7 plants
Canada – 19 certificates, 24,222 plants
Compliance agreements – 2 CO, 1 for CA, 1 for WA, number of plants are not available

2012 CO – 5 certificates, 188 plants
OR – 2 certificates, 175 plants
SD – 1 certificate, 80 plants
Canada – 7 certificates, 8,683 plants (these numbers are much lower due to Canada deregulating several provinces and no longer requiring JB information on the certificates
Compliance agreements – 1 CO agreement for 10 shipments with 548 plants, CA- 1 agreement for 121 shipments with 31,971 plants

Lessons Learned

NDA received a one year extension of the initial project, in order to complete all the goals and objectives. The original timeline for work conducted as part of the one-year project actually extended past the initial September 2011 end date, and so NDA requested and received a one year extension to complete the retrieval of traps and dissemination of information.

Beneficiaries

The beneficiaries of this project primarily include individual within the Nebraska nursery and landscape industry. There are over 1,200 licensed Nebraska Nursery Dealers and Nursery Growers in the state. There are also a significant number of Nebraska sod producers need certification in order to legally move their product from our partially-infested state to uninfested states. Firms that have positive beetle catches in their traps can request additional regulatory work, such as soil sampling or treatment verification, to meet certification standards. Additionally, early information on infestations is important, not just in terms of product certification, but also for management purposes. Japanese beetle has a broad host range of well over 300 plant species, from landscape plants to corn, soybeans and grapes. Documenting infestations in uninfested areas allows producers to consider and implement appropriate management techniques for their particular crop and situation. An overall benefit of this survey project was the determination of Japanese beetle status, on a county-by-county basis. In areas where beetle numbers are low, soil survey or additional trapping to delimit the population may be sufficient to achieve certification. In areas where beetle numbers are relatively high, NDA can assist producers in choosing best management practices to reduce beetle numbers within their operation, and witness treatment applications for certification. The SCBGP-FB funding also allowed trapping and survey work at nurseries that may otherwise not be able to afford the regulatory work.

NDA staff disseminated the information through the NDA Entomology Program Annual report, various display booths (including those events attended in 2010), and the NDA web site (by January 15, 2012). Additionally, updated information on the known infested areas in Nebraska, and interstate and international

shipping requirements, will be sent to the approximately 1,200 NDA Nursery licensees, through a direct mailing by March 1, 2012. A follow-up article will be submitted to NNLA for inclusion in their Spring 2012 newsletter, providing results from the 2011 survey, and updates to interstate and international shipping requirements.

As stated in the Goals and Outcomes Achieved portion of this report, this project also benefited the attendees at the Nebraska Green Expo Conference, NNLA Annual Business Meeting, NAA Annual Winter Meeting, Governor's Ag Conference, NNLA/NAA Summer Field Day, and Nebraska State Fair. It also benefited the readership of the NNLA Newsletter and the NNLA web site.

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Additional Information

None.

Project Title

Increase Profitability of Specialty Crop Entrepreneurs at the Siouxland Garden Show

Project Summary

The purpose of this project is to help specialty crop entrepreneurs expand the exposure and increase the profitability of their products and services through the Siouxland Garden Show held in South Sioux City, Nebraska. In order for the producers' market for specialty crops to expand, consumers need more exposure to the wide variety of specialty crop producers in the Siouxland area. The project was designed to increase the competitiveness & visibility of regional entrepreneurs in the multi-state area that produce horticulture specialty crops. The Siouxland Garden Show provided education and opportunities for entrepreneurs to showcase and sell their horticulture specialty crops and value added products.

Project Approach

Regional specialty crop businesses were invited to be vendors at the Siouxland Garden Show. At the event, they had the opportunity to increase the exposure of their products and services to thousands of people. The vendors ranged from local specialty crop growers of new and/or established crops such as aronia berries, irises, or trees to regional chain stores like Earl May and Bomgaars who are distributors of locally grownnursery and flower crops. When surveyed six months after the show, one hundred percent of the vendors reported their business increased in leads for potential customers, new customers, sales, and store traffic as a result of being a vendor at the Siouxland Garden Show. Sixty-four percent reported an increase of eleven or more leads, and fifty percent reported an increase of eleven or more new customers. Ninety-one percent reported an increase in gross revenue ranging from $1,000 to over $10,000 since the March 2011 Siouxland Garden Show.

All of the vendors surveyed said attendees at the Siouxland Garden Show became more aware of specialty crop plants, horticultural products and related services. Ninety percent of the vendors recounted on the survey that 100 or more people learned about their specialty crops and/or services at their booth during the show. All of the businesses surveyed listed that they gained exposure for their business, specialty crops, and/or services at the Siouxland Garden Show.

"Our product is a new concept, essentially unknown, so having a venue for demonstration works well for us, and we obtain feedback from prior customers," said one vendor. Funds from the grant helped with marketing the Siouxland Garden Show. Marketing channels included radio, television, magazines, newspapers, billboards, social media and web sites. Approximately 5,000 people

attended the 2011 Siouxland Garden Show. The attendees were primarily from Nebraska, South Dakota, and Iowa with participants coming from a total of nine states throughout the country. Ninety-eight percent of the attendees, who completed an evaluation, said they are more likely to purchase locally grown products after attending the Siouxland Garden Show. Speakers presented 30 educational talks at the Siouxland Garden Show. Many of the speakers encouraged attendees to become a specialty crop producer/vendor or taught those who are currently producing specialty crops how to have greater success. Presenters also educated general attendees on the value of growing specialty crops themselves or purchasing specialty crops from others. Based on a survey conducted at the Siouxland Garden Show, ninety-two percent of those who attended educational sessions said the information presented by the speakers was beneficial to them. When asked if the presentations encouraged them to consume fruit, vegetables or other specialty crops, seventy-three percent said "yes."

Ninety-seven percent said they plan to put into practice what they learned from speakers. From the presentations, survey participants said they learned how to grow a specialty crop, plan to grow a specialty crop they haven't grown before, and/or plan to increase the variety of specialty crops they grow. Seventy-nine (6%) of the 1,312 people who filled out the survey plan on selling some or all of the specialty crops they grow. A workshop for specialty crop entrepreneurs entitled, "Promote Your Product" was held before the Siouxland Garden Show. The workshop was open to all specialty crop producers and vendors. The workshop was advertised to local and regional farmers' market vendors, University Extension program participants and past Siouxland Garden Show vendors. Twenty-four people attended the program that focused on engaging potential customers, making the most of vending space, creating an appealing product display, matching marketing style with business, signage that sells, and developing leads.

A six month follow-up survey indicated that sixty-six percent of those who attended the workshop implemented what they learned. This survey also showed that 50 percent of those who attended the workshop implemented the following strategies learned at the workshop: making the most of their space, creating an appealing product display, and signage that sells. Fifty percent also said they increased the visibility of their business as a result of attending the workshop. Thirty-three percent said they have a better booth display due to the changes they made after attending the workshop. The planning committee of the Siouxland Garden Show consists of representatives of the University of Nebraska –Lincoln (UNL) and Iowa State University (ISU) Extension, ISU Extension Master Gardeners, and local specialty crop producers and vendors of specialty crops.

UNL and ISU Extension worked cooperatively in securing speakers, marketing the "Promote Your Product" event and the Siouxland Garden Show in

publications, radio and TV and evaluation of the workshop and the show. UNL Extension provided leadership for this grant. Local specialty crop producers provided evaluation input for the evaluation tool used for each event.

Goals and Outcomes Achieved

The two activities completed as part of the grant were the "Promote Your Product" workshop and the Siouxland Garden Show. Ninety one percent of the vendors reported a measurable increase of sales due to the Siouxland Garden Show in the follow-up survey six months after the event. The one goal established in the grant proposal was to increase attendance at the Siouxland Garden Show by 15 percent. The attendance stayed the same as the previous year. However, that did not negatively impact the success of the specialty crop growers as 91% reported an increase in sales due to the Siouxland Garden Show.

A survey was conducted six months after the show. One hundred percent of the vendors reported an increase in leads for potential customers, new customers, sales, and store traffic as a result of being a vendor at the Siouxland Garden Show. Sixty-four percent reported an increase of eleven or more leads, and fifty percent reported an increase of eleven or more new customers. Ninety-one percent reported an increase in gross revenue ranging from $1,000 to over $10,000 since the March 2011 Siouxland Garden Show. All of the vendors surveyed said attendees at the Siouxland Garden Show became more aware of specialty crop plants, horticultural products and related services. Ninety percent of the vendors recounted on the survey that 100 or more people learned about their specialty crops and/or services at their booth during the show. All of the businesses surveyed listed that they gained exposure for their business, specialty crops, and/or services at the Siouxland Garden Show.

Beneficiaries

Due to the Specialty Crops Grant, thousands of people became aware of the products and services of regional specialty crop businesses through the Siouxland Garden Show. The vendors ranged from local specialty crop growers of new and/or established crops to regional chain stores.

Specialty crop producers also learned new business marketing techniques by attending the "Promote Your Product" workshop. Approximately five thousand attendees had the opportunity at the Siouxland Garden Show to benefit from the project by becoming more aware of specialty crops in the area. Over 1,100 people who attended educational programs on specialty crop topics felt the information would benefit them, according to the speaker evaluations at the Siouxland Garden Show. As a result of specialty crop sessions, 704 people said they would be increasing their consumption of fruits, vegetables and other specialty crops. Ninety-seven percent, or 869 people, said they would put into

practice ideas learned from specialty crop speakers. Two hundred sixty people learned how to grow a specialty crop they had not grown before. One hundred ninety-six people were planning to increase the variety of specialty crops they grow. One hundred thirty were planning to expand the amount of specialty crops they already grow. Three hundred twenty- eight people learned how to better grow a specialty crop. Two hundred twenty-nine youth also learned about specialty crops in the Children's Corner at the show. They planted marigolds, discovered the parts of a flower, colored pages that illustrated specialty crops, and several other child-friendly activities related to specialty crops. Local businesses such as hotels, gas stations, restaurants and retail stores, increased their sales during the two-day Siouxland Garden Show. UNL and ISU Extension both furthered their missions by providing more people with research-based education. The Nebraska Department of Agriculture also gained exposure from talks given by Casey Foster. Topics included "Nebraska Farmers Market Programs: Opportunities and Benefits" and "Selling Strategies for Nebraska Produce Growers" at the Siouxland Garden Show.

Lessons Learned

From the "Promote Your Product" workshop, we learned that established vendors weren't as willing to participate in discussion because they were reluctant to share their "trade secrets". They also weren't as open to try new ideas. New vendors were excited to be there and gather useful new ideas. Participant comments included:

> "...beneficial on how to get started..."
>
> "(I have) immediate plans to improve (my) booth."
>
> "Very informative. We are first time vendors at the garden show."
>
> "Being a specialty crop vendor at the Siouxland Garden Show increases a business' leads, new customers and sales."

The Siouxland Garden Show is an excellent venue to educate thousands of people on the value of specialty crops. This increased consumption and sales of specialty crop products and services among attendees at the show.

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Additional Information

Photographs of the Siouxland Garden Show are available upon request.

Project Title

Enhancing Good Agriculture Practices to Today's Disadvantaged Farmers and Tribal Members

Project Summary

The primary purpose of this project was to:

1. Foster and to support the development of community farms and farmers' markets;

2. Encourage widespread individual production of specialty crops among tribal members and beginning Nebraska farmers in general;

3. Improve beginning farmer cash flows through such production;

4. Increase participation in beginning farmer programs among socially disadvantaged producers of specialty crops; and

5. Foster and to support the use and consumption of locally produced specialty crops in regional public and Tribal schools.

The importance of this project was seen to lie in:

1. Support for small-scale agricultural enterprises among socially disadvantaged producers, as an engine for economic growth; and

2. Encouragement of the production and consumption of nutritionally superior food.

It seemed a remarkable timely project given the dovetailing of interest in local food production, primarily for nutritional purposes, and support for the incorporation of small-scale direct marketing enterprises among beginning farmers.

Project Approach

The overall approach of the project was to:

1. Prepare useful and useable information on various aspects and activities of direct farm marketing, including Community Supported Agriculture, Farm-to-School, Farm-to-Table, and Farmers' Markets;

2. Disseminate this information broadly;

3. Conduct workshops for interested parties; and

4. Meet one-on-one with those individuals interesting in seriously pursing direct marketing enterprises.

We (Legal Aid of Nebraska (LAN)) worked with low income Native American farmers and tribal members, along with tribal leadership councils and staff, to encourage local production and consumption of specialty crops. The intent was that this will promote nutritional health, individual enterprise, and economic self-reliance through the use of existing resources with minimal capital investment.

Our Farm and Ranch staff assembled, analyzed, distilled, and disseminated information on the establishment of and participation in community gardens, farmers' markets, cooperative ventures, and Farm-to-School programs.

We researched and prepared direct marketing information in various formats, including handouts, power points and brochures. This information was then disseminated in various manners and forums. We then scheduled and advertised workshops in and near Tribal areas. We attended the Winnebago Farmers' Market and met with participants to discuss local food production. We disseminated materials throughout the Tribal areas as well as in statewide venues such as Husker Harvest Days and the Nebraska State Fair, where we staffed information booths and met with individuals to answer questions and discuss direct marketing. We distributed approximately 125 brochures and discussed material with approximately 74 interested parties.

We distributed materials, including brochures, throughout the Winnebago and Omaha tribal areas. We conducted workshops and a clinic in Center, Nebraska, in which we worked with 4 participants, including tribal members, to discuss local food enterprises, and beginning farmer enterprises.

The materials produced under this grant have also been made available and distributed throughout the state in monthly Nebraska Farm and Ranch Legal and Financial Clinics (Norfolk, Fairbury, Valentine, Ainsworth) (Approximately 47 copies of material disseminated.)

Goals and Outcomes Achieved

We were able to produce useful and useable information and materials on various aspects of direct farm marketing. This information and material was widely disseminated and we will continue to make it available. This part of the work of the grant was accomplished with success.

More specifically, we prepared information covering federal, private, and state support for such programs and activities. It covered the legal and operational risks incurred through participation in such programs. This information was

assembled into four written documents and one power point presentation. The documents discussed, in detail, how to create, expand, and participate in Farm-to-School programs, Community Supported Agriculture (CSAs), and farmers' markets. It addressed the amount of work involved to ensure an operation meets the requirements of a Farm-to-School program, how CSAs work and the benefits and challenges of selling through a CSA, how to sell directly to restaurants, and guidelines for starting and/or selling at a farmers' market. The documents addressed the reliability of these markets, how to meet their demands, and the risks and liabilities associated with selling through these outlets.

2011

This information was disseminated in the form of written materials at meetings with LAN staff. It was available at the Justice Center, Macy Tribal Court, Winnebago Community Center, Little Priest Tribal College, and HoChunk Tribal Headquarters.

At Husker Harvest Days in Grand Island, Nebraska, in 2011, we had approximately 280 inquiries and approximately 45 copies of the documents were disseminated

At the Women in Ag Conference in Kearney, Nebraska, in 2011, there were 108 attendees who attended our workshop and approximately 75 copies of each write-up was disseminated. Jo Hawbaker was the featured presenter at the workshop.

Materials have also been made available and distributed through monthly Nebraska Farm & Ranch Legal and Financial Clinics in Norfolk, Beatrice, Valentine, and Ainsworth. Approximately 35 copies of these materials were disseminated in 2011.

A Power Point presentation of selling to restaurants was created to be used at future workshops.

A Tribal Specialty Crop Hotline was established by using the existing Rural Response Hotline to provide instant information and referrals to members of the target population who are looking to begin or increase specialty crop production including those pursuing farmers' markets and/or Farm-to-School distribution. In 2011, approximately 5 calls were made to the hotline that include questions and interest in specialty crop production.

2012

In 2012, we attempted to attract interest to conduct three workshops in or near Tribal areas on direct marketing enterprises. We were able to conduct only one such workshop as we encountered an apparent lack of interest in attending the workshops. We attribute this lack of interest primarily to two things. First, the remarkable and unexpected change in the strength of traditional and

conventional agricultural practices seemed to dampen interest in alternative production. Second, the lack of resources available to commence even small scale enterprises was an obstacle we had not perhaps sufficiently foreseen. This problem was compounded both by tribal land ownership and management arrangements and by the remarkable escalation in land values that have occurred in the last two years.

In the workshop we did conduct, we were able not only to discuss generally the various types of direct marketing and the support for such programs, but then to work one-on-one with 4 individuals to answer questions and make suggestions. We expect that these individuals will continue to make use of our services through our ongoing clinics. We are also hopeful that the dissemination of material, the contacts created in trying to put together workshops and our intention to continue to disseminate the material prepared under this project will lead to more opportunities for interested individuals to start up direct farm marketing enterprises and to seek our assistance in structuring and analyzing the enterprise.

At the Winnebago Farmers' Market, we met with met with approximately 13 market patrons. We distributed and discussed local food materials with the patrons.

At the Little Priest Tribal College, Winnebago, Nebraska, we distributed materials to 21 individuals.

At the Nebraska State Fair booth, which was staffed in conjunction with NDA, we distributed 36 brochures and discussed material with 28 interested parties.

At the Winnebago Community Center, we distributed materials to 11 individuals.

At Husker Harvest Days in Grand Island, Nebraska, we staffed a booth, distributed 89 brochures, and discussed materials with 46 interested parties.

We conducted a workshop and clinic in Center, Nebraska, on September 21, 2012. Four people attended, which included tribal members. Local food enterprises was a key topic of discussion with the attendees.

Materials have also been made available and distributed through monthly Nebraska Farm & Ranch Legal and Financial Clinics (Norfolk, Fairbury, Valentine, Ainsworth). Approximately 47 copies of material have been disseminated.

Beneficiaries

In addition to the workshop attendees, we believe the benefit of this project extends primarily to the numerous individuals we have met with and who have

received our materials. These individuals have thereby been made more fully aware of the nature, risks, benefits, and support for direct farm marketing opportunities. We also believe that the Nebraska Farm Hotline, and its partners, including Interchurch Ministries and the Farm Mediation Service Clinics, have benefited greatly in the deepening of their service to include knowledge of direct marketing opportunities, structures, and support. This expanded expertise will continue to be made available to Tribal members and other socially disadvantaged producers through the ongoing numerous services of these groups.

Lessons Learned

Initially, we found it difficult to use electronic and telephone communications to find partners to disseminate materials and host seminars within the Tribal areas.

In addition, strong agricultural prices for traditional production have tempered interest in local food production among some resource owners and producers. We have accomplished much of this work through the dissemination of useful materials in the tribal areas.

We continue to believe that there is true opportunity for individual entrepreneurial enterprise in direct farm marketing. We believe this even more strongly as a result of the work which we undertook under this project. However, the obstacles to our hopeful intention to assist a number of individuals in setting up such enterprises were formidable. These obstacles included primarily the astounding strength that has moved through the conventional row-crop agriculture in the past two years and the attendant remarkable increase in assets and resource values, effectively putting those resources out of reach to would-be beginners. In addition, and in particular with respect to our goals in the Native American communities, we were frustrated by the arrangements for management of tribal lands, which effectively put those resources out of direct reach of individual Tribal members. It appears from our discussions with Tribal educators and leaders, however, that at least among the Winnebago Tribe this manner of land management may be changing and that there may be opportunities in the near future to put to use the expertise we have developed under this grant to assist in a Farm-to-School effort in Winnebago. In addition, and in support of this hope, we are researching and preparing presentation material on the intersection of Tribal Law and succession/estate planning. We believe this will be a topic that will attract participants, which might further our efforts to encourage local food production.

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Additional Information

None.

Project Title

Increasing Accessibility and Nutritional Knowledge of Nebraska's Specialty Crops at Farmers' Markets

Project Summary

The Old Cheney Road Farmers' Market (OCRFM) identified the need to improve the accessibility of fresh, locally-grown produce to all community members, especially to members of the community who are underserved (low-income population). In this project, OCRFM partnered with St. Paul's United Church of Christ's Farmers' Market to increase the accessibility by providing Electronic Benefits Transfer (EBT) machines at both markets so that Supplemental Nutrition Assistance Program (SNAP) benefits could be used. These machines would increase the consumption of specialty crops by customers receiving those benefits.

This project also provided specialty crop nutrition and health education to customers at Lincoln farmers' markets. OCRFM developed a series of nutrition education outreach activities with assistance from UNL Nutrition and Education Extension Educators at markets in Lincoln.

The goals of this project were two-fold. The goals and their respective objectives are listed below.

Goal #1: Increase the nutrition knowledge among adults and children of fresh foods, particularly the specialty crops that are available at Lincoln farmers' markets.

> Objective #1: Provide adults and children relevant information regarding health and nutrition.
>
> Objective #2) Teach adults and children how select, prepare and store specialty crop items found at farmers' markets.
>
> Objective #3) Teach adults how to effectively apply health and nutrition information in helping themselves and their young children live healthier lives.

Goal #2: Increase the accessibility of specialty crops at Lincoln Farmers' market via SNAP benefits.

> Objective #1: Provide low income citizens accessibility to fresh farm products.
>
> Objective #2: Provide farmers the ability to accept SNAP benefits to sell

their products to underserved clients.

Project Approach

Activities under this project focused on developing a system to accept SNAP benefits at Lincoln farmers' markets, to increase SNAP participation at farmers' market, and to provide nutrition education at those markets.

Outreach and educational resources were made available at markets. Resources included recipes and handouts focused on nutrition and food safety. Cooking demonstrations and information booths also aided in these efforts. Ten cooking demos were held that focused on preparing healthy dishes using market products. These demos provide shoppers an opportunity to see first-hand how to prepare food dishes and allowed them an opportunity to ask the chef questions about the ingredients and preparation. These events also helped to connect small, local restaurants and chefs to the market. Southeast Community College's culinary program continues to be a partner with OCRFM for these events.

Alice Henneman, UNL Extension Educator, provided information on food safety, nutrition, and preparation at a booth during 4 weeks of the 2012 season, reaching over 100 market patrons. The collaboration between UNL Nutrition Extension and OCRFM was an essential partnership that aided in the project's success.

Below is a more detailed summary of this project's success.

1. Approximately 62 seasonal recipes were shared with market patrons. They were also uploaded to the OCRFM's web site and were sent via email.

2. OCRFM sent out 46 market emails, which included recipes and links to information on health and nutrition. Every time an e-maio was sent, it reached 300 – 500 consumers.

3. An information booth was staffed every Sunday at the OCRFM and provided customers with several different handouts from UNL Extension Nutrition. These handouts included information on how to select, store, and prepare specialty crops sold at the market. The handouts were very popular with the market patrons. Each season, as many as 900 consumers had access to this information.

It is also important to note that SNAP! Market Match Program, which was launched in 2012. Because of the extension and left over money, OCRFM's board of directors agreed to match up to $2,000 in SNAP benefits used at OCRFM in September and October. The matching program increased the purchasing power for SNAP users. SNAP participants were able to utilize their

benefits at the market. Remaining grant funds were used to advertise the project, print fliers and education materials, and to pay for personnel time to administer this project.

The OCRFM formed a partnership with the Lincoln Food Bank to help spread the word about the SNAP! Market Match Program. Information was disseminated through various outreach projects such as the Backpack Program. It enabled OCRFM with the opportunity to reach hundreds of new customers. The Food Bank also assisted in translating project materials into Spanish.

As a result of this partnership. the SNAP! Market Match more than doubled the number of SNAP customers each week. The average number of SNAP customers each week from April 29 – August 28, 2012, was 4; during the SNAP! Market Match Program (September 2 – October 28) the average number of customers per week was 10. Developing further community partners to assist with outreach and financial sponsorship will be a priority for OCRFM.

OCRFM and St. Paul's UCC Farmers' Market participated in the USDA's Supplemental Nutrition Assistance Program (SNAP). Both markets began accepting SNAP benefits in May 2011. Currently, these are the only two markets in the Lincoln area that accept SNAP benefits. It was recommended that these markets encourage and support other farmers' markets to participate in SNAP programs in order to increase the overall awareness and use of SNAP benefits at farmers' markets.

Both markets implemented a script project to allow vendors to accept SNAP benefits through the use of wooden tokens. The tokens serve as a form of SNAP currency. Materials were developed to train participating vendors to accept SNAP tokens. Approximately 67 farmers' market vendors were trained from 2011 to 2012. Vendors benefited from being able to accept SNAP tokens, which saved vendors a significant amount of time and money to become a SNAP retailer. In 2011, OCRFM required vendors to take an hour-long training either in person or via a webinar. The training materials were modified in 2012 and required participating vendors to read the guidelines on the program, sign an agreement form, and take an on-line quiz created in Survey Monkey. The latter was more time efficient and believed to be just as effective. It is recommended that markets continue to require annual training for vendors to renew and participate in the SNAP program. The differences between the governmental nutrition programs like SNAP, WIC, and SFMNP can be confusing to vendors. Therefore, clear communication about the SNAP program and reminders throughout the season from market management is essential to ensure program compliance.

A system was developed and implemented to allow vendors to redeem SNAP tokens in exchange for specialty crops. Vendors to accepted tokens were required to submit a redemption receipt to the market management to exchange

the tokens for cash. SNAP tokens are tracked separately for each vendor. The system keeps a record of the tokens redeemed at each market.

A campaign was launched to advertise the use of SNAP benefits at the two participating markets. This campaign included newsprint, social media, and radio advertisements. All promotional market materials, including banners, ads, and fliers were modified to advertise SNAP participation.

Grant funds were used to pay for radio advertisements that specifically promoted specialty crops. OCRFM also promoted the use of SNAP benefits through their marketing activities. However, because the SNAP promotions were not specific solely to specialty crops, funds were not used to cover the expenses associated with these promotions.

Goals and Outcomes Achieved

Goal #1: Increase the nutrition knowledge among adults and children of fresh foods, particularly the specialty crops that are available at Lincoln farmers' markets.

This goal was achieved. Every week, seasonal recipes were featured at the market, which highlighted ingredients that could be purchased. UNL Extension Nutrition Specialist, Alice Henneman, staffed an information booth at OCRFM. She developed educational materials that were handed out to market patrons. The handouts were uniquely branded for markets that provided food safety instructions on how to select, store, and prepare specialty crops found at farmers' markets. OCRFM originally set out to have volunteers at the market visit with customers regarding nutrition and food safety, but found it difficult to find the volunteers. Consequently, the market manager assumed much of this responsibility. First time market patrons were greeted by the market manager. She assisted consumers in finding specialty crops they wanted. Many shoppers would ask for specific items or growing practices and the manager was always available to assist. OCRFM also sent out weekly emails to nearly 500 customers. The e-mails featured local, seasonal produce recipes and links to web sites that pertained to health and nutrition. From the reports received back from the emails, the most popular links visited are those with recipes and nutrition information. This information was also available at the OCRFM information booth. On a monthly basis, a local chef demonstrated how to prepare a healthy dish using products found at the market. A total of 10 cooking demonstrations were conducted. These demos provided shoppers an opportunity to see, first-hand, how to prepare the dish and ask the chef questions about the ingredients and food preparation.

Goal #2: Increase the accessibility of specialty crops at Lincoln Farmers' markets via SNAP benefits.

Although the OCRFM advertised more in 2011 than it had in the past, it seems as though people are still just learning about the program. The SNAP! Market Match was successful at increasing awareness and use. Developing community partnerships and support for outreach and education opportunities may be just as effective (if not more effective) than traditional paid media (newspaper and radio advertisements).

OCRFM and St. Paul's UCC Farmers' Market participated in the USDA's Supplemental Nutrition Assistance Program (SNAP). Both markets began accepting SNAP benefits in May 2011. Each week, individuals could use their SNAP benefits to shop at the markets. Vendors who wished to participate in this program were required to attend a webinar training program. Afterwards, they received a placard to identify themselves as a vendor who accepted SNAP benefits. This provided vendors an opportunity to sell products to SNAP participants, who may not have otherwise shopped at the market. The program was first promoted in 2011. Four print ads were placed in the *Lincoln Journal Star*, one in the *Buy Fresh Buy Local Guide*, and three week long ads on local radio stations. Additionally, posters and flyers were distributed in Lincoln to inform people that these markets accepted SNAP benefits.

In 2011, $2,155 in SNAP benefits was used to purchase products at the OCRFM. From this amount, $1,008 was used to purchase specialty crops. In 2012, the SNAP benefits increased to $3,073. The SNAP! Market Match Program increased the use, awareness, and purchases of SNAP benefits at the OCRFM from September through October 2012. St Paul's UCC, which a very small market, also accepted SNAP benefits. A total of $182 of SNAP benefits were used to purchase specialty crops in 2011. In 2012, the market season was 22 weeks long. The market did not have any SNAP activity during the month of May. There were also several weeks throughout the summer where the market did not have any activity. The total SNAP benefits used in 2012 equated to $223, with the highest week totaling $35.

A survey was conducted to measure the impact of the program for both vendors and customers. Vendors reported the program as having a positive impact on their sales and as being very beneficial to the market as a whole. Customers reported the program overall was very beneficial to them as well. While many are still learning about the program, those who indicated that they were aware of it, used it nearly every week.

Two measurable outcomes were identified for this project.

Outcome #1: Nutrition knowledge among adults and children will be measured before and after education and outreach activities.

The baseline was set at the beginning of the 2011 season by asking customers how familiar they were with types of products available at market. Many

customers were aware of what was available, but many of them didn't know about different ways of preparing and preserving foods. OCRFM provided information from UNL Extension Nutrition and Food Safety to market patrons. During the middle of the season, OCRFM began asking customers again about their awareness and behavior in purchasing products at the market. It was noted that the number and type of customers during the peak of the season in the summer are different than in the first part of the season. It was discovered that the mid-season customers are often looking for specific items such as corn, tomatoes, cucumbers, etc. However, these customers were often times surprised to see the variety available and were interested in learning more about proper food preparation and preservation practices. Customers were continually surprised to learn that onions and tomatoes can be stored in a freezer.

At the end of the season, customers were asked to participate in a survey. It was surprising to find that only half of those surveyed used the recipes and information the market had available to them. Overall sales and consumption of fresh produce did not necessarily increase, but patrons were trying new items. One nutrition specialist summed it up best by stating that food is a personal choice and it takes time for people to change their choices. Customers are not going to simply start eating better just because they have more information about how to do so. The market is committed to continuing to share information and encourage the community to purchase fresh produce, even though it could take more than one year of measurement to see the impact.

Outcome #2: The dollar amount in SNAP benefits spent on specialty crops at farmers' markets will be measured.

As stated above, in 2011, $2,155 in SNAP benefits was used to purchase products at the OCRFM. From this amount, $1,008 was used to purchase specialty crops. In 2012, the SNAP benefits increased to $3,073. The SNAP! Market Match Program increased the use, awareness, and purchases of SNAP benefits at the OCRFM from September through October 2012. St Paul's UCC, which a very small market, also accepted SNAP benefits. A total of $182 of SNAP benefits were used to purchase specialty crops in 2011. In 2012, the market season was 22 weeks long. The market did not have any SNAP activity during the month of May. There were also several weeks throughout the summer where the market did not have any activity. The total SNAP benefits used in 2012 equated to $223, with the highest week totaling $35.

At OCRFM, many customers used their SNAP benefits. This increased usage demonstrates a growing awareness and patronage of SNAP users at farmers' markets. This is expected to increase from year to year as more people know they can use their SNAP dollars at farmers' markets. However, encouraging more Lincoln area markets to participate and increasing the outreach efforts will help everyone involved.

The original plan was to partner with four other Lincoln markets. St. Paul UCC Farmers' Market was the only one who partnered with OCRFM. Havelock closed, and the Haymarket decided to try something different. St. Paul UCC Farmers' Market was a great partner. The process of becoming certified to accept SNAP is lengthy and it was very beneficial to have another market working through the process with OCRFM. The markets also partnered in training vendors which was beneficial to start the season off with all vendors understanding the rules and guidelines of these new market programs.

Beneficiaries

The two participating farmers' markets, their vendors, and SNAP participants most directly benefitted from this project. SNAP is the nation's largest nutritional assistance program. SNAP participation at farmers' markets helps provide fresh fruit and vegetable to families and expands the customer base for local farmers – a win-win for agriculture and local communities. Providing customers access to nutrition information while they were shopping in addition to allowing them to utilize their SNAP benefits increased the likelihood that they would purchase specialty crops at market. Vendors benefited by having more underserved populations in Lincoln able to choose their products and by having more educated shoppers.

Although it was difficult to pinpoint exactly how many people in the Lincoln area are currently participating in a food assistance program. Well over half of Nebraska's population resides in the metro areas, which includes the city of Lincoln. By making fresh produce, such as specialty crops, available for purchase through SNAP, both markets had the an opportunity to impact the lives and health of people living in the Lincoln community while increasing the profits of specialty crop growers. There are an estimated 60 – 75 vendors currently selling specialty crops at Lincoln farmers' markets.

The beneficiaries of this project will have increased knowledge about the health and nutrition of specialty crops and will have better accessibility to them. They can improve their overall health by learning about specialty crops, including how to cook, where to buy, and how to preserve them. Vendors will have a larger customer base, which now includes SNAP participants/

This project also was an opportunity to partner with community organizations such as the Lincoln Food Bank and UNL Extension. OCRFM remains committed to increasing the access of fresh, local food to low-income families and community members. This project aided in finding partners that can assist in outreach.
Other unknown, but realistic beneficiaries, are grocery stores and health food markets. By encouraging SNAP participants to purchase fresh produce at farmers' markets and providing nutrition education at the markets, it is likely to have influenced their healthy eating choices.

Lessons Learned

OCRFM is dedicated to building a healthy community that is food secure by providing access to high quality, fresh food produced by local family farmers and producers. They recognize the need to improve the accessibility of farm-direct food to low-income community members. One way to begin to address the barriers that exist for people to have access to farm fresh food is to make SNAP benefits usable at existing farmers' markets.

This project achieved the goals of this project. It was unfortunate that only two farmers' markets participated and that other markets have not made progress toward accepting SNAP benefits at their markets. The optimal situation for markets, vendors, and low-income families requires that most, if not all markets, in the Lincoln area accept SNAP benefits. By working together, there would potentially be an increase in the number of SNAP purchases, which would increase the income of our local farmers.

The challenges farmers' markets would face if they chose to set up a similar project would include time, staff resources, funding to operate the program, and organization, modifying the project to meet the needs of market patrons and vendors. There are also some barriers for SNAP participants choosing to shop at farmers' markets. Cost of produce, transportation to the market, and lack of awareness are potential barriers. This project provided funds to help overcome some of those challenges, but the barriers for SNAP participants cannot be underestimated. More time and resources should be targeted towards developing community partnerships to assist in outreach and education.

Contact Person

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Additional Information

Below is a copy of the SNAP! Market Match Program promotional piece that is bilingual in English and Spanish.

OLD CHENEY ROAD FARMERS' MARKET
Mercado de productos frescos en Old Cheney Road

When: Every Sunday, 10 a.m. - 2 p.m through October 28th
Día: Domingos 10 a.m. - 2 p.m., Del 2 de Septiembre al 28 de Octubre

Location: 55th & Old Cheney Road, behind the Lincoln Racquet Club
Lugar: 55th y Old Cheney Road, detras del Lincoln Racquet Club

Up to $10 free, fresh produce for SNAP users every Sunday!

¡Hasta $10 de productos fresco para los usuarios del SNAP todos los domingos!

SNAP! Market Match

Mercado que acepta beneficios de SNAP!

1. Go to the information booth at the market.
   Visite la mesa de información.
2. Swipe your EBT card.
   Deslice su tarjeta de EBT.
3. Buy $1 tokens to purchase food at the market.
   Compre fichas por un $1 para comprar comida en el mercado.
4. Get a free $1 token for every token you buy, up to $10.
   Gane una ficha de $1 gratis por cada ficha que compre, hasta por $10.

For more information call (402) 309-9096 or visit www.oldcheneyroadfarmersmarket.com
Para más información llame al 402-309-9096 o Visite la página web www.oldcheneyroadfarmersmarket.com.

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Below is a copy of the Token Redemption Receipt.

Token Redemption Receipt
Date: _____ Name:

_____

$5 TOKENS: _____ x 5 =

$_____

$1 TOKENS: _____ x 1=

$_____

*Received by:*_____
(Market Management)

_ _
Date:

Name_____

Total: _____ _____

Vendor Copy MM Initial

Project Title

Columbia Root Knot Nematode Survey

Project Summary

The goal of this project was to facilitate the trade of Nebraska-grown potatoes and horticultural nursery stock on the international market, by documenting Nebraska's freedom from Columbia root knot nematode (*Meloidogyne chitwoodi*). This was accomplished through three objectives:

1. Conducting soil sampling surveys of 50 percent of potato seed and 10 percent of commercial potato production fields, and three percent of horticultural nursery stock fields, by acreage, with a focus on international shippers;

2. Conducting a minimum of 50 inspections of seed potato distribution facilities to ensure compliance with the Nebraska Department of Agriculture's Columbia root knot nematode (CRKN) quarantine; and

3. Monitoring of potato sorting/cleaning lines at packing sheds for evidence of CRKN infested potatoes.

Project Approach

NDA began contacting potato producers in July, 2011, via a direct mailing to approximately 20 growers, informing them of the opportunity to participate in the CRKN soil survey. Sites to be surveyed were chosen based on response, location, and grower intent to ship product internationally.

A radio public service announcement informing the public on the purpose of and need for this survey ran from October 3 – 9, 2011. It was available on the NDA web site, and carried by various radio stations statewide. The Department also has over 2,600 individuals that have subscribed to receive these reports directly.

NDA began contacting potato producers in July, 2011, via a direct mailing to approximately 20 growers, informing them of the opportunity to participate in the CRKN soil survey. Sites to be surveyed were chosen based on response, location, and grower intent to ship product internationally.

Field staff with the NDA Entomology Program began collecting soil sampling of potato and nursery fields in the summer and fall of 2011. Staff members collected soil from 48 fields total, in 10 counties.

In late winter and early spring of 2011, NDA Entomology staff conducted inspections of seed potato distribution facilities. Seventy-six locations in 11

counties were inspected to confirm compliance with the NDA CRKN quarantine. During the spring of 2012, 70 inspections were conducted in 12 counties. This exceeds the target of 50 sites. No violations of the quarantine were found.

The Potato Certification Association of Nebraska (PCAN) had agreed to visually inspect 25 potato sorting/cleaning lines at packing sheds for evidence of CRKN infested potatoes. Those inspections did not occur. PCAN did conduct 1,650 inspections, facilitating the interstate movement of 1,400 shipments and 61,200,000 pounds of commercial potatoes. Part of the inspection protocol for these inspections includes visual inspections for evidence of CRKN. No signs or symptoms of CRKN were found during these inspections.

Goals and Outcomes Achieved

The measurable outcomes for this project included:

1. Documenting the number of certificates issued for potatoes and nursery stock in 2011;

2. Disseminating survey information in the NDA Entomology Program Annual Report;

3. Incorporating project results on the NDA web site; and

4. Inclusion of survey results on NDA Entomology Program display booth at the Nebraska Green Expo.

NDA issued 35 federal phytosanitary certificates for nursery stock shipments to Canada since October 1, 2010. These certificates have facilitated the movement of approximately 6,311 Nebraska grown nursery stock plants to Canada. Additionally, eight Federal phytosanitary certificates were issued for Nebraska grown seed potatoes to Canada, totaling 385,000 pounds. Each of these shipments was possible because of the soil sampling conducted by NDA in 2010 and 2011.

The Potato Certification Association of Nebraska (PCAN) assisted in the development of the project proposal. They are responsible for the visual inspection of potatoes on the sorting lines at packing sheds. PCAN is also the primary conduit for disseminating information to the potato industry, and has been a valuable partner on that front.

The NDA State Entomologist presented information on this project to the Nebraska Potato Council at their meetings in October 2010, March 2011, October 2011 and March 2012. Attendance at each meeting was approximately eight individuals. Approximately eight additional conference calls and/or meetings were held with PCAN staff, relative to this project. NDA included

information on previous CRKN survey results in their 2010 and 2011 Entomology Program Annual Report. This information was also included as part of displays at several meetings and conferences, including the 2010, 2011 and 2012 Nebraska Green Expo (approximately 700 attendees) held in January; Governor's Ag Conference (approximately 200 attendees) in held March 2011 and 2012; and the Nebraska State Fair (approximately 300,000 attendees) held in August 2011 and 2012.

Since the inception of this project, NDA Entomology staff has spent more than 129 hours and driven more than 1,465 miles in support of this project.

Beneficiaries

There are approximately 20 large commercial potato producers in Nebraska, planting over 20,000 acres each year, and certifying nearly 5,000 acres of seed potatoes, annually. The value of this crop was estimated at $82 million in 2008. The state also has over 1,200 licensed nursery dealers and growers employing thousands of Nebraskans. Nebraska-grown potatoes and nursery stock can enter countries like Mexico, because of our CRKN free status. But in order to keep these markets open, NDA must conduct official surveys for CRKN. If this survey was not conducted, markets would likely close.

Lessons Learned

The initial timeline for this project actually extended beyond the end date of the one year project. NDA requested and received a one year extension to complete the work.

The fall soil sampling was delayed due to weather and staffing problems. Field staff duties were shifted to allow for the completion of this project. Samples were processed by the UNL Nematology lab. The delay in sampling also resulted in a delay in disseminating this information through reports, the NDA web site, and meetings/conferences.

Contact Person

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julie.vanmeter@nebraska.gov

Additional Information

The results of the project can be found at http://www.agr.ne.gov/plant/nematodes.html. The link for the quarantine can be found at http://www.agr.ne.gov/plant/crk_nematode.pdf .

Project Title

Development of an Internet-Based Pesticide-Sensitive Crop Locater

Project Summary

This project builds on the initial development, and public announcement in the fall of 2009, of the Pesticide Sensitive Crop Locater, which in May, 2012, merged with DriftWatch (ne.driftwatch.org). Nebraska DriftWatch is an internet-based map system for displaying pesticide sensitive crops. The map is promoted to pesticide applicators who can use it as a resource to reduce sensitive crop damage caused by pesticide drift. Commercial pesticide sensitive crops, such as fruits, vegetables, apiaries, vineyards, fish farms, and organic crops are increasingly dotting the landscape. With this increase, is the potential for increased incidents of pesticide drift because applicators may not realize the sensitivity of these crops, and they may not be aware of the increase in acreage and locations in their geographic area of interest.

Nebraska DriftWatch offers many advantages over the old web site; most notably, a better system for approving and administrating the data. In addition, the system uses Google Maps™ technology which is more familiar to the general public, and allows growers to draw their fields or property directly online. Lastly, the system allows pesticide applicators to sign up for notifications when new locations are added to their area of interest.

SCBG-Farm Bill funds were used to enhance the development of the Locater in 2010-2011, and the current SCBG-Farm Bill award was used to allow the conversion from the Locater to DriftWatch, and to increase participation of underrepresented grower categories.

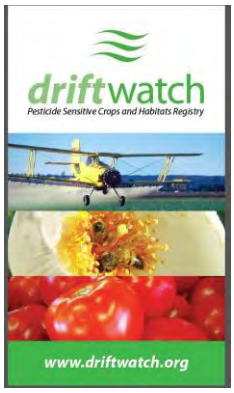
Project Approach

In April, 2012, letters went to approximately 100 aerial business license holders explaining the benefits of DriftWatch to applicators. These businesses must register with NDA and provide info on pilots that will be working for them in that year. In June 2012, an e-mail invitation was sent to approximately 500 pesticide sensitive crop growers, using e-mail addresses compiled from USDA National Organic Program, NDA organic transition program, and NDA specialty crop grower and farmer market databases.

Nebraska DriftWatch business cards (Figure 1) were distributed to both growers and pesticide applicators. Approximately 7,000 business cards have been distributed to various partners and individual growers since inception of the project. Partners were asked to incorporate the business card image in their own newsletters and web sites, as well. NDA personnel attended various trade

shows, farm shows, and fairs where brochures and business cards were made available. These are listed in Appendix B.

Since the Fall of 2012, anyone requesting a reciprocal commercial applicator license having right of way or aerial categories – approximately 400 in that time - received a DriftWatch business card along with their applicator license.
In February, 2013, approximately 1,650 informational letters were mailed to potential commercial sensitive crop growers, using mailing lists from NDA, USDA, and various sensitive crop organizations in Nebraska. Beginning in March 2013, NDA coordinated on-the-spot sign-ups for growers at several meetings, including the Nebraska Winery & Grape Grower Forum, the Healthy Farms Conference, the Lincoln Farmers' Market Vendor Workshop, OCIA Chapter #1 annual meeting, and others. In addition, email messages, letters, and phone calls were also used to encourage growers in DriftWatch to update their information.



In all of the correspondence to growers, beginning in February 2013, the offer of free DriftWatch field signs was promoted. Each grower who either updated their information, or was newly approved in the DriftWatch system, was eligible to receive two free DriftWatch signs (Figure 2). These signs not only identify the property as having a pesticide sensitive crop, it also promotes the web site where applicators can sign up for the notifications and look at the map for sensitive crops near their application area.

In the Spring of 2013, NDA made presentations to the Nebraska Weed Control Association, and a non-NDA presentation was also made to the Nebraska Aviation Trades Association. Applicators attending University of Nebraska

training for obtaining their initial commercial applicator license, as well as most applicators attending training to recertify their license, watched a video containing a segment on DriftWatch. In addition, private applicators also had this segment as a part of their training.Through a cooperative agreement with FieldWatch, the parent organization of DriftWatch, 432 DriftWatch signs were distributed to Nebraska growers of pesticide sensitive crops (see map below of the Nebraska cities receiving signs). As crop locations were added or updated in DriftWatch, growers received information on how to order 2 free signs (courtesy of SCBG-Farm Bill funds). A portion of the current SCBG-Farm Bill award was also used by Purdue University Extension Bookstore to develop the recording, tracking, and accountability software for keeping track of these orders. Table 1 below lists the number of sign packets distributed monthly in 2013. This offer to Nebraska growers ended on September 30, 2013, however all growers are still able to purchase these field signs.

Figure 3. A map showing the geographic distribution of DriftWatch signs delivered to sensitive crop growers in Nebraska. This shows number of orders per city – each order was for two signs.

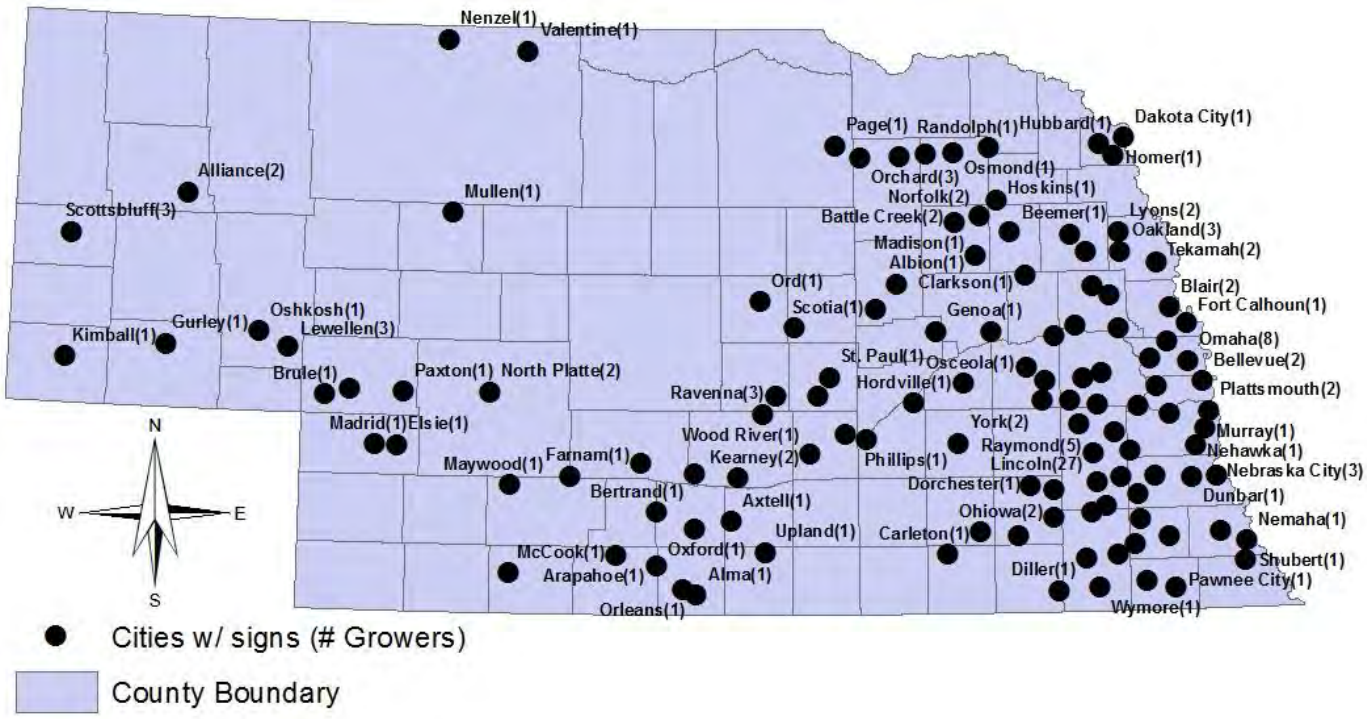


Table 1. Monthly count of DriftWatch sign orders from Nebraska growers during the 2013 period when signs were offered for free using SCBG-Farm Bill funds. Each order shown here equals one 2-pack order for a total of 432 signs distributed.

Month	Packet Count
March	75
April	25
May	4
June	1
July	38
August	43
September	30
	216

The numbers of growers and crop locations in DriftWatch has increased significantly over the last couple of years (see Figure 5 in the Goals and Outcomes section). Both the number of growers and crop locations are approximately double since the conversion of the Locater to DriftWatch. These totals, however, are much lower than USDA estimates of pesticide sensitive crop growers in Nebraska (2007 USDA National Agricultural Statistics Service estimates for specialty crops include approximately 25,000 acres and 36,700 bee colonies, and non-specialty crops also considered pesticide sensitive include approximately 83,000 acres. See this URL for more info: http://www.nass.usda.gov/Statistics_by_State/Nebraska/index.asp). Estimates of the total number of DriftWatch eligible farms or growers include 550 specialty crop farms and 193 honey producers, and approximately 450 farms having the other pesticide sensitive crops. This is likely an overestimate because of overlap between and within these categories, i.e. farms growing more than one type of crop. Figure 4 shows the general distribution of the DriftWatch crop categories throughout the state.

Figure 4. Generalized locations of pesticide sensitive crop taken from the DriftWatch database at the end of September 2013.

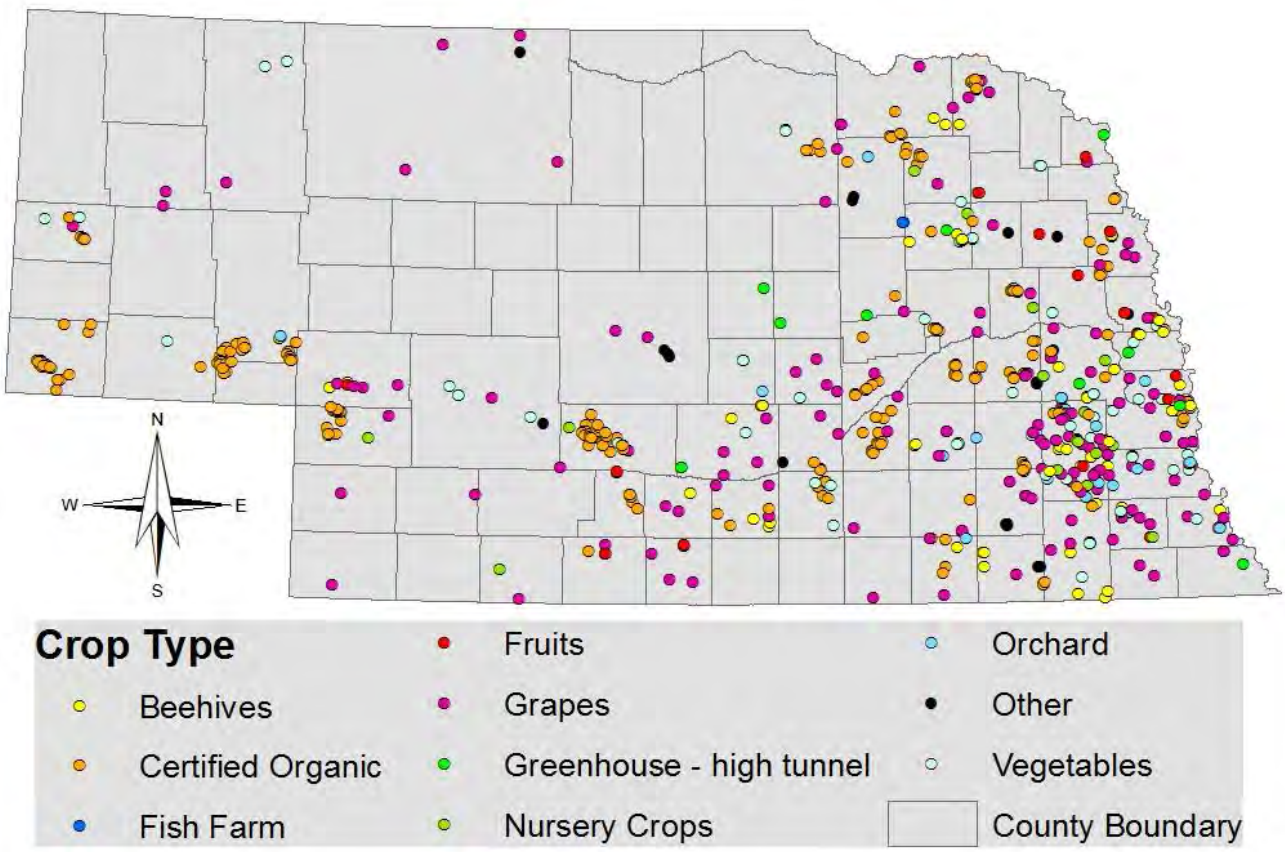


Table 2. Number of fields or sites of pesticide sensitive crops in DriftWatch, listed by crop type category.

Crop Type	Total
Beehives	60
Certified Organic	254
Fish Farm	2
Fruits	31
Grapes	157
Greenhouse - high tunnel	15
Nursery Crops	21
Orchard	31
Other	19
Vegetables	70
Grand Total	660

The University of Nebraska Extension and the Pesticide Safety Education Program (UNL PSEP) have been NDA's most valued partner in promoting the benefits of DriftWatch to applicators for reducing incidents of pesticide drift on sensitive crops. UNL PSEP and approximately 80 Extension Educators across the state are responsible for developing and delivering the training material needed for applicators to become certified to apply pesticides in the state. Approximately 10,000 commercial/noncommercial applicators and 21,000 private applicators have an NDA license. Of those, approximately 27,000 would benefit from the services provided by DriftWatch (all private applicators, and commercial/noncommercial applicators having right of way, ag plant, aerial, and ornamental/turf categories).

All certified applicators must recertify their license every three years; roughly one third of the applicators attend training sessions in any given year. The following numbers represent the number of applicators receiving DriftWatch information in 2013.

Training Session	**Attendance**
Private Applicators (farmers)	6,548
Crop Production Clinics (ag plant category)	679
Commercial Applicator recertification - general standards video (all commercial applicators)	1,001

In October 2012, UNL Extension published a new informational circular, *Protecting Pesticide Sensitive Crops*, which was promoted at the 2013 training sessions for private and commercial applicators. DriftWatch is featured as one of the considerations for applicators in reducing the incidents of pesticide drift to sensitive crops. This circular can be found at http://www.ianrpubs.unl.edu/epublic/live/g2179/build/g2179.pdf.

In June 2013, UNL Extension published three videos on protecting pesticide sensitive crops, which will be included in pesticide applicator training session beginning in 2014. The videos are: *Sensitive Sites: Grapes and Vineyards*; *Sensitive Sites: Bees and Pollinators*; and *How to use Driftwatch: a National Specialty Crop Site Registry*. The DriftWatch video is included in both the Pollinator and Vineyard videos. All three videos can be found at: http://www.youtube.com/user/UNLExtensionPSEP

In August 2013, EPA came out with new label language for neonicotinoid products for pollinator protection. These products contain the active ingredients clothianidin, dinotefuran, imidicloprid, and thiamethoxam, and have been implicated in honey bee loss incidents within the last several years. This information, along with links to EPA's web page, was posted in NDA's Plant

Health Protection Update RSS Feed at
http://www.nda.nebraska.gov/plant_health_update/082013.pdf.

In September 2013, UNL Extension developed a new informational circular, *Bee Aware: Protecting Pollinators from Pesticides*, to be used and promoted in pesticide applicator training sessions in 2014. Directed mainly to pesticide applicators, this circular also contains considerations for beekeepers, including information on how DriftWatch might benefit them. This circular is found at: http://www.ianrpubs.unl.edu/epublic/live/ec301/build/ec301.pdf.

Through SCBG Farm Bill funds, NDA distributed Driftwatch signs to 215 Nebraska growers. The recipients primarily consisted of fruit and vegetable growers (see below table). However, upon conclusion of the project, it was discovered that 17 of the 215 signs were sent to growers who do not raise or produce specialty crops. Fifteen of these went to organic crop growers, and two to native grass and flower producers who sell their seeds for land restoration purposes.

Crop Type	# sign packets
Beehives	17
Certified Organic	31
Fruits	18
Grapes	76
Greenhouse - high tunnel	9
Nursery Crops	11
Orchard	15
Other	7
Vegetables	31
Grand Total	215

NDA printed approximately 7,500 one-page flyers to applicators during the grant period. These flyers were given to the university pesticide education office who distributed them to people recertifying both private and commercial licenses throughout the state. The cost of printing these flyers was not covered through the grant, and totaled approximately $1,600.

In addition, NDA provided much in-kind match through promoting the Driftwatch web site at conferences, grower meetings, radio spots, and media announcements.

Since 17 Driftwatch signs were sent to growers who do not raise or produce specialty crops, NDA will request that funds from the state's APHP Pesticide Cash Fund be transferred back into the Specialty Block Grant fund in the amount

of $482.97 as soon as possible. This calculation was based on the cost of the individual signs plus the added prorated cost of shipping and handling /per sign, which was determined to be $ 28.41 per sign. This correction will be journal-entered into our accounting system soon and USDA should be able to note the transfer within their SCBGP budget data.

Goals and Outcomes Achieved

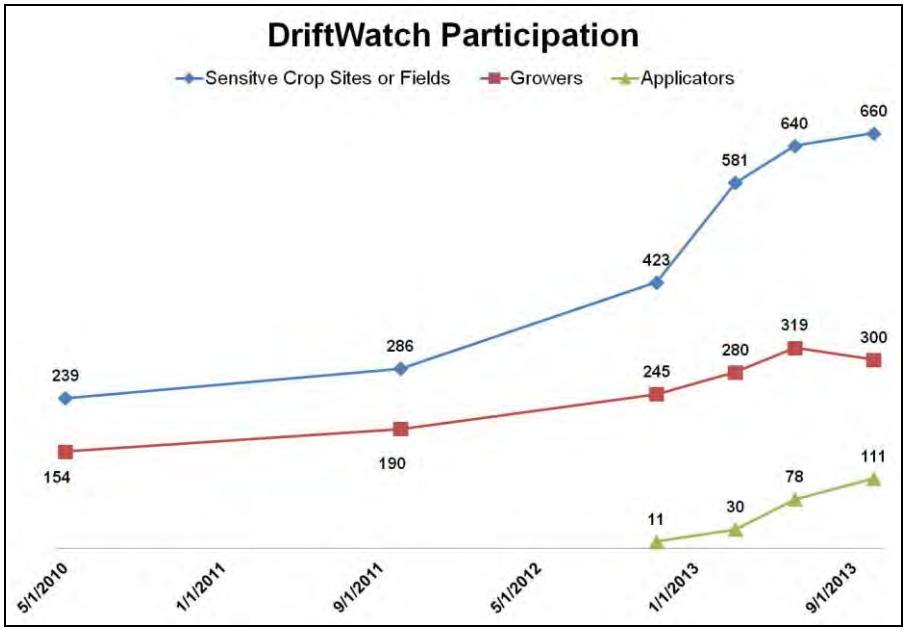
The activities described above were undertaken to achieve desired outcomes to meet the goals shown below. As can be seen, most were short of expectations. The goals and outcomes are described below, along with rationale as to why expectations weren't reached and what could be done to improve future outcomes.

Expected Measureable Outcome 1: A substantial increase in the number of grower data available in DriftWatch.

Benchmark 1	**Goal 1**	**Measure 1**
100 database records representing approximately 100 distinct vineyards (farms)	Locations in the database will represent 80% of farms growing specialty and other pesticide sensitive crops (using 2007 Census estimates), or approximately 1,000 farms (counting distinct individuals or companies separately)	At the end of FY13, there are 300 growers registered in DriftWatch, or 30% of Goal 1.
Benchmark 1a	**Goal 1a**	**Measure 1a**
100 database records representing approximately 100 distinct crop/field locations	1,500 database records, representing 10- to 160-acre fields	At the end of FY13, there are 660 separate fields or locations found on the DriftWatch map, or 44% of Goal 1a.

The numbers for Measures 1 and 1a are disappointing to some degree, because NDA believes there are many commercial growers who should be taking advantage of DriftWatch. Their reasoning for not participating is unknown. The possibility is great that many of these growers have not heard about DriftWatch. With the exception of the grape growers and the nursery growers, their grower associations are not as organized and structured, and communications about DriftWatch may not be reaching them. The possibility also exists that communication from NDA – whether it was electronic or hard copy – was discarded or forgotten. Regardless, NDA will continue to make contact with these organizations through meetings and electronic mail.

Figure 5. A chart of participation numbers in the DriftWatch database (Goals 1 and 1a). The Nebraska Pesticide Sensitive Crop Locater formally became a part of DriftWatch in May 2012.

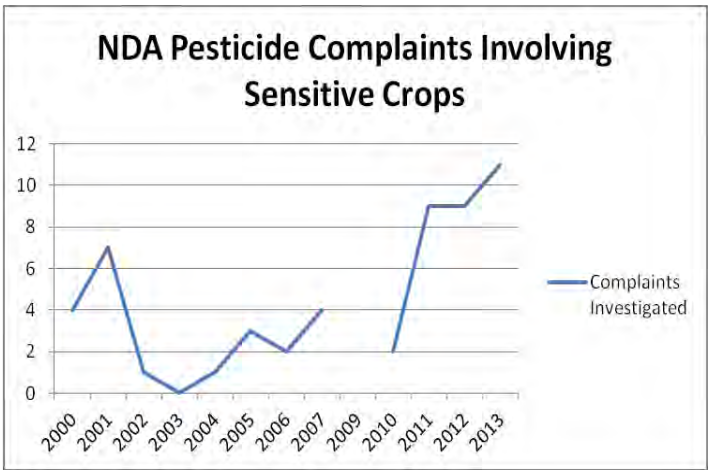


Expected Measureable Outcome 2: A reduction or, at least, no significant increase in the number of pesticide complaints, resulting in a violation of the Nebraska Pesticide Act.

Benchmark 2	Goal 2	Measure 2
An average of three annual complaints involving pesticide sensitive crops over the last nine years, ranging from 0-7 complaints per year.	No significant increase in the number of complaints received annually, and a decrease in the number of violations resulting from these complaints.	FY13, NDA received 11 formal pesticide complaints and several inquiries by pesticide sensitive crop growers.

In theory, as the number of sensitive crop growers in the database increase (including specialty crop growers), pesticide applicators will become accustomed to using the web site as a resource of information. As a result of that increased use and awareness, it is believed that complaints about pesticide drift should decrease. However, because of differences in categorizing these types of complaints over the years and the difficulty of filtering these specific cases from the data, confidence in the numbers of complaints each year is lacking. In addition, it is apparent this is a project “in progress,” so reaching all of the growers and applicators about the benefits of the project will take time. The

number of complaints may even rise over the short term, as specialty crop growers learn of the project and become aware of NDA's pesticide enforcement program. It is apparent from several grower conversations that they were unaware of NDA's authority to regulate and enforce pesticide use prior to implementation of this project. In addition, the summer of 2012 was somewhat of an outlier in the way of weather and spray operations: an early spring and early plant development timed with earlier than normal spray operations combined to cause a number of drift incidents resulting in crop sensitive damage. NDA believes the caveats above should be considered before taking the chart below at face value, and viewing achievement of this goal as a failure.



Expected Measureable Outcome 3: A substantial interest on the part of applicators in viewing DriftWatch.

Benchmark 3	Goal 3	Measure 3
An estimate of 25,000 to 50,000 annual pesticide applications potentially affecting pesticide sensitive crops.	DriftWatch will be accessed for at least half of the estimated number of applications, or 12,800 times annually, once the project is implemented, promoted, and grower data increases.	Counts of web access to the DriftWatch page were incomplete in FY13 due a switch of servers and other issues. However, after the system was switched to the new server, there were 2,300 web hits for the period April to October, 2013.

Table 3. A summary of DriftWatch web statistics for the top 12 states, including those participating in DriftWatch.

Web Site Analytics Data
April 11 - Oct 31, 2013

DriftWatch Specialty Crop Site Registry
Useage By All States - Member States in Bold

State	Visits	New Visits	% New Visit	New Visits % of Total	Unique Visits	% Unique vs Visits	Bounce Rate	Pages per Visit	Avg. Visit Duration
Indiana	**3766**	**1180**	**31.3%**	**15.5%**	1205	32%	**46%**	**3.73**	**4.07**
Illinois	**3065**	**1580**	**51.5%**	**20.8%**	1602	52%	**50%**	**2.85**	**2.59**
Nebraska	**2303**	**941**	**40.9%**	**12.4%**	956	42%	**44%**	**3.28**	**3.45**
Wisconsin	**1344**	**564**	**42.0%**	**7.4%**	574	43%	**48%**	**3.65**	**3.68**
Minnesota	**1162**	**651**	**56.0%**	**8.6%**	669	58%	**49%**	**3.13**	**2.99**
Michigan	**1031**	**484**	**46.9%**	**6.4%**	500	48%	**60%**	**2.48**	**2.16**
Colorado	**765**	**354**	**46.3%**	**4.7%**	361	47%	**51%**	**3.20**	**2.83**
Missouri	**656**	**260**	**39.6%**	**3.4%**	274	42%	**54%**	**3.20**	**3.03**
Ohio	291	138	47.4%	1.8%	143	49%	62%	2.53	1.45
Iowa	235	119	50.6%	1.6%	125	53%	62%	2.18	1.65
California	221	135	61.1%	1.8%	140	63%	69%	2.23	1.26
Montana	**194**	**103**	**53.1%**	**1.4%**	103	53%	**54%**	**3.35**	**2.23**

While these statistics show an obvious shortfall in web activity compared to the goal that was set for this project, it should be noted that Nebraska's activity is comparable to several other states whose participation began at approximately two years prior to Nebraska's. Indiana began in March 2009, and Michigan, Illinois, and Wisconsin began in June, July, and December of 2010, respectively. Nebraska started in DriftWatch in May/June of 2012, but also went through a transition from the previous web site, which began in late 2009.

Benchmark 3a	Goal 3a, 3b, & 3c	Measure 3a, 3b, & 3c
Subjective evidence that there is an interest on the part of applicators, based on requests for such information over the last several years, from both applicators and growers.	Approximately 80% of applicators surveyed will have heard about DriftWatch; 60% of those surveyed will have accessed the web site; and Of those stating sensitive crops are nearby, 60% will indicate taking extra precautions.	Approximately 20% of applicators (including private and commercial) had heard of the DriftWatch website prior to attending the training session where the survey was conducted. In FY13, approximately 21% of applicators (both private and commercial) had actually accessed the web site. Approximately 60% of the people accessing the web site stated sensitive crops were nearby and took precautions to avoid drift.

As stated previously, applicators must recertify NDA's license every three years, so video segments and informational material should be new to anyone attending these sessions in the last three years. Given that fact, the low DriftWatch recognition is not surprising. However, all commercial applicators receive the *Pesticide and Noxious Weed Newsletter*, which has had information about DriftWatch (or its predecessor) in each issue the last three years (twice per year). Recognition of DriftWatch by commercial applicators was slightly higher than private applicators, but still fairly low.

Of those applicators who indicated they had visited the DriftWatch web site and found sensitive crops nearby, a fairly high percentage indicated that they took additional steps to avoid drift and subsequent crop damage.

Because of several high profile complaints in the last two years involving vineyards, word of pesticide damage to sensitive crops has increased in the media. Legislation was introduced in 2012 that would have required increased regulation of products containing 2,4-D and dicamba, as well as increased grower notification of applications. This legislation did not make it out of committee, but an interim study was designated, and continued discussions are

taking place. Because of this exposure, it is likely that applicator awareness will increase the use of DriftWatch.

NDA will continue to explore ways to increase applicator registration and use of DriftWatch.

Beneficiaries

A listing of NDA's partners, targeted grower groups, newsletters, web sites, and other outlets for promoting the DriftWatch is provided in Appendices A and B. NDA's Ag Promotion and Development Focus Area has been the primary avenue for distributing brochures and business cards. NDA personnel attend many grower events where one-on-one contacts were made.

UNL Extension is the primary partner for reaching the applicator audience, through their training sessions and outreach material. Appendix A and B highlight this outreach material, including informational circulars, YouTube Videos, and training material. NDA also maintains contact with pesticide industry organizations with requests for assistance in helping to promote the project. These are also listed in Appendix A.

Lessons Learned

This project, including the earlier phases, has been a learning experience. The main lesson is that it takes time for people to see value in a service like this and to make new habits. Both the grower and applicator database won't grow overnight. While, overall, project goals were unmet, the project is still in place and continues to make headway toward meeting the overarching goals of raising awareness of pesticide sensitive crops and reducing incidences of drift and damage to these crops. The tables below compares participation among all states currently in DriftWatch. Overall, NDA is pleased in how we 'measure up' to other participants, even if we are disappointed in our measured outcomes when compared to the goals that were set.

driftwatch

DriftWatch User Participation Data
Nov 2, 2013

DriftWatch Participation Total By State

State	Start Date	Registered Applicators	Registered Producers	Total Users	% of Total	Registered Fields	% of Total	Registered Acres	% of Total	Registered Apiaries	% of Total
Indiana	Mar-09	162	866	1028	29.9%	591	18.7%	29144	11.5%	441	21.8%
Illinois	Jul-10	75	573	648	18.8%	327	10.3%	16561	6.5%	1212	60.0%
Nebraska	Jun-12	116	367	483	14.0%	660	20.8%	43439	17.1%	59	2.9%
Wisconsin	Dec-10	20	413	433	12.6%	492	15.5%	25471	10.0%	144	7.1%
Michigan	Jun-10	48	186	234	6.8%	477	15.1%	36764	14.4%	30	1.5%
Missouri	Jan-13	10	217	227	6.6%	256	8.1%	8816	3.5%	32	1.6%
Minnesota	Aug-11	21	172	193	5.6%	239	7.5%	6461	2.5%	0	0.0%
Colorado	Aug-12	29	112	141	4.1%	69	2.2%	11182	4.4%	101	5.0%
Montana	Aug-12	20	33	53	1.5%	57	1.8%	76611	30.1%	2	0.1%
Total:		**501**	**2939**	**3440**		**3168**		**254449**		**2021**	

Driftwatch Comparative Acres By Crop			
Crop Type	2012 Registered Acres	2013 Registered Acres	% Change
Certified Organic	17103	39855	133%
Other	206	1223	494%
Grapes	435	857	97%
Vegetables	95	584	515%
Orchard	95	441	364%
Nursery Crops	33	241	630%
Fruits	88	201	128%
Greenhouse	11	36	227%
Fish Farm	0	1	-
Total:	**18066**	**43439**	

Driftwatch Comparative Number of Fields By Crop			
Crop Type	2012 Registered Fields	2013 Registered Fields	% Change
Certified Organic	102	254	149%
Grapes	64	158	147%
Vegetables	14	70	400%
Beehives	15	59	293%
Orchard	4	31	675%
Fruits	7	31	343%
Nursery Crops	5	21	320%
Other	6	19	217%
Greenhouse	5	15	200%
Fish Farm	0	2	-
Total:	**222**	**660**	

Contact Person

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Additional Information

Please refer to Appendices A and B for a listing of organizations and agencies that have received announcements, reports, and updates of the project, as well as a list of publications, web sites, and newsletters that have featured articles about the DriftWatch project.

Appendix A

Project partners receiving announcements and subsequent updates on DriftWatch.
Grower Groups:

- Nebraska Winery and Grape Growers Association
- Nebraska Beekeepers Association
- Mid-America Fruit Growers Association
- Organic Crop Improvement Association
- Nebraska Chapter, Buy Fresh Buy Local
- Nebraska Nursery and Landscape Association
- Nebraska Sustainable Agriculture Society

- Nebraska Fruit and Vegetable Growers Association
- University of Nebraska Acreage E-News newsletter
- University of Nebraska Extension Specialists with agronomic expertise with these crops

Pesticide and Agricultural Industry Groups:

- Nebraska Aviation Trades Association
- Nebraska Agribusiness Association
- Nebraska Corn Growers Association
- Nebraska Sorghum Growers Association
- Nebraska Wheat Growers Association
- UNL CropWatch (an agricultural agronomy/Integrated Pest Management newsletter)

Local, State, and Federal Agencies:

- NDA's Ag Promotion and Development Division
- Nebraska Natural Resources Districts
- USDA Natural Resources Conservation Service
- USDA Farm Service Agency
- USDA Resource Conservation and Development
- UNL Extension Offices
- UNL Pesticide Safety Education Office

Appendix B

List of meetings, presentations, publications, newsletters, web site, and direct mailing promotions for DriftWatch.
List of meetings attended or presentations given:

- Nebraska Power Farming Show (December 2012)
- Governor's Ag Conference (March 2012)
- AKSARBEN (September 2012 & 2013) (NDA table with DriftWatch information available)
- Husker Harvest Days (September 2012 & 2013) (two NDA tables at separate locations with DriftWatch information available)
- Nebraska State Fair (August 2012 & 2013) (NDA table with DriftWatch information available)
- Lincoln/Lancaster County Farmer Market Vendor Training – 2011, 2012 & 2013 (NDA presentation) (100 grower participants)
- UNL Extension Crop Production Clinics (applicator license recertification) – January 2012 & 2013 (video segment with DriftWatch highlighted; approximately 1,600 applicator participants each year)
- Nebraska Ag Classic (NDA table with DriftWatch information available)

- Governor's Agri/Eco-Tourism Workshop (February 2012 & 2013) (NDA table with DriftWatch information available)
- Nebraska Winery & Grape Growers Association Herbicide Drift Seminar (November 2012) – approximately 35 people in attendance, with and unknown number online.
- Nebraska Weed Control Association Spring Meeting (April 2013) – NDA presentation to approximately 80 applicators.
- UNL Private Applicator Training sessions – February to March 2011(10,560 applicator participants)
- UNL Commercial Applicator Training sessions – January to March 2012 & 2013 (video segment with DriftWatch highlighted; approximately 1,2 applicator participants each year)
- Nebraska Agri-Business Exposition (2011, 2012, & 2013)
- Great Plains Vegetable Growers Conference, St. Joseph, Missouri, (four-state region table display, and NDA representation at Nebraska Roundtable) – January 2012 & 2013 (25 grower participants each year)
- Nebraska Winery and Grape Grower Association convention, Kearney, Nebraska, (NDA presentation) – March 2012 & 2013 (35 grower participants each year)
- Nebraska Aviation Trades Association Conference, Kearney, Nebraska, (NDA and/or industry presentation) – February 2012 & 2013 (approximately 100 applicator participants each year)
- Nebraska Sustainable Ag Society Conference, Lincoln, Nebraska, (business card/brochure handouts) – February 2012 & 2013 (70 grower participants)
- Nebraska Beekeepers Association, Seward, Nebraska. (NDA presentation) – July 2012 (20 grower participants)
- Nebraska Grape & Winery Board Meetings
- Nebraska Fruit & Vegetable Growers Meetings

Major publications:

- Protecting Pesticide Sensitive Crops. University of Nebraska Extension.
- Sensitive Sites: Grapes and Vineyards. University of Nebraska (YouTube video)
- Sensitive Sites: Bees and Pollinators. University of Nebraska (YouTube video)
- How to use DriftWatch, a National Specialty Crop Site Registry. University of Nebraska (YouTube video)
- How herbicide drift threatens Nebraska vines. Nebraska Public Radio (audio, pictures, and text)
- Bee Aware: Protecting Pollinators from Pesticides. University of Nebraska Extension.

Newsletters:

- *Midwest Small Fruit and Grape Spray Guide* (2011, 2012, & 2013)
- Nebraska Nursery and Landscape Association (Fall 2011, Summer 2012, and Fall 2013)

- NDA *Pesticide and Noxious Weed Newsletter* (winter and summer 2011, 2012, & 2013)
- Nebraska Aviation Trades Association (July 2011, 2012, & 2013)
- Ag Air Update – June 2011 (also at http://issuu.com/aau_proofs/docs/06june2011)
- Nebraska Beekeepers Association (June and August 2012, and July and September 2013)
- UNL CropWatch (November 2012, March and May 2013)
- UNL Acreage E-News (May 2012 and June 2013)
- Lancaster County Extension *NebLine* (May 2013)
- NationAir (aviation insurance broker) 2013
- Central Platte Natural Resources District (June 2013)
- Nebraska Agribusiness Association (Spring 2013)
- Northeast Nebraska RC&D (Summer 2012)
- NDA *Plant Health Protection Update* (May 2012, August 2012, March 2013, May 2013)
- Nebraska Loess Hills (C&D (June 2012)

Web Sites:

- Scientific Beekeeping. The Extinction of the Honey Bee? July 2012. (mentions DriftWatch and benefits to beekeepers)
- AgFax.com (May 2013)
- UNL Entomology – Extension Program links
- Nebraska Winery and Grape Growers Association (link to DriftWatch, UNL circular, and other resources)
- Nebraska Nursery and Landscape Association news (June 2013)
- Nebraska – Our Best To You (2011, 2012 & 2013)
- NDA Facebook Page (May 2011, May 2012, & April 2013)
- NDA Twitter page (May 2011)
- NDA Update – (June 2012, February & March 2013) un-archived audio files distributed to Nebraska Media (May 2011)
- UNL IPM in Schools blog
- Nebraska Aviation Trades Association
- UNL Water Portal
- UNL Pesticide Safety Education Program
- Nebraska Farmer (March 2013)
- UNL Extension Educators
  - York County Twitter (May 2012)
  - Bob Wright, UNL Extension, Twitter (July 2012)
  - UNL Pesticide Safety Education Program Twitter (June 2012)
  - Saline County update (February 2013)
  - Fillmore County update (May 3013
  - South Central Ag Lab Facebook (April 2013)
  - South Central Ag Lab Facebook (March 2013)
  - UNL Extension Facebook (March 2013)

- Platte County update (April 2013)
- Clay County update (July 2013)
- Nemaha County update (June 2013)
- York County update (June 2013)
- Platte County update (April 2013)
- Lancaster County Extension habitat project (June 2013)

- Yankton Press and Dakotan Do the Neighborly Thing (May 2012)
- Fremont Tribune (April 2013) report on NDA presentation at Nebraska Weed Control Association meeting
- Grant Tribune (April 2013) report on NDA presentation at Nebraska Weed Control Association meeting
- mycentralnebraska.com (May 2013) reprint of Platte County Extension update
- DriftWatch listing in the Private Landowner Network Conservation Toolbox
- Nebraska Corn Growers Association podcast (May 2012)
- Nebraska Corn Growers Association news (May 2012)
- Nebraska Corn Growers Association Facebook (May 2012)

Note: Web links to the entries listed above are provided, if they currently contain information on DriftWatch. Electronic files for many of these have been saved and are available upon request.

Direct Mailings:

- E-mail to USDA Organic, NDA Organic, and NDA Specialty Crop Growers; February 2012 (count = 520)
- Direct hard copy letter to approximately 100 Aerial Business License holders, including DriftWatch cards and background info. (April 2012)
- Direct hard copy letter to 1,650 sensitive crop growers using mailing lists from NDA, USDA, and various sensitive crop organizations in Nebraska. (March 2013)
- Direct hard copy letter to approximately 115 growers in DriftWatch without current info. (March 2013)
- DriftWatch cards are sent to every out of state applicator having right of way and aerial categories and requesting a reciprocal license – approximately 400 people in 2013.

Project Title

Improving Nebraska Dry-Edible Bean Utilization by the Food Industry Through Applied Research on New Product Formulations

Project Summary

This proposal is to requested funds for a noodle making machine for our on-going research efforts in development of new processing technologies to improve the utilization of Nebraska-produced dry-edible beans in commercial food processing operations. Instant noodles, commonly known as “junk food” is consumed worldwide. Long-term consumption of such foods could lead to nutritional deficiencies and certain health issues. Improving the nutritional value of instant noodles, and related products, therefore, is important. Dry-edible beans were used in improving nutritional properties of instant noodles. Our goals was to create new market opportunities for the Nebraska dry beans worldwide, especially in China where approximately 50% of global production of instant noodles is consumed. This acquisition of a noodle machine enabled us to test prototype products under more realistic, and close to commercial processing conditions, prior to introducing the technology to the food industry.

This project enhanced and complimented our efforts to improve the utilization of Nebraska dry beans in commercial food processing operations though previous Specialty Crop Block Grant funded project (contract No.18-13-188). Our previous projects explored the properties and functionalities of Nebraska Great Northern beans in noodles under laboratory conditions, which were not adequately simulating industrial processing conditions. The Noodle processing machine, acquired under this grant, enabled us demonstrating the processing operations to representatives from the food industry and also to collect supporting research evidence, on close-to-commercial quality products prepared using machine, to verify the potential of Great Northern beans as a valuable ingredient in noodle processing.

Project Approach

We prepared new improved instant noodles with wheat flour replacement with Great Northern bean flour, up to 60%. Very successful results were obtained for products made with up to 25% flour replacement with Great Northern bean powder. These instant noodles had significantly higher levels of protein and fiber, and low levels of total fat, compared to ‘regular’, traditional instant noodles. Flour replacement above 25% was difficult due to issues with product integrity – low gluten protein levels caused breakage of noodle strands during processing. Although this could be corrected by addition of certain ingredients (such as gums and starches), it was not experimented due to economic reasons. Instant noodles being a ‘cheap’ convenience food, a higher processing cost is deemed

unacceptable by the industry. Added texturizers to increase the bean powder content would significantly increase the cost of production.

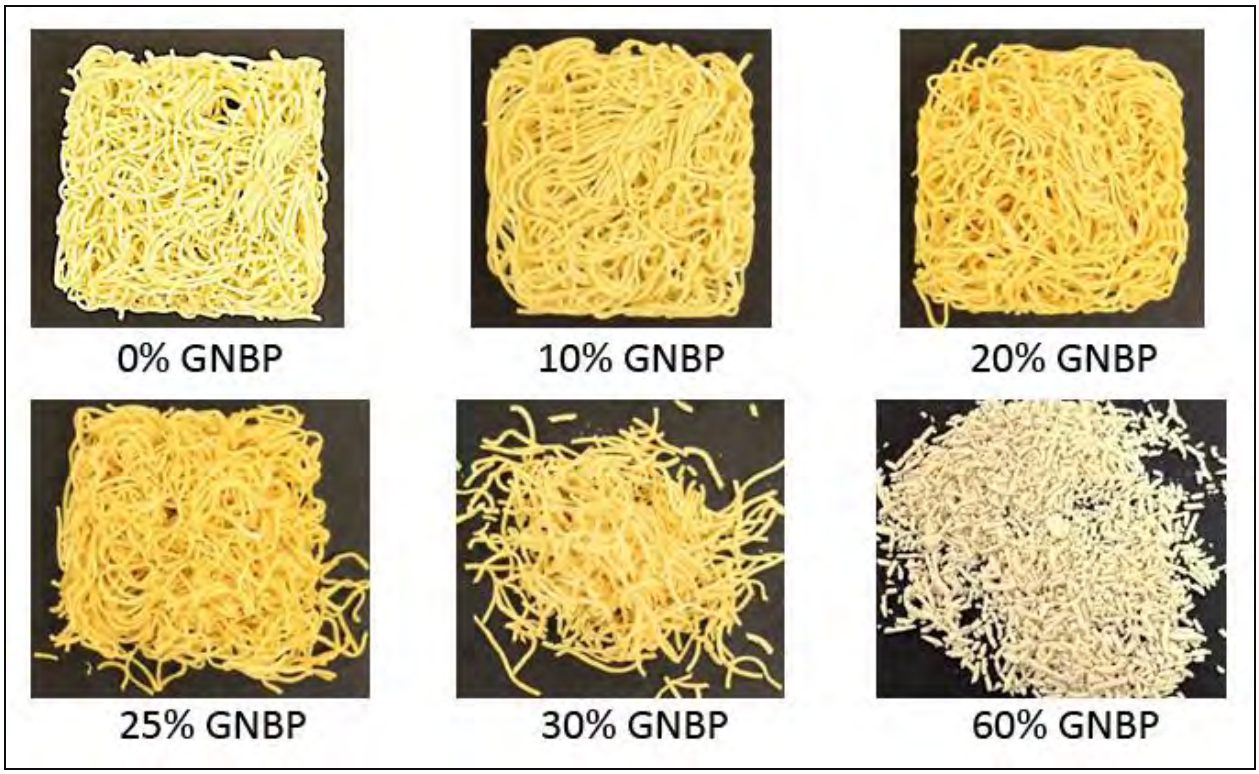

Figure: Instant noodle products made with selected levels of Great Northern bean powder (GNBP). Figure adapted from the publication cited below.

The noodle processing machine is kept in the Food Processing Center Pilot Plant due to safety reasons, space availability, and maintenance requirements. The Pilot Plant is well equipped to handle periodic maintenance of the equipment, such as cleaning, sanitation, lubrication, and minor repairs. These activities must be conducted in a food-grade space and the Pilot Plant meets all the safety and regulatory requirements to maintain and operate a food processing machine. The small food-grade laboratory, (17.5 Filley Hall - Dr. Ratnayake supervises), does not have sufficient space, power requirements, and cleaning facilities, to keep the noodle processing machine and technical expertise and man-power to carry out other important activities listed above. In addition, the cleaning, sanitation, and maintenance of the machine was/is performed by the Food Processing Center Pilot Plant staff without any additional cost to the project.

The noodle machine requires 3-phase power, which is not available in other food-grade spaces (including my laboratory, 17.5 Filley Hall), in the building. The Food Processing Center Pilot Plant has the power requirements to operate this machine.

Further experiments are currently being conducted on incorporating more than 50% of dry-bean powder in to instant noodles, using this noodle processing machine. The test results, if successful, would be available from these tests in the near future. These would be in addition to our previous findings on 60% bean powder incorporation into instant noodles. It is important to note that instant noodles, being an inherently cheap product, may not be the ideal candidate for incorporating very high levels of dry bean powder, which would significantly increase the end product price. The market and economic realities are such that high-priced instant noodles would not be successful in international (especially Chinese) markets, because it is a product primarily consumed by most people due to its cheap price.

Mr. Weier is the Manager of the Food Processing Center Pilot Plants. He has years of experience in operating and maintaining food processing machines. Considering this noodle machine was a previously used system (which does not carry manufacturer warranties), Mr. Weier's and his staff's assistance in maintenance of the machine is critical. During our experiments so far, he was a very important resource in troubleshooting some mechanical issues of the system and performing minor repairs. The manufacturer of this noodle machine has no U.S. representatives, to the best of our knowledge. Hiring a third-party engineer to troubleshoot and conduct minor repairs would have cost large expenses to the project. Mr. Weier's assistance in such occasions was critical in conducting our experiments.

Goals and Outcomes Achieved

We prepared a series of test samples with selected levels of wheat flour replacement with Great Northern bean powder, using the processing machine made available by this grant. We successfully developed a new generation of instant noodle products with superior nutritional value, compared to traditional products. Flour replacement above 25% was difficult due to product integrity issues. However, this is an area we plan to investigate in the future, in order to increase the levels of bean powder used in instant noodles.

Currently, dry beans are not used in instant noodles product. Approximately 1,400 packets of instant noodles in consumed in China every second, making the annual consumption of approx. 44 billion packets (of approx. 100g, each). The global consumption is much higher than this. In our opinion, utilization of dry beans, even at very low levels at the beginning, would create a significantly higher market demand for Nebraska dry beans in the future. As mentioned elsewhere, instant noodle being a cheap convenience food, it takes some time (and probably government involvement) to motivate food manufacturers to improve the nutritional value and quality of these widely consumed products. This project, however, provided critical research proof required for such an initiation.

Beneficiaries

The goal of this project was to improve the demand for Nebraska produced dry beans in the food industry, especially in China. Increased demand would eventually create better economic returns to approximately 1,300 dry bean farmers in Nebraska Panhandle region.

Outreach activities:
A product processing demonstration and several presentations were conducted, based on this project's outcomes, for a group of visiting Chinese food manufacturing industry representatives on Aug. 06th and 07th, 2013. This group included the following individuals; Mr. Chuang Kuo-Hung (Assistant Vice President of Research and Development, KSF Instant Noodle Business), Dr. Zhang Liping (Chief Engineer, National Coarse Cereals Engineering Research), Mr. Zhu Xiaowei (General Manager, Yihai (Shijiazhuang) Oils, Grains & Foodstuffs Industries Co. Ltd.), and Mr. Pei Zhiyong (Agricultural Marketing Specialist, U.S. Agricultural Trade Office – Beijing). The group received hands-on experience in noodle processing with dry beans and learned about the improved nutritional value and quality of the products.

The Project Director attended the 2013 Convenience Foods Expo and 2013 Sino-U.S. Health and Nutrition Forum in Beijing, China (Sept. 03-07) and a presentation entitled "Instant noodle products made with dry-edible bean flour" was made to introduce the new processing technologies and nutritionally improved noodle products to Chinese food manufacturers and technologists. The Expo was attended by approximately 3,000 industry professionals and academic researchers. The presentation was attended by approximately 200 of the attendees. During this meeting, the Project Director had meetings with Master-Kong Noodle Co. and several other noodle processors in China. Some of these companies have expressed interest in adopting our findings to improve their products.

Research presentations:
A research presentation was made at the 2013 American Association of Cereal Chemists International (AACCI) annual meeting (Albuquerque, NM, Sept. 29 – Oct. 02). The citation is provided below:

Wang, H., Ratnayake, W.S., Chiang, E. (2013). Improving nutritional value of instant noodles using Great Northern bean. *Cereal Foods World, 58* (4), A74. Link:
http://www.aaccnet.org/meetings/Documents/2013Abstracts/2013Pab174.htm

The meeting was attended by approximately 9,000 academic and food industry professionals, from both U.S. and international institutions.

Lessons Learned

The goals of the project were achieved and we were able to introduce the new formulations, with improved nutritional value and product quality, to the food industry through this project. The main lesson learned was that it would be possible to use dry beans in improving the nutritional value of instant noodle products. The only drawback/issue was that we were unable to achieve flour replacements above 25% due to product integrity issues that could not be resolved economically (*i. e.,* without significantly increasing the final product price). This is more applicable for the Chinese market due to price-based customer acceptance of products. However, if this technology were to be introduced in the U.S. market, we expect this not to be a huge issue (healthy convenience foods are in demand in the U.S. market and this demand is expected to increase in the future).

Contact Person

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Additional Information

The research poster presented at the AACCI meeting is attached.

This grant also created an opportunity for a Graduate Student (Ms. Hui Wang) to complete the second phase of her graduate research on utilization of Great Northern beans in food processing. An additional research publication on noodle processing with Great Northern beans is in preparation.

Improving nutritional value of instant noodles using Great Northern bean

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Poster No. 174-P

Abstract

Great Northern bean powder (GNBP) was used to fortify the traditional instant noodle formulation in order to improve the nutritional value. Instant noodles were prepared using a noodle processing machine, which simulated the commercial processing steps, using Hard Red Winter (HRW) wheat flour, in combination with selected levels (0, 10, 20, 25, 30, and 60% of flour replacement) of GNBP. Properties of flour mixtures and finished products were evaluated for functionalities and properties. This study showed that, under normal processing conditions, wheat flour could be replaced up to 25% (w/w) with GNBP in the conventional instant noodle formulation to obtain acceptable products with significantly improved nutritional value.

Introduction

The inherent advantages, such as low price, long shelf-life, and easy preparation, make instant noodle products popular among consumers. The demand for instant noodles is expected to increase, especially in the rapidly developing regions, such as China and U.S. Instant noodle is usually accused of being deficient in nutritional value, particularly protein, dietary fiber, and vitamins. Great Northern bean, a white color variety of dry-edible beans, is a widely available light color bean that has a better nutritional profile compared to wheat. In this study, GNBP was used to improve the nutritional quality of instant noodles, by replacing a portion of wheat flour in the formulation.

In this study, fried instant noodles prepared with selected levels of GNBP incorporation, replacing HRW wheat flour, were evaluated to determine the maximum level of GNBP substitution without compromising product quality.

Objectives

- To prepare instant noodles with selected levels of GNBP incorporation.
- To evaluate the properties of prepared instant noodle samples.
- To improve the nutritional value of conventional instant noodles.

Materials & Methods

Instant noodles were made by HRW wheat flour (ConAgra Mills, Omaha, NE, USA) and GNBP (VegeFull™, Archer Daniels Midland Company, Edible Bean Specialties, Decatur, IL, USA), following a previously published procedure (Hou, 2009).

- Pasting properties of flour mixtures were analyzed by Rapid Visco Analyzer (RVA).
- Colors of prepared noodle samples were analyzed in CIELAB color space using a Minolta CR-300 Chroma Meter (Minolta Camera Co., Ltd., Osaka, Japan).
- Cooking loss of instant noodles was measured by AACC method 66 – 50 (AACC International 2002). Water absorption ratio was calculated by the method reported by Kamolchote et al. (2010).
- Cooked noodle texture was analyzed by CT3 Texture Analyzer equipped with a 1000g load cell (Brookfield Engineering Laboratories, Middleboro, MA).

Results

Table 1. Color space analysis results of prepared instant noodles.

% Flour substitution with GNBP	Moisture (%)	Color		
		L* (lightness)	a* (red - green)	b* (blue- yellow)
0	4	99 a	-0.5 d	1.6 d
10	3	97 b	-0.2 c	7.7 c
20	3	95 c	0.4 b	9.5 b
25	6	93 d	0.7 a	12.1 a

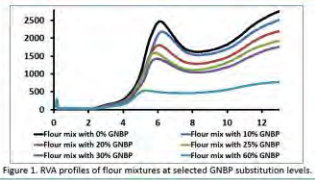

Figure 1. RVA profiles of flour mixtures at selected GNBP substitution levels.

Table 2. Cooking properties.

% Flour substitution with GNBP	Water absorption ratio	Cooking loss mg/g
0	1.2 b	69 b
10	1.2 ab	72 b
20	1.3 a	95 a
25	1.3 a	99 a

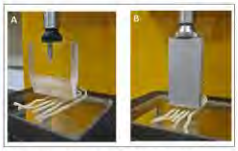

Figure 2. Texture analysis of cooked instant noodles
(A) TPA testing with wedged TA-PFS probe. (B) Compression testing with rectangular flat TA-PTF probe

Table 3. Texture analysis of cooked instant noodles.

% Flour substitution with GNBP	Adhesiveness (mJ)	Springiness (mm)	Hardness (g)
0	0.03 a	1.0 a	632.5 b
10	0.02 a	0.8 b	507.6 c
20	0.02 a	0.7 b	650.5 b
25	0.03 a	0.6 c	818.9 a

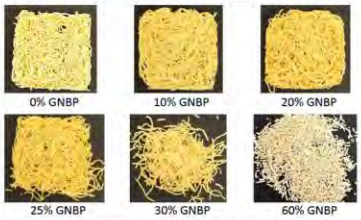

Figure 3. Appearance of finished instant noodle products.

- The noodle sheet with 30% GNBP substitution sliced into short fragile strands during slitting.
- The noodle dough with 60% GNBP substitution broke into small pieces during sheeting.

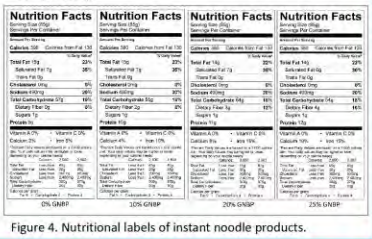

Figure 4. Nutritional labels of instant noodle products.

Discussion & Conclusions

- Under conventional processing conditions, acceptable instant noodle products were obtained with 0, 10, 20, and 25% HRWWF replaced by GNBP.
- Increasing GNBP level lowers pasting viscosities of flour mixtures (Figure 1).
- Increasing GNBP level increased the darkness and yellowness of noodle products (Table 1).
- Nutritional profiles, especially protein and fiber, and lipid contents, of traditional instant noodles could be improved by substituting a portion of wheat flour with GNBP (Figure 4).
- GNBP containing instant noodles were generally comparable to the control in product properties, although there were differences in color, cooking properties, and texture.

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