FY 2010 SPECIALTY CROP BLOCK GRANT PROGRAM- FARM BILL

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FINAL REPORT
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PROJECT 1: Eliminating Sunflower Rust in Confection Sunflower through Aggressive Breeding and Isolate Identification.

Final Report

Project Summary

Sunflower rust *Puccinia helianthi* is a serious disease that has been increasingly prevalent in much of the U.S. sunflower producing region. Confection sunflower is particularly vulnerable to the disease. The disease can dramatically lower yield and reduce quality of the seed. Developing genetic rust resistance in confection hybrids is the goal of this project. The project incorporated three identified rust resistant genes into two acceptable confection genetic backgrounds and made them available to the private seed industry for incorporation into finished commercial hybrids. The resistant genes were molecularly 'marked' for ease of identity in the numerous backcrosses that are required. Resistance to rust is an important agronomic factor in keeping U.S. confection sunflower competitive in key international markets. This project was not submitted or funded by another Federal or State grant program.

Project Approach

Our approach had three parts. First, we made two to three generations of backcrosses each year. Approximately seven generations with plant material containing a resistant gene will be required for the final product. We now obtained BC_3F_2 and BC_4F_2 generations for three combinations. Rust screening was applied to each generation to select resistant plants for backcross. Second, we developed molecular markers linked to the rust resistance genes R_4 and R_5 which are the current candidate genes of choice for introgressing into confectionery sunflower. Molecular markers linked to two new rust resistance genes, R_{11} and R_{12}, were also developed in line Rf-ANN 1742 and RHA 464 which are resistant to rust race 777, most virulent race currently known. Continued presence of the rust resistant gene will be confirmed by genetic DNA markers. In addition, each generation will show agronomic improvement in terms of plant vigor, plant height, seed size and seed color. These are all quantitative factors. Third, we are working on mapping of new rust resistance genes found in the inbred lines HA-R6, HA-R8, and RHA 397. The line HA-R6 is the only confection type known harboring a rust resistance gene.

Goals and Outcomes Achieved

The goals for 2011

a. Create BC_3, BC_4, and BC_4F_2 generations in the greenhouse.
b. Continue lab/greenhouse tests of all generations for resistance.
c. Develop molecular markers linked to the rust resistance gene *R5* in HA-R2 line and a new rust gene in RHA 464.
d. Allelic analysis of new rust resistance genes among HA-R6, HA-R8, RHA 397, and RHA 464. Produce test-cross F_1 and F_2.

Outcomes achieved in 2011

1. Production of BC_3F_2 and BC_4F_2 generations

The crosses were made between CONFSCL B1 and both MC29 (harboring rust resistance gene R_2) and HA-R2 (harboring R_5 gene), as well as between CONFSCL R5 and HA-R3 (harboring R_4 gene) in the greenhouse in winter 2009. We obtained the BC_4 generation of two crosses with rust resistance genes, R_2 and R_4, and the BC_3 generation of the gene R_5 in the spring and fall 2011. The rust tests were applied in each generation to issue that the resistant plants were selected and backcrossed to the recurrent parents. Advancement from the BC_3F_1 and BC_4F_1 to the BC_3F_2 and BC_4F_2 generations was performed in the winter 2011and the BC_3F_2 and BC_4F_2 progenies were recently harvested. Selection of homozygous rust resistance plants from BC_4F_2 populations by combining DNA markers and rust tests is underway in spring 2012. If possible, the selected homozygouse BC_4F_3 families will be grown for agronomic characteristics in the field in summer 2012. Otherwise, they will be grown in the Chile nursery in winter 2012.

2. Development of molecular markers linked to rust resistance genes R_5 in HA-R2 and R_{12} in RHA 464

Sunflower rust (*Puccinia helianthi)* emerged as a serious disease in North America in the last few years. A germplasm line, HA-R2, carrying the rust resistance gene R_5 was released as a multi-race rust resistant line in 1985 and has not been widely used in commercial hybrid production. R_5 remains effective against prevalent rust races of sunflower in North America and is our choice to transfer this gene to the confectionery sunflower from oil seed. We mapped this gene to sunflower linkage group (LG) 2. R_5 is the first disease resistance gene mapped to sunflower LG 2. Two molecular DNA markers, ORS1197 and ORS653, were identified that flank the R_5 gene closely on both sides. The development of linked markers for R_5 is an important advance and should provide a useful tool to speed up deployment of the R_5 gene in confectionery sunflower hybrid production.

RHA 464, a newly released sunflower inbred line, was identified to resist the most predominant and virulent rust races, 336 and 777. RHA 464 was crossed with HA 89 (a highly rust susceptible inbred line) and F_2 seedlings were tested for segregation of rust resistance. Rust resistant genotypes of F_2 individuals were confirmed with segregation of $F_{2:3}$ families. The results indicated a single dominant gene confers the rust resistance in RHA 464, and this gene was designated as R_{12}. We used 870 previously mapped SSR markers of sunflower to make bulked segregant analysis. Subsequent F_2 genotyping mapped R_{12} on linkage group 11. The same population was also used in our SNP mapping project. We identified SNP markers linked to R_{12} at 1.4 and 0.9 cM of genetic distance. R_{12} is unlinked to other known rust resistance genes in sunflower, indicating a novel rust resistance locus.

3. Production of test-crosses for allelic analysis of new rust resistance genes among HA-R6, HA-R8, RHA 397, and RHA 464

The goal of field test progeny in three field locations with inoculated rust spores was replaced with allelic analysis of new rust resistance genes among HA-R6, HA-R8, RHA 397, and RHA 464. The reason for the change was due to the second generation of backcrosses (BC_2) being unstable and unsuited for field testing, which kept the screening in the greenhouse. Rust testing is also more uniform and accurate when being done in the greenhouse or a growth chamber with a controlled environment, so the testing of sunflower germplasm for rust resistance was inadvertently stated as being done in field trials in the original proposal. The scope of the project has not changed.

From our previous survey, four USDA-released lines, HA-R6, HA-R8, RHA 397 and RHA 464 are resistant to both rust races 336 and 777. The rust resistances in these lines are from different origins, indicating diverse genetic sources. Six test-crosses, HA-R6 × HA-R8, HA-R6 × RHA 397, HA-R6 × RHA464, HA-R8 × RHA397, HA-R8 × RHA464, and RHA397 × RHA464, were made and advanced to F_2 generation. These F_2 populations will be used for allelic analysis of new rust resistance genes.
In addition, phenotyping of rust resistance in three F_3 populations of the crosses, HA89 × HA-R6, HA89 × HA-R8, HA89 × RHA397, is underway to further mapping of the rust resistance genes in these lines.

Beneficiaries

The beneficiaries are broad and varied. It is estimated that 825 farmers nationwide (half of whom are in North Dakota) will benefit directly by rust resistant hybrids. The cost of a fungicide application varies between $14 and $24 per acre, depending on which fungicide is used. With an average cost of $17.30 per application, the costs would equate to $6 million nationally of which $3 million would be in North Dakota. In early and severe infestations confection sunflower fields would require up to three applications resulting in costs of $18 million nationally and $9 million in North Dakota. Those farmers choosing not to spray a fungicide could lose 80 percent of their potential yield and the remainder of the crop would not be marketable. In an experimental strip in 2008 near Minot ND the yield was reduced from 1400 pounds/acre to 400 pounds/acre when no fungicide was used. That yield loss represents $350 per acre. The unmarketable remaining 400 pounds of production due to low test weight and discolored seed would represent an additional $140 per acre. Host resistance is the most effective way to control the disease and reduce the yield loss. In May 21 2010, USAgNet reported 'Confection Sunflower Rust Project Progresses' as National & World Ag News Headlines. This is second year of a three-year project. The NSA reported 'Confection Rust Project Makes Good Progress' on this research for *The Sunflower* magazine (2011 October/November issue) that goes to all U.S. growers and industry persons on. The both Drs Lili Qi and Li Gong gave reports on progress of the project at the annual NSA Research Forum in January 12 of 2012. Those reports reached key seed company breeders and grower leaders, which are available on the NSA website http://www.sunflowernsa.com/research/searchable-database-of-forum-papers/. This site is accessible to anyone. Of specific interest are the rust resistant genes that are now mapped and these markers are now available to breeders for use in their breeding efforts.

In 2012 there were 29 growers and crop consultants who attended the NSA Sunflower Research Forum. In addition to the growers and crop consultant there were 142 public and private sunflower breeders, researchers and industry leaders in attendance.

Lessons Learned

This is Year 2 of a proposed 3-year project, so it is a little early to offer insight into lessons learned. However, one result that was largely unanticipated was the lack of resistance to newer races of rust in the sunflower Plant Introductions that were previously classified as rust resistant in the sunflower GRIN (Germplasm Resources Information Network) database. It demonstrates that "rust resistant" lines must be checked for resistance to the new rust races before enlisting them into breeding programs. This is a high priority project and it will continue under separate funding if this grant is unavailable.

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Additional information available (e.g. publications, web sites)

1. Qi L L, Gulya T, Seiler GJ, Hulke BS, Vick BA 2011. Identification of resistance to new virulent races of rust in sunflowers and validation of DNA markers in the gene pool. Phytopathology 101:241-249.

2. Qi L L, Hulke BS, Vick BA, Gulya T 2011. Molecular mapping of the rust resistance gene R_4 to a large NBS-LRR cluster on linkage group 13 of sunflower. Theoretical and Applied Genetics 123:351-358.

3. Qi LL, Gulya TJ, Hulke BS, Vick BA 2011 Chromosome location, DNA markers and rust resistance of the sunflower gene R_5. Mol. Breeding DOI 10.1007/s11032-011-9659-6

4. Qi LL, Seiler GJ, Vick BA, Gulya TJ 2011 Genetics and mapping of two tightly linked novel genes, a rust resistance gene R_{11} and a fertility restorer gene *Rf5*, in sunflower (*Helianthus annuus* L.). Theoretical and Applied Genetics (got review back and is in revision)

5. Gong L, Gulya TJ, Markell S, Hulke BS, Qi LL 2012 Molecular tagging of a novel rust resistance gene R_{12} in sunflower (*Helianthus annuus* L.) (Abstract) The Plant & Animal Genome XX Conference, P0704

PROJECT 2: Northern Hardy Fruit Evaluation Project

Final Report

Project Summary

Background: In early 2006, Carrington Research Extension Center (CREC) director, Blaine Schatz, attended North Dakota's first Grape Growing and Wine Making meeting, held at the CREC facilities. Conversations with the over 70 attendees, and other CREC contacts over the years, reinforced the need to form a long-term project to provide North Dakotans with a place to see and taste hardy fruits that are grown worldwide. The needs Mr. Schatz heard are conveyed in the words of long-time NDSU woody plant researcher, Dr. Dale Herman, in his letter of support for this project: "Many years ago all tree fruit and small bush fruit research was cut from the Dept. of Horticulture (now Dept. of Plant Sciences) at the main NDSU campus in Fargo. This created a difficult situation, in that many people continue to contact the faculty seeking current information on many fruit growing and production problems. It is difficult to respond to our North Dakota constituency when little or no research is being conducted." Research-based results from the Northern Hardy Fruit Evaluation Project provide potential users, growers and homeowners with reliable information for making decisions for their businesses and families. CREC has a history of innovation and self-funded a deer-exclusion fence, site preparation, plant purchases and personnel to jump-start the project.

Motivation: At a time when we are encouraged to eat more fruits and vegetables and to shop locally, public funding of specialty crop research has not kept up with the value of its production. (Public Funding for Research into Specialty Crops. HortScience 43(5):1461–1470. 2008.) USDA's Agricultural Marketing Service reports show that the number of farmers markets in the US has increased 53% from 4,685 in 2008 to 7,175 in 2010. (www.ams.usda.gov, graph, Farmers Market Growth: 1994-2011) In North Dakota, there are 36 markets listed in the North Dakota Farmers Market and Growers Association 2011 Directory, a *33% decrease* from the 48 markets reported in 2008. (www.ndfarmersmarkets.com) The 2010 US Census indicated a 4.7% growth in North Dakota population in the past decade. Therefore, though our population is increasing, people may have less access to sources of locally-grown foods. With this project, they have the information they need to grow fruits themselves.

Currently there are eight wineries in North Dakota with one more scheduled to open in 2013. Three to four new wineries are planned for the near future with a total of 15 new wineries under consideration in North Dakota (personal communication, Rod Ballinger, chairman, North Dakota Grape and Wine Program Committee.) All of these wineries have the potential to use not only locally-grown grapes, but also, locally-grown fruits. In fact, two wineries currently focus on fruit wines and have utilized fruits from our project to make wines that they and their customers like. Adverse weather events such as the lack of snow and variable temperatures this past winter and spring affect grapes more, while the hardier fruits of our program should produce a crop more reliably. Fellow winemakers encourage each other to diversify their vineyards with other fruits.

Project Approach

Hardy Fruits: After spring pruning, general management of the fruit trial takes up much of the rest of the season as we mulch, fertilize, mow and control weeds. In order to evaluate each fruit

crop for adaptation, disease resistance, winter hardiness, productivity, fruit quality and vinification quality under central North Dakota growing conditions, we take notes on diseases, insect damage, growth and vigor both during the growing season and in the fall. Fruit production is evaluated by harvesting and measuring the amount of fruit produced *(Appendix A1, A2 measurements).* After freezing, the fruit is distributed to cooperators and the project manager also prepares jellies, jams and juices for meeting participants to taste. In fall, management includes cleaning up fallen leaves, mowing the grass short and removing the clippings, setting out rodent bait near plants susceptible to damage, as well as thinning extra-vigorous grape plants to prevent winter snow-load damage.

In general, the plants selected for the project grow well, are winter hardy, disease free and many have excellent fruits. They have been well-received by visitors. However, evaluation of growth and harvest notes indicated that some plants should be removed to make way for better or different fruit selections. Removal and replacement of some of the elderberries, gooseberries and currants with superior varieties was partly completed in 2010-11. All of the seaberries were removed due to the difficulty of harvesting the fruit as well as concerns about invasiveness. USDA-APHIS in Bismarck, ND was contacted with our concerns.

During the grant period, 617 people participated in outreach activities where information about the fruit project was presented. Despite temperatures approaching 95 degrees and high humidity, approximately 80 people joined the fruit project tour and tasted ripe or semi-ripe fruit at the annual field day event hosted by CREC on July 19, 2011. University of Minnesota Horticultural Research Center vineyard manager, John Thull, and assistant, Jenny Bradley, spoke at the event.

> **Partners:** Four cooperators utilized fruit from the project in 2011. Three vintners made wines from aronia berries, honeyberries, haskaps, black currants or red currants. One jelly maker made new jams from black currants and aronia as well as a familiar jam from Juneberries. Not all products have been released to customers yet, but the manufacturers have been happy with the fruit.

Grapes: In order to encourage more normal growth and to bring our grape varieties into bearing, we are utilizing methods for growing grapes on highly-productive soils suggested by viticulturists from University of Iowa. The plan to lower soil nitrogen and reduce overall plant vigor was implemented in 2010 and has had positive effects on the grapes. Most had good bud survival in winter 2010-11 for the first time since 2006-07. In 2011, small plants had the numbers of fruit reduced and very vigorous plants were allowed to keep all of their fruit, as fruit production uses a lot of energy. As a result of following these instructions, many canes appeared to have 'moderate' growth this past fall and showed signs of becoming hardy for winter. Depending on winter conditions, we anticipate good bud survival into 2012.

The third planting of the trial on the use of grow tubes in starting dormant, rooted grapes was installed in 2011. Rootstock was of average quality and some plants did not grow. Measurements and notes were taken after growth had initiated and again in the fall. The trial has to continue into spring 2012 to assess whether the tubes had any effect on the overwintering success of the plants. Our initial conclusion, based on the previous two planting years in which all plants died back to several buds despite snow cover, is that grow tubes do not help the establishment of grapes in rich soils, but do help with management during the growing season.

> **Partners:** The North Dakota Grape Growers Association kindly sponsored the travel of University of Minnesota Horticultural Research Center vineyard manager, John Thull, and assistant, Jenny Bradley, so that they could speak at the CREC annual field day.

Additional Achievements from the Plan of Work: With information from the fruit project and the fruit project manager, a member of the North Dakota Grape Growers Association conducted a second 'buy' of Canadian cherries and haskaps in 2011. We helped coordinated the distribution of plants for a second year, for *a total of 4,671 hardy fruit plants planted in the area in two years*. The sourcing of this fruit plant material represents a significant expansion of fruiting plants in North Dakota. It is suspected that these plantings are but the initial phase of expanded fruit plantings in North Dakota in response to interest by both commercial producers and homeowner/hobbyists.

A full-color brochure advertising the fruit project was developed with assistance from NDSU ExtensionAg Communications *(Attachment B, brochure).* The funding also allowed us to take the time to add project information, handouts and pictures to the CREC website: http://www.ag.ndsu.edu/CarringtonREC

As noted, the fruit project manager spoke to 617 people at 13 events this past year. She also spoke to over 40 people who called for information (Between May 1 and Aug. 1 additional calls were received, but not noted due to workload.), and more than 35 individuals contacted her by email.

The project manager attended the annual conferences of the Minnesota Grape Growers Association and North Dakota Grape Growers Association.

A college student was hired for the summer to assist the project manager. This allowed us to take better notes and to implement some disease control trials.

Goals and Outcomes Achieved

Outcome: Established food and wine companies in North Dakota will utilize CREC fruit to develop new products and then either grow the fruit themselves or buy it from North Dakota growers. Two bakeries, eight wineries and eight jam/jelly/syrup makers who are Pride of Dakota (PoD) members have been identified as businesses that use fruit in North Dakota.

1. Goal: To make these 18 businesses aware of the new fruits at CREC.
2. Performance Measure: The number of businesses that express a desire to put new products into production.
3. Benchmark: In 2009, one business utilized CREC fruit for wine.
4. Target: 25 to 50% of the contacted businesses will express a desire to continue utilizing these fruits.

Results: The eighteen businesses were contacted by email in fall/winter 2010/11. No responses were received. With phone calls and contacts through the ND Grape Growers Association, 2 wineries, 1 jelly maker and 4 home vintners agreed to try fruits. In summer 2011, these same three businesses requested more fruit from the 2011 growing season than they used in 2010. One other non-PoD winery requested fruit as well. We fell short of our target as only 17% of the contacted businesses participated. However, now that these four companies have made successful products with the fruits, they are very excited by the products. Two of the wineries are now planting their own fruit plants to meet their production needs.

Each of the businesses than used fruit from the 2011 growing season was surveyed. Their positive responses are attached *(Attachment C).*

Outcome: Grape plants at CREC will have a normal cycle of bearing fruit and become winter hardy.

1. Goal: To utilize methods for growing grapes in highly fertile soils to bring CREC grape plants into a normal cycle of bearing fruit and being winter hardy.
2. Performance Measure: The hardiest plants will survive the winter and produce fruit.
3. Benchmark: To date, only three varieties have fruit-bearing plants.
4. Target: Seven to ten other hardy varieties will start producing fruit.

Results: We are seeing great success with these methods. After four years of 'rampant' growth and subsequent winter injury in many of the 18 varieties of grapes, almost all have now expended their excess energy and have produced fruit. In fall 2010, canes with moderate growth were laid on the ground and covered with snow to ensure winter survival. In spring 2011, 5-7 canes were tied to the trellis and allowed to grow as they wished, and fruit if they could. We exceeded our target of 7-10 additional varieties starting to bear fruit as all the varieties (18 total and thus, 15 more than expected) fruited in 2011 and showed good signs of becoming dormant in late fall. Signs of bud survival are promising now in spring 2011. However, recent cool weather has slowed bud development and we have not been able to assess bud and vine survival yet this year.

Beneficiaries

The beneficiaries of this project are North Dakotans who will grow fruit plants: 1. for their own use, 2. to produce commercial wine, 3. to sell the fruit to others and, 4. to make other commercial products such as jellies and juices. We feel that this is the order of interest at this time.

During the grant period, 617 people participated in outreach activities where information about the fruit project was presented. One hundred-forty people attended hands-on tours and 492 attended presentations. We also responded to more than 75 phone or email inquiries.

One jelly maker tried our Canadian Juneberries, aronia and black currant berries in products. They thought that their customers were very receptive to the Juneberries and aronia jams. The black currant jam was not purchased as often, but was also not promoted as well by the sales people (personal communication).

Of the three winemakers who used fruit during the grant period, two requested and liked the aronia berries and plan to continue to make this wine. One has planted about 500 of his own plants. Two winemakers requested haskaps and honeyberries. Both are very excited about the fruit and both have planted several hundred plants each of several varieties. Two winemakers also requested and were very satisfied with black currant wines and both planted multiple varieties.

Members of the North Dakota Grape Growers Association have learned about the project from the fruit project manager at each annual meeting since 2007. Of 11 member wineries, three are devoted entirely, or with a majority of their production, to fruit wines. One member, Bob Thaden, of Tongue River Vineyard, Miles City, MT, is a well-respected winemaker and a vocal advocate for adding diversity to a northern winery by adding these hardy fruits to the orchard. We are grateful for his voice!

Lessons Learned

There are five things which became obvious to the fruit project manager:

1. Grapes require a lot of attention during the growing season when grown on productive soils. The 'rules' for vine management must be adapted for these soils.
2. In these same soils, fruit shrubs require almost no attention during the growing season.
3. It is difficult to interest processors in new fruits.
4. Individuals are really excited and interested in our fruit plants.
5. Diverse fruit crops spread out the blossom and harvest seasons to lower risk of crop failure due to weather events.

Comments: 1. The Central Drift Prairie region of North Dakota has wonderful loam soils. In Carrington, soil organic matter (OM) content is about 3.5 to 4% while grapes require just 1.5% to grow well. Typical recommendations for growing grapes suggest allowing just one cane to become the trunk of the plant and two lateral shoots to become the horizontal cordons for future production. At CREC, this results in the formation of 'bull canes' in the second growing season due to the large amounts of energy stored in the roots being funneled through one trunk. These plants do not create hardy buds in the fall. After several seasons of frustration, we implemented changes recommended by University of Iowa researchers and hope to be able to scale back our level of attention in the future. In a typical season, there is an 8 to 10-week period when our ½ acre of vines requires attention five or more hours per day, three days a week, to train and comb the shoots and remove lateral growth as well as normal maintenance such as exposing fruit to sunlight, thinning under-ripe fruit, weeding and mowing. John Marshall, of Great River Vineyard, Lake City, MN, comments that, "If you grow grapes, you don't take vacations in the summer."

2. On the other hand, fruiting shrubs at CREC have required little extra effort. After pruning (including grapes) in the spring, one application of fertilizer is made to the soil followed by bi-weekly applications of foliar fertilizers. Some fruits that are more attractive to birds are netted, but most vineyards in North Dakota net grapes, too. By their growth, hardiness and fruit production, the plants selected for the project are, by and large, easy to grow, attractive to gardeners and make excellent fruit products.

3. For one year before, and now during the grant period, North Dakota companies that use fruits were contacted by email or letter to inform them about the CREC fruit project. The fruits were explained and the processors were told that they could receive free fruit, in the quantity they needed, for making test batches of products. Only one jelly maker responded for Juneberries, a fruit she already used. With encouragement, she also tried aronia and black currants. She reported that aronia was actively promoted and customers bought it. She did not actively promote black currant jam and reported that it did not sell as well. One wine maker asked for aronia fruit. We contacted a new winemaker who specializes in fruit wines, and he was given samples of all types of fruit we had available. A third winemaker from Montana, familiar to us through the ND Grape Growers Association, requested fruit. Each of these four is now very happy with the fruits and would like more of every kind. The Montana winemaker, who is very active and well-known to North Dakota winemakers, encourages fruit crop diversification and fruit winemaking in general. It may be that a personal visit to the business owner would encourage them to try these fruits. We may also try to create message cards for each fruit.

4. During the grant period, 617 people participated in outreach activities where the fruit project was presented. More than 75 people also requested information personally. In total, since tours and presentations began in 2008 through March 31, 2012, 1,722 people have attended an event or contacted us about the project. Newspaper articles, word-of-mouth and the new website articles have brought requests for information from South Dakota, Minnesota and Montana. We consider this a resounding success as we had no web presence until 2010 and the fruit project manager is limited to part-time work by her employment status.

As noted earlier, Mr. Thaden, a member of the North Dakota Grape Growers Association, with information from the fruit project, coordinated a 'buy' of Canadian cherries and haskaps in 2010 and 2011 and we assisted with plant distribution. In spring 2011, from a list of 96 CREC fruit project contacts who wanted more information about fruits, 57 people placed orders for 1,239 cherry and haskap plants; the order total was 3,430 plants. This is a significant expansion of fruit plantings in North Dakota. In the forthcoming 2011-12 grant period, we will survey participants to more closely determine the increase in fruiting plants in North Dakota since 2006.

5. Red grape varieties require a longer season to ripen. In many years, the growing season is too short to fully ripen the varieties available to North Dakota growers. Most white grape varieties ripen well, however. Late spring frosts, short falls or warm periods during the winter can damage fruiting buds. The other hardy fruits in the project, however, are all conditioned to growing zones 2, 3 or 4 and flower and ripen at different times from each other (Appendix D as well as Appendixes A1 and A2). During the several years that North Dakota grape growers reported under-ripened grapes, these other hardy fruits had already been harvested at maximum ripeness.

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Additional information available

Hardy Cherries

Winter 2010-11

Fall in the Orchard

Black Currants

Summer Field Day Tour

Haskaps

'Somerset Seedless' Grape

Juneberries

Type of Plant	Cultivar Name	Number of plants	Year Planted	Ave Height	Ave Canopy Width	Vigor	Fruit Set	Harvest Date	Weight of Fruit	Ave. Wt of 10 berries	Brix	Rust	Powdery Mildew	Aphids	Disease	Insect Damage	Note
				cm	cm	0-5	yes/- -		gm	gm	% solids = % sugars	0-3	0-3	0-3	0-3	0-3	
					Trunk Caliper mm												
Apples - *Malus domestica*																	
	Haralred	2	2006	295	42	3.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Haralred	2	2008	196	28	4.0	Y	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Hazen	4	2006	326	62	4.8	Y	- -	- -	- -	- -	- -	- -	- -	1	- -	Fireblight
	Sweet Sixteen	4	2006	351	61	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	No blossoms yet
	Honey Crisp	6	2006	315	57	4.8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Leaf Mottling
	Zestar	4	2007	273	32	4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	First blossoms
Aronia - *Aronia melanocarpa*																	
	Nero	4	2007	126	160	4.8	Y	9-9	16974	13.1	17.9	- -	- -	- -	- -	Y	Leaves skeletonized
	Raintree Select	4	2007	130	171	4.8	Y	9-8	13528	13.7	18.0	- -	- -	- -	- -	Y	Leaves skeletonized
	Raintree Seedling	4	2007	114	167	5.0	Y	9-10	18330	12.8	16.0	- -	- -	- -	- -	Y	Leaves skeletonized
	Viking	4	2007	137	182	5.0	Y	9-10	18445	13.9	16.3	- -	- -	- -	- -	Y	Leaves skeletonized
	McKenzie	4	2010	36	36	4.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	Y	Leaves skeletonized
Dwarf Hardy Cherry - *P. cerasus* x *P. fruiticosa*																	
	Carmine Jewel	12	2007	175	163	4.9	Y	7-28	17002	- -	16.4	- -	- -	- -	- -	- -	First fruit
	Crimson Passion	11	2007	150	144	4.8	Y	7-28	3500	55.7	18.6	- -	- -	- -	- -	- -	First fruit
Black Currants - *Ribes nigrum*											7-27						
	Ben Lomand	4	2008	92	111	4.5	Y	8-2	2206	8.6	- -	2.0	3.0	0.0	- -	- -	First fruit
	Champion	4	2008	89	116	5.0	Y	8-2	1898	6.5	- -	2.0	3.0	0.3	- -	- -	
	Consort	4	2007	100	112	4.8	Y	7-29	2380	5.2	- -	0.0	3.0	0.8	- -	- -	Replace cultivar 2011
	Crandall *	4	2007	118	127	4.3	Y	Sept.	- -	- -	- -	0.0	0.0	0.0	- -	- -	
	Minaj Smyriou	4	2008	96	102	4.5	Y	7-29	1983	10.8	- -	0.0	3.0	0.8	- -	- -	First fruit
	Ben Sarek	16	2007	69	107	4.6	Y	8-3	11193	13.4	16.8	0.9	1.9	1.1	- -	- -	Replace cultivar 2011
	Black Down WF	5	2007	88	132	4.8	Y	8-2	1368	8.6	19.5	2.0	0.0	1.0	- -	- -	
	Black Down OGW	11	2007	96	129	4.7	Y	7-29	12024	11.5	19.5	1.3	2.0	0.8	- -	- -	
	Hilltop Baldwin	16	2008	89	121	4.8	Y	7-29	5148	7.1	18.0	2.1	2.5	0.6	- -	- -	
	Swedish Black	14	2007	75	118	4.4	Y	8-2	1236	9.7	20.2	1.9	0.6	0.3	- -	- -	
	Titania	16	2007	113	136	4.8	Y	8-2	4730	11.7	20.0	0.0	1.9	0.5	- -	- -	
	* *Ribes odoratum*. A mild, sweeter N. American currant that ripens unevenly in September.																
Red Currants - *Ribes rubrum*																	
	Jhonkheer Van Tets	4	2008	105	114	4.8	Y	8-11	2117	7.8	- -	0.0	1.0	0.0	- -	- -	
	Red Lake	4	2007	110	119	4.3	Y	7-29	9665	5.4	- -	0.0	0.0	0.0	- -	- -	
	Redstart	4	2007	87	106	5.0	Y	8-9	5582	n	- -	0.0	1.0	0.0	- -	- -	
	Rosetta	4	2007	100	141	5.0	Y	8-11	3835	6.1	- -	0.0	0.0	0.0	- -	- -	
	Rovada	4	2007	92	120	5.0	Y	8-10	4607	6.0	- -	0.0	0.0	0.0	- -	- -	
White Currants - *Ribes rubrum*																	
	Blanka	4	2007	94	125	4.5	Y	8-10	8598	5.9	- -	0.0	2.0	0.0	- -	- -	
	Swedish White	4	2007	88	125	5.0	Y	8-3	6645	5.5	- -	0.0	0.0	0.0	- -	- -	

Type of Plant	Cultivar Name	Number of plants	Year Planted	Ave Height	Ave Canopy Width	Vigor	Fruit Set	Harvest Date	Weight of Fruit	Ave. Wt of 10 berries	Brix	Rust	Powdery Mildew	Aphids	Disease	Insect Damage	Note
				cm	cm	0-5	yes/- -		gm	gm	% solids = % sugars	0-3	0-3	0-3	0-3	0-3	
Gooseberries - *Ribes uva-crispa*																	
	Captivator*	4	2008	89	115	3.0	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	*Imported currant*
	Black Velvet*	4	2007	114	142	5.0	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	*worms ate all foliage*
	Hinnomaki Red*	4	2007	75	150	5.0	Y	- -	- -	- -	- -	- -	1.0	- -	1.0	Y	*in mid-August*
	Hinnomaki Yellow	4	2008	43	65	1.5	- -	- -	- -	- -	- -	- -	3.0	- -	2.8	Y	Removed
	Invicta	4	2008	53	82	2.7	- -	- -	- -	- -	- -	- -	3.0	- -	3.0	Y	Removed
	Jahn's Prairie*	4	2008	101	98	3.5	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	
	Jewel*	4	2007	88	130	5.0	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	
	Lepaa Red*	4	2007	83	150	5.0	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	
	Pixwell	4	2007	44	78	2.5	- -	- -	- -	- -	- -	- -	3.0	- -	3.0	Y	Removed
	Poorman	4	2008	44	62	1.7	- -	- -	- -	- -	- -	- -	2.8	- -	2.8	Y	Removed
	Red George*	4	2007	102	135	4.8	Y	- -	- -	- -	- -	- -	0.0	- -	1.0	Y	
	Red Jacket*	4	2007	59	100	3.0	Y	- -	- -	- -	- -	- -	3.0	- -	1.0	Y	
	Tixia	4	2007	65	99	4.0	- -	- -	- -	- -	- -	- -	3.0	- -	3.0	Y	Removed
	* = Reduced plant number to 1 and moved Oct. 2010.																
Edible Blue Honeysuckle [Russian Honeyberry] *Lonicera caerulea ssp edulis or kamtshatica*																	
	Berry Blue	4	2007	117	121	5.0	Y	7-2	4236	- -	- -	- -	- -	- -	- -	- -	
	Blue Belle	4	2007	70	69	4.5	Y	6-15	2554	7.6	- -	- -	- -	- -	- -	- -	
	Blue Moon	4	2007	66	105	5.0	Y	7-7	1613	8.1	- -	- -	- -	- -	- -	- -	
	Blue Velvet	4	2007	60	114	4.8	Y	7-2	1247	- -	- -	- -	- -	- -	- -	- -	
	Kamchatka	4	2007	77	68	4.8	Y	7-2	899	- -	- -	- -	- -	- -	- -	- -	
Edible Blue Honeysuckle [Oregon Haskap] *Lonicera caerulea ssp emphylocalyx.*																	
	22-37	3	2008	80	87	4.3	Y	7-6	1051	18.5	14.6	- -	- -	- -	- -	- -	
	41-100	3	2008	80	79	5.0	Y	7-6	1745	11.4	12.2	- -	- -	- -	- -	- -	
	43-87	3	2008	80	65	5.0	Y	7-6	497	15.5	15.4	- -	- -	- -	- -	- -	
	43-97	3	2008	75	84	5.0	Y	7-6	1558	12.8	18.3	- -	- -	- -	- -	- -	
	45-57	3	2008	84	72	5.0	Y	7-6	1493	14.7	14.0	- -	- -	- -	- -	- -	
	85-26	3	2008	82	87	5.0	Y	7-6	1753	15.7	13.6	- -	- -	- -	- -	- -	
Edible Blue Honeysuckle [Canadian Haskap] *Lonicera caerulea*																	
	9-15	5	2008	63	72	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Cut back in Spring
	9-91	5	2008	56	103	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Cut back in Spring
	Tundra (9-84)	5	2008	55	96	4.2	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Cut back in Spring
	Borealis (9-94)	5	2008	51	105	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Cut back in Spring
	MT 46-55	1	2009	25	22	3.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Cut back in Spring
Juneberry - *Amelanchier alnifolia*																	
	Honeywood	20	2006	96	97	3.2	Y	7/7-16	16975	12.4	- -	- -	- -	- -	- -	- -	
	JB30	20	2006	97	104	3.4	Y	7/7-16	17051	13.3	- -	- -	- -	- -	- -	- -	
	Martin	20	2006	91	88	3.1	Y	7/7-16	6295	14.5	- -	- -	- -	- -	- -	- -	
	Smoky	20	2006	104	97	3.4	Y	7/7-16	19632	10.1	- -	- -	- -	- -	- -	- -	
	Thiessen	20	2006	104	98	3.4	Y	7/7-16	13342	13.6	- -	- -	- -	- -	- -	- -	
					Trunk												
Plums - Native x *P. salicina*					Caliper mm												
	Prairie Red Hyb.	2	2010	91	9	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Pembina	4	2006	294	61	- -	Y	8/15-18	- -	3750	- -	- -	- -	- -	- -	- -	
	Pipestone	5	2006	345	51	- -	Y	8/15-18	- -	2320	- -	- -	- -	- -	- -	- -	
	Toka	5	2006	374	66	- -	Y	n	- -	- -	- -	- -	- -	- -	- -	- -	
	Waneta	5	2006	266	48	- -	Y	9-3	- -	- -	- -	- -	- -	- -	Fruit	- -	Like blossom end rot.

Type of Plant	Cultivar Name	Number of plants	Year Planted	Ave Height	Ave Canopy Width	Vigor	Fruit Set	Harvest Date	Weight of Fruit	Ave. Wt of 10 berries	Brix	Rust	Powdery Mildew	Aphids	Disease	Insect Damage	Note
				cm	cm	0-5	yes/- -		gm	gm	% solids = % sugars	0-3	0-3	0-3	0-3	0-3	
					Trunk Caliper mm												
Apples - *Malus domestica*																	
	Haralred	2	2006	323	51	4.5	Y	- -	- -	- -	- -	- -	- -	- -	- -	- -	*HR:Allowed small crop*
	Haralred	2	2008	244	38	5.0	Y	- -	- -	- -	- -	- -	- -	- -	- -	- -	*Most apples removed*
	Hazen	4	2006	338	72	4.8	Y	9-13	- -	- -	- -	- -	- -	- -	- -	- -	Good crop, good apples
	Sweet Sixteen	4	2006	374	72	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Honey Crisp	6	2006	347	69	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	Leaf Mottling
	Zestar	4	2007	339	39	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	One apple
Aronia - *Aronia melanocarpa*																	
	Nero	4	2007	138	190	4.8	Y	9/19-23	12768	10.1	15.0	- -	- -	- -	- -	Y	Leaves lightly skeletonized
	Raintree Select	4	2007	148	195	4.5	Y	9-19	10125	10.6	17.3	- -	- -	- -	- -	Y	by pear sawfly larvae
	Raintree Seedling	4	2007	127	195	5.0	Y	9-23	9275	9.9	14.8	- -	- -	- -	- -	Y	Leaves lightly skeletonized
	Viking	4	2007	144	198	5.0	Y	9-19	9203	10.6	17.0	- -	- -	- -	- -	Y	Leaves lightly skeletonized
	McKenzie	4	2010	57	75	4.8	Y	- -	- -	- -	- -	- -	- -	- -	- -	Y	Leaves lightly skeletonized
Dwarf Hardy Cherry - *P. cerasus* x *P. fruiticosa*																	
	Carmine Jewel	12	2007	209	Fills 5' space	4.7	Y	8/2-4	15464	41.1	12.1	- -	- -	- -	- -	- -	Hail damaged fruit
	Crimson Passion	11	2007	184	156	4.1	Y	8-4	1213	58.7	14.6	- -	- -	- -	- -	- -	Hail damaged fruit
Black Currants - *Ribes nigrum*																	
	Ben Lomand	4	2008	105	142	4.8	Y	8-16	2679	8.3	- -	3.0	2.0	- -	- -	- -	
	Blackcomb	4	2011	33	21	3.8	Y	- -	- -	- -	- -	0	0	- -	- -	- -	New 2011
	Champion	4	2008	103	133	5.0	Y	8-16	3892	5.0	- -	3.0	2.5	- -	- -	- -	
	Crandall *	4	2007	125	167	4.8	Y	- -	- -	- -	- -	0	0	- -	- -	- -	
	Minaj Smyriou	4	2008	100	132	4.8	Y	8-16	3840	8.3	- -	0	1.0	- -	- -	- -	
	Black Down WF	5	2007	98	142	5.0	Y	8-23	5283	6.5	- -	3.0	0.4	- -	- -	- -	
	Black Down OGW	11	2007	107	152	5.0	Y	8-15	17183	9.2	- -	2.7	0	- -	- -	- -	
	Hilltop Baldwin	16	2008	97	135	4.8	Y	8-18	19256	7.2	- -	3.0	1.3	- -	- -	- -	
	Swedish Black	14	2007	73	112	4.5	Y	8/16-22	11460	8.7	- -	2.7	0.3	- -	- -	- -	
	Titania	16	2007	120	169	4.9	Y	8/23-25	20746	8.3	- -	0.1	0	- -	- -	- -	
	Whistler	12	2011	47	31	4.3	Y	- -	- -	- -	- -	0	0	- -	- -	- -	New 2011
	* *Ribes odoratum*. A mild, sweeter N. American currant that ripens unevenly in September.																
Red Currants - *Ribes rubrum*																	
	Jhonkheer Van Tets	4	2008	120	148	4.8	Y	8-25	8021	6.1	- -	0.5	0.5	- -	- -	- -	
	Red Lake	4	2007	119	138	4.5	Y	8-9	13759	5.1	- -	0	0.5	- -	- -	- -	
	Redstart	4	2007	95	121	4.0	Y	8-8	11208	5.5	- -	1.0	1.5	- -	- -	- -	
	Rosetta	4	2007	108	145	5.0	Y	8-17	18359	6.5	- -	1.0	0.5	- -	- -	- -	
	Rovada	4	2007	98	136	4.8	Y	8-17	15116	8.3	- -	1.0	0.5	- -	- -	- -	
White Currants - *Ribes rubrum*																	
	Blanka	4	2007	100	135	4.5	Y	8/26-9/1	16365	5.8	- -	1.5	2.0	- -	- -	- -	
	Swedish White	4	2007	101	140	5.0	Y	8-4	13155	5.9	- -	0.5	0.5	- -	- -	- -	

Type of Plant	Cultivar Name	Number of plants	Year Planted	Ave Height	Ave Canopy Width	Vigor	Fruit Set	Harvest Date	Weight of Fruit	Ave. Wt of 10 berries	Brix	Rust	Powdery Mildew	Aphids	Disease	Insect Damage	Note
				cm	cm	0-5	yes/- -		gm	gm	% solids = % sugars	0-3	0-3	0-3	0-3	0-3	
Gooseberries - *Ribes uva-crispa*																	
	Captivator*	1	2008	58	134	5.0	- -	- -	- -	- -	- -	- -	?	- -	2.0	- -	*All have spots and*
	Black Velvet*	1	2010	70	130	3.0	- -	- -	- -	- -	- -	- -	?	- -	1.0	- -	*missing leaves due*
	Hinnomaki Red*	1	2010	38	34	2.0	- -	- -	- -	- -	- -	- -	?	- -	2.0	- -	*to disease.*
	Jahn's Prairie*	1	2008	78	110	5.0	- -	- -	- -	- -	- -	- -	?	- -	3.0	- -	
	Jewel*	1	2010	36	55	2.0	- -	- -	- -	- -	- -	- -	?	- -	3.0	- -	*Observed too late to*
	Lepaa Red*	1	2010	28	120	3.0	- -	- -	- -	- -	- -	- -	?	- -	2.0	- -	*record powdery*
	Red George*	1	2010	58	100	3.0	- -	- -	- -	- -	- -	- -	?	- -	3.0	- -	*mildew.*
	Red Jacket*	1	2010	34	72	2.0	- -	- -	- -	- -	- -	- -	?	- -	2.0	- -	
	* = Reduced plant number to 1 and moved Oct. 2010.																
Edible Blue Honeysuckle [Russian Honeyberry] *Lonicera caerulea ssp edulis or kamtshatica*																	
	Berry Blue	4	2007	117	141	5.0	Y	7-12	5745	6.8	15.4	- -	3.0	- -	- -	- -	*PM is late in year*
	Blue Belle	4	2007	70	78	4.5	Y	7-7	2825	6.6	14.2	- -	3.0	- -	- -	- -	*Only mars appearance*
	Blue Moon	4	2007	73	122	5.0	Y	- -	- -	- -	- -	- -	1.0	- -	- -	- -	
	Blue Velvet	4	2007	66	141	5.0	Y	- -	- -	- -	- -	- -	1.0	- -	- -	- -	
	Kamchatka	4	2007	82	90	4.3	Y	7-7	2908	- -	13.6	- -	1.5	- -	- -	- -	
Edible Blue Honeysuckle [Oregon Haskap] *Lonicera caerulea ssp emphylocalyx.*																	
	22-37	3	2008	93	115	3.7	Y	7-28	1105	24.2	12.6	- -	2.0	- -	- -	- -	
	41-100	3	2008	96	101	4.7	Y	7-28	1267	10.8	10.8	- -	2.0	- -	- -	- -	
	43-87	3	2008	92	103	4.3	Y	7-21	1990	21.2	14.7	- -	2.0	- -	- -	- -	
	43-97	3	2008	82	103	4.7	Y	8-1	1454	15.6	13.6	- -	2.0	- -	- -	- -	
	45-57	3	2008	99	94	4.7	Y	7-27	1985	19.7	12.0	- -	2.0	- -	- -	- -	
	85-26	3	2008	95	112	4.7	Y	7-27	2919	19.2	11.8	- -	2.0	- -	- -	- -	
Edible Blue Honeysuckle [Canadian Haskap] *Lonicera caerulea*																	
	9-15	5	2008	74	119	5.0	Y	7-20	231	11.4	16.6	- -	0.5	- -	- -	- -	
	9-91	5	2008	74	114	5.0	Y	7-14	3997	9.7	15.8	- -	0.5	- -	- -	- -	
	Tundra (9-84)	5	2008	61	103	3.6	Y	7-12	2181	11.1	15	- -	0.5	- -	- -	- -	
	Borealis (9-94)	5	2008	69	107	5.0	Y	7-14	644	11.4	12.2	- -	0.5	- -	- -	- -	
	MT 46-55	1	2009	50	74	2.0	Y	- -	- -	- -	- -	- -	0.5	- -	- -	- -	
Juneberry - *Amelanchier alnifolia*																	
	Honeywood	20	2006	116	x	3.4	Y	7/15-25	19821	11.3	- -	- -	- -	- -	2.7	- -	*Entomosporium leaf*
	JB30	20	2006	123	x	3.8	Y	7/15-25	23460	15.0	- -	- -	- -	- -	1.1	- -	*and berry spot on all*
	Martin	20	2006	126	x	3.6	Y	7/15-25	12765	16.6	- -	- -	- -	- -	1.1	- -	*leaves due to weather.*
	Smoky	20	2006	126	x	3.7	Y	7/15-25	13228	10.0	- -	- -	- -	- -	1.9	Y	Thrips in flowers
	Thiessen	20	2006	128	x	3.6	Y	7/15-25	21847	15.8	- -	- -	- -	- -	1.4	- -	
					Trunk												
Plums - Native x *P. salicina*					Caliper mm												
	Prairie Red Hyb.	2	2010	97	10	4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Pembina	4	2006	373	72	4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Pipestone	5	2006	376	58	4.4	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Toka	5	2006	415	79	5.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	
	Waneta	5	2006	320	57	4.2	Y	9-7	3708	- -	- -	- -	- -	- -	- -	- -	med size plum = 46g

Interest in Hardy Fruits

The NDSU Carrington Research Extension Center developed a Northern Hardy Fruit Evaluation Project as a result of numerous inquiries from home gardeners, fruit enthusiasts and people wanting to create a new source of income from their land.

Production information on adapted fruit species in North Dakota was limited. New and recently improved fruit species grown in similar latitudes around the world had not been evaluated for their potential in North Dakota.

For more information
or to arrange a tour, contact

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NDSU.Carrington.rec@ndsu.edu

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Visit Us

The Carrington Research Extension Center orchard is 3.5 miles north of Carrington on U.S. Highway 281.

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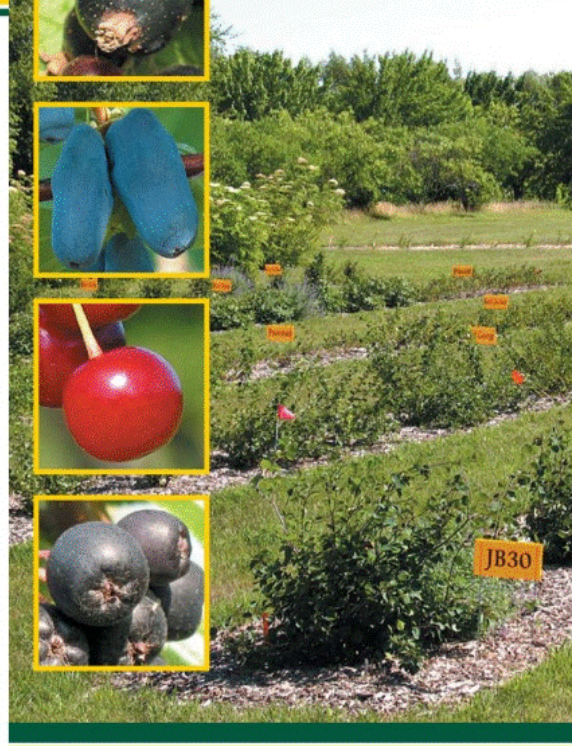
Northern Hardy Fruit

Evaluation Project



NDSU
North Dakota State University
ND Agricultural Experiment Station

Carrington
Research Extension Center

The Project

The Northern Hardy Fruit Evaluation Project was initiated in 2006. On-going research and demonstrations include variety evaluations to determine hardiness, productivity, cultural techniques and fruit quality.

A deer-proof fence protects this three-acre orchard, which contains 15 kinds of fruit and more than 750 plants.

This project fits the center's mission of creating and improving economic opportunities through the use of our natural resources and expanding knowledge.

Project Goals

- Introduce growers, processors and consumers to healthy and delicious fruits that can be grown easily in North Dakota
- Provide home gardeners and new or existing agribusinesses with information they need to grow these fruits successfully

Fruit Being Evaluated

Aronia – A native plant gaining in popularity for its nutraceutical fruit, ease of growth and large yields

Dwarf sour cherry – Moderately sized, very low suckering, hardy shrub that produces high-quality, deep red fruit

Black currant – Easy-to-grow shrub with unique, healthful black fruit that makes delicious jam, wine or liqueur

Grapes – Eighteen varieties are being evaluated for making wine, jelly and juice, and eating fresh

Haskap – This new, extremely hardy edible blue honeysuckle grows in almost any soil and can be used like blueberries

Juneberry – Well-loved native fruit also known as Saskatoon or serviceberry

Other Fruits in the Project: Apples, tree cherries, red currants, white currants, elderberries, gooseberries, honeyberries, plums and seaberries

Project Activities

Fruit crops are evaluated for:

- Adaptation to North Dakota's growing conditions
- Production practices
- Disease resistance
- Productivity
- Fruit quality
- Suitability for processing and wine production

Sharing Project Results

The CREC shares results with gardeners and commercial enterprises through:

- Yearly field tours with presentations by fruit production experts
- Offering fruit to food processors and winemakers
- Presentations to groups and at events
- Annual reports and Web-based reporting

Fall 2010 to Spring 2011
Compiled Survey from 4 Businesses Regarding Fruit Provided by Carrington Research Extension Center

Year	**2011 Crop**	**2010 Crop**		
Aronia	88 pounds	96 pounds		
Cherry	--	--		
Black Currant	113 pounds	42 pounds		
Red Currant	163 pounds	56 pounds		
Honeyberry/Haskap	42 pounds	15 pounds		
Juneberry	116 pounds	24 pounds		

Did you make new products with the fruit? *All 'A' answers are from same company, etc.*

A. Black Currant Jam, Juneberry Jam, Aronia Jelly
B. With each of these fruits we made dry wine.
C. (Aronia) Wine
D. Aronia wine, red currant wine, black currant wine and haskap wine.

Did you like working with the fruit?

A. Yes
B. Yes, we like working with both fruits.
C. Yes
D. Yes, the Research Center did a very good job picking the fruit in a timely and cleanly (sic) manner.

Did you like the products produced?

A. Yes
B. The black currants are the main flavor ingredient of our Foxy Lady wine, which has been one of the most popular wines we produce. It is a semi-sweet blend of black currant and apple. The haskap/honeyberries we also use for wine, and find that the flavor is intriguing, different than anything else and well received. We wish we had a lot more to use each year.
C. Yes
D. Yes, the fruit was of good quality and made some nice wine.

If you sold or sampled the products, did your customers like the products?

A. Juneberry and Aronias sold better than black currant
B. If we had hundreds of black currants, we'd sell black currant wine as a separate product. Some of our customers rave over it. But they all like the foxy lady wine.
C. We did sell, and it was very much liked!
D. We have sold and sampled the Red Currant (wine) and with it being a new product in the market, it was well received, with demand being noticed.

Will you look to use this fruit again?

A. Definitely Aronia.
B. We absolutely will use both fruits again. We have an interested customer who has excess irrigated land who would like to grow out 100 black currants for us.
C. Yes
D. Yes, if possible. We do not currently know of any growers of the above berries. Reliable fruit availability is a big demand on our winemaking abilities.

Will you grow this fruit?

A. Possibly.
B. WE have planted 100 of the honeyberry/haskap fruits and about a dozen black currants.
C. Thinking about it.
D. Yes, we have planted haskap and the Black Currant in the last couple of years, and will plant Red Currant if we are able to access plant stock.

Will you ask someone else to grow it for you?

A. Possibly
B. We have an interested customer who has excess irrigated land who would like to grow out 100 black currants for us.
C. Maybe
D. It would be wonderful to be able to buy fruit/berries from area growers. There are little amounts of fruit available at this period of time.

Anything else you'd like to tell us?

A. I appreciate the opportunity to try the fruit.
B. We've been the organizer of a major importation of fruiting plants from Canada, with most recipients in North Dakota of both haskap/honeyberry plants and U of Sask. Cherry shrubs. We should be picking the first of our cherries and haskaps this year and look forward to many years of production.
C. Aronias make good Wine! Thanks Kathleen.
D. Kathy and the CREC has (sic) been very valuable to us in our Fruit planting decisions and growth of unique products in our winery. Fruit and Berry production could have a big impact in the development of smaller production ag. The shift of Ag. to conventional crop "megafarms" leaves the small acreage owner with few ways to make money, and this fills the void.

	May 2011							Flowering Dates/Rate																Appendix D Page 1										June
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
Red Lake																buds				30-50			75			75						100
Jhonkeer Van Tets																buds extending				40-50			100			100						done
Red Start																buds extending				50-60			90+			100						100
Rosetta																buds				30			100									done
Rovada																buds				20			75			80						done
Blanka																buds				30			75-90			100						done
Primus (all red)																buds				50			100			100						done
Swedish White																buds				30-50			85-90			100						done
White Imperial R W R W	All of these plants are different fr each other.																															
Ben Lomand																							80		100							done
Champion																							80		100							done
Crandall																							buds		5%							50
Blackcomb	Planted 5/20																															
Minaj Smyriou																							100		100							done
Whistler	Planted 5/19																															
Black Down - smooth																				15-25			75		95							done
Black Down - regular																				10-20					100							done
Hilltop Baldwin	All flowers look alike.																			10-20			25-40		90							done
Titania																				10-20			50-70		95							done
Swedish Black																				50-80			100									done
Cherries																																
Carmine Jewel																							10		75				bottom done, top 75%			
Crimson Passion																							85		100							done
Joy Bush																							5									100

	June			
Aronia	3	4	5	6
Viking	b			A
RT select	u			l
RT Seedling	d			l
RT Seedling	s			90-
RT Seedling	A			95%
RT Seedling	l			
Nero	l			

		May 2011							Flowering Dates/ Rates																							June
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
Berry Blue																		10-15		90				90			100						done
Blue Belle																		25		85				100									done
Kamchatka																		25		50				100									done
Blue Velvet	w		BV- just blooms on tips this year																	tips				20			20						25
Blue Moon	e		BM- just blooms on tips this year																					20			20						25
Haskap	5 ea + 1MT																																
9-15	ne																	50		85				90			90						100
Borealis	se																	15-20		50				80			80						100
9-91	nw																	10-20		50				75			75						100
Tundra	sw																	10-15		60				75			75						100
MT 46-55	sw																	buds		buds				40			100						100
22-37	ne	Not many blooms this year.																		none				tips			tips						75
41-100																				buds				10			20						75
43-97	se																			buds				tips			20						75
43-87	sw																			buds				tips			20						100
45-57																				1 or 2 open				15			25						80
85-26	nw																			5-10 open				20			25						50
Thiessen																								50			95						done
Martin																								50			95						done
Smoky																								25			90						done
Honeywood																								25			85						100
JB30																								25			85						done
Pembina																					buds			95-100									done
Pipestone,																					buds			95-100									done
Waneta																					buds			95-100									done
Toka																					buds			95-100									done
Prairie Red																																	
Hazen																																	2%
Harelred																																	2%
Honeycrisp																																	none
Sweet 16																																	none
Zestar																								NE tree has blossoms. No others.									2%

PROJECT 3: Developing Innovative Market Access Strategies for Pulses Grown in North Dakota, Montana, and South Dakota

Final Report

Project Summary

Pulses have become very important crops for the region's agriculture industry and are primarily used as rotational crops with cereal grains and oilseed crops. The biology of this cool-season legume makes it particularly suited to the region. Legumes work well in crop rotations as they fix atmospheric nitrogen which greatly reduces the commercial nitrogen fertilizer needed for the current and following crop. Another benefit of pulses in crop rotations is to break disease cycles associated with cereal grains. The United States food industry has an increasing interest in using pulses and pulse derivatives as natural food ingredients to develop new value added food products. Over the past four years the Northern Pulse Growers Association (NPGA) has been working with the USA Dry Pea & Lentil Council (USADPLC) and Northern Crops Institute (NCI) to expand market access of pulses throughout the United States and the World. The NPGA has partnered with the USADPLC and NCI to support outreach programs for the food industry that will be used by doctors, dietitians, teachers, research chefs, food buyers and other end users. This outreach was made possible by USDA Specialty Crop Block Grants. Within this project we conducted a national ingredient quality evaluation, developed gluten free and fiber based formulas, created a gluten free baking guide, attended and exhibited at several health and nutrition trade shows/symposiums and co-sponsored informative, hands-on product/menu development courses. The courses targeted food scientists, research chefs and marketing representatives from food manufacturers and food service entities throughout the United States.

Project Approach

Project was conducted by NPGA staff, NCI staff and USADPLC staff.

1. <u>Evaluate the Ingredient Quality of Pea, Lentil and Chickpea Crops Grown in North Dakota, South Dakota, Montana, Idaho, Washington:</u> In 2010, dry peas average protein and starch was relatively high at 27.1% and 44.7% respectively. Lower unsoaked or hard seed was observed in 2010 at 1.1% compared to 3.9% in 2009. The peak viscosity, hot paste viscosity, cold paste viscosity, and setback were higher than the 4 year average. Green peas color quality remains similar to 2008 and 2009 quality. Slightly higher brightness and yellowness were observed in dry yellow peas.

   Protein content in lentil was at 26.9%, higher than the 3 year average of 25.2%. Higher peak viscosity, hot paste viscosity, cold paste viscosity and setback were observed in 2010, when compared to the 3 year average. Less greenness was observed in the green lentil when compared to previous years. Red lentil color quality was similar to 2009. Red lentil had slightly higher protein content at 27.6%, when compared to 26.3% in green lentil. Red lentil contained slightly higher starch content at 45.1%, 6.6% higher than 42.3% protein in green lentil. Increased in unsoaked seed or hard seed was observed in

red lentil at 2.1%, when compared to green lentil at 1.7%. In general, dry peas and lentils quality was excellent in 2010 and we confirmed this observation with several industry contacts in the U.S.

2. Development of Gluten Free Formulas: The NCI recently developed 14 new gluten free formulas for the food industry. The products developed included gluten free pasta, pound cake, cinnamon hazelnut muffins, chocolate chip muffins, cinnamon raisin cookies, butterscotch cookies, cake donuts, pancakes, pie crust, pizza crust, chocolate chip cookies, wholesome crackers, tortillas and white bread formulas. Nutritional labels were also done for each product.

The recipes were developed by the NCI in Fargo, ND and the formulas used dry pea flour, lentil flour and/or chickpea flour. Many of the recipes were prepared during the USADPLC Pulse Utilization Course at the Culinary Institute of America and were very well received by the company R&D chefs and scientists in attendance. The recipes are featured within a gluten free baking guide and the materials are being distributed through the NPGA and the USADPLC at national trade shows and are promoted on the organizations websites.

3. Development of Fiber Based Formulas: The NCI has developed eight formulations using pea fiber to fortify baked products. The prototypes that the NCI staff worked on include formulas for white bread, pasta, cookies, burger buns, pancakes, bagels, muffins and tortillas. Nutritional labels were also done for each product. The materials are being distributed through the NPGA and the USADPLC at national trade shows and are promoted on the organizations websites.

4. Gluten Free Bakery Guide: The NPGA and the NCI have created a gluten free baking guide for the food industry. This guide features technical information about using dry pea, lentil and chickpea flours in gluten free baking. Professional photographs were taken of six of the products and these formulations are featured in the guide. The remaining formulations that were developed are listed on the NPGA website.

   The materials include information such as the macronutrient content comparisons of pulses, rice and grains and the macronutrient content of various flours such as pulse, peanut, potato and rice flour, etc. The material also features glycemic index information, baking tips and nutritional labels for each formula. The materials are being distributed through the NPGA and the USADPLC at national trade shows and are promoted on the organizations websites.

5. Attendance at Food Technology and Health/Nutrition Trade Shows and Symposiums: The NPGA, the NCI and the USADPLC staff attended national and regional trade meetings and shows to increase the awareness of pulses and products in the food marketplace. The shows attended were the Institute of Food Technologists Annual Meeting, the Food & Culinary Professionals – American Dietetic Association, the

Culinary Institute of America Healthy Flavors-Healthy Kids and the American Dietetic Association Food & Nutrition Conference & Expo.

6. Sponsorship of USADPLC Culinary Institute of America Pulse Product Development Courses: The USA Dry Pea & Lentil Council and the Northern Pulse Growers Association hosted the 'Legumes: Wholesome Ingredients for Value-Added Foods' courses to educate the food industry about the nutritionally powerful, versatile, and wholesome goodness of legumes as ingredients. The courses were geared toward those developing product applications for food manufacturers, and recipes for large-scale restaurant chains. Over 60 representatives from national companies and organizations participated in the events.

   The three-day, hands-on educational seminars, took place at the premier culinary college, the Culinary Institute of America (CIA) in Napa Valley, California, and introduced the most innovative product applications for dry peas, lentils, chickpeas, and the flours/fractions. Dry peas, lentils, and chickpeas are used in more well-known applications like hummus and soups, but legumes can also be utilized in snacks, nutrition bars, baked goods, pasta and gluten-free foods. Some of the featured speakers of the events included the following:

   2011 Course

- **Michael Sansolo, Retail Food Industry Consultant, Food Marketing Institute.** Years of work with some of the world's most innovative companies have given Michael Sansolo a diverse view of trends impacting shoppers, employees, competition, economics, supply chains and management. As senior vice president of the Food Marketing Institute and a consultant, speaker and author, Sansolo works with companies on adjusting to new market conditions.
- **Dr. A. Elizabeth Sloan, President, Sloan Trends, Inc. A**n Escondido, California-based consulting firm that offers trend-tracking and predictions, strategic counsel and business-building ideas for food, supplement and food service/restaurant marketers. Dr. Sloan is also the Consumer and Product Trends Columnist for Food Technology Magazine, Trends Editor for Flavor & The Menu magazine and monthly columnist for Nutraceuticals World magazine.
- **Lynn Senecal, Registered Dietitian and Certified Diabetes Educator.** Senecal is a Registered Dietitian and Certified Diabetes Educator working as a Regional Clinical Manger for an insulin pump company. Her public speaking focus is diabetes and Celiac disease awareness and education, since she was diagnosed with diabetes in 1964.
- **Amy Myrdal Miller, MS, RD, Culinary Institute of America (CIA). Myrdal Miller** is the program director for strategic initiatives at the CIA in Napa Valley, CA. She leads planning for the college's nutrition, health, and sustainability conferences and leadership retreats. A registered dietitian with a master's degree in nutrition communication, Myrdal Miller has focused her career on nutrition research, education, and marketing with an emphasis on promoting the nutrition, health, and culinary benefits of whole foods.

- **Richard Coppedge, CMB , Culinary Institute of America (CIA).** During his tenure at the CIA, he has taught various bread baking courses, is the author of Gluten-Free Baking with The Culinary Institute of America and helped develop and provide content for the CIA's bread baking instructional video series.
- **Mehmet C. Tulbek, Technical Director, Northern Crops Institute. Dr. Tulbek** provides leadership in technical services at Northern Crops Institute (NCI) for regional crops in the form of processing, consulting, processing solutions to processors and end users. Dr. Tulbek develops and conducts educational programs that identify market opportunities and addresses quality characteristics desired by buyers and processors of regional crops and conducts market development activities to promote sales of regional crops.
- **Joyce Goldstein, Food Writer/ Food Industry Consultant.** Joyce Goldstein is a consultant to the restaurant and food industries. Her areas of expertise are menu design, recipe development, staff training and kitchen planning. For twelve years she was Chef/Owner of the ground-breaking Square One restaurant in San Francisco. Her menu presented the foods of Italy, Spain, France, Greece, Turkey, the Middle East and North Africa. Square One won numerous prestigious industry awards for food, wine and service.
- **Alex Guarnaschelli, Chef, Butter Restaurant.** The daughter of esteemed cookbook editor Maria Guarnaschelli, Guarnaschelli learned to eat according to whatever book her mother was working on at the time, be it Indian or Italian. This early emphasis on her palate truly shaped her future in food. After graduation from Barnard College in 1991, Guarnaschelli began working under acclaimed American chef and restaurateur Larry Forgione and studied at La Varenne Culinary School in Burgundy. She moved to Paris and worked for four years at the Michelin three-star restaurant Guy Savoy and at La Butte Chaillot, another Savoy establishment.
- **Kantha Shelke, R&D Scientist, Corvus Blue. Dr. Shelke** is founder and principal at Corvus Blue, a consumer packaged goods consultant. Ms. Shelke also Chairs the Scientific Advisory Board of a global food brand co., advises as Director of the Illinois Global Partnerships (a private /government partnership), is Ingredients Editor for Food Processing, Wellness Foods, and Natural Products Industry (largest trade publications in respective sectors), and provides industry analyses on the mid-market sector ($50 - $500m sales).

2012 Course

- **Patricia Johnson, Food & Drink Analyst, Mintel International. Patricia Johnson has an extensive background in food product marketing, new product development and food business ventures. Her background also includes 12 years of multi-unit restaurant management and hands-on experience as a chef and wine tour company owner.**
- **Thunyaporn Jeradechachai (Naggie), Food Scientist, Northern Crops Institute. Naggie is a food scientist at the Northern Crops Institute in Fargo, ND. She provides technical solutions to food manufacturers on the quality and utilization of many crops. Her specialties are traditional and gluten free baking, pasta processing, snack and cereal extrusions.**

- **Walter Potenza, Chef Educator & Restaurateur, Potenza Ristorante.** Walter Potenza is a native of Mosciano SantAngelo in Abruzzo, Italy and is one of the most accomplished practitioners of traditional and innovative Italian cooking in the nation. Walters holds many culinary awards and in the last 10 years has expanded his culinary research to nutrition and the connection with Celiac and Diabetes through food science.
- **Aaron Flores, Executive Chef, Finn& Porter, Embassy Suites.** Aaron has been an Opening Sous Chef for the Disney Grand Californian Hotel, Executive Chef of Marshall Field's Store in Chicago, and the Embassy Suites in Washington, D.C. He is considered a pioneer in the Gluten Free World and has served as Executive Chef of the Celiac Sprue Associations and the Gluten Intolerance Group of North America for a number of years.
- **Janice Rueda, Director of Health & Nutrition, American Pulse Association.** Dr. Rueda holds a doctorate degree in Nutrition & Food Science from Wayne State University in Detroit, Michigan. Before joining the APA she worked extensively with Detroit Public Schools on several projects including development of nutrition education for teachers, analysis and evaluation of the Fresh Fruit and Vegetable Program. As Director of the APA Dr. Rueda is tasked with implementing the Pulse Health Initiative, a comprehensive research program that aims to elucidate the unique potential of pulse crops to substantially impact the global and domestic challenges of obesity and chronic disease, global hunger, functionality and end-use, and environmental sustainability.
- **Noel Rudie, Harvest Innovations.** Dr. Rudie has 20 years of experience in the food industry including Hershey Food Corp., Kraft Food, Inc., Opta Food Ingredients (SunOpta), Soy Link, LLC and Harvest Innovations. He has developed numerous products for the pasta, dairy, baking and beverage industries and holds a number of patents. Dr. Rudie has also adapted extrusion cooking to deliver neutral flavored pulse flours including pea, lentil and chickpea flours. These flours are being used in a variety of gluten-free and multi-grain pastas and other applications including cakes, coatings meat binders and breads.
- **Richard Coppedge –** See above
- **Amy Myrdal Miller –** See above

Goals and Outcomes Achieved

1. <u>To develop new pulse based food products which were targeted to the gluten free market:</u> The NPGA teamed with the NCI to develop 14 new gluten free formulas, a gluten free baking guide and ingredient specifications for the food industry. The guide included market statistics and facts, technical information and nutritional analysis of pea, lentil and chickpea flours. The major outcome of this goal was to introduce prototype formulations of gluten free pulse-based food products. The formulations were made using dry pea flour, lentil flour and chickpea flour. The products developed included mainstream products including cakes, cookies, muffins, pizza crust, donuts, pancakes, crust, crackers, breads, pie crust, tortillas, and pasta.

   A key to developing successful pulse based products for the gluten free market is the continued interest from companies who process pulse flours and fractioned pea protein and starch derivatives in the United States. Within the past two years there is a growing

list of companies who are adding pulse products to their milling operations (see attached list). This list is compiled and promoted by the USADPLC, the NPGA and the NCI through national trade shows and other marketing events. These companies are supplying high-end products such as flours, powders, flakes, proteins and fibers. The price for pulse flours is currently in the range of $.60 to $1.20 which is 5-6 times higher than pulse crops.

Two of the companies listed are pulse processing plants that are or will become operational in North Dakota within this year. These plants will employ 73 people and offer a variety of pulse products including pulse flours, pulse protein and pulse starch. The economic impact of these facilities is very important to the state's agriculture industry.

2. To develop new strategies and value added solutions for the increasing awareness of pulse crops and create market development materials for the U.S. functional food industry: The NPGA and the NCI worked on this goal and the outcome was to develop materials that will introduce the concept of pulse flours and other pulse derivatives to the food industry. The project included the previously mentioned 14 gluten free formulations, the gluten free bakery guide and also the development of 8 pulse-fiber based formulas using a pre-cooked finely milled pea fiber. The fiber formulas included a hamburger buns, muffins, bread, pancakes, tortillas, bagels, cookies and pasta. The new formulas and resource materials will help U.S. companies develop value added solutions for the gluten free and functional food market using natural pulse ingredients. The materials are being distributed through the NPGA and the USADPLC at national trade shows and are promoted on the organizations websites (see attached list of 2010-2012 trade shows).

3. To conduct market access and development activities by implementing technical education programs, which were organized by the NPGA and the USADPLC. In addition participate in health and nutrition sponsorship programs and trade exhibitions: The NPGA, NCI and the USADPLC have seen an increasing interest in using pulses and pulse derivatives in value added products. An introduction through trade shows to these products has created interest in using edible beans/pulses as new functional ingredients. Because it is a relatively new concept, a major goal was to educate and train research chefs, food scientists and marketing representatives on how to incorporate these products into baked goods and savory dishes. This was done through two pulse product development courses at the Culinary Institute of America. The training increased awareness of the types of pulses and pulse products available, baking characteristics including taste and texture attributes and marketing opportunities. There is now a growing list of companies that are researching or using pulses as ingredients in new product development. Some companies that have recently introduced products using pulses include The Good Bean, Mars Foodservice, JR Simplot, Mary's Gone Crackers, Crunchfuls, Mediterranean Snack Foods and Plentils. Other successes from the CIA

Courses included a gluten free coating, aseptic packaging for lentil puree in soups, pea flour in pet treats to increase protein, chickpeas in pizza to increase nutrition and increased awareness. Over 63% of the 2011 Course participants have done R&D formulations with dry peas, lentils and chickpeas. Over 62% of the 2012 Course participants have indicated that they are extremely likely to incorporate dry peas, lentils, and chickpeas into new or existing menu items.

Beneficiaries

There has been an increased awareness of pulse crops due in part to the outreach made possible by the USDA Specialty Crop Block Grant. The continued marketing development activities have helped increase the production of peas and lentils in the past years. The primary beneficiaries of this project are the region's pulse producers who grow dry pea, lentil and chickpea crops. In 2010, pulse crop production represented more than $350 million dollars. The industry has been successful in marketing pulses through food aid and commercial channels internationally.

Acreage has continued to expand over the past five years in Montana, North Dakota and South Dakota. The states of Montana, North Dakota and South Dakota currently account for 80-85% of the Nation's pulse production. In 2010, the United States planted more than 1.4 million acres of pulses. Due to extreme weather circumstances in 2011, North Dakota harvested pulse acreage (which is the largest pulse producing State in the Nation) was significantly affected. However, the 2012 USDA/NASS Crop Production Report for North Dakota shows a substantial acreage increase from the prior year. Dry edible pea harvested acreage is estimated at 240,000 acres above the 80,000 acres harvested in 2011. Lentil harvested acreage is estimated at 174,000 up from 77,000 acres last year. It is expected that acreage in the region will continue to increase because pulses provide many agronomic benefits as rotational crops including fixing nitrogen, providing a break in disease cycles and increasing wheat and other major cereal yields.

Lessons Learned

In this project we learned that pulse flours can fortify baked goods with powerful nutrients including protein, fiber and B-vitamins. In fact, precooked pulse flours are a great way to add structure and enhance nutrition in products made with other gluten-free ingredients such as rice flour, tapioca and potato starches. Substituting pulse flours for other high protein alternatives in this mix provides more fiber and high quality protein – the perfect balance of amino acids.

Because pulse flours are a unique and new concept, it will be very important to continue marketing efforts to expand the domestic market which will create new prospects for producers and the pulse industry. Promotion and education within the food industry and with consumers will be key component to future marketing strategies. This in turn provides companies with

significant new ideas and opportunities that will create jobs for the region further enhancing the value of pulse crops.

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Additional information available

See Attachments

NATIONAL PULSE QUALITY SURVEY 2010

Funding and Support

Provided by:

Northern Pulse Growers Association

And

North Dakota USDA Specialty Crop Grant

Conducted at:

Northern Crops Institute

By Thunyaporn Jeradechachai
Crop Quality Specialist

Mehmet C. Tulbek, Ph.D.
Technical Director

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EXECUTIVE SUMMARY

Northern Pulse Growers Association has funded Northern Crops Institute to conduct crop quality surveys of the regional pulse since 2007. This year, we are conducting the national pulse quality survey. The survey covers the crops from North Dakota, Montana, South Dakota, Minnesota, Idaho, and Washington. Participating companies provided lentil and dry pea samples for the survey. Two hundred and nine dry peas samples and 83 lentil samples from different regions were analyzed. The report is divided into two individual sections: 1) Dry Pea Quality Survey, 2) Lentil Quality Survey.

The quality parameters that we included are proximate attributes, seed density, soaking quality, starch pasting properties, and color. For green peas, we conducted canning quality based on variety.

It is difficult to conclude the quality of US pulse as a whole. This report is intended to be used as a guide for a better understanding of the pulse grown in the US. The objective of this survey is to educate growers, processors, exporters, domestic and international buyers, and to establish quality parameters for regional pulses.

SUMMARY OF RESULTS

DRY PEAS Due to high moisture during harvesting season, 2010 dry peas contained 13.2% moisture, higher than the 4 year average of 11.8%. Average protein was at 27.1%, higher than the 4 year average of 23.6%. Average starch content was also relatively high at 44.7%. In 2009, unsoaked or hard seed percentage for dry peas was 3.9%. Lower unsoaked seed was observed in 2010 at 1.1%. Peak viscosity, hot paste viscosity, cold paste viscosity, and setback were higher than the 4 year average. Green peas color quality remains similar to 2008 and 2009 quality. Slightly higher brightness and yellowness were observed in dry yellow peas. For green peas, Cruiser and Columbia showed superior canning quality when compared to other varieties.

LENTILS 2010 lentils contained moisture at 11.5%, higher than the 3 year average at 10.6%. Protein content was at 26.9%, also higher than the 3 year average of 25.2%. Higher peak viscosity, hot paste viscosity, cold paste viscosity and setback were observed in 2010, when compared to the 3 year average. Less greenness was observed in the green lentil when compared to previous years. Red lentil color quality was similar to 2009. Red lentil had slightly higher protein content at 27.6%, when compared to 26.3% in green lentil. Red lentil contained slightly higher starch content at 45.1%, 6.6% higher than 42.3% protein in green lentil. Higher amount of unsoaked seed or hard seed was observed in red lentil at 2.1%, when compared to green lentil at 1.7%.

Food & Culinary Professionals

a dietetic practice group of the

eat right. American Dietetic Association

April 19, 2011

Kaye Effertz
Northern Pulse Growers Association
1710 Burnt Boat Dr.
Bismarck, ND 58503

Dear Kaye:

On behalf of the Food and Culinary Professionals (FCP) DPG, I want to extend my heartfelt thanks to the Northern Pulse Growers Association for sponsoring our PASSPORT TO FLAVOR World Cuisines Culinary Workshop held in Napa Valley, California this past March. I was so pleased FCP was able to work you, Kaye, and with the Northern Pulse Growers Association to present this educational opportunity to members.

We're so glad you could join us for the Thursday night reception. Members loved the lentil salsa and the opportunity to learn more about dry peas, lentils and chickpeas. Your new printed materials are filled with bright, valuable information about tasty, healthy options. Thank you for sharing them so generously with members.

Again, thank you for generously sponsoring the workshop. I am so grateful for your support of the Food and Culinary Professionals DPG, and I do hope we get the chance to work together very soon to do more good work educating culinary nutrition professionals about the culinary and health benefits of pulses!

Sincerely,

Amy Myrdal Miller

Amy Myrdal Miller, MS, RD
2010 – 2011, Food and Culinary Professionals DPG Chair

PO Box 46998 - Seattle, WA 98146 - 206-935-5104 (p) - fcp@quidnunc.net - www.foodculinaryprofs.org

FCP Reception and Meetings – March 24-26, 2011

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es are:

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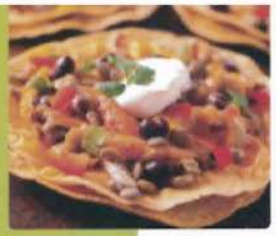

Visit our website today for nutritional information, tasty recipes and to sign up for our new USA Dry Pea & Lentil Council newsletter.

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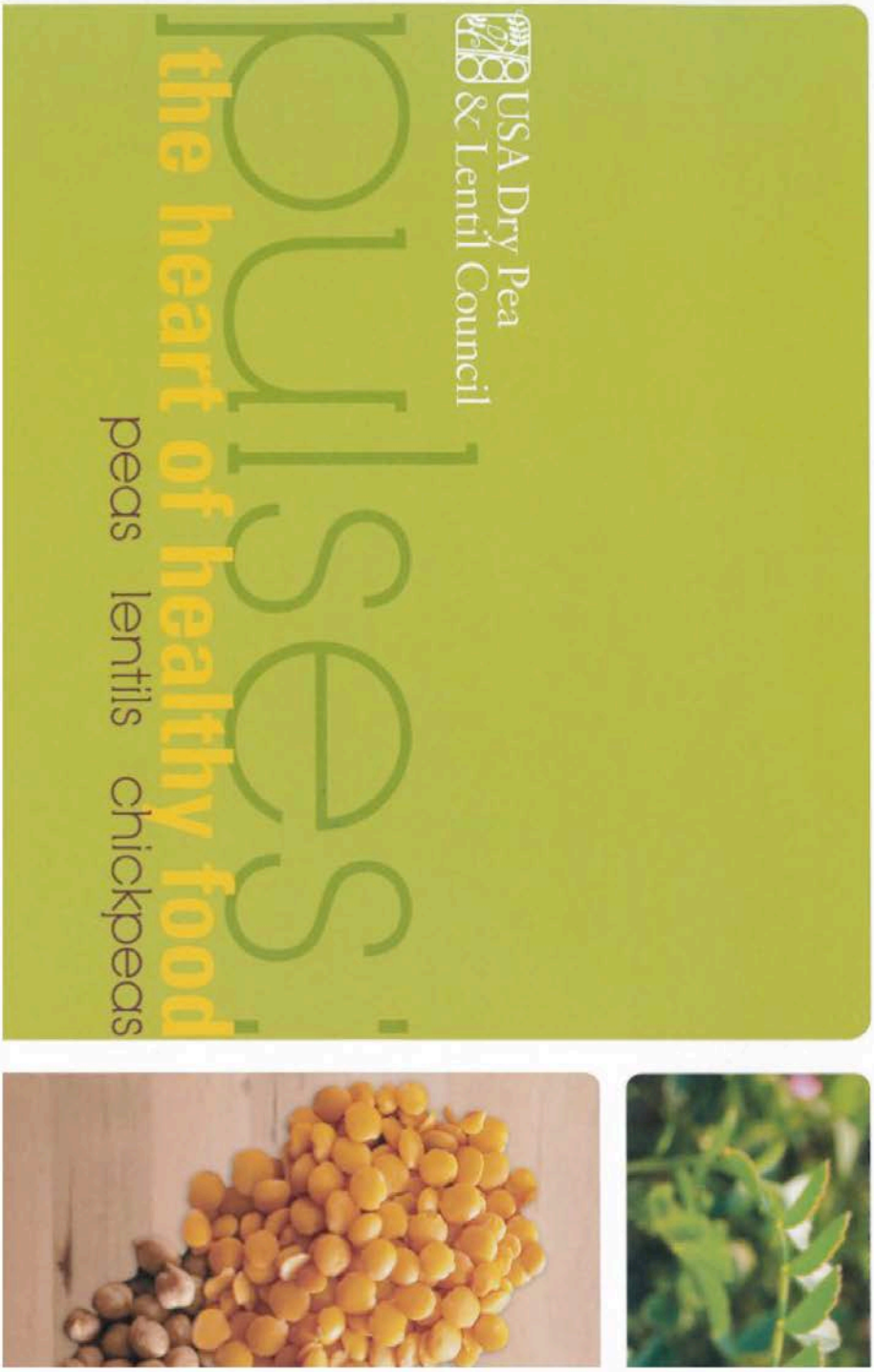
USA Dry Pea
& Lentil Council
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the heart of healthy food
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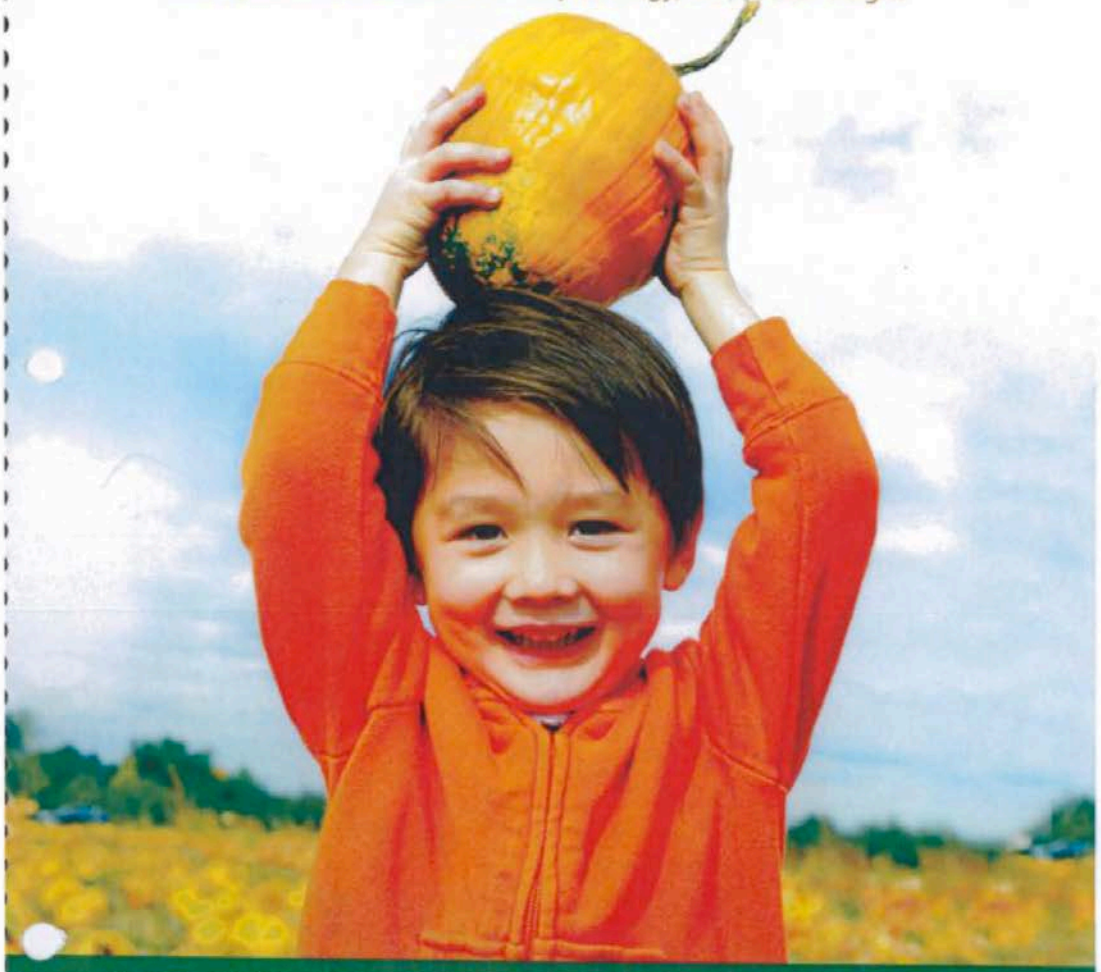

NATIONAL INVITATIONAL LEADERSHIP SUMMIT

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NATIONAL INVITATIONAL LEADERSHIP SUMMIT
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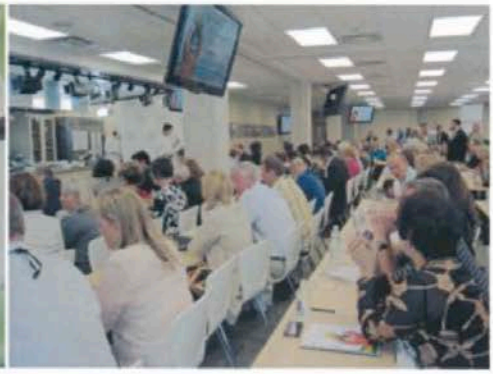
Pea/Lentil Trail Mix

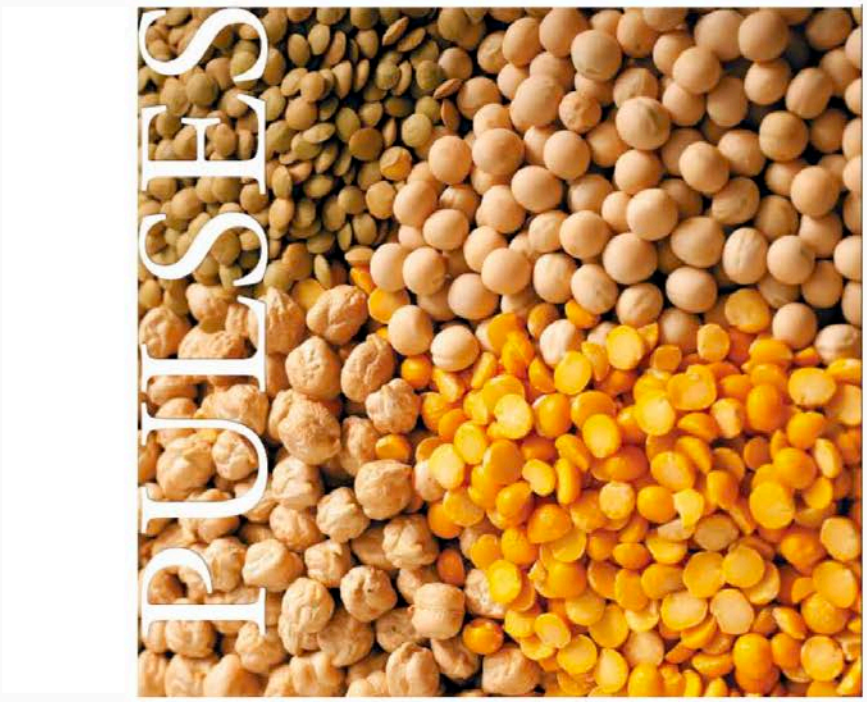


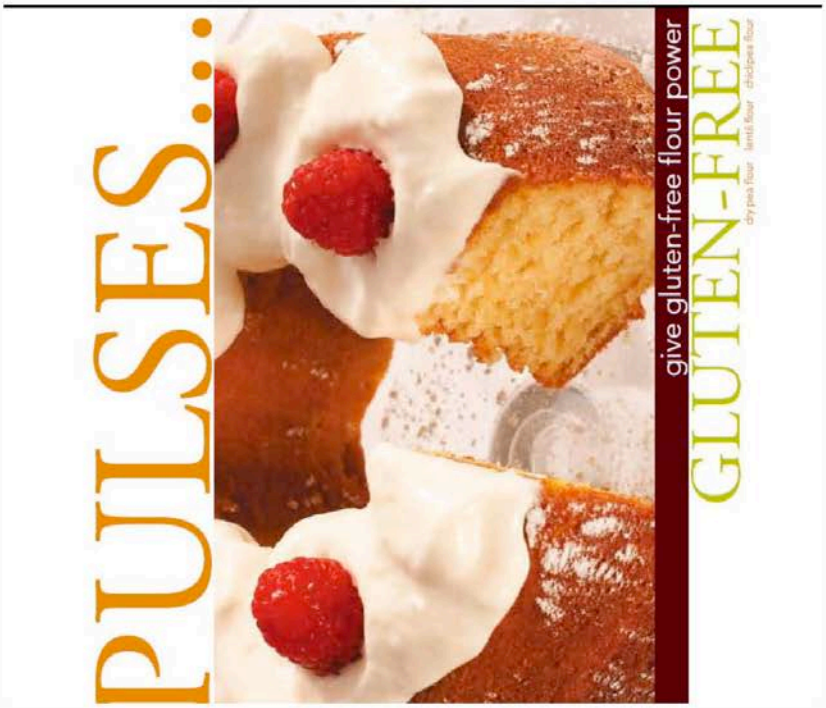
Attendees

Kaye Effertz, NPGA, Mehmet Tulbek, NCI, Jennifer William, USADPLC

Chef Rick Bayless, Frontera Grill, Kaye Effertz-NPGA

Gluten Free
Photographs
NCI – July 2011


PULSES

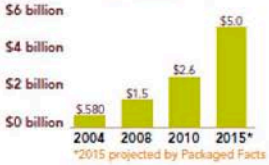

PULSES...
give gluten-free flour power
GLUTEN-FREE
dry pea flour
lentil flour
chickpea flour

THE HEART OF HEALTHY "GLUTEN-FREE" FOODS

More normal than niche, 'gluten-free' foods have become mainstream. Many in the trade—including the National Restaurant Association—list the gluten-free diet as one of the hottest trends in the food industry today. The market research firm Packaged Facts reports that the market for gluten-free foods and beverages has grown at a compound annual rate of 30% since 2006 to hit $2.6 billion in 2010. The firm projects U.S. gluten-free sales will almost double by 2015 to exceed $5 billion.

Finding a unique and marketable edge in this category is as close as the nearest "pulse." Pulses, such as yellow peas, lentils and chickpeas, are already gaining recognition as the "new and improved" heart of healthy foods. So it's only logical that pulse flours can pack gluten-free foods with powerful nutrition and goodness. According to the Harvard Health Letter, food makers have learned how to use xanthan and guar gums to replace gluten's elasticity but many of these formulations are leaving diets short on protein, fiber and B-vitamins. Indeed, healthier alternatives top the wish list of many who follow a gluten-free diet. Using precooked pulse flours to fortify gluten-free baked goods can make that dream a reality.

US GLUTEN-FREE SALES



*2015 projected by Packaged Facts

The greatest need is for more nutritious alternatives to traditiona gluten-containing baked goods.

High Quality Protein

The high quality protein in pea, lentil and chickpea flour makes for a perfect amino acid offering when blended with other gluten-free grains such as rice flour. What's more, these pulses deliver quantity as well as quality: Dry pea, lentil and chickpea flours contain 22%-25% protein, are high in lysine and listed as both a vegetable and protein source in USDA's Food Guide MyPlate.

All Natural Fiber

Consuming adequate fiber is a major issue for celiacs and the gluten intolerant. Precooked pulse flours made from yellow peas, lentils and chickpeas can enrich gluten-free baked goods with all-natural dietary fiber that contains the desirable duo of both soluble and insoluble fiber. At 33% and 26% fiber respectively, dry pea and lentil flours, in particular, can transform many gluten-free foods from fiber-poor to fiber-rich.

GLUTEN-FREE GOODNESS

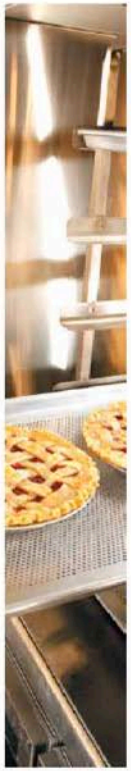
Protein	**Fiber**
Folate	**Iron**
Zinc	**Potassium (lentils)**
Low sodium	**Low fat**

Full of Folate

B vitamins such as Folate are often lacking in many gluten-free foods. This adds insult to injury for many celiacs who may have spent years undiagnosed and malnourished as gluten interfered with their ability to absorb vital B vitamins. Pulses are an excellent natural source of Folate: just 100 grams of dry yellow pea flour can provide almost 70% of the daily value of Folate. Precooked pulse flours can reduce the need for additional Folate fortification.

Low Fat & Low Sodium Goodness

Peas and lentils are both fat free and sodium free; chickpeas are low fat and low sodium. Pulses are also a dependable source of essential micronutrients such as zinc, potassium, iron and thiamine.



FUNCTIONALIT

PRECOOKED PULSE FLOURS = GLUTEN-FREE FUNCTIONALITY

Advanced processing technology (heat and steam) is naturally produ precooked pulse flours with great functionality in gluten-free applic
Look for properly processed precooked flours; the heat or steam partially ge the starch, denatures the protein, inactivates enzymes for longer shelf life, a general makes for a highly functional and versatile gluten-free mainstay. In p the slightly golden color and remarkably bland flavor of precooked yellow p bakers mimic the look and taste of the gluten-containing original.

Precooked pulse flours function just like other high-protein flours but typical contribute far more fiber and micronutrients. An economical alternative, the non-GMO and low allergen-- significantly less allergenic compared with soy flours. Precooked pulse flours are a great way to add structure and enhance in products made with other gluten-free ingredients such as rice flour, tapioc potato starches. Substituting pulse flours for other high protein alternatives provides more fiber and high quality protein--the perfect balance of amino a

Expect pulse flours to improve moisture retention, flexibility and resilience i free bakery items. Reliance on expensive gums is rarely needed in most ap
Pregelatinized pulse flours have strong gelling properties that can help create a more functional gluten-like network by taking advantage of the starch in other gluten-free ingredients such as rice flour. Forget powdery cakes, rubbery breads and cardboard cookies: With deliberate optimization, pre-cooked pulse flours can mimic the taste, texture and mouth feel of many gluten-containing favorites.
Formulation Tip: focus on end product texture and appearance, rather than the look of the dough or batter.

REASONS TO RE PULSE FLOURS

- **Neutral color**
- **Bland flavor**
- **Traditional textu**
- **Moisture retenti**
- **Resilience and fl**
- **Non-GMO**
- **Low allergen**

A GROWING NUMBER OF PEOPLE DODGING GLUTEN FALL INTO A GRAY AREA; THEY DON'T HAVE CELIAC DISEASE BUT SEEM UNABLE TO DIGEST GLUTEN PROPERLY.

"G-FREE" NO FAD

More than 3 million Americans may suffer from celiac disease; 95% yet undiagnosed

Sensitivity to gluten is more prominent; as many as one in 7 or more than 20 million classified gluten intolerant

Gluten-free also popular among people who suffer from other auto-immune disorders and maladies such as irritable bowel syndrome, ADD, autism and MS

Gluten-free growing among non-celiac consumers who believe they "feel" better avoiding gluten; perceive gluten-free as healthier

Gluten intolerance now four times more common than 50 years ago, according to landmark Mayo Clinic study; authors suggest perhaps celiac screening needs to become as customary as cholesterol and blood pressure testing

The Challenge

A gluten-free diet is the only therapy for people with celiac disease (celiacs). Celiac disease is an auto-immune disorder triggered by gluten, a protein found in wheat, barley, rye and spelt. In celiacs, gluten damages villi in the small intestine and interferes with the absorption of vital nutrients. Symptoms of the disease can mimic many other gastrointestinal disorders, but left untreated celiac disease can be much more serious. Malnutrition, despite adequate food intake, as well as other auto-immune diseases, osteoporosis, thyroid disease and some cancers may explain why a landmark Mayo Clinic study found that untreated celiacs have a four-fold increase in early death compared to those without celiac disease. U.S. health care cost of untreated celiacs is estimated to be between $14.5 and $34.8 billion per year.

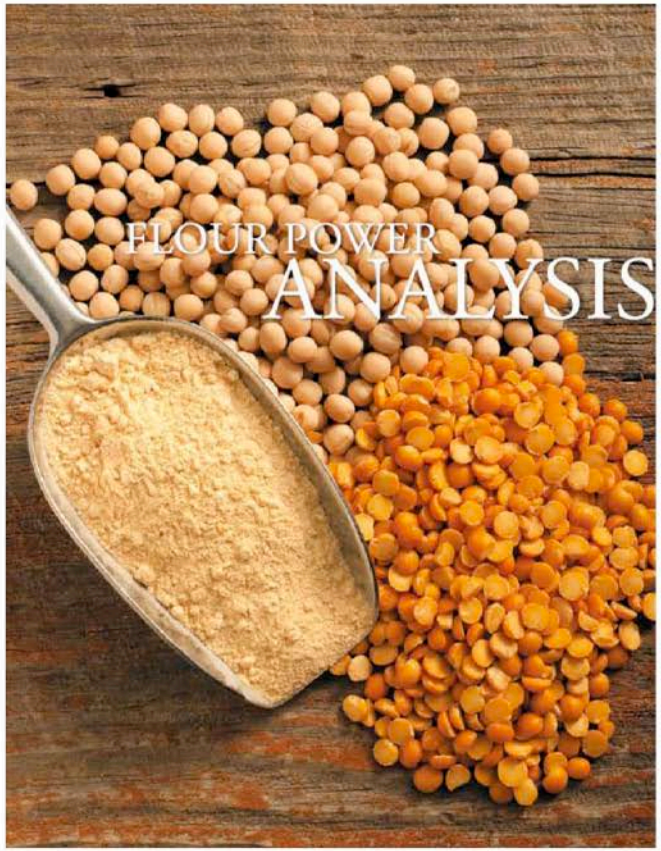
The Scope

The Mayo Clinic study found that celiac disease is no longer rare, affecting at least one in 100 Americans. They also found that it is one of the most under-diagnosed conditions because its symptoms often mirror other GI problems such as Crohn's disease, colitis and irritable bowel syndrome. Of the estimated 3 million Americans who may be celiacs, 95% do not yet know they

have the disease. These "silent celiacs" could raise the count to one case in 83. The Mayo Clinic study authors concluded that this increasing prevalence, combined with the mortality impact suggests that celiac disease could be a significant public health issue. They also suggested that the U.S. may need to look for celiac disease in the general population in the same way it tests for cholesterol or blood pressure levels.

The Opportunity

Gluten intolerance or gluten sensitivity appears to have reached levels associated with other major health issues. Indeed, the Harvard Health Letter reports "a growing number of people dodging gluten fall into a gray area; they don't have celiac disease but seem unable to digest gluten properly." The Center for Celiac Research at University of Maryland School of Medicine estimates that up to 7% or 8% of the U.S. population have some degree of sensitivity to gluten. This means more than 20 million Americans may require gluten-free alternatives. Many afflicted with a plethora of other health problems including autism, attention deficit disorder, irritated bowel syndrome and MS also believe a gluten-free diet will ease their suffering. Add these to an expanding populace who want to avoid gluten simply because they perceive the practice is healthier and the aggregate generates an exploding demand for gluten-free foods.



DISCOVER

HOW THE HEART OF HEALTHY FOODS
GREAT OPTIONS FOR GLUTEN-FREE E

(see formulas on the following pages) For infor
pulse flour suppliers go to **www.northerr**

MACRONUTRIENT CONTENT
OF 100g SAMPLES OF VARIOUS FLOURS

ALORIES(kcal)	TOTAL FAT(g)	CARBOHYDRATE(g)	FIBER(g)	PROTEIN(g)
365	2	65	26	24
353	1	65	33	25
387	7	58	11	22
428	22	31	16	34
357	0	83	6	7
366	1	80	2	6
361	4	77	7	7
364	1	76	3	10
r 339	2	73	12	14

ional Nutrient Database for Standard Reference

CHICKPEA FLOUR ANALYSIS
(Value Per 100 Grams)

Nutrients	Chickpea	% Daily Value
Calories (kcal)	387.0	
Calories from Fat (kcal)	60.0	
Fat (g)	6.69	10
Saturated Fat (g)	.693	3
Trans Fatty Acid (g)	0.0	
Cholesterol (mg)	0.0	
Sodium (mg)	64.0	3
Carbohydrates (g)	57.82	19
Dietary Fiber (g)	10.8	43
Total Sugars (g)	10.85	
Protein (g)	22.39	45
Calcium (mg)	45.0	5
Iron (mg)	4.86	27
Potassium (mg)	846.0	24
Zinc (mg)	2.81	19
Vitamin A - IU (IU)	41.0	1
Vitamin C (mg)	0.0	
Thiamin (mg)	.486	32
Riboflavin (mg)	.106	6
Niacin (mg)	1.762	9
Vitamin B-6 (mg)	.492	25
"Folate, total (mcg)"	427	109

Compiled from the data provided by USDA database and ESHA Genesis SQL software

LENTIL FLOUR ANAL
(Value Per 100 Grams)

Nutrients	L
Calories (kcal)	3
Calories from Fat (kcal)	
Fat (g)	
Saturated Fat (g)	
Trans Fatty Acid (g)	
Cholesterol (mg)	
Sodium (mg)	
Carbohydrates (g)	6
Dietary Fiber (g)	
Total Sugars (g)	
Protein (g)	
Calcium (mg)	
Iron (mg)	
Potassium (mg)	9
Zinc (mg)	
Vitamin A - IU (IU)	
Vitamin C (mg)	4.4
Thiamin (mg)	0.873
Riboflavin (mg)	0.211
Niacin (mg)	2.605
Vitamin B-6 (mg)	0.54
"Folate, total (mcg)"	479.0

Compiled from the data provided by USDA database and ESHA Genesis SQL software

THEY WON'T BELIEVE IT'S G-FREE!

Finally a gluten-free white bread that isn't a brick or rubbery. Pre-cooke Baker's % not only delivers neutral flavor but 3 grams of fiber per serving

Create yummy cinnamon-hazelnut or chocolate chip muffins by taking ad mild nuttiness in pregelatinized lentil and chickpea flours.

Fiber-rich, gluten-free pasta that mimics the texture and mouth feel of th simple as mixing 97% pregelatinized yellow pea flour with about 3% Xan

Satisfy the craving for the traditional taste and texture of a pizza crust or using about 30 Baker's % precooked yellow pea flour in the formula and protein and fiber in the process.

Put no-crumble crunch back in a gluten-free cracker and the resilience ba free flour tortilla with pulse flours.

Let them eat cake—as in scrumptious pound cake or cake donuts that us pulse flours to produce that telltale texture.

Dare the discriminating palate to detect gluten-free in a delectable choc that is over 40 Baker's % pregelatinized pea and chickpea flour.

GLUTEN-FREE POUND CAKE

Ingredients	Grams	Baker's %
Butter	155	107.6
Sugar	260	180.6
Salt	1	0.7
Egg yolks (4)	65	45.1
Eggs (2)	100	69.4
Yellow pea flour	32	22.2
Potato starch	67	46.5
Tapioca flour	45	31.3
Brown rice flour	30	20.8
Baking powder	5	3.5
Xanthan gum	2.6	1.8
Whole milk	92	63.9
Vanilla	13.3	9.2
Total Amount	***837.9***	***602.7***

Procedure

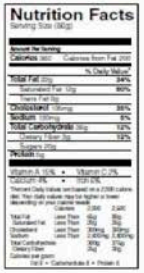
1. *Using a whip attachment. Cream butter, sugar and salt. Mix for 1 min on low, scrape, and mix 1 min on high.*
2. *Slowly add egg yolks and whole eggs into the butter mixture. Mix for 1 min, scrape, and whip for another 3 mins.*
3. *Sift together flour blend and baking powder.*
4. *Alternately add milk and flour blend to the creamed mixture.*
5. *Mix for 1 min, scrape, and mix for another 2 mins.*
6. *Pour the mixture to greased bundt pan.*
7. *Bake for about 40 mins at 350°F (convection oven).*

GLUTEN-FREE CINNAMON HAZELNUT MUFFIN

Ingredients	Grams	Baker's %	Volume
Sugar	131	98	1/2 cup 2 tbsp
Butter	113	85	1/2 cup
Eggs (2)	100	75	2 eggs
Heavy cream	60	45	1/4 cup
Lentil flour	37	28	1/4 cup
Chickpea flour	25	19	1/4 cup
Potato starch	41	31	1/4 cup
Tapioca flour	30	22	1/4 cup
Salt	0.6	0.4	pinch
Baking powder	4.4	3.3	1 tsp
Cinnamon	1.0	0.7	1 tsp
Chopped hazelnut	60	45	1/2 cup 2 tbsp
Total Amount	***603***	***452***	

Procedure

1. *Make sure that all the ingredients are at room temperature.*
2. *Using a paddle attachment, cream sugar and butter on speed 8 for 30 seconds, scrape and mix for 1 min.*
3. *Scrape the bowl. Add eggs. Mix for 1 min on speed 8.*
4. *Scrape the bowl. Add heavy cream. Mix for 1 min on speed 8.*
5. *Add flour, baking powder, salt and cinnamon.*
6. *Mix for 30 seconds, scrape, and mix for 30 seconds.*
7. *Fold in hazelnuts.*
8. *Scoop the dough into a muffin liner. Fill it to the rim.*
9. *Bake at 350°F for 22 mins in convection oven.*



GLUTEN-FREE CAKE DONUT

Ingredients	Grams	Baker's %
Yellow pea flour	68	25.2
Chickpea flour	68	25.2
Tapioca flour	67	24.8
Potato starch	67	24.8
Xanthan gum	5.4	2.0
Baking powder	13	4.8
Sugar	86	31.9
Salt	4.1	1.5
Nutmeg	2	0.7
Nonfat dry milk	15	5.6
Butter	57	21.0
Egg (1)	50.2	18.6
Water	150	55.6
Total Amount	***652.45***	***241.6***

Procedure

1. *Combine flours, starch, gum, and baking powder. Set aside.*
2. *Mix together, sugar, salt, nutmeg and non fat dry milk.*
3. *Add and mix in butter.*
4. *Add egg and mix.*
5. *Add water and mix.*
6. *Add dry ingredients to the wet ingredients.*
7. *Sheet the dough to about 3/4 inch thickness.*
8. *Cut the dough with donut cutter.*
9. *Fry the donut in oil at 193°-196°F for 1 min on each side.*
10. *Drain on a paper towel.*

GLUTEN-FREE PANCAKES

Ingredients	Grams	Baker's %
Eggs (2)	100	63.3
Melted butter	56	35.4
Milk	170	107.6
Yellow split pea flour	38	24.1
Corn flour	15	9.5
Tapioca flour	60	38.0
Brown rice flour	30	19.0
Potato starch	15	9.5
Baking powder	5.3	3.4
Salt	4.2	2.7
Xanthan gum	1.2	0.8
Vanilla extract	4.2	2.7
Sugar	83	52.5
Cider vinegar	3.2	2.0
Total Amount	***585.1***	***370.3***

Procedure

1. *Combine and mix (whisk) egg, butter, and milk in a large bowl.*
2. *Sift in dry ingredients. Mix well.*
3. *Add in apple cider vinegar and vanilla at the end of mixing. Mix for 30 seconds.*
4. *Cook the pancake batter on a nonstick pan at low-medium heat until golden brown.*
5. *Serve warm.*

GLUTEN-FREE WHITE BREAD

Ingredients	Grams	Baker's %
Canola oil	80	15
Water	560	105
Egg yolk (by weight)	15	3
Egg white (by weight)	125	23
Yellow pea flour	152	29
Potato starch	180	34
White rice flour	200	38
Xanthan gum	14	3
Salt	6	1
Yeast	13	2
Sugar	50	9
Baking powder	20	4
Vinegar	37	7
Total Amount	***1452***	***273***

Procedure

1. *Mix water and gum until the gum is dissolved.*
2. *Add oil and eggs to the water mixture. Mix until well incorporated.*
3. *Sift dry ingredients to the wet ingredients. Mix until the dough is smooth.*
4. *Proof the dough for 30 mins in a warm humid environment.*
5. *Bake at 340°F for 1hr and 10 mins.*

Nutrition Facts

Serving Size (110g)

Amount Per Serving	
Calories 140	Calories from Fat 40
	% Daily Value*
Total Fat 4.5g	7%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 15mg	2%
Sodium 330mg	16%
Total Carbohydrate 24g	8%
Dietary Fiber 2g	10%
Sugars 2g	
Protein 3g	

Vitamin A 0% • Vitamin C 0%
Calcium 0% • Iron 2%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

GLUTEN-FREE CHOCOLATE CHIP COOKIES

Ingredients	Grams	Baker's %
Butter, softened	170	57.3
Brown sugar	112	37.7
Sugar	112	37.7
Eggs (by weight)	114	38.4
Vanilla	8	2.7
Yellow pea flour	64	21.7
Chickpea flour	64	21.7
Rice flour	52	17.6
Potato starch	87	29.3
Tapioca flour	29	9.8
Xanthan gum	3.8	1.3
Gluten free baking powder	5	1.8
Baking soda	6	2.1
Salt	3	1.1
Semi-sweet chocolate chips	280	94.3
Total Amount	***595***	***201***

Procedure

1. *Cream butter and sugar. Add eggs and vanilla.*
2. *Sift together all the dry ingredients. Gradually add the dry ingredients to wet ingredients.*
3. *Mix at medium speed for 1 min.*
4. *Stir in chocolate chips.*
5. *Drop a spoonful of dough onto a greased cookie sheet.*
6. *Flatten the top of the dough slightly.*

* *The dough spreads very little, flattening is necessary.*

7. *Bake for 8-10 mins at 375°F in the convection oven or until light golden brown.*
8. *Cool on the cookie sheet.*

Nutrition Facts

Serving Size (50g)

Amount Per Serving	
Calories 210	Calories from Fat 90
	% Daily Value*
Total Fat 10g	15%
Saturated Fat 6g	30%
Trans Fat 0g	
Cholesterol 40mg	13%
Sodium 160mg	7%
Total Carbohydrate 26g	9%
Dietary Fiber 2g	8%
Sugars 15g	
Protein 3g	

Vitamin A 4% • Vitamin C 0%
Calcium 2% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

12

GLUTEN-FREE PIZZA CRUST

Ingredients	Grams	Baker's %
Water	373	74.9
Oil	50	10.0
Egg (1)	50	10.0
Xanthan gum	3.5	0.7
White rice	197	39.5
Yellow pea flour	138	27.7
Tapioca flour	105	21.1
Potato starch	58	11.7
Yeast	3	0.6
Salt	7	1.4
Total Amount	***508***	***102***

Procedure

1. *Using whip attachment, combine water, oil, and egg together.*
2. *Mix xanthan gum at high speed for 30 seconds.*
3. *Sift in all the dry ingredients.*
4. *Ferment the dough for 45 mins.*
5. *After 45 mins, mix the dough at medium speed for 30 seconds.*
6. *Grease cake pan or pie pan with oil. Spread the dough on to the prepared pan.*
7. *Proof the crust for 15 mins in a warm humid environment.*
8. *Parbake the crust for 15 mins at 375°F.*
9. *Put on the toppings. Completely bake the pizza for 8-10 mins.*

Nutrition Facts

Serving Size (100g)

Amount Per Serving	
Calories 230	Calories from Fat 50
	% Daily Value*
Total Fat 6g	9%
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 20mg	7%
Sodium 290mg	12%
Total Carbohydrate 41g	14%
Dietary Fiber 4g	16%
Sugars 0g	
Protein 5g	

Vitamin A 0% • Vitamin C 0%
Calcium 3% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

13

GLUTEN-FREE FLOUR TORTILLA

Ingredients	Grams	Baker's %
Tapioca flour	30	19
Potato starch	50	31
Brown rice flour	40	25
Chickpea flour	40	25
Salt	3	2
Xanthan gum	6	4
Whey powder	5	3
Canola oil	26	16
Vinegar	5	3
Water	100	63
Total Amount	***305.4***	***191***

Procedure

1. *Sift all the dry ingredients. Combine dry ingredients with canola oil.*
2. *Add vinegar and water to the ingredients.*
3. *Knead the dough using mixer or hands until smooth.*
4. *Divide the dough into 5 pieces (about 60g / piece).*
5. *Sheet the dough very thin to a round shape on a wax paper (~2-3mm).*
6. *Cook the dough on a hot skillet. The skillet should be about 392°F. *The dough should be cooked 30 secs on one side.*
7. *Flip the dough and cook for another 30 seconds.*
8. *Flip the last time and cook for another 30 seconds or until it is fully inflated.*

Nutrition Facts

Serving Size (51g)

Amount Per Serving	
Calories 160	Calories from Fat 50
	% Daily Value*
Total Fat 6g	9%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 350mg	15%
Total Carbohydrate 21g	8%
Dietary Fiber 2g	8%
Sugars 0g	
Protein 3g	

Vitamin A 0% • Vitamin C 0%
Calcium 3% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

GLUTEN-FREE PIE CRUST

Ingredients	Grams	Baker's %	Volume
White rice flour	108	31.6	2/3 cup
Tapioca flour	85	24.9	2/3 cup
Yellow pea flour	112.8	33.0	1/3 cup
Potato starch	35.6	10.4	1/4 cup
Whey	6	1.8	1 tbsp
Sugar	23.6	6.9	2 tbsp
Salt	17.4	5.1	1 tsp
Cold butter	165.6	48.5	12 tbsp
Egg (1)	50	14.6	1 egg
Ice water	18	5.3	1 tbsp
White vinegar	25	7.3	1 tbsp
Total Amount	***647***	***189.5***	

Procedure

1. *Sift all the dry ingredients*
2. *Cut butter into the dry ingredients*
3. *Mix together egg, ice water, and white vinegar.*
4. *Blend wet ingredients to the dry to form a dough.*
5. *Sheet out the pie to about 1/8 inch thickness on a wax paper.*
6. *Sheeted pie crust can be used in any pie recipes.*

Nutrition Facts

Serving Size (54g)

Amount Per Serving	
Calories 210	Calories from Fat 100
	% Daily Value*
Total Fat 12g	18%
Saturated Fat 8g	40%
Trans Fat 0g	
Cholesterol 50mg	17%
Sodium 1,170mg	24%
Total Carbohydrate 20g	6%
Dietary Fiber 3g	12%
Sugars 2g	
Protein 4g	

Vitamin A 0% • Vitamin C 0%

Calcium 2% • Iron 2%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 • Carbohydrate 4 • Protein 4

GLUTEN-FREE WHOLESOME CRACKER

Ingredients	Grams	Baker's %
Corn flour	40	34.8
Corn starch	16	13.9
Potato starch	18	15.7
Lentil flour	41	35.7
Minced dry onion	0.7	0.6
Salt	3.0	2.6
Italian seasoning	0.07	0.1
Water	83	72.2
Oil	28	24.3
Coarsely chopped sunflower seed	16	13.9
Sesame seeds	10	8.7
Total amount	***255.8***	***222.4***

Procedure

1. *Sift dry ingredients together.*
2. *Combine oil and water together.*
3. *In a small mixer, using a paddle attachment, add dry ingredients, follow by wet ingredients.*
4. *Mix at medium speed for 2 mins.*
5. *Combine sesame and chopped sunflower seeds together.*
6. *Dip the dough in to the seeds on both sides.*
7. *Sheet the dough onto a cookie sheet. Sprinkle the rest of the seeds on to the dough. Sheet the dough as thin as 1mm thickness.*
8. *Bake 355°F for 20 mins in a convection oven.*

Nutrition Facts

Serving Size (37g)

Amount Per Serving	
Calories 120	Calories from Fat 50
	% Daily Value*
Total Fat 6g	9%
Saturated Fat 0.5g	3%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 150mg	6%
Total Carbohydrate 15g	4%
Dietary Fiber 3g	8%
Sugars 0g	
Protein 3g	

Vitamin A 0% • Vitamin C 0%

Calcium 0% • Iron 10%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 • Carbohydrate 4 • Protein 4

14

Northern Pulse Growers Association
Bismarck, North Dakota
www.northernpulse.com

USA Dry Pea & Lentil Council
Moscow, Idaho
www.pea-lentil.com

Procedure for Making Pea Fiber

1 Line a collander with 4 layers of cheese cloth
2 Add 1 part of the milled pea hulls to the collander
3 Add 2 parts water to the milled pea hulls and stir
4 Once most of the water has been strained, squeeze the remaining water through the cheese cloth
5 Repeat steps 3-4 three more times
6 Spread the pea hulls on to a pan
7 Bake in an oven for 90 minutes at 250F
8 Let cool on the pan
9 Mill very finely

Hamburger Bun

Ingredients	Grams	Baker's %
Sponge		
HRS Patent Flour	**350**	70
Water	**295**	59
Instant Yeast	**7.5**	1.5
Sodium steroyl lactylate (SSL)	**2.5**	0.5
Pea Fiber	**24**	4.8
Dough		
HRS Patent Flour	**150**	30
Water	**110**	22
Salt	**10**	2.0
Sugar	**60**	12
Vegetable Oil	**20**	4.0
4x Dri-Do*	**0.5**	0.1
Instant Yeast	**5**	1.0
Total Amount	**1035**	**207**

Nutrition Facts
Serving Size (61g)
Servings Per Container

Amount Per Serving

Calories 160 Calories from Fat 20

	% Daily Value*
Total Fat 2g	3%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 280mg	12%
Total Carbohydrate 31g	10%
Dietary Fiber 3g	12%
Sugars 4g	
Protein 5g	

Vitamin A 0% • Vitamin C 4%
Calcium 0% • Iron 8%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories:	2,000	2,500
Total Fat	Less than		65g	80g
Saturated Fat	Less than		20g	25g
Cholesterol	Less than		300mg	300mg
Sodium	Less than		2,400mg	2,400mg
Total Carbohydrate			300g	375g
Dietary Fiber			25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

*4x Dri-Do, Caravan Ingredients - Calcium Sulfate, Salt, and Calcium Peroxide

1 Make sponge by mixing ingredients for 1 minute on low and 4 minutes on high speed
2 Bulk ferment the sponge for 3 hours (85°F, 95% R.H.)
3 Make the dough by adding the sponge and the remaining ingredients in the mixer
4 Mix on low for 1 minute and 4 minutes on high
5 Divide dough to 71 g pieces, round and flour
6 Rest for 5 minutes
7 Sheet the dough using a sheeter (setting 6.5 mm thickness)
8 Proof for 55 minutes (90°F, 95% R.H.)
9 Bake at 450°F in deck oven for 10 minutes

Lemon Poppy Seed Muffin

Ingredients	Grams	Baker's %
Sugar	340	106
Lemon Extract	9.0	2.8
Vanlite Cake Emulsifier*	1.7	0.5
Eggs	100	31
Nonfat Dry Milk	39	12
Water	276	86
Vanilla extract	6.0	1.9
Vegetable Oil	150	47
Yellow Coloring	0.1	0.03
Pastry Flour	320	100
Poppy Seed	15.0	4.7
Salt	2.5	0.8
Baking Powder	10.5	3.3
Pea Fiber	11.0	3.4
Sugar (for topping)	16.0	5.0
Total Amount	**1297**	**405**

Nutrition Facts
Serving Size (146g)
Servings Per Container

Amount Per Serving

Calories 490 Calories from Fat 160

	% Daily Value*
Total Fat 19g	29%
Saturated Fat 3g	15%
Trans Fat 0g	
Cholesterol 50mg	17%
Sodium 280mg	12%
Total Carbohydrate 76g	25%
Dietary Fiber 3g	12%
Sugars 43g	
Protein 7g	

Vitamin A 4% • Vitamin C 0%
Calcium 15% • Iron 6%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

*Vanlite Cake Emulsifier, Caravan Ingredients- water, Propylene Glycol Monostearate, Monoglycerides, Lactylic Esters of Fatty Acides with Potassium Sorbate (preservative)

1 Combine sugar, lemon extract, and vanlite in mixer and mix on low until well blended
2 Add the eggs, nonfat dry milk, water, vanilla and oil and continue mixing until well blended
3 In separate bowl, combine the dry ingredients
4 Slowly add the flour mixture to the liquids
5 Mix on medium until the all the flour becomes hydrated
6 Put muffin liners in a muffin pan and add 144g of batt
7 Top batter with 2g of sugar
8 Bake in a 360°F convection oven for 26 minutes
9 Cool in pan

Cinnamon Swirl Bread

Ingredients	Grams	Baker's %
Sponge		
All-Purpose Flour	**490**	70
Water	**420**	60
Instant Yeast	**17.5**	2.5
Pea Fiber	**84.5**	12.1
Dough		
All-Purpose Flour	**210**	30
Salt	**7**	1.0
Sugar	**70**	10
Cinnamon powder	**7**	1.0
Vegetable Oil	**74**	10.5
Water	**105**	15
Filling		
Milk, whole, 3.25%	**17.5**	2.5
Sugar	**179**	26
Cinnamon powder	**7**	1.0
Total Amount	**1688**	**241**

Nutrition Facts
Serving Size (71g)
Servings Per Container

Amount Per Serving

Calories 180 Calories from Fat 30

	% Daily Value*
Total Fat 3.5g	5%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 490mg	20%
Total Carbohydrate 37g	12%
Dietary Fiber 5g	20%
Sugars 11g	
Protein 3g	

Vitamin A 0% • Vitamin C 4%
Calcium 10% • Iron 8%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

1 Make sponge by mixing ingredients for 1/2 minute on low and 2 minutes on high speed
2 Bulk ferment the sponge for 3 hours (85°F, 95% R.H.)
3 Make the dough by adding the sponge and the remaining ingredients in the mixer
4 Mix on low for 1 minute and high for 2 minutes
5 Let dough rest for 10 minutes
6 Divide dough into 550g pieces and round
7 Sheet dough into rectangular shape about 1/2 inch thick
8 Mix filling ingredients together and divide into 2 equal parts
9 Spread half of the filling mixture evenly on sheeted dough; leaving 2 inches on an end with no fillin
10 Mold the dough by rolling the sheeted dough towards the end with no filling
11 Seal the seam and ends of the loaf
12 Repeat steps 9-12 with the second scaled dough and second half of the filling mixture
13 Place in a greased pan and proof for 40 minutes (85°F, 95% R.H.)
14 Bake at 370°F for 26 minutes
15 Remove from pan and cool

Blueberry Pancake

Ingredients	Grams	Baker's %
Egg Whites	**60**	32
Egg Yolks	**36**	19
Non-Fat Dry Milk	**43.2**	23
Butter, melted	**41**	22
All-Purpose Flour	**188**	100
Baking Powder	**11.25**	6.0
Sugar	**45**	24
Salt	**4.5**	2.4
Pea Fiber	**13**	6.9
Water	**209**	111
Dried Blueberries	**60**	32
Total Amount	**651**	**346**

Nutrition Facts
Serving Size (62g)
Servings Per Container

Amount Per Serving

Calories 160 Calories from Fat 40

	% Daily Value*
Total Fat 4.5g	7%
Saturated Fat 2.5g	13%
Trans Fat 0g	
Cholesterol 50mg	17%
Sodium 330mg	14%
Total Carbohydrate 25g	8%
Dietary Fiber 3g	12%
Sugars 5g	
Protein 5g	

Vitamin A 2% • Vitamin C 0%
Calcium 10% • Iron 6%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

1 In mixer, whip egg whites until stiff.
2 In second bowl, beat the egg yolks, non-fat dry milk, water and melted butter
3 Add egg mixture to dry ingredients and mix until batter is smooth.
4 Stir in dried blueberries
5 Fold in egg whites
6 Pour 67g of the batter on hot griddle
7 Cook on each side until pancake is cooked through

Tortilla

Ingredients	Grams	Baker's %
All-Purpose Flour	**700**	100
Salt	**14**	2.0
Vegetable Shortening	**70**	10
Pea Fiber	**98**	14
Reduce 150*	**3.5**	0.5
Water	**525**	75
Total Amount	**1411**	**102**

Nutrition Facts
Serving Size (50g)
Servings Per Container

Amount Per Serving

Calories 140 Calories from Fat 30

	% Daily Value*
Total Fat 3.5g	5%
Saturated Fat 1g	5%
Trans Fat 0.5g	
Cholesterol 0mg	0%
Sodium 230mg	10%
Total Carbohydrate 27g	9%
Dietary Fiber 5g	20%
Sugars 0g	
Protein 3g	

Vitamin A 0% • Vitamin C 0%
Calcium 0% • Iron 8%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

*Reduce 150, Caravan Ingredients - Sodium Stearoyl Lactylate (SSL), Calcium Sulfate, and Sodium Sulfite

1 Mix the ingredients on low for 1 minute and high for 4 minutes
2 Scale to 60 grams and round
3 Let sit for 5 minutes
4 Roll to a round shape
5 Grill on hot griddle (30 seconds per side)
6 Flip tortilla twice
7 Let cool and package immediately

Everything Bagel

Ingredients	Grams	Baker's %
Sponge		
HRS Patent Flour	**210**	30
Water	**231**	33
Instant Yeast	**3.5**	0.5
Pea Fiber	**15**	2.1
Dough		
HRS Patent Flour	**490**	70
Water	**189**	27
Salt	**16.1**	2.3
Sugar	**21**	3.0
Instant Yeast	**3.5**	0.5
Topping		
Parmesan Cheese	**8.5**	1.2
Dried Minced Onion	**3.5**	0.5
Italian Seasoning	**0.55**	0.1
Coarse Salt	**2.5**	0.4
Sesame Seed	**4**	0.6
Poppy Seed	**3**	0.4
Garlic Powder	**0.75**	0.1
Total Amount	**1202**	**172**

1 Make sponge by mixing ingredients for 1 minute on low and 4 minutes on high speed
2 Bulk ferment the sponge for 1.5 hours (85°F, 95% R.H.)
3 Make the dough by adding the sponge and the remaining ingredients in the mixer
4 Mix on low for 10 minutes
5 Divide dough to 100 g pieces, round
6 Rest for 5 minutes
7 Poke hole through center of dough and shape into bagel shape
8 Proof for 45 minutes (85°F, 95% R.H.)
9 Boil in 2.5 % sugar solution for 30 seconds on each side
10 Place on pan and top with 2g of topping mixture
11 Bake at 475°F in convection oven for 11 minutes
12 Take off the pan, cool

Pasta

Ingredients	Grams	% Solids
Enriched Semolina	**1000**	93.5
Pea Fiber	**65**	6.5
Water	**330**	
Total Amount	**1395**	**100**

1 Blend the semolina and pea fiber
2 Add the semolina mixture to the extruder; then add the water
3 Mix in a pasta press/extruder.
4 Extrude the pasta
5 Air dry or in a pasta dryer.

Chocolate Cookies

Ingredients	Grams	Baker's %
Vegetable Shortening	150	86.2
Sugar	130	74.7
Brown Sugar	93	53.4
Vanilla extract	5.25	3.0
Eggs	100	57.5
Salt	2	1.1
All-Purpose Flour	174	100
Cocoa Powder	51.5	29.6
Baking Soda	1.25	0.7
Pea Fiber	38	21.8
Total Amount	**745**	**428**

Nutrition Facts

Serving Size (35g)
Servings Per Container

Amount Per Serving

Calories 150	Calories from Fat 70
	% Daily Value*
Total Fat 8g	12%
Saturated Fat 2g	10%
Trans Fat 1g	
Cholesterol 20mg	7%
Sodium 60mg	3%
Total Carbohydrate 20g	7%
Dietary Fiber 3g	12%
Sugars 10g	
Protein 2g	
Vitamin A 0% • Vitamin C 0%	
Calcium 2% • Iron 4%	

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories:	2,000	2,500
Total Fat	Less than		65g	80g
Saturated Fat	Less than		20g	25g
Cholesterol	Less than		300mg	300mg
Sodium	Less than		2,400mg	2,400mg
Total Carbohydrate			300g	375g
Dietary Fiber			25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

1 In a mixer, cream the vegetable shortening and sugars on medium high speed for 3 minutes
2 Add the eggs and vanilla and continue mixing on medium for 1 minute
3 Add the remaining ingredients to the mixer and mix on low for 30 seconds and on medium until all ingredients are incorporated
4 Place dough into cookie press and press onto ungreased cookie sheets
5 Bake at 375F° for 7 minutes
6 Remove from pan and cool

Procedure for Making Pea Fiber

1 Line a collander with 4 layers of cheese cloth
2 Add 1 part of the milled pea hulls to the collander
3 Add 2 parts water to the milled pea hulls and stir
4 Once most of the water has been strained, squeeze the remaining water through the cheese cloth
5 Repeat steps 3-4 three more times
6 Spread the pea hulls on to a pan
7 Bake in an oven for 90 minutes at 250F
8 Let cool on the pan
9 Mill very finely

Legumes: Wholesome Ingredients for Value-Added Foods

A free educational course hosted by the USA Dry Pea & Lentil Council

August 17-19, 2011
The Culinary Institute of America
Greystone, Napa Valley, CA

U★S★A Dry Peas, Lentils & Chickpeas

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SCHEDULE

Day One: August 17, 2011

1:45 PM	**Bus Departs El Bonita** – *Will pick- up in front of Office*	
2:00 PM	**Bus Departs Vineyard Country Inn** – *Will pick-up in Parking Lot*	
2:15 PM	**Welcome & Opening Remarks** **Session Overview & Group Introductions** *Jennifer William* *Food Marketing Manager* *USA Dry Peas, Lentils, & Chickpeas*	Ecolab Theater, 1st Floor
2:45 PM	**What's Hot: Trends, Tastes, & Traffic Builders 2011+** *Dr. A Elizabeth Sloan* *President* *Sloan Trends, Inc.*	
3:15 PM	**Nutritional Value of Peas, Lentils, & Chickpeas** *Amy Myrdal Miller, MS, RD* *Director of Programming, Strategic Initiatives* *The Culinary Institute of America*	
3:45 PM	**Kitchen Orientation**	Teaching Kitchen, 3rd Floor
4:00 PM	**Hands-on Culinary Session "ice breaker"** ***Focus: Easy, full-flavor Appetizers incorporating Dry Peas, Lentils, and Chickpeas*** *The group will be broken into teams to work on a few dishes each. The CIA instructors and Guest Chef will float between the teams to provide inspiration and assistance.* **Baking Kitchen** *Guest Chef Richard Coppedge, C.M.B.* *B&P Chef Stephen Durfee* **Hot Kitchen** *CIA Chef Instructor Scott Samuel*	
5:30 PM	**Appetizers and Wine Reception** **Introduce & Recognize Industry Members**	Piano Lounge, 2nd Floor
6:15 PM	**Dinner at Wine Spectator at Greystone Restaurant**	
8:30 PM	**Buses Depart for Hotels** – *From Restaurant Patio*	

Day Two: August 18, 2011

7:30 AM	**Bus Departs El Bonita Motel**	
7:45 AM	**Bus Departs Vineyard Country Inn**	
8:00 AM	**Continental Breakfast Buffet**	Teaching Kitchen, 3rd Floor
8:30 AM	**How to Win in the Marketplace with Lentils & Peas** *Kantha Shelke* *Feunder and Principal* *Corvus Blue*	Ecolab Theater, 1st Floor
9:00 AM	**Pulse Flours and Their Uses** *Mehmet Tulbek, PhD* *Technical Director* *Northern Crops Institute*	
9:45 AM	**Masking Flavor Notes of Vegetable Proteins & Fibers** *Lee Slimek* *Director of Research* *Saber Foods*	
10:15 AM	**World Flavors with Dry Peas, Lentils, & Chickpeas** *Alexandra Guarnaschelli* *Executive Chef, Butter Restaurant* *Host, Food Network's Alex's Day Off*	Ecolab Theater, 1st Floor
10:45 AM	**Hands-on Culinary Session** *Guest Chef Alexandra Guarnaschelli* *CIA Baking & Pastry Chef Richard Coppedge, C.M.B.* *CIA Chef Instructor Scott Samuel*	Viking Kitchen, 1st Floor
1:00 PM	**Lunch from Production**	Café Area, 1st Floor
2:00 PM	**Life without Gluten** *Lynn M. Senecal, RD, CDE* *Regional Clinical Manager* *Animas Corporation*	Ecolab Theater, 1st Floor
2:30 PM	**Gluten Free Baking** *CIA Baking & Pastry Chef Richard Coppedge, C.M.B.* *The Culinary Institute of America*	
3:00 PM	**Afternoon Lecture/Demonstrations** *Alexandra Guarnaschelli* *Executive Chef, Butter Restaurant* *Host, Food Network's Alex's Day Off*	
3:30 PM	**Afternoon Lecture/Demonstrations** *CIA Baking & Pastry Chef Stephen Durfee*	
4:00 PM	**Concurrent Hands-on Culinary Sessions** **Baking Kitchen** *CIA Baking & Pastry Chef Richard Coppedge, C.M.B.* *CIA Baking & Pastry Chef Stephen Durfee* **Hot Kitchen** *Guest Chef Alexandra Guarnaschelli* *CIA Chef Instructor Scott Samuel*	Teaching Kitchen, 3rd Floor
6:30 PM	**Wrap up, Review, & Critique**	
6:40 PM	**Dinner from Production**	
7:30 PM	**Buses Depart for Hotels** – *From CIA Front Entrance*	

Day Three: August 19, 2011

7:30 AM	**Bus Departs El Bonita Motel**--*Bring luggage to CIA & check-out of hotel*	
7:45 AM	**Bus Departs Vineyard Country Inn** – *Bring luggage to CIA & check-out of hotel*	
8:00 AM	**Continental Breakfast Buffet**	Teaching Kitchen, 3rd Floor
8:30 AM	**They are what they eat: Nutrition and shopping trends in 2011** *Michael Sansolo* *Retail Food Industry Consultant*	Ecolab Theater, 1st Floor
9:15 AM	**World Flavors with Dry Peas, Lentils, & Chickpeas** *Joyce Goldstein* *Chef & Cookbook Author*	
9:45 AM	**Hands-on Culinary Session** *CIA Baking & Pastry Chef Richard Coppedge, C.M.B.* *Guest Chef Joyce Goldstein* *CIA Chef Instructor Scott Samuel*	Viking Kitchen, 1st Floor
12:00 PM	**Lunch from Production**	
1:00 PM	**Program Adjourns**	Ecolab Theater, 1st Floor

2011 Course Success

- JR Simplot
  - Formulated 10 new products using Chickpeas and Lentils
- Gluten Free coating developed
- Aseptic packaging for lentil puree in soups
- Pea flour in pet treat to increase protein
- Chickpeas in pizza to increase nutrition
- Several discussion groups and increased awareness

63.5% of participants have formulated with DPLC since the course

Value-Added Products

MARS
foodservice

ORGANIC
MARY'S Gone CRACKERS
Love Cookies
Traditional flavors, Revolutionary ingredients.™

Simplot
UpSides™
savory side dishes

LEGUMES:
Wholesome Ingredients for Value-Added Foods

August 1-3, 2012

Course Curriculum
&
Program Guide

at the Culinary Institute of America

U★S★A
Dry Peas,
Lentils &
Chickpeas
The Standard for Quality

www.pea-lentil.com

home attend course event details

Legumes: Wholesome Ingredients for Value-Added Foods

A free educational course hosted by the USA Dry Pea & Lentil Council

August 1-3, 2012
The Culinary Institute of America at Greystone
Napa Valley, California

Join the USA Dry Pea & Lentil Council for a two-day, hands-on educational seminar at the premier culinary college, The Culinary Institute of America, in the beautiful Napa Valley.

This complimentary course is designed for product and recipe developers at large-scale food manufacturers and foodservice operations and will focus on innovative and trendsetting product applications for dry peas, lentils, chickpeas, and their flours.

Course registration and lodging are provided by The USA Dry Pea & Lentil Council. As space is limited, please submit your application to attend by Friday, July 20, 2012.

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Apply Today

Fill out our application form today to attend

Follow us on twitter

Find us on facebook

home attend course event details

Applications are now closed

Applications are now closed for this year's event.

If you have any questions, please contact Ali McDaniel at amcdaniel@pea-lentil.com for assistance.

Download Agenda

Download the latest agenda (PDF)

Follow us on twitter

Find us on facebook

Industry Members invited to attend product development course.

Legumes: Wholesome Ingredients for Value-Added Food.

Hosted by the USA Dry Pea & Lentil Council at The Culinary Institute of America's Greystone campus in Napa Valley, California.
August 1-3, 2012

Dear Industry Members,

The USA Dry Pea & Lentil Council would like to extend the opportunity for you to attend the product development course hosted at The Culinary Institute of America August 1-3, 2012. There are **4 slots** available for our industry members to attend at their own cost.

The course is **an invitation-only** event for corporate and executive chefs, research chefs, food scientists, product developers and other influencers from the food industry. Through a blend of *discussion, cooking demonstrations,* and *hands-on kitchen sessions,* the participants will learn the high value that **USA dry peas, lentils, chickpeas, and their flours** offer for new menu items and food products. Our goal is to inspire the participants to incorporate more of these particular legumes as ingredients because they are versatile super foods!

If you are interested in attending the course, please fill out the following application and email or mail it back to Ali McDaniel by Friday June 22, 2012. Applications will then be reviewed by the Domestic Marketing Committee and the applicants will be notified of the their acceptance.

Website:
For more information on the course, please visit the website.
www.pealentilculinarycourse.com

If you have any questions at all, please do not hesitate to contact us.

Sincerely,
Ali

Ali McDaniel
Food Marketing Manager
USA Dry Pea & Lentil Council
2780 West Pullman Rd
Moscow, ID 83843
208-882-3023
amcdaniel@pea-lentil.com

Application Form

Legumes: Wholesome Ingredients for Value-Added Foods
The Culinary Institute of America's Greystone Campus
August 1-3, 2012

Please return to Ali McDaniel (amcdaniel@pea-lentil.com) by June 22, 2012, 5 PM PDT.

Name:

Company:

Phone:

Email:

Address:

Have you previously attended one of the product development courses? (Please Circle) Yes/No

If yes, please circle the year: 2009/ 2011

Reason for attending: (Please write a few sentences on why you would like to attend the course.)

Event Details

A free educational course hosted by the USA Dry Pea & Lentil Council

Seminar sessions will consist of a mix of lecture, roundtable discussions and hands-on culinary activities. Topics of focus include the nutritional value of dry peas, lentils and chickpeas, gluten-free cooking and baking, consumer trends and more. Download the latest agenda (PDF) .

Our speakers include a group of highly informed and respected experts on these topics.

Patricia Johnson, MBA

Global Food and Drink Analyst
Mintel International

Patricia has an extensive background in food product marketing, new product development and food business ventures. Her 20-plus years of food marketing experience includes trends analysis, marketing strategy formulation, advertising, public relations, sales development and culinary education program design. Patricia's food industry background also includes 12 years of multi-unit restaurant management and hands-on experience as a corporate chef and wine tour company owner. She holds an MBA in Marketing from Claremont's Peter Drucker Management Center.

Thunyaporn Jeradeehachai (Naggie)

Food Scientist
Northern Crops Institute

Naggie is a food scientist at the Northern Crops Institute in Fargo, ND. She provides technical solutions to food manufacturers on the quality and utilization of sunflower, flaxseed, canola, peas, lentils, chickpeas, dry edible beans, soybean, and wheat. Naggie travels in the U.S. and internationally to teach seminars and consult with food manufacturers on the value of the U.S. northern grown crops. Her specialties are traditional and gluten free baking, pasta processing, snack, and cereal extrusions. Naggie is originally from Bangkok, Thailand.

Richard Coppedge

Certified Master Baker
The Culinary Institute of America

During his tenure at the CIA, Richard has taught various bread baking courses, is the author of Gluten-Free Baking with The Culinary Institute of America and helped

develop and provide content for the CIA's bread baking instructional video series. Prior to joining the college's faculty in 1992, Chef Coppedge held positions in such prestigious properties as The Ritz-Carlton Hotel Company and Walt Disney World. The CIA Faculty Member of the Year for 1994, Chef Coppedge is a member of the Bread Bakers Guild of America and the Retailer's Bakery Association, received First Place for Pastry Grand Buffet, and a Silver Medal, Bronze Medal, and Judges Award at the Boston Food Show.

Amy Myrdal Miller, MS, RD

Director of Programs & Culinary Nutrition
The Culinary Institute of America

Amy is the director of programs and culinary nutrition for The Culinary Institute of America (CIA). Amy is a farmer's daughter from North Dakota who has focused her career on nutrition and culinary research, education, and communication with a focus on promoting the health, flavor, and culinary benefits of whole foods. She received her bachelor's in dietetics from the University of California Davis, completed her dietetic internship at the University of Minnesota Hospital, and received a master's in nutrition communication from Tufts University School of Nutrition, Science & Policy in Boston. Amy and her husband Scott Miller live in Sacramento, California.

Walter Potenza

Chef Educator & Restaurateur
Potenza Ristorante

Walter, a native of Mosciano Sant'Angelo in Abruzzo, Italy, is known as one of the most passionate and accomplished practitioners of traditional and innovative Italian cooking in the nation. Walter's culinary awards include the Six Star Diamond Award, the Portonovo Award from the Marcha Region of Italy, and the prestigious Insignia Award received in the year 2000 by the Italian Government. Walter was one of a select group of chefs named to the James Beard Specialty Chef Program, held during the 2002 Winter Olympic Games, Utah. In the last 10 years Chef Walter has expanded his culinary research to nutrition and the connection with Celiac and Diabetes through Food Science. As a member of RCA (Research Chefs of America), Chef Walter spends endless hours in developing new recipes, and innovative flavors to complement the diet restrictions of his patrons. In spring 2012 Chef Walter launched Chef Walters Cooking School in the city of Cranston, RI with curriculums for Professional Chefs, Novice, Kids, Total Hospitality, as well as Wellness and Weight Loss Programs.

Aaron Flores

Executive Chef
Finn & Porter, Embassy Suites

Aaron began his cooking career back when he was just 16 years old as a young boy washing dishes for the Brinker International restaurant group. Over the years, Aaron spent time as Opening Sous Chef for the Five Diamond Disney Grand Californian Hotel, Executive Chef of Marshall Field's Flagship Store at State Street and

Executive Chef of the Embassy Suites DC Convention Center. Aaron is considered a pioneer in the Gluten Free World. He has served as National Executive Chef of the Celiac Sprue Association and The Gluten Intolerance Group of North America for a number of years working to create awareness of celiac disease and the need for a gluten-free lifestyle. Writing a monthly column, contributing to numerous gluten-free cookbooks and planning national conferences around the country Chef Flores has truly brought the awareness of gluten-free cuisine to the industry.

SCHEDULE

"Legumes: Wholesome Ingredients for Value-Added Foods"
Hosted by the USA Dry Pea & Lentil Council at
The Culinary Institute of America's Greystone campus August 1-3, 2012

Day One: August 1, 2012

1:45 PM **Bus Departs El Bonita Motel** *–Pick-up in the Front Office*

2:00 PM **Welcome and Opening Remarks** **DeBaun Theater, 1st Floor**
Session Overview and Group Introductions
Ali McDaniel, MS
Food Marketing Manager
USA Dry Pea & Lentil Council

2:30 PM **Nutritional Value of Peas, Lentils, and Chickpeas**
Amy Myrdal Miller, MS, RD
Director of Programs and Culinary Nutrition, Strategic Initiatives
The Culinary Institute of America

3:00 PM **Health and Wellness Trends**
Patricia Johnson, MBA
Global Food and Drink Analyst
Mintel International

3:30 PM **Kitchen Orientation** **Teaching Kitchen, 3rd Floor**

3:45 PM **Hands-on Culinary Session "Ice-breaker"**
Focus: Easy, Full-Flavor Appetizers Incorporating Dry Peas, Lentils, and Chickpeas
The group will be broken into teams to work on a few dishes each. The CIA instructors will float between the teams to provide inspiration & assistance.

Baking Kitchen
CIA Baking and Pastry Chef Richard Coppedge, C.M.B.
CIA Baking and Pastry Chef John Difillipo

Hot Kitchen
CIA Chef Instructor Scott Samuel

5:30 PM **Appetizers and Wine Reception** **Piano Lounge, 2nd Floor**
Introduction and Recognition of Industry Members

6:15 PM **Dinner at Wine Spectator at Greystone Restaurant**

8:30 PM **Buses Depart for Hotel** – *From Restaurant Patio*

Ventura Center Classroom 3, 3rd Floor
CIA Director of Consulting Ted Russin
Noel Rudie, Ph.D., Director of Research, Harvest Innovations

12:00 PM **Reports from the Round Table Discussions**
Chef Aaron Flores, Finn and Porter, Embassy Suites
Patricia Johnson, MBA, Global Food and Drink Analyst, Mintel International
CIA Director of Consulting Ted Russin

12:30 PM **Buffet Lunch** **Teaching Kitchen, 3rd Floor**

1:30 PM **The Chemistry Behind Pulse Flours and Fractions** **DeBaun Theater, 1st Floor**
Noel Rudie, Ph.D.
Director of Research
Harvest Innovations

2:15 PM **Innovative Uses of Dry Peas, Lentils, and Chickpeas, Culinary Demonstrations**
Chef Walter Potenza
Educator and Restaurateur
Potenza Ristorante

2:45 PM **Break**

3:00 PM **Gluten-Free and Specialty Diets Culinary Demonstrations**
Chef Aaron Flores
Finn and Porter, Embassy Suites

3:45 PM **Introduction to Hands-On Session** **Teaching Kitchen, 3rd Floor**
Concurrent Hands-On Sessions: Participants will be in opposite groups from Day 1

Baking Kitchen
CIA Baking and Pastry Chef Richard Coppedge, C.M.B.
CIA Baking and Pastry Chef John Difillipo
Chef Aaron Flores, Finn and Porter, Embassy Suites

Hot Kitchen
CIA Chef Instructor Scott Samuel
Chef Walter Potenza, Educator and Restaurateur, Potenza Ristorante

6:30 PM **Wrap-Up, Review, and Critique**

6:40 PM **Dinner from Production**

7:30 PM **Buses Depart for Hotel** – *From the CIA Front Entrance*

CHEF AND SPEAKER BIOGRAPHIES

RICHARD COPPEDGE, CMB, is a professor in Baking and Pastry Arts at The Culinary Institute of America (CIA). Chef Coppedge currently teaches Advanced Baking Principles to students pursuing their bachelor's and associate degrees from the CIA. During his tenure at the CIA, he has taught various bread baking courses.

Chef Coppedge is the author of *Gluten-Free Baking with The Culinary Institute of America* (Adams Media, 2008). He also helped develop and provide content for the CIA's bread baking instructional video series.

Prior to joining the college's faculty in 1992, Chef Coppedge held positions in such prestigious properties as The Ritz-Carlton Hotel Company and Walt Disney World. Chef Coppedge was also the bread baker for The Dunes Club in Providence, Rhode Island and the Narragansett Bay Baking Company in Newport, Rhode Island. For 10 years he was an assistant professor in the baking program at Johnson & Wales University in Providence.

The CIA Faculty Member of the Year for 1994, Chef Coppedge is a member of the Bread Bakers Guild of America and the Retailer's Bakery Association. He received First Place for Pastry Grand Buffet, and a Silver Medal, Bronze Medal, and Judges Award at the Boston Food Show. Chef Coppedge earned awards for his bread displays at the New York Food Show from 1993 to 1995. He was a member of the CIA faculty team that won the coveted Marc Sarrazin Cup, grand prize of the *Société Culinaire Philanthropique's* New York Culinary Salon, in both 1996 and 1997. Chef Coppedge is a Certified Master Baker (C.M.B.).

JOHN DIFILIPPO is a Pastry Instructor at The Culinary Institute of America at Greystone. He was executive pastry chef at Auberge du Soleil in Rutherford, California prior to joining the CIA faculty. Chef Difilippo has held a number of professional pastry positions in California, and served as pastry chef at The Ritz-Carlton Hotel in Phoenix, Arizona. He also attended Chef Ewald Notter's International School of Confectionery Arts.

SCOTT EXO consults on third party certification, sustainable agriculture, and values-based food marketing. For eight years, Scott led Food Alliance, a national non-profit that uses market incentives to promote sustainable agriculture, and operates a third-party certification program for environmentally friendly and socially responsible agricultural practices.

Prior to joining Food Alliance in 1999, Scott served six years as the director of the Grassroots Leadership Project at 1000 Friends of Oregon, and managed rural development and study abroad programs in Asia and Africa. Scott earned master's degrees in geography and in urban and regional Planning from the University of Hawaii at Manoa.

AARON FLORES began his cooking career back when he was just 16 years old as a young boy washing dishes for the Brinker International restaurant group. It's here where he found

vegetables, and meat, poultry, and seafood. She currently serves as the Treasurer for the International Foodservice Editorial Council and is the President of United Way of Magic Valley.

ALI MCDANIEL , MS, is the Food Marketing Manager for the USA Dry Pea & Lentil Council. Ali earned her bachelor's degree in Food Science from the University of Georgia (UGA). Upon graduation from UGA, Ali participated in an exchange program with Universität Hohenheim in Stuttgart, Germany where she studied in the Organic Food Chain Management program and worked in a food chemistry lab analyzing specific fatty acids in food samples to determine differences between organic and nonorganic sources. Ali then completed an internship with Chick-fil-A, Inc. in the Brand Development Department where her projects focused on product development and shelf-life studies. Following her internship, Ali went on to North Carolina State University where she earned her master's in Food Science with a minor in Nutrition. Working in the USDA-ARS peanut lab, Ali's master's research focused on roast effects on peanut flavor, mechanical and nutritional properties.

AMY MYRDAL MILLER, MS, RD, is the director of programs and culinary nutrition for strategic initiatives at The Culinary Institute of America (CIA). A registered dietitian with a master's degree in nutrition communications from Tufts University School of Nutrition Science and Policy, Amy has focused her career on nutrition research, education, and communication with a focus on promoting the health, flavor, and culinary benefits of whole foods.

An invited presenter at state, national, and international conferences, Amy is also frequently interviewed by national print and online media outlets for stories related to culinary nutrition, trends, and sustainability. Amy's newest responsibilities at the CIA including leading planning for Healthy Flavors, Healthy Kids, the CIA's national initiative focused on food education, culinary strategy, and flavor insights that will improve children's access to fresh, flavorful food in a variety of environments. She is also the principal investigator on a study looking at how culinary techniques and flavor development strategies influence consumer liking of health-promoting foods.

Prior to joining the CIA, Amy led domestic marketing and health research efforts for the California Walnut Commission, directed nutrition education and nutrition marketing programs for Dole Food Company, and conducted cardiovascular health research studies at the Rippe Lifestyle Institute in Shrewsbury, Massachusetts. Amy was the 2003 recipient of the Produce for Better Health Foundation Diamond Crystal Award for her leadership in developing an online children's nutrition education program. Amy is the co-author of *The Healthy Heart Cookbook for Dummies* and the executive editor of the *Dole 5 A Day Kids Cookbook*.

Amy is a member of the Academy of Nutrition and Dietetics (formerly the American Dietetic Association) and a past chair of the Food & Culinary Professionals Dietetic Practice Group of the Academy of Nutrition and Dietetics. She is also a member of the United Fresh Produce Association Retail-Foodservice Board, the Farm Foundation "Dialogue Project"

planning, analysis and evaluation of the Fresh Fruit and Vegetable Program, and analysis of procurement aimed at increasing locally sourced fruits and vegetables.

As the Director of Health and Nutrition for the American Pulse Association, Dr. Rueda is tasked with implementing the Pulse Health Initiative, a comprehensive research program that aims to elucidate the unique potential of pulse crops to substantially impact the global and domestic challenges of obesity and chronic disease, global hunger, functionality and end-use, and environmental sustainability.

Dr. Rueda holds an adjunct faculty position at Washington State University in the School of Food Science. She is a member of the American Association for the Advancement of Science, American Association of Cereal Chemists, American Chemical Society, American Diabetes Association, American Heart Association, American Society of Nutrition, and the Obesity Society.

TED RUSSIN, MSC, is director of consulting at the CIA. He was previously an applications scientist with CP Kelco in San Diego, California and a consulting expert for Nathan Myhrvold's Modernist Cuisine. Mr. Russin has created new food products ranging from the traditional to the truly innovative, including non-diluting ice cubes and self-layering dessert systems. In addition to hands-on laboratory development and collaboration with large-scale food producers, he has consulted with some of the world's most influential chefs who use hydrocolloids in the kitchen, including Thomas Keller, Corey Lee, Adrian Vasquez, and Wylie Dufresne. Mr. Russin has published academic papers on such topics as protein extraction, analytical food chemistry, and lipid oxidation. In 2010, his patent-pending layered dessert gel system utilizing gellan gum was awarded the North American Food Ingredients Technology Innovation of the Year Award from Frost & Sullivan. Born and raised in Winnipeg, Canada, Mr. Russin holds undergraduate degrees in philosophy and food science and a master's in food chemistry.

SCOTT SAMUEL is a Chef Instructor at The Culinary Institute of America at Greystone. With more than 20 years in the restaurant industry, Chef Samuel is an accomplished chef with a wide range of experience. Chef Samuel was most recently a chef-instructor for Seattle Culinary Academy and the owner of Simply Brilliant, a business specializing in catering and private culinary instruction. He was previously a private chef; sous chef for the four-star Herbfarm restaurant in Woodinville, Washington; and the original executive chef at Brie & Bordeaux in Seattle, where he was nominated for the James Beard Foundation "Rising Star Chef of the Year" award. In addition to other chef positions in Hawaii and Washington State, Chef Samuel completed an apprenticeship at The French Laundry in Yountville, California. He holds a bachelor's of arts in hotel/restaurant administration from Washington State University.

USA Dry Pea & Lentil Council

Legumes: Wholesome Ingredients for Value-Added Foods

Evaluation Form – DAY 1: August 1, 2012

For each of the following questions please select the best answer(s).

1. What topics were you most interested in learning about from today's sessions?
   a. ☐ Industry trends regarding pulses and nutrition
   b. ☐ Pulse and pulse flour preparation/usage tips, including recipes
   c. ☐ Marketing opportunity for pulse-based foods
   d. ☐ Gluten-free or allergy-friendly recipes
   e. ☐ OTHER _____

2. How would you describe the pace of today's sessions?
   a. ☐ Too slow
   b. ☐ Just right
   c. ☐ Too fast

   Comments: _____

3. How much did you learn during today's sessions?
   a. ☐ I learned a lot – we covered many unfamiliar topics.
   b. ☐ I learned a fair amount – there were a few unfamiliar topics.
   c. ☐ I didn't learn much – most of the topics were familiar or review.
   d. ☐ I expected to learn more – there were many topics of interest that weren't covered.

   Please elaborate on topics you would like to have learned more/less about: _____

For each of the following, please provide a brief answer.

1. What did you find most valuable about today's sessions?

   _____

2. What would you have changed about today's sessions?

   _____

3. Other comments?

   _____

USA Dry Pea & Lentil Council

Legumes: Wholesome Ingredients for Value-Added Foods

Evaluation Form – DAY 2: August 2, 2012

For each of the following questions please select the best answer(s).

1. What topics were you most interested in learning about from today's sessions?
   a. ☐ Industry trends regarding pulses and nutrition
   b. ☐ Pulse and pulse flour preparation/usage tips, including recipes
   c. ☐ Marketing opportunity for pulse-based foods
   d. ☐ Gluten-free or allergy-friendly recipes
   e. ☐ OTHER _____

2. How would you describe the pace of today's sessions?
   a. ☐ Too slow
   b. ☐ Just right
   c. ☐ Too fast

   Comments: _____

3. How much did you learn during today's sessions?
   a. ☐ I learned a lot – we covered many unfamiliar topics.
   b. ☐ I learned a fair amount – there were a few unfamiliar topics.
   c. ☐ I didn't learn much – most of the topics were familiar or review.
   d. ☐ I expected to learn more – there were many topics of interest that weren't covered.

   Please elaborate on topics you would like to have learned more/less about: _____

For each of the following, please provide a brief answer.

1. What did you find most valuable about today's sessions?

   _____

2. What would you have changed about today's sessions?

   _____

3. Other comments?

   _____

Legumes: Wholesome Ingredients for Value-Added Foods
August 1-3, 2012
USA Dry Pea & Lentil Council

Program Sponsors
USA Dry Pea & Lentil Council
MONTANA Department of AGRICULTURE
Northern Pulse Growers Association
Industry Sponsors
TIMELESS SEEDS, INC.
Harvest INNOVATIONS

Value-Added Product Sponsors
Cookies
plentils
crunchy lentil chips

Who Are We ?
Non-profit organization
Represents over 5,000 members
Growers
Processors
Exporters / Traders
Value-Added Companies
Dry Peas, Lentils, and Chickpeas Grown in the United States
GOALS:
1. Develop new markets for dry peas, lentils, and chickpeas as ingredients!
2. Educate consumers and the food industry
a. Health Benefits
b. Functionality
USA Dry Pea & Lentil Council

Legume vs Pulse

- Legumes:
  Simple dry fruits or pods that contain seeds or dry grains; fix atmospheric nitrogen into the soil; used as rotation crops to wheat and barley; reduce or eliminate the need for chemical fertilizers;
- Pulses:
  Crops harvested solely for dry grains found in their pods, yielding 1-12 seeds in pods dried naturally in field; used for food and animal feed only; not crops grown for oil extraction,

ABCs of PEAS

*What is the difference between a **PEA** and a **BEAN**?*

- Different climate conditions necessary for growth
  - PEAS – cool season legumes – more tolerant of cold temperatures (US Northern plains)
  - BEANS – warm season legumes – require much warmer temperatures (Midwest and Southern California)
- Growing structure / support
  - PEAS plants / pods grow on a vine
  - BEANS typically grow in a pod on a bush
- Difference in growing season
  - PEAS mature and harvest in 70-90 days
  - BEANS mature and harvest in 85-115 days

USA Dry Peas

What Is a Dry Pea?

- Originated in Northwest Asia
- 11,000 year old peas found in Thailand
- Both green / yellow varieties commercially grown
- US growers produce two different types of peas, smooth dry peas and fresh garden peas.
- Fresh garden peas, snap peas ARE NOT dry peas.

USA Chickpeas

What is a Chickpea?

- Also called garbanzo beans
- Originally cultivated on the lands bordering Mesopotamia/Eastern Mediterranean →India and some parts of East Asia
- Idaho produces almost 50% of the Chickpeas in the U.S.
- Two kinds of chickpeas are raised by US Growers
- Chickpeas are a main ingredient in hummus

CHICKPEA VARIETIES
- Desi
- Kabuli (Small)
- Kabuli (Large)

USA Lentils

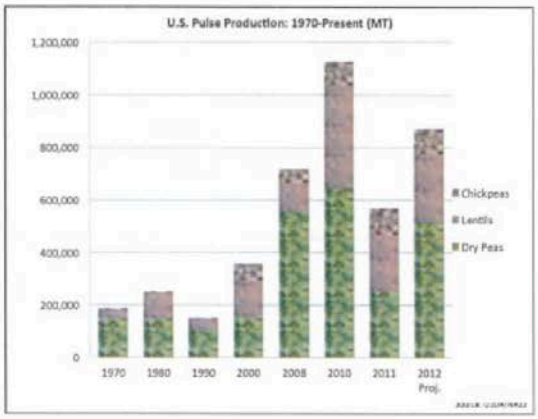
What is a Lentil?

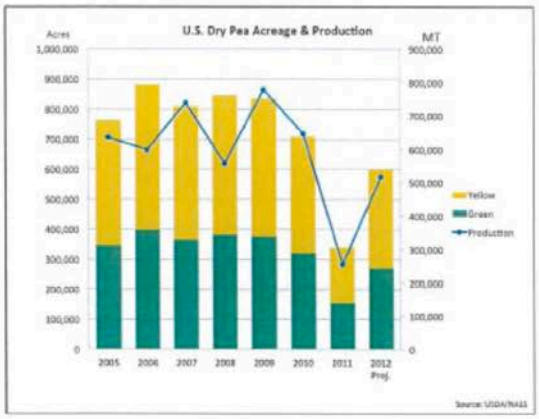
- Shaped like a lens
- Outer seed coat = mottled or speckled
- Inner coat, or cotyledon, can be red or yellow
- The first growing region Palouse – extending into North Idaho and Eastern Washington about 90 miles in any direction from Moscow, ID or Pullman, WA.
- Bulk of US pulses crops are now grown in North Dakota & Montana

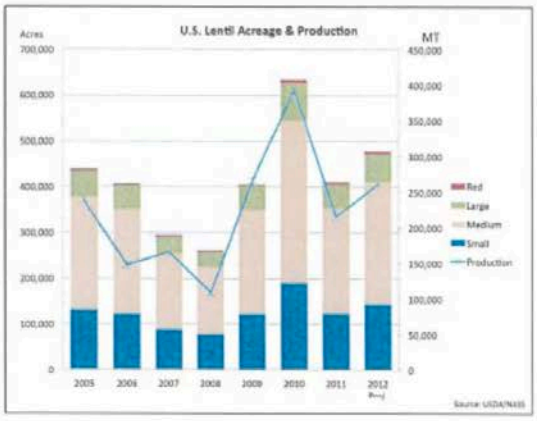
LENTIL VARIETIES

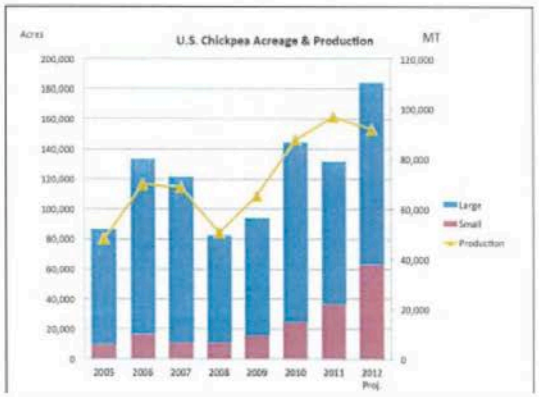
- Regular
- Eston
- Large Green
- Crimson
- Crimson decorticated
- Red Chief
- Pardina
- Richlea
- Morton

Where Are They Grown?






U.S. Lentil Acreage & Production
Acres
MT
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2005
2006
2007
2008
2009
2010
2011
2012 Proj
Red
Large
Medium
Small
Production
Source: USDA/NASS


U.S. Chickpea Acreage & Production
Acres
MT
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
120,000
100,000
80,000
60,000
40,000
20,000
0
2005
2006
2007
2008
2009
2010
2011
2012 Proj.
Large
Small
Production

What to Expect
Marketing and Consumer Trends
Technical Product Applications
Sustainability and Public Health
Culinary Inspiration and Product Innovation!

Pulses

SUPPLIERS OF LEGUME FLOURS
POWDERS, FLAKES, PROTEINS, FIBERS

ADM	Box 1470 Decatur, IL 62525 800-637-5843; 217-451-2849 www.adm.com/ediblebeans	Whole/Pieces/Grits/Powder chickpea (garbanzo)
DAKOTA DRY BEAN, INC.	2392 Star Avenue South Grand Forks, ND 58201 www.dakotadrybean.com 1-866-DRY-PEAS / 1-701-398-3112	Flours: pea Fiber: pea Starch pea Protein pea
GEORGE F. BROCKE & SONS	P.O. Box 159 Kendrick ID 83537-0159 Tel: (208) 289-4231	Flours: pea
HARVEST INNOVATIONS	1210 North 14th St. Indianola IA 50125 www.harvest-innovations.com 515-962-5063	Flours: pea lentil chickpea (garbanzo)
INLAND EMPIRE FOODS, INC.	5425 Wilson St. Riverside CA 92509-2434 www.inlandempirefoods.com 951-682-8222	Flours/Powders/Flakes/Grits: green pea yellow pea lentil
NORBEN COMPANY	P.O. Box 766 Willoughby, OH 44096 www.norbencompany.com 440-951-2715 / 888-4-NORBEN	Pea Protein Isolate Functional and Dietary Fiber Low Fat Shortening Replacement Native and Modified Pea Starch Pea Flours and Special Blends
SK FOOD INTERNATIONAL	4666 Amber Valley Parkway Fargo, ND 58104 skfood@skfood.com 701-356-4106	Flours/Powders/Flakes: green pea yellow pea lentil
UNITED PULSE TRADING	1611 E. Century Ave. Suite 102 Bismarck, ND 58503-0780 Phone: 701-751-1623 Fax: (701) 751-1626	Flours/Powders: yellow pea lentil fiber
WOODLAND FOODS, INC.	2011 Swanson Court Gurnee, IL 60031 www.woodlandfoods.com 847-625-8600	Flour: chickpea (garbanzo) Powders: green pea yellow pea

Tradeshow Exhibits	Dates
International Baking Industry Expo	September 26-29, 2010
Supply Side West Show	October 20-22, 2010
American Society of Baking	February 27-March 1, 2011
Research Chefs Association Conference	March 2-5, 2011
Natural Products Expo West /Healthy Baking Seminar	March 10-11, 2011
Food & Culinary Professionals/ADA	March 23-25, 2011
Healthy Flavors; Healthy Kids	May 11-13, 2011
International Association of Culinary Professionals	June 1-3, 2011
Institute of Food Technology	June 12-14, 2011
School Nutrition Association Annual National Convention	July 10-13, 2011
USADPLC Hosted Product/Menu Development Course	August 17-19, 2011
American Dietetic Association Conference	September 24-27, 2011
Minnesota IFT Section 36th Annual Suppliers' Expo	October 27, 2011
International Foodservice Editorial Council	November 7-10, 2011

Tradeshow Exhibits	Dates
Chicago Section IFT – Suppliers' Night	November 9, 2011
Healthy Baking Seminar + Southern California IFT Section Suppliers' Night + Natural Products Expo West	March 8-11,2012
Research Chefs Association Conference & CULINOLOGY Expo	March 21-24, 2012
International Association of Culinary Professionals	March 30 – April 2, 2012
Healthy Flavors; Healthy Kids	May 9-11, 2012
Institute of Food Technologists Annual Meeting & Food Expo	June 25-29, 2012
USADPLC Hosted Product/Menu Development Course	August 2012

PROJECT 4: Growing Knowledge and Farmers' Markets

Final Report

Project Summary

1) During the 2010 market season, the NDFMGA collected data from member markets and compiled it into a comprehensive report. Although this information provided the NDFMGA with valuable insight into the markets, information that had never before been collected, the information received varied widely from market to market and very few conclusions could be drawn from the information. Using the 2010 Specialty Crop Grant, a more cohesive effort was made to collect information from the markets. This provided valuable information to the Board of Directors of the NDFMGA so they can better serve the needs of their member markets through education and promotional efforts. This also helped fruit and vegetable growers increase their incomes.

2) The NDFMGA made available a mini-grant marketing program to promote local, organized farmers' markets solely for the purpose to increase awareness of the availability of local fruits and vegetables at those farmers' markets. Although the demand for local produce continues to rise, most North Dakota markets have unpaid managers and little funding and struggle to inform customers of their existence. This grant program ensured that marketing and promotional efforts were carried out.

3) In the past, the 'Green & Growing' school garden grant program has awarded 31 different schools with a $500 grant to start a school garden program. This program has enabled schools to overcome the initial hurdle of getting the garden started and they've continued to fund themselves and run their programs on their own after that first year. The goal for the 2010 Grant is to provide 7 – 10 new schools with a grant to being a school garden program of their own. The goal is to provide students with the opportunity to learn about the production and marketing of vegetables and fruits.

The purposes of the project, as stated above, include: being able to better serve the needs of member markets through education and promotional efforts, promoting local farmers' markets solely to increase awareness of the availability of fruits and vegetables, and to provide students with the opportunity to learn about specialty crops through marketing and production. All of these issues have been addressed by this project. This projects importance is enormous. North Dakota has a strong agricultural economy and by being able to make the younger generation, as well as those that stem straight from our economy, aware of specialty crops from all aspects-growing, marketing, and educating, we are able to push specialty crops ahead in a way that is needed greatly not only now, but in the years to come.

Project Approach

To approach the problem, the NDFMGA initiated the following:

1) Provided 'Market Exploration' grants to 25 farmers markets in North Dakota. In exchange for

the grant funds, the markets provided the NDFMGA with valuable information to better serve the needs of their member markets through education and promotional efforts thus helping the fruit and vegetable growers increase their incomes. All of the markets were required to provide us with pricing data, giving the NDFMGA valuable insight on this topic for markets all across the state.

2) Provided a mini-grant marketing program to 35 locally organized farmers markets solely for the purpose of increasing awareness of the availability of local fruits and vegetables at those farmers markets.

3) Provided 'Green and Growing' grants to 17 schools in North Dakota who had not been previously funded to begin a school garden or locally sourced produce program. This was 7 more than initially planned as there was such a great interest in this program. These grants created an opportunity for students in North Dakota schools to learn about the production and marketing of vegetables. The NDFMGA was very encouraged to see that each school took on a variety of community partners to accomplish their goals including local farmers markets, FFA Alumni, Extension Service personnel, local garden center and nursery retailers, local nursing home staff and residents, and local residents. These partners made significant investments in time, labor, and donations to make the 'Green and Growing' programs successful.

Goals and Outcomes Achieved

To achieve the goals for the project, the NDFMGA followed the procedures outlined below for each phase of the endeavor:

1) The 'Market Exploration' grant program was advertised to all North Dakota farmers markets via the newsletter, mass mailings and press releases. Funds were available to assist up to 25 markets with $500 grants. Grant applications also stated that any funds remaining in the event that there were not sufficient applications to spend the entire amount allocated for this program, would be pro-rated to the successful applicants over and above the $500 grant. Application deadline was April 15th, 2011 and ½ of the funds were dispersed in June with the remainder dispersed after the markets completed the terms of the grant agreement and finished providing the NDFMGA with the agreed upon information. Each applicant market entered into a customized contract with the NDFMGA based on their ability and market needs. These contracts outlined the type and amount of information the market would gather and report to the NDFMGA from the market season with all markets being required to provide at least pricing data. The NDFMGA administrative assistant was responsible for collecting information and guiding markets with data collection. All data was collected and combined into a single report and dispersed to the North Dakota Department of Agriculture, the NDFMGA, its Board and members. This report is posted online at the NDFMGA so the greater specialty crop community can benefit from the information collected.

2) The mini-grant program was advertised to all North Dakota farmers markets via the NDFMGA newsletter, mass mailings and press releases. This amount was enough to fund 35 markets at $500. Grant applications also stated that any funds remaining in the event that there were not sufficient applications to spend the entire amount allocated for this program would be

pro-rated to the successful applicants over and above the $500 grant. Applications were due April 15th, 2011 and funds were dispersed by the NDFMGA in June. Each market approved for the grant was required to submit receipts for marketing and promotional items purchased with grant funds as well as examples of marketing materials. All receipts and examples were gathered and compiled by the Executive Director and assistant of the NDFMGA.

3) Each school in North Dakota was contacted via e-mail in regards to the 'Green and Growing' grant program opportunity. The list of schools was obtained from the North Dakota Department of Instruction. Grant applicants were asked to identify: the project coordinator, the goals of the project, additional school resources that would be used to fulfill the project goals, teachers and faculty that would be involved in the program, school financial resources used for the project, support from school administration, community resources that would be used and a budget for the project. Grants were reviewed and approved on a first-come first-serve basis. Funds in this portion of the Specialty Crop grant were capable of serving 10 schools with $500 grants. Nineteen applications were received and additional funding from the North Dakota Department of Agriculture was obtained to approve 17 of those grant requests. Grantees were required to report by November 15th, 2011 on the results of their project. The reports were to include: learner environment and activities, learner outcomes, partners, resources used, funding sources, project evaluation and plan for sustaining the activities as a result of this program. All reports were gathered and compiled by the Executive Director and assistant of the NDFMGA.

Accomplishments

1) Market Exploration Grants – Twenty-five applications were received for the 'Market Exploration' grant and all twenty-five 'Market Exploration' grants received were awarded to farmers markets in North Dakota. All of the markets were required to submit price and product information. From these lists it is clear that pricing varies widely across the state and the method of 'what the market will bear' is a good pricing strategy for producers in North Dakota. Further information such as gross sales figures, vendor numbers, market reports, promotional activities, and other related information was also gathered and provides valuable insight on how to best help markets and specialty crop producers across the state. The information was collated and a report on key findings has been made available to the North Dakota Department of Agriculture, the NDFMGA board members, and online for all audiences.

The full report for the Market Exploration Grant is included at the end of this project report and can also be found online at: http://www.ndfarmersmarkets.com/2011_report_39.html. Some of the data in this report includes the availability of specialty crops, price comparison, and the top selling specialty crops at each market. Most of the markets also found that tomatoes, onions, and peppers are the highest available and the highest selling specialty crops and the prices for each product have a different range at each market. This information has been used to educate and inform other new markets, consumers and specialty crop producers on pricing, seasonality of products, availability of products, customer base and top selling produce.

2) Mini Grant Program – Thirty-five mini-grant applications were received for the Mini Grant Program. All thirty-five mini-grants were awarded to locally organized farmers markets for the purpose of increasing awareness and availability of local fruits and vegetables at those farmers markets. The markets used a variety of methods for marketing, including newspaper

advertisements, bags with the market logo, banners, signs, fliers, and much more. Markets submitted receipts and examples of marketing and promotional materials as validation the funds were spent in a manner compliant with the grant. Markets who had not previously received funds or were new markets utilized the funds to increase the awareness of local fruit and vegetable availability in their communities. The increase in markets and production/availability of local fruits and vegetables is an indicator of the success of this program.

3) Green and Growing grants – Seventeen applications were received for the "Green and Growing" grants. All seventeen 'Green and Growing' grants were awarded to schools in North Dakota who had not been previously funded to begin a school garden or locally sourced produce program. Ten were originally funded through the Specialty Crops program and through the generosity of the North Dakota Department of Agriculture, the NDFMGA was able to fund an additional seven schools. Although approached differently, each school created a garden or production area that will incorporate fruits and vegetables into the activities of the students. Several schools chose to plant fruit trees with their grant funds. This method of introducing children to gardens and edible products works well for the schools in North Dakota as the blooming time and harvest time better correspond to the school year. Almost all school incorporated the products from the gardens either into their lunch or snack programs for the students. Some schools sold extra product at local farmers markets, thereby giving students a chance to learn about marketing and sales while some donated extra produce to local food banks incorporating a service learning theme to their gardens. All schools identified and implemented curriculum into classrooms to broaden the experience for students. Each school identified ways in which they will keep the gardens going in future years. These plans included using revenue from farmers' market sales to fund future seed and maintenance needs, incorporating the school garden with local community garden plots funded through the city, use of parent fees for sustainment, and incorporation of the school garden into FFA and other school organization activities. Learner outcomes are too numerous to mention although a few of the most important were the students opportunity to be part of their schools and communities through farmers markets, food bank donations, relationships built with the elderly through cooperative work in the gardens and the pride students took in using what they had grown in their school garden in school lunch and snack programs.

Beneficiaries

This project's accomplishments and beneficiaries are many. Each of the 25 Exploration Grant markets, 35 Mini Grant markets and 17 schools receiving Green and Growing grants benefitted from this project. Through trickle down, each of the over 250 vendors at the participating markets and children in all of the schools also benefit from the project. Schools worked with local retail businesses, nursing homes, local organizations, local food bank personnel and others within their communities to continue the trickledown effect of this grant.

Additionally, the NDFMGA benefitted from the project by gaining valuable information regarding market economics in North Dakota. This information will be used to apply for additional grants and funding that will be used in 2012 to promote the consumption and sale of locally grown produce.

Quantitatively, information gained regarding product pricing, gross sales by market vendors, and market total gross sales will form the base for economic modeling of the impact of farmers markets on their communities. This information will be used to validate the importance of a farmers market in communities, garner community and private sector support for markets and integrate markets as institutions within communities.

Schools were not required to report the number of students involved in their school garden program, however extrapolating from other information gathered, there were approximately 68 students per school times the ten schools funded with SCBG funds, so approximately 680 students participated in this project.

Lessons Learned

The Specialty Crop grant program was a very successful one for the NDFMGA. Using the funds to grant markets and schools money for the production and sale of locally produced fruits and vegetables has helped establish a future market for producers across the state. Especially helpful was the 'Market Exploration' grants program which has provided the NDFMGA, state and local economic development entities, and communities with economic impact data and producer networks on which to base future programs. This information will be invaluable as the local foods movements work toward a sustainable future in the North Dakota. Lessons learned from each of the three granting programs carried out by the NDFMGA through the Specialty Crops grant are outlined below.

1) Market Exploration Grants - The information gathered from the markets was not only extremely valuable; it was very eye opening as well. By having all of the markets provide pricing data, a more in-depth look at pricing statewide was gathered. Markets also submitted contact information for producers. This will allow the Association better access to producers to offer educational and networking opportunities and build a coordinated system of delivery for information regarding workshops, conferences, and the exchange of ideas. Overall, the Market Exploration grant program will be the most valuable to the producers and communities within North Dakota and the NDFMGA.

2) Mini Grant Program – Besides the anticipated newspaper advertisements and signs indicating the location of the market, several markets were very creative in getting their name out there and attracting new customers. This included promotional events like live music or dinners, coupon programs for food shelf and pantries to serve the low income sector, reusable tote bags with the market logo, and drawings and prizes for market attendees.

Informal survey of market managers indicates the mini-grant program is an integral part of the marketing funds for these farmers markets. Many North Dakota markets, while organized with boards and by-laws, are managed by volunteer staff with little or no experience. Many of the volunteer managers are also vendors at the market. By nature then, all marketing, promotion and event planning is completed by a person who is not paid but willingly gives any extra moment to these duties; but time is always in short supply. Market managers in North Dakota struggle to spend time on appropriate marketing and the necessary fund raising to keep a market financially

viable. Some markets operate with fewer than six vendors. With small vendor numbers, stall fees – unless unreasonably high – will never cover the marketing it takes to inform the geographically widespread consumers in rural areas of the availability of produce, market days, times and events. The lesson learned with this portion of the project is that the North Dakota Farmers Market and Growers Association should pursue a way to continue the mini-grant program until the markets have enough vendors and supporters to be self-sustaining or risk a decline in the number of markets. It has also become apparent that training program for market managers would be greatly beneficial and one will be pursued in the 2012 year.
3) Green and Growing grants – This program continues to be extremely popular and it is clear that it has many benefits for the schools. The NDFMGA would like to continue to offer this program to new schools and provide information on other funding options for past recipients. It has become clear that connecting the schools with each other and maintaining the educational outreach between the NDFMGA and the schools will be beneficial for all involved.

Contact

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Additional information available (e.g. publications, web sites)

- The North Dakota Farmers Market and Growers Association website: www.ndfarmersmarkets.com
- Past quarterly NDFMGA newsletters available upon request.
- Copies of the final 'Market Exploration Grant' report are available upon request with a small mailing and copying charge.
- Copies of 'Green and Growing Grant' final reports from schools available upon request for a small mailing and copying charge.
- Copies of the 'Market Mini-grant' program market receipts available to the North Dakota Department of Agriculture and the USDA upon request.

2011 Market Exploration Grant Report

A summary of information collected during the 2011 market season from grant recipients.

Compiled and Reported by:
Stacy Baldus

Abstract:

In the spring of 2011, the North Dakota Farmers Market and Growers Association (NDFMGA) offered its member markets a $500 grant in exchange for collecting information to aid the Association and its members. The information collected as a result of this grant varied from customer counts and produce prices to reports on promotional events.

The following report is a brief compilation of some of the relevant information collected through this grant.

Keep in mind that 2011 was a particularly difficult year for the markets. Much of the state saw extensive flooding in the spring and early summer. This affected the availability of produce, market start dates, and even how many vendors had produce to sell during the summer of 2011.

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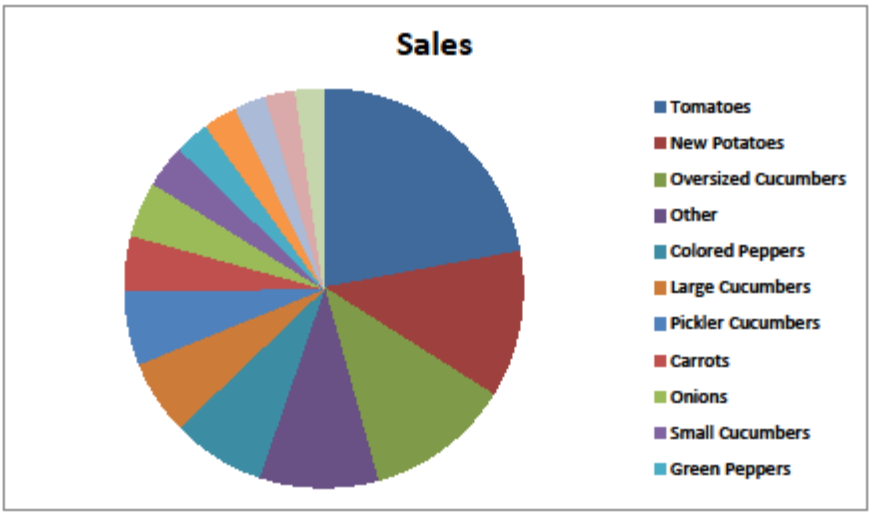
Lewis & Clark Farmers Market Top Sellers*



Tomatoes:	$3,640.00	or	22.08% of Sales
New Potatoes:	$1,959.00	or	11.88% of Sales
Oversized Cucumbers:	$1,931.00	or	11.72% of Sales
Colored Peppers:	$1,244.00	or	7.55% of Sales
Large Cucumbers:	$990.00	or	6.01% of Sales
Pickle Cucumbers:	$980.00	or	5.95% of Sales
Onions:	$741.00	or	4.49% of Sales
Carrots:	$740.00	or	4.49% of Sales
Small Cucumbers:	$570.00	or	3.46% of Sales
Green Peppers:	$450.00	or	2.78% of Sales
Zucchini:	$453.00	or	2.75% of Sales
Beets:	$420.00	or	2.55% of Sales
Kohlrabi:	$401.00	or	2.43% of Sales
Pumpkins:	$370.00	or	2.24% of Sales

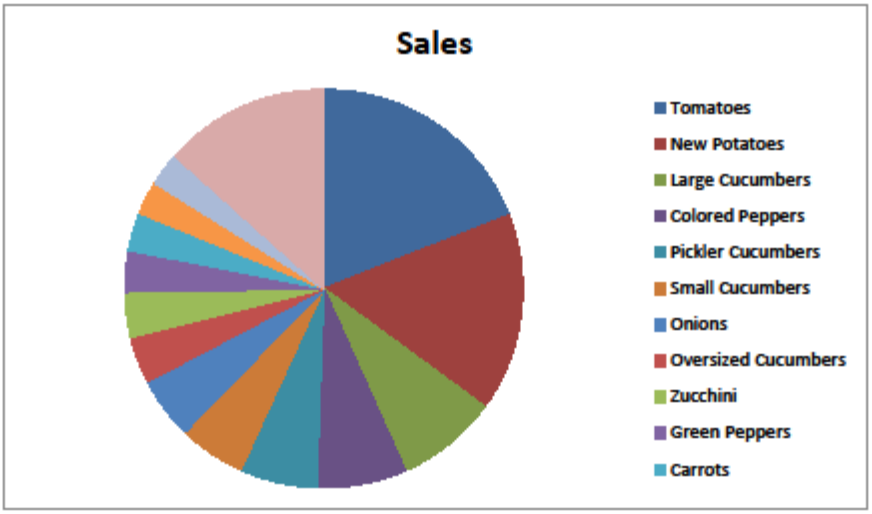
These fourteen items accounted for 90.38% of all sales.

All other goods sold accounted for 9.62% of total sales. This includes kale, lettuce, eggplant, fennel, cabbage, spinach, other potatoes, summer squash, winter squash, hot peppers, scallions, sweet peppers, Swiss chard, strawberries, rhubarb, and radishes.

Sales Total: $16,483.00

* Top Sellers in this instance means any 1 item that brought in over $300 in total sales.

Sakakawea Farmers Market Top Sellers*



Tomatoes:	$5,350.00	or	19.00% of Sales
New Potatoes:	$4,524.00	or	16.07% of Sales
Large Cucumbers:	$2,316.00	or	8.23% of Sales
Colored Peppers:	$2,048.00	or	7.27% of Sales
Pickle Cucumbers:	$1,770.00	or	6.29% of Sales
Small Cucumbers:	$1,524.00	or	5.41% of Sales
Onions:	$1,415.00	or	5.03% of Sales
Oversized Cucumbers:	$1,061.00	or	3.77% of Sales
Zucchini:	$1,028.00	or	3.65% of Sales
Green Peppers:	$952.00	or	3.38% of Sales
Carrots:	$870.00	or	3.09% of Sales
Kohlrabi:	$760.00	or	2.70% of Sales
Strawberries:	$755.00	or	2.68% of Sales

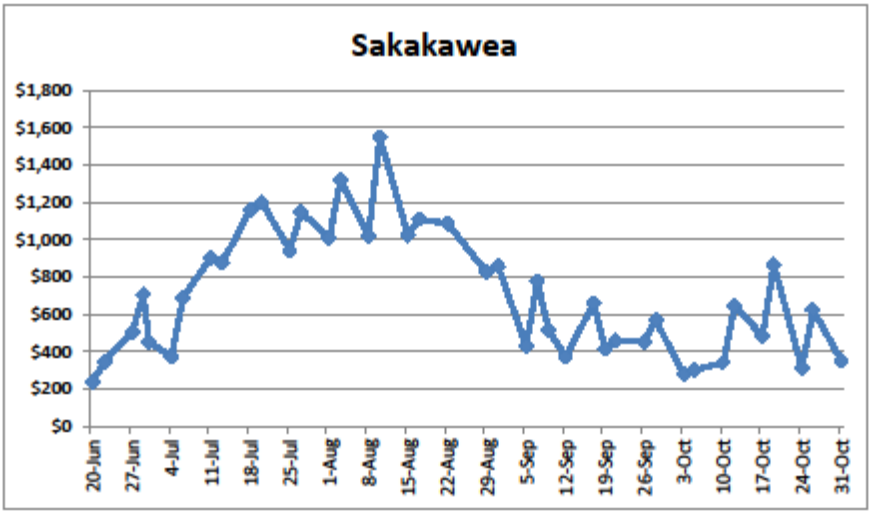
These thirteen items accounted for 86.57% of all sales.

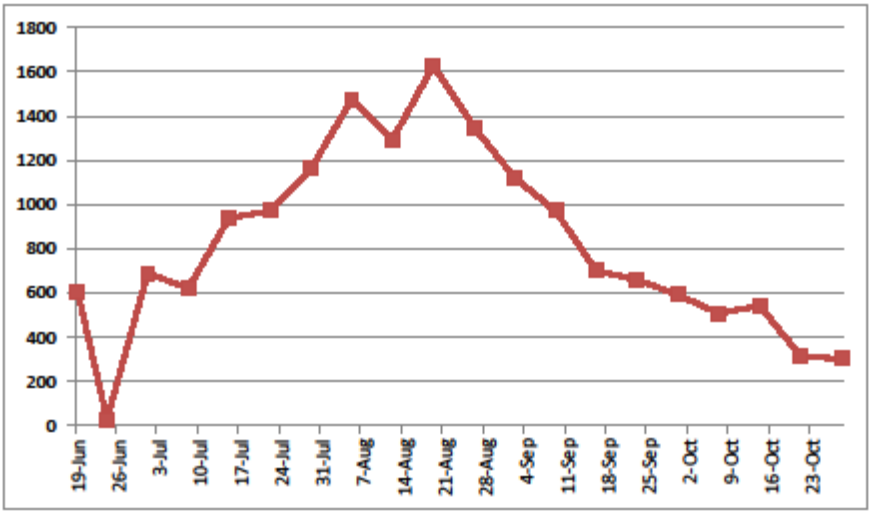
All other goods sold accounted for 13.43% of total sales. This includes pumpkins, kale, lettuce, eggplant, fennel, cabbage, spinach, other potatoes, summer squash, winter squash, hot peppers, scallions, sweet peppers, Swiss chard, rhubarb, radishes, and beets.

Sales Total: $28,155.00

* Top Sellers in this instance means any 1 item that brought in over $600 in total sales.

Total Sales Graphed By Week

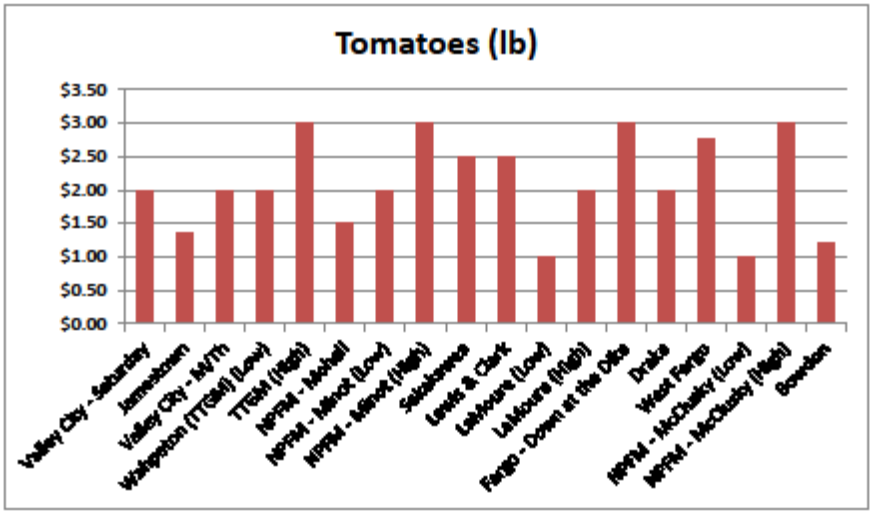




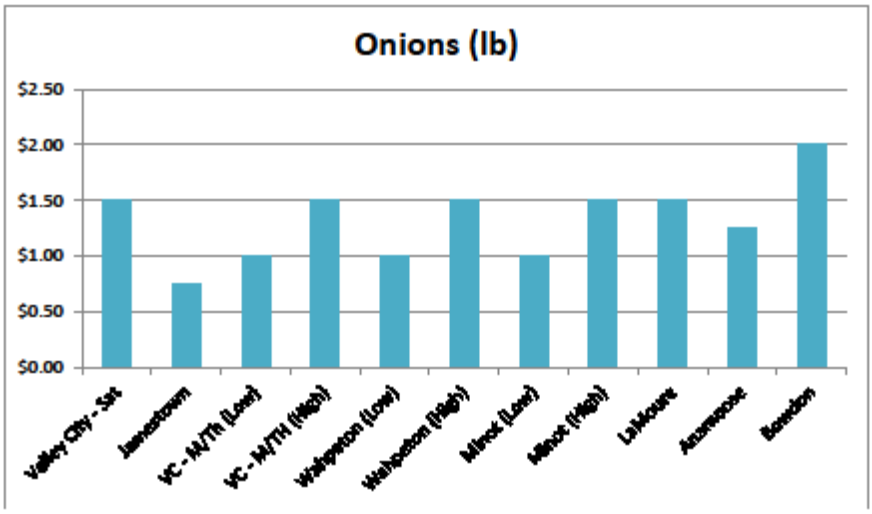
Product Price Comparison

The 2011 Market Exploration Grant provided a lot of data on the price for produce at various farmers' markets. The information below is a selection of this information to show how the price of some popular items compared between markets. Remember, prices are a reflection of a number of variables, from local demand, product quality, and production cost as well as a reflection of the local market prices. This comparison is simply to give you an idea of what local markets across the state are doing.

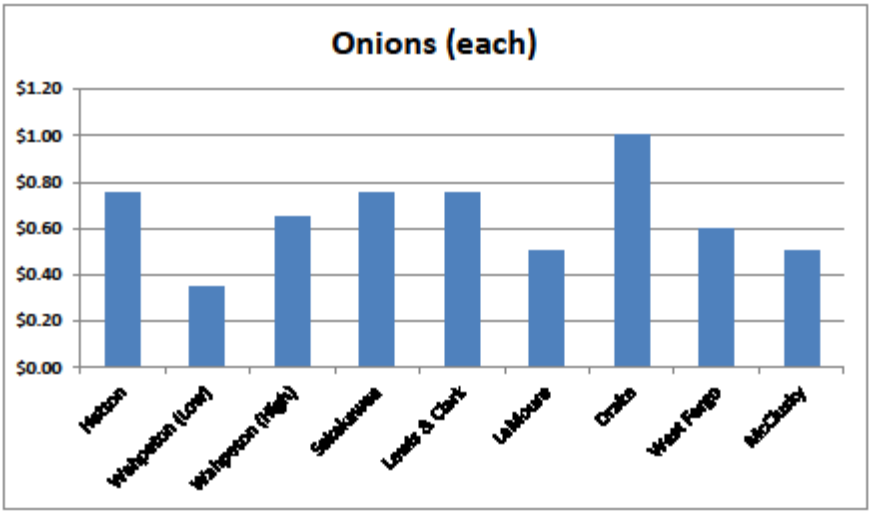
Please note some markets have two values listed, reporting a low and a high price for the product.



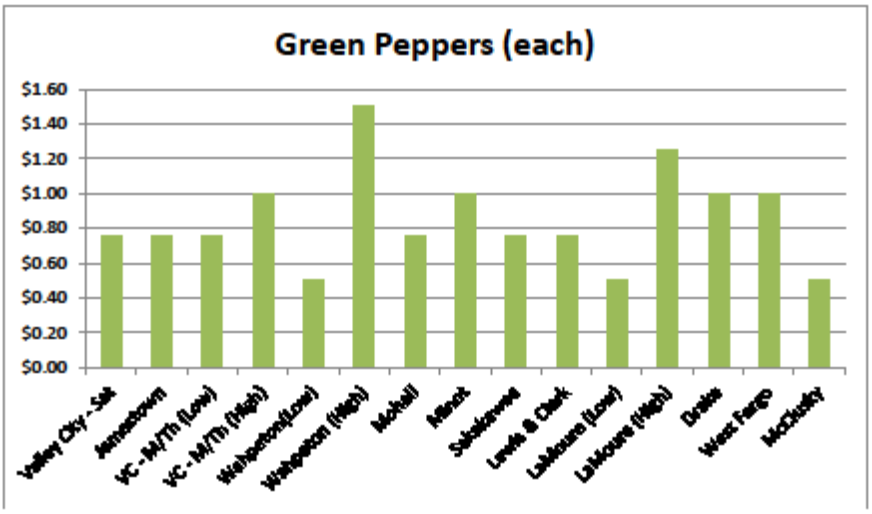
Lowest Price: $1.00 per pound
Highest Price: $3.00 per pound



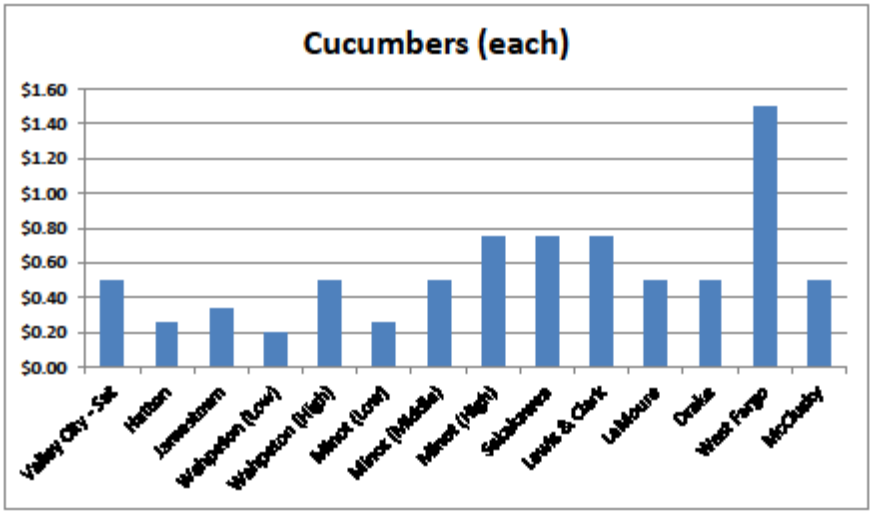
Lowest Price: $0.75 per pound
Highest Price: $2.00 per pound



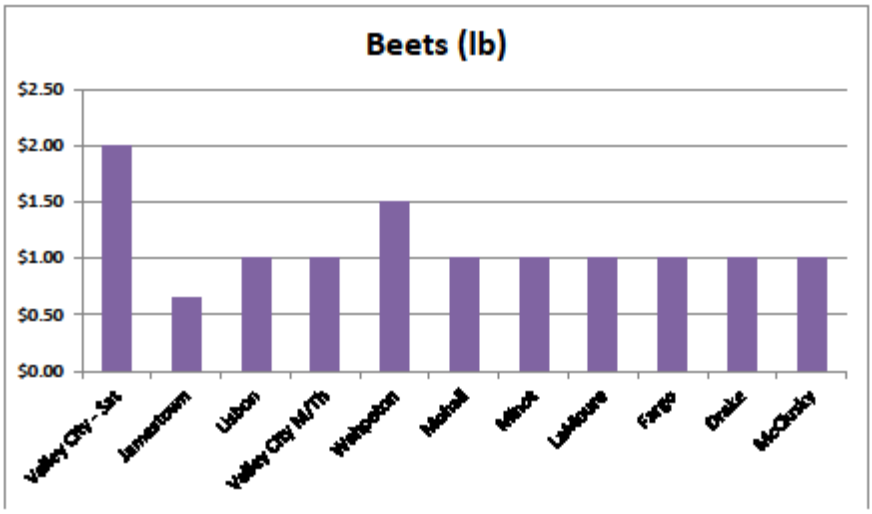
Lowest Price: $0.35 each
Highest Price: $1.00 each



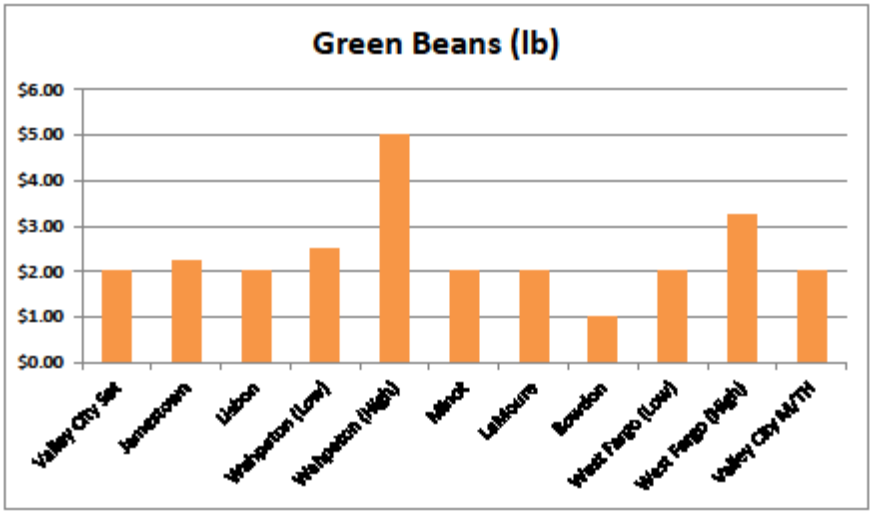
Lowest Price: $0.50 each
Highest Price: $1.25 each



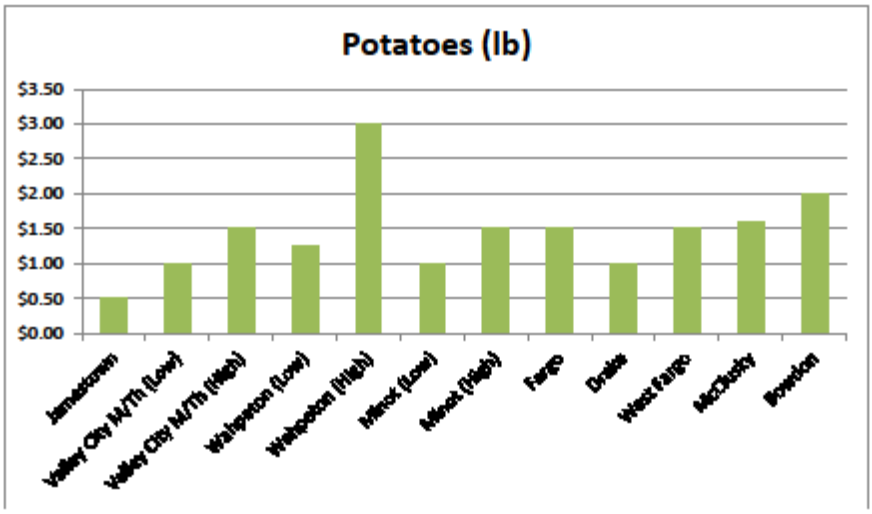
Lowest Price: $0.20 each
Highest Price: $1.50 each



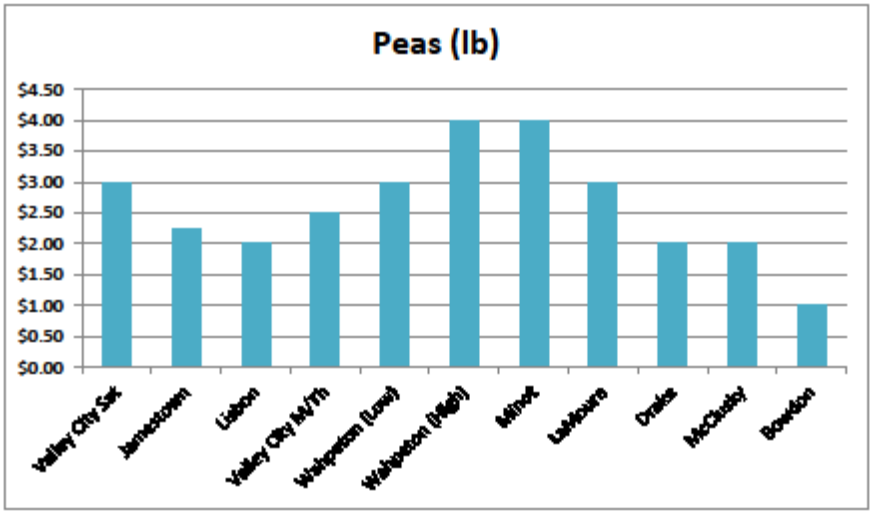
Lowest Price: $0.65 per pound
Highest Price: $2.00 per pound



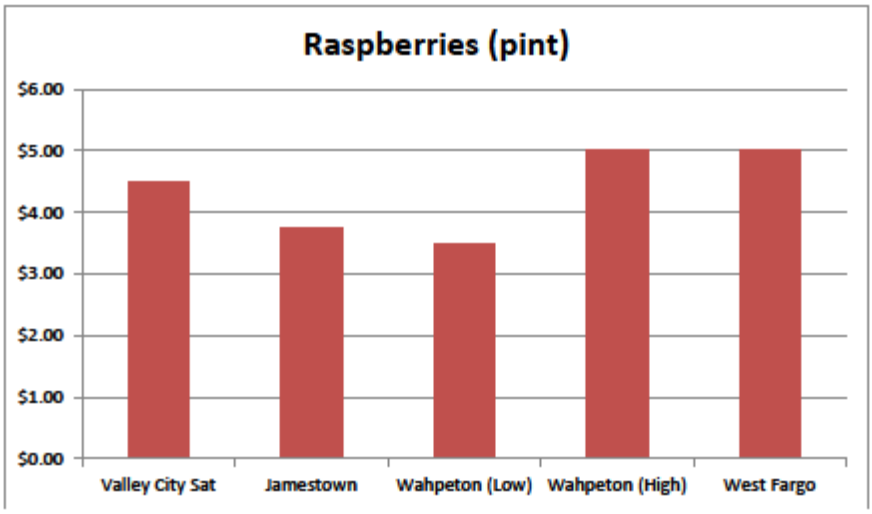
Lowest Price: $1.00 per pound
Highest Price: $5.00 per pound



Lowest Price: $0.50 per pound
Highest Price: $3.00 per pound

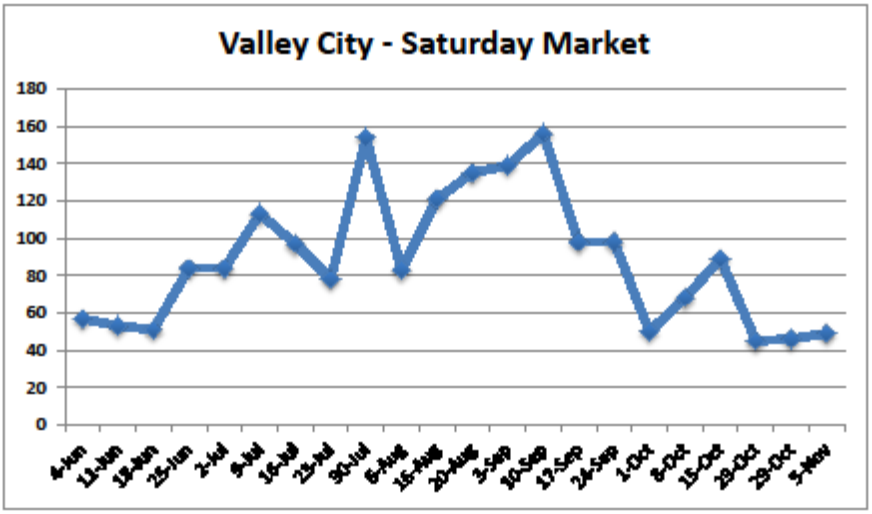


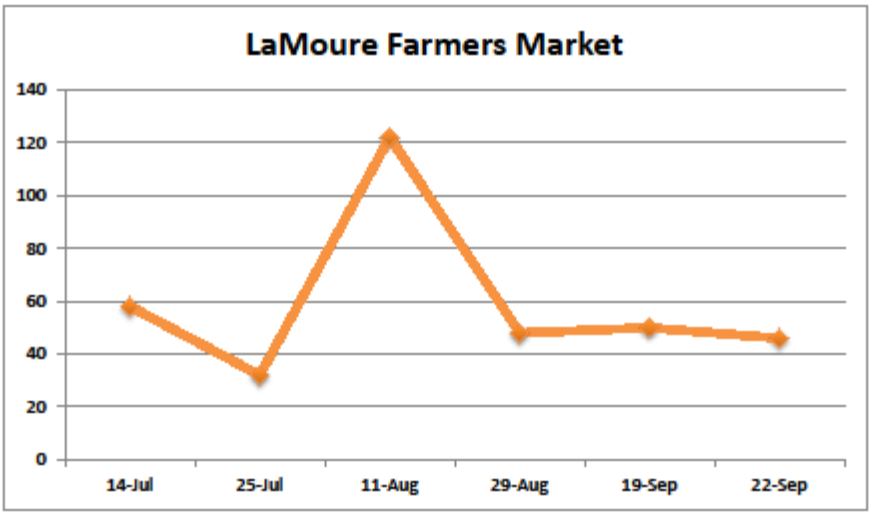
Lowest Price: $1.00 per pound
Highest Price: $4.00 per pound

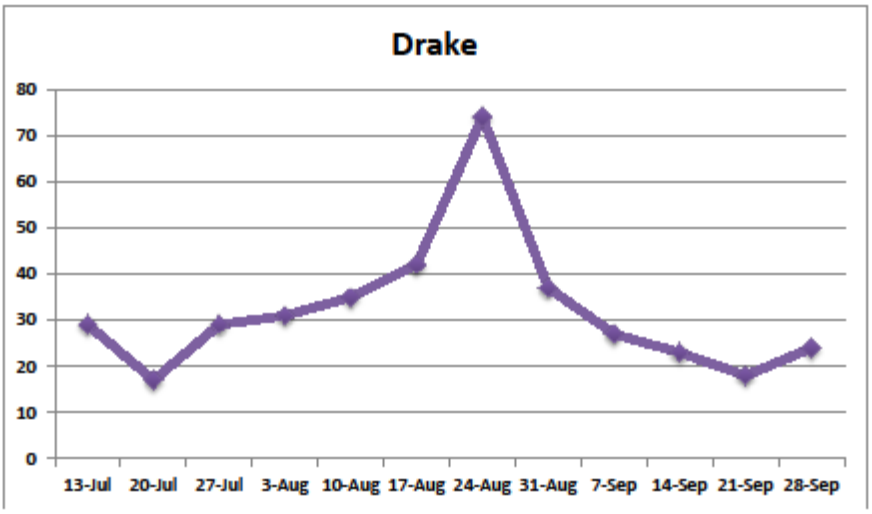


Lowest Price: $3.50 per pint
Highest Price: $5.00 per pint

Customer Counts






Drake
80
70
60
50
40
30
20
10
0
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
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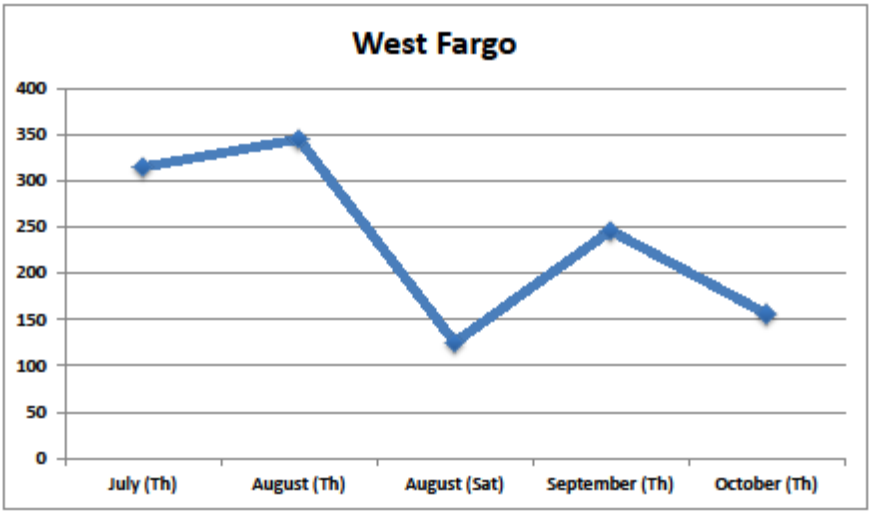
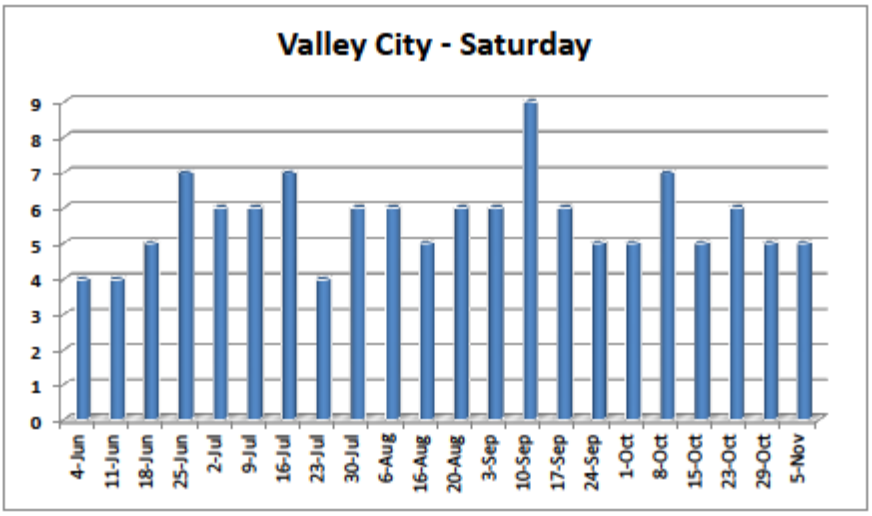
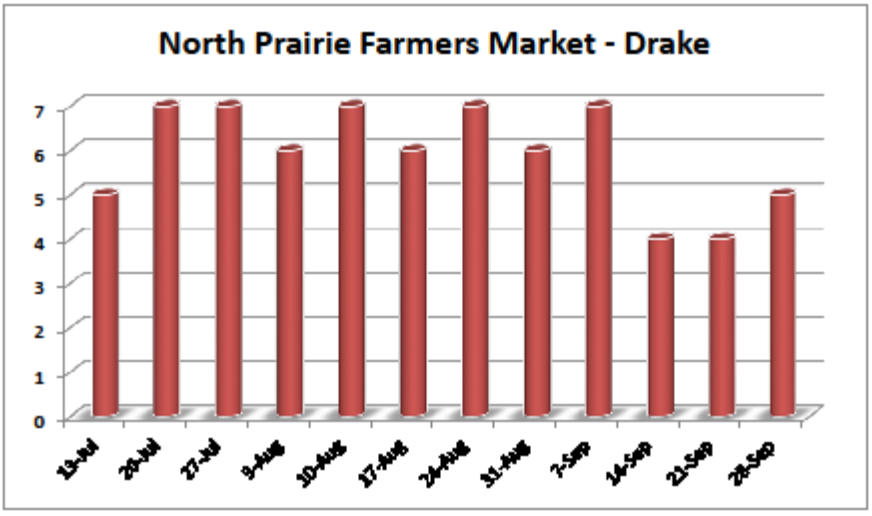
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep


West Fargo
400
350
300
250
200
150
100
50
0
July (Th)
August (Th)
August (Sat)
September (Th)
October (Th)

Vendor Numbers



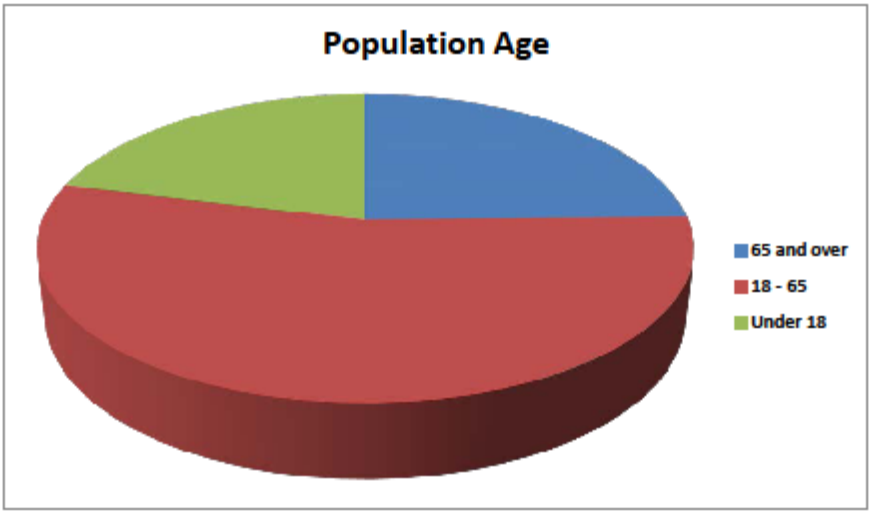


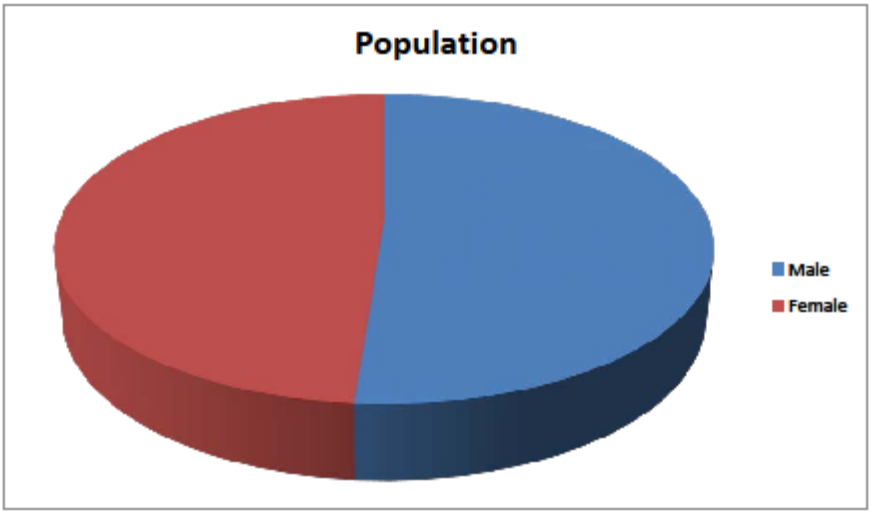
Fruit and Vegetable Availability

	Valley City - Sat		Wahpeton		LaMoure		West Fargo	
	Start Date	End Date	Start Date	End Date	Start Date	End Date	Start Date	End Date
Apples	28-Oct	4-Nov	1-Sep	29-Sep	No Data	No Data	14-Jul	8-Oct
Beans, Green	29-Jul	9-Sep	21-Jul	15-Sep	25-Jul	No Data	14-Jul	15-Sep
Broccoli	17-Jun	22-Oct	28-Jul	8-Sep	7-Jul	No Data	No Data	No Data
Cabbage	15-Jul	4-Nov	14-Jul	15-Sep	7-Jul	No Data	30-Jul	8-Oct
Carrots	22-Jul	22-Oct	21-Jul	29-Sep	25-Jul	No Data	7-Jul	8-Oct
Corn, Sweet	12-Aug	23-Sep	28-Jul	8-Sep	28-Jul	No Data	11-Jul	8-Oct
Cucumbers	15-Jul	23-Sep	21-Jul	22-Sep	8-Aug	No Data	7-Jul	8-Oct
Kohlrabi	8-Jul	5-Aug	14-Jul	25-Aug	No Data	No Data	28-Jul	8-Oct
Leeks	No Data	No Data	29-Sep	29-Sep	8-Aug	No Data	No Data	No Data
Lettuce	8-Jul	15-Jul	14-Jul	21-Jul	No Data	No Data	7-Jul	11-Aug
Muskmelon	No Data	No Data	1-Sep	22-Sep	No Data	No Data	15-Sep	8-Oct
Onions	17-Jun	28-Oct	14-Jul	29-Sep	7-Jul	No Data	11-Jul	8-Oct
Peas	1-Jul	22-Jul	14-Jul	21-Jul	25-Jul	No Data	7-Jul	8-Oct
Peppers, Green	12-Aug	4-Nov	21-Jul	29-Sep	11-Jul	No Data	7-Jul	8-Oct
Peppers, Hot	19-Aug	4-Nov	4-Aug	15-Sep	11-Jul	No Data	No Data	No Data
Potatoes	15-Jul	4-Nov	14-Jul	29-Sep	11-Jul	No Data	7-Jul	8-Oct
Pumpkins	30-Sep	4-Nov	15-Sep	29-Sep	12-Sep	No Data	8-Sep	8-Oct
Radish	17-Jun	15-Jul	No Data	No Data	7-Jul	No Data	7-Jul	8-Oct
Raspberries	22-Jul	9-Sep	21-Jul	29-Sep	No Data	No Data	21-Jul	8-Oct
Squash	16-Sep	4-Nov	21-Jul	29-Sep	1-Sep	No Data	15-Sep	8-Oct
Strawberries	24-Jun	8-Jul	14-Jul	22-Sep	No Data	No Data	No Data	No Data
Tomatoes	12-Aug	4-Nov	21-Jul	29-Sep	8-Aug	No Data	28-Jul	8-Oct
Watermelon	26-Aug	4-Nov	22-Sep	22-Sep	25-Aug	No Data	20-Aug	8-Oct
Zucchini	29-Jul	22-Oct	14-Jul	29-Sep	11-Jul	No Data	28-Jul	8-Oct

Community Demographics

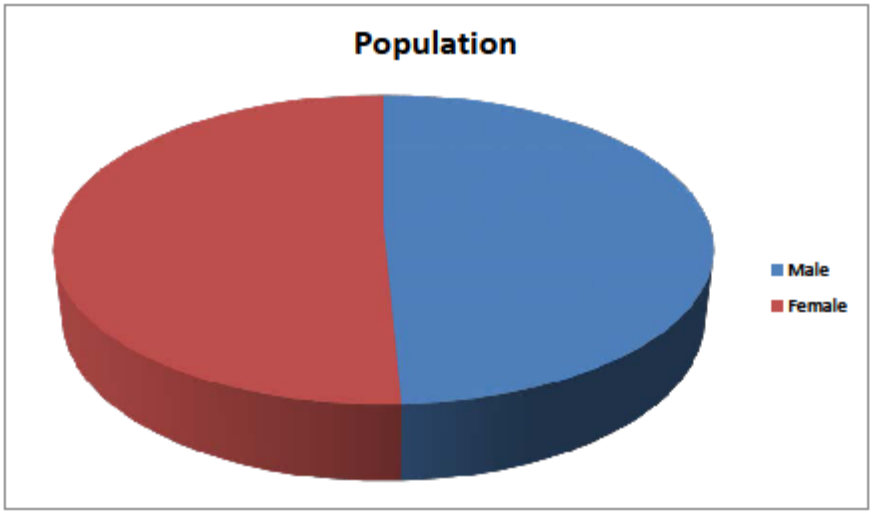
LaMoure County





% High School Graduates, (25+)	84.60%
% BA or higher (25+)	18.10%
Households	1895
Persons per Household	2.15
Per capita income in past 12 months	$25,696
Median household income, 2009	$45,767
Person below poverty level, 2009	10.90%
Land Area	1,146 sq. miles
Person per square mile	3.6
Local Grocery	4 within 40 miles
Total Population:	4,139

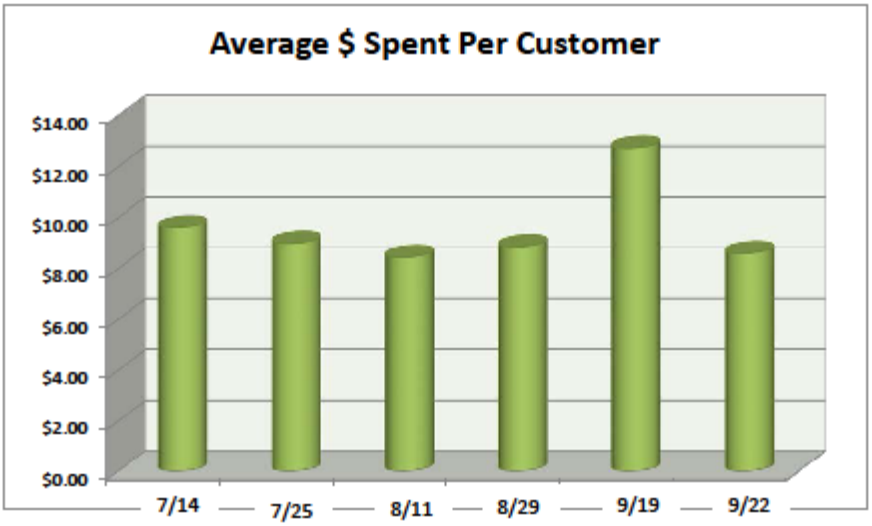
LaMoure City



Population	889
Median Age	46.7
Median age of female population	50.1
Median age of male population	44
Households	394
Local Grocery	1 (SuperValu) 4 others within 40 miles

Average Amount Spent Per Customer

LaMoure



PROJECT 5: Development of Nitrogen Management Practices in Minnesota and North Dakota to Reduce Acrylamide Levels in Processed Potato Products

Final Report

Project Summary

The most important vegetable and horticultural crop in the Northern Plains continues to be potato. Potatoes were planted on about 84,000 ac in North Dakota and 49,000 ac in Minnesota in 2011; the total area harvested was approximately 77,000 ac in North Dakota and 47,000 ac in Minnesota. The average yield was 245 cwt./ac in North Dakota and 355 cwt./ac in Minnesota. Total production for 2012, despite drought conditions across the region, is estimated at 25 million cwt. in North Dakota, an increase of about 32% over 2011 production. Production in Minnesota in 2012 was up 13%, to 18.8 million cwt. About 60% of potato production in North Dakota and Minnesota goes for processing into frozen products such as French fries (and others) and chip production.

Health concerns have become a topic of interest to potato processors, producers and consumers, following the discovery of the neurotoxin, acrylamide, in processed potato products (Tareke et al, 2002). The US Food and Drug Agency is currently developing mitigation plans to reduce risk from consuming processed foods containing this byproduct. This research is particularly important and timely, because French fries from North Dakota and Minnesota appear to have higher acrylamide levels than those from other regions (Collindge, 2010); thus, the issue becomes a threat to our local potato industry.

Acrylamide levels in potato are affected by cultivar, processing method, and gene expression for sugar accumulation and amino acids. Altering cultural management practices, such as nitrogen fertilization rates, influences the levels of reducing sugars and asparagine, precursors to acrylamide (Mottram et al, 2002; Stadler et al, 2002 and Becalski et al, 2004), and may reduce acrylamide levels immediately. Our research efforts reported here will aid in establishing baseline acrylamide levels in French fries and potato chips made from Russet Burbank and Snowden, compared to newer processing cultivar releases, including Alpine Russet, Dakota Trailblazer, and Ivory Crisp, which initial research indicates have lower reducing sugar levels, and in some cases lower asparagine levels, as well. Secondly, the effect of nitrogen rate on processing quality attributes, including acrylamide, for these cultivars was also evaluated.

Project Approach

In 2011, five genotypes (Alpine Russet, Dakota Trailblazer, Russet Burbank, Ivory Crisp, and Snowden) were grown at varying rates of nitrogen (30, 120, 180, 2400, and 300 lbs/ac) in order to determine nitrogen management effect on acrylamide levels and processing quality. A randomized complete block design was used with four replicates and cultivar and amount of nitrogen fertilizer applied as main effects.

The trials were planted at the Northern Plains Potato Growers Association (NPPGA) research site at the Forest River Colony, Inkster, ND, on June 2, and at the Sand Plain Research Farm in Becker, MN, on May 3. Four, 20-ft rows were planted for each plot, with the middle 18 feet of

the middle two rows used for sampling and harvest. Row spacing was 12 inches within each row and 36 inches between rows.

Different methods of nitrogen fertilization were used at the two sites. In ND, 23 lbs/ac N was broadcast over the trial area prior to planting; 26 lbs/ac was banded at planting to all plots. Split, in-season fertilizer applications were broadcast per treatment on June 29 and July 19, and 27 lbs/ac and 18 lbs/ac were fertigated across all treatments on August 9 and 19.

In MN, potassium was added before planting, and multiple nutrients were applied at planting, on May 3. These included 30 lbs N/ac as monoammonium phosphate and ammonium sulfate. Environmentally Smart Nitrogen (Agrium, Inc.; referred to hereafter as ESN) was banded per treatment at emergence, on May 25, and mechanically incorporated during hilling. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

In ND, petioles were sampled on August 3, August 17 and September 26 (prior to vine flailing on Oct. 4), dried, and will be analyzed to determine nitrogen status. Plots were harvested on October 6 and samples stored at about 55 ˚F to suberize until grading.

In MN, plant stand was measured on June 6 and stem number per plant on June 14. Petiole samples were collected from the fourth leaf from the terminal on four dates: June 20, June 28, July 11, and July 26. Petioles were analyzed for nitrate-N on a dry weight basis. The vines of the chipping cultivars were mechanically beaten on September 15 and those of the frying cultivars on September 23. The plots were machine harvested on September 29, and total tuber yield and graded yield were measured. Tuber sub-samples were also collected and used to determine the incidence of hollow heart, brown center, and scab, and tuber dry matter and specific gravity. Additional sub-samples were collected for whole-tuber analyses and frying tests. Whole-tuber nitrogen concentration was measured on tubers collected at harvest and assumed not to change substantially throughout subsequent storage.

From both sites, approximately 50 lbs of tubers in the 6- to 10-ounce size category from each plot were shipped to the USDA-ARS Potato Research Worksite in East Grand Forks for sugar analysis and frying. Whole-tuber sucrose and glucose concentrations were determined at harvest and after three, six, and nine months of storage at 45˚F. At the same times, a subset of the tubers was processed into fries (Alpine Russet, Dakota Trailblazer, and Russet Burbank) or chips (Ivory Crisp and Snowden), and the fresh-weight acrylamide concentrations of the fried products were determined.

In addition to tubers from the two study sites, tubers were also collected from growers' fields in MN to determine if acrylamide levels in fried potatoes from the commercial fields were similar to those in the study. Three, 50 pound bags of tubers were collected from each field and shipped along with tubers from the Becker study samples to East Grand Forks.

Fried samples were shipped frozen to the University of Minnesota's St. Paul Campus for acrylamide analysis. The amount of acrylamide was determined and expressed as ng

acryamide/g solid material (ppm fresh weight). All analyses were conducted at the University of Minnesota Center for Mass Spectrometry and Proteomics.

For the North Dakota site, ANOVAs of chip color, Agtron score, whole-tuber sugar concentrations, and fried-potato acrylamide concentrations as functions of treatment, cultivar, and replicate were conducted.

For the Minnesota site, ANOVAs of above-ground plant traits, petiole nitrate, tuber yield, tuber characteristics, chip color, Agtron (AGT) score, whole-tuber nitrogen and sugar concentrations, and fried-potato acrylamide concentration as functions of treatment, cultivar, their interaction, and replicate, were conducted. Because fresh-weight acrylamide concentration differed greatly between the two preparation methods (French fries are moister than potato chips), ANOVAs were also performed for chipping and frying cultivars separately for these variables (Table 4). Because of grower interest in varietal performance, results for each cultivar were also analyzed separately. Regressions of fried-potato acrylamide concentration against whole-tuber nitrogen and sugar concentrations were performed for each cultivar at each sampling time.

Outreach activities performed

North Dakota

We presented updates and status of the project at the Northern Plains Potato Growers Association (NPPGA) Research Reporting Conferences in February 2011 and 2012 and the Minnesota Area II Potato Promotion Council Educational Conference in March of both years, at the NPPGA Field Days in late August of 2011 and 2012 and the Sand Plains Research Center Field Day in both years. Additionally, the work was mentioned at the RDO/Lamb Weston field day (late August both years), regional research meetings, and meetings of the US Potato Board Processing Consortium.

Minnesota

A field day was held for growers at the study site in Becker, MN, in the summer of 2012. Twenty-five growers attended. Only yield and quality data were discussed, as the data on whole-tuber sugar concentrations and acrylamide concentrations in French fries and potato chips had not yet been fully collected and analyzed. Some of the research was discussed at an RDO/Lamb Weston think-tank session to about 10 people in November 2012.

Preliminary results for 2011, excluding acrylamide concentrations all data for tubers after 3, 6, and 9 months of storage, were published in the Minnesota Area II Potato Research and Promotional Council and Northern Plains Potato Growers Association (NPPGA) 2012 Research Reports. All results for 2011, as well as growing-season results for 2012, have been submitted for publication in the 2013 Research Reports. An update will be provided at the 2013 NPPGA in growers meeting in February with about 100 growers and industry personnel attending.

This research was discussed at the NPPGA Field Day event (attended by producers, seeds men, processors, and other research and industry personnel) on August 23, and results to date were

shared with producers at the NPPGA Research Reporting Conference (Grand Forks, ND) in February 2013.

Field day events were held in Inkster and Becker in 2012. Approximately 25 growers attended the field day in Becker. Acrylamide analyses were not complete; only yield and quality results were discussed. Approximately 200 people attended the Inkster field day, primarily producers and those in the industry. The trial was briefly described in a field day handout, and a brief verbal update was given as to status of the FY11 trials. No formal feedback was received from the attendees at either event, but the potato processors (chips and frozen) and their producers (both non-irrigated and irrigated) are very interested in the project and the results. They are progressive and want to be proactive before regulation may occur, and they want good reasons to persuade quick-serve restaurants to adopt more sustainable and better quality potato cultivars. Approximately 210 growers/consultants/industry personnel attended the NPPGA conference.

Goals and Outcomes Achieved

Clone (cultivar) means for sucrose, glucose and acrylamide content across nitrogen rates in the North Dakota site are presented in Table 1 for each storage period. Sucrose is broken into the reducing sugars, fructose and glucose, in storage. Sucrose levels were highest at harvest (0 time). Across clones, sucrose levels were lowest following the six month storage period. Glucose levels trended toward an increase with time, with the exception of the six month storage period when levels were the lowest. Acrylamide levels for the improved and more recent cultivar releases (Alpine Russet, Dakota Trailblazer, and Ivory Crisp) were significantly lower compared to industry standards Russet Burbank and Snowden, across nitrogen rate. Acrylamide levels were lowest following the three and six month storage period, seemingly influenced by sugar levels and native asparagine levels.

Effect of nitrogen rate across clones on sucrose, glucose, and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F for the North Dakota Site is presented in Table 2. At 0 time, sucrose and glucose levels increase with nitrogen rate. There was no trend for acrylamide level based on nitrogen rate. Following three months storage, sucrose and glucose levels were not significantly different based on nitrogen rate. Glucose levels were highest at the 270 lb. rate, however. Following six months storage, sucrose, glucose and acrylamide levels were not significantly different for nitrogen rates. However, glucose and acrylamide levels increased as nitrogen rate increased. Nine month storage results mimicked the six month levels and trends.

Effect of nitrogen rate on sucrose, glucose and acrylamide level of five potato cultivars, grown at Inkster, ND, in 2011, are presented in Table 3. Per results presented above and found in Tables 1 and 2, cultivars tended to vary, with the older cultivars Snowden and Russet Burbank having higher levels of sucrose, glucose and acrylamide across nitrogen rate and storage time. Notably on Table 3, acrylamide levels for the chip cultivars (Ivory Crisp) was considerably higher when evaluation of processed chips occurred versus French fry processing cultivars processed as French fries prior to acrylamide determination.

The effects of nitrogen fertilization on acrylamide concentrations varied among sites, between years, and among varieties. ANOVAs were performed for each site and year for acrylamide concentration as a function of treatment, cultivar, and their interaction, for French-fry cultivars and potato chip cultivars separately (because fresh-weight acrylamide concentrations are much higher in potato chips, due to their low moisture contents).

Acrylamide concentrations were higher for tubers from Becker than from Inkster in 2011, except for Dakota Trailblazer, for which they were similar or slightly lower. So far in 2012, Alpine Russet and Russet Burbank tubers grown at Becker yield lower acrylamide concentrations than tubers from Park Rapids, while the other three cultivars have similar concentrations between the two sites. Acrylamide concentrations are higher at Becker in 2012 than they were in 2011. The treatment-by-cultivar interaction term was sometimes highly significant, reflecting variation among cultivars in how their acrylamide concentrations responded to nitrogen treatment. Overall, the optimum nitrogen fertilization rate for minimizing acrylamide formation was found to be specific to cultivar, site, year, and (in 2011) storage time, and we therefore discuss fertilization recommendations specific to each circumstance. The control treatment (30 lbs N/ac) will be excluded from consideration due to its extremely low marketable yields.

Acrylamide concentrations in Alpine Russet decreased with increasing application rate at Inkster in 2011 for all sampling times except nine months' storage, when the trend was reversed. At Becker that year, acrylamide concentrations generally increased with increasing nitrogen application rate at six and nine months' storage, with no directional effect of treatment before six months. Acrylamide concentrations increased with storage time at Becker, but not at Inkster. In 2012, there was no clear relationship between nitrogen treatment and acrylamide concentration for either site. Based on acrylamide concentrations alone, we would recommend fertilizing at 240 – 300 lbs N/ac at Inkster and 120 – 180 lbs N/ac at Becker in 2011, and we would advise against long storage at Becker. We can offer no recommendations for Becker and Park Rapids in 2012 based on data collected to date.

For Dakota Trailblazer tubers from Inkster in 2011, acrylamide concentration tended to increase with increasing nitrogen application rate for all sampling times except at three months' storage, when there was no clear trend. At Becker that year, acrylamide concentration tended to increase with nitrogen application rate at three and nine months' storage, with no trend at harvest or six months' storage. Acrylamide concentration was lowest for freshly-harvested tubers, but showed no response to storage time after three months. In 2012, acrylamide concentration at harvest tended to increase with increasing nitrogen application rate at Becker, but showed no clear relationship to nitrogen treatment at Park Rapids. Based on acrylamide concentration alone, we would recommend a fertilization rate of 120 – 180 lbs N/ac for this variety. It is best used fresh, but acrylamide levels did not increase greatly after three months' storage or change substantially thereafter.

Acrylamide levels in French fries made from Russet Burbank tended to decrease with increasing nitrogen application rate for tubers grown at Inkster in 2011, for all storage times. At Becker in 2011, acrylamide concentration was not linearly related to fertilizer treatment. There was a weak tendency for acrylamide levels to increase with storage time for Becker tubers. At both Becker and Park Rapids in 2012, acrylamide concentration tended to increase with increasing nitrogen application rate for freshly-harvested tubers. Based on acrylamide concentration, we would recommend fertilization at 240 – 300 lbs N/ac at Inkster in 2011 and at 120 – 180 lbs N/ac at both sites in 2012. We cannot make a recommendation for Becker in 2011, except that it would be preferable to use tubers early in storage.

Acrylamide concentrations of Ivory Crisp chips increased with increasing nitrogen application rate for tubers grown at Inkster in 2011. The trend was stronger at harvest and after three months' storage than it was later. For tubers grown at Becker, nitrogen treatment had no effect on acrylamide concentration at harvest before nine months' storage, when acrylamide concentration decreased with increasing application rate. Acrylamide levels decreased with storage time at both sites. In 2012, acrylamide concentration decreased with increasing application rate for Park Rapids tubers, but was not related to treatment at Becker. We would recommend fertilizing at 120 – 180 lbs N/ac at both sites in 2011, but at 240 – 300 lbs N/ac at Park Rapids in 2012. We can make no recommendation for Becker in 2012. It appears that storing this cultivar for more than three months decreases its potential to form acrylamide.

Acrylamide concentrations of Snowden potato chips were unrelated to nitrogen treatment at Inkster in 2011. At Becker, acrylamide concentration declined with increasing nitrogen application rate at all times except harvest, when there was no directional relationship. At both sites, acrylamide concentrations increased dramatically between 6 months' and 9 months' storage, without changing directionally over time before 6 months. At harvest in 2012, nitrogen treatment had no clear effect on acrylamide concentrations. Based on the results at harvest at Becker in 2011, we would suggest fertilization at 240 – 300 lbs N/ac. None of the other results offer any basis for a recommendation. However, it is clear that this cultivar should be stored no longer than six months, in order to minimize acrylamide formation.

The application rate that maximized marketable yield differed between the two years. In 2011, the highest yield was seen at 180 lbs N/ac for all varieties except Ivory Crisp, for which the peak yield was observed at 240 lbs N/ac. In 2012, yield was maximized at 240 lbs N/ac for Dakota Trailblazer and Snowden, and at 300 lbs N/ac for the other three varieties. 2012 was a warmer year, with more heating-degree-days between planting and harvest, and yields were higher overall, so yield was probably limited more by nitrogen than by other factors in that year. In contrast, in 2011, with growing time limiting tuber production more than nitrogen, nitrogen applied at high rates may have resulted in a greater allocation of photosynthate to canopy growth instead of tuber growth, with insufficient growing time for this investment in canopy to yield increased sugar availability for tuber production.

Table 1. Whole-tuber sucrose and glucose concentrations and French-fry or chip acrylamide concentrations at harvest in 2011 and 2012, at Becker (both years), Inkster (2011), and Park Rapids (2012), for treatments receiving 120 – 240 lbs N/ac, for each cultivar. (Mean ± S.D., *min – max* for each; N = 12.)

Cultivar	Sucrose (mg/g dry)	Glucose (mg/g dry)	Acrylamide (ppb fresh)
Alpine Russet (fry)	1.68 ± 0.25 *1.34 – 2.22*	1.35 ± 0.95 *0.22 – 3.34*	872 ± 636 *205 – 2192*
Dakota Trailblazer (fry)	1.63 ± 0.39 *1.05 – 2.41*	0.61 ± 0.45 *0.18 – 1.19*	321 ± 172 *85 – 554*
Russet Burbank (fry)	0.94 ± 0.11 *0.78 – 1.08*	2.05 ± 1.18 *0.40 – 3.82*	1159 ± 886 *355 – 2754*
Ivory Crisp (chip)	1.27 ± 0.44 *0.61 – 2.05*	0.34 ± 0.27 *0.14 – 0.94*	4378 ± 1849 *1898 – 7515*
Snowden (chip)	1.28 ± 0.19 *0.95 – 1.67*	0.35 ± 0.23 *0.06 – 0.73*	4016 ± 1618 *2084 – 6247*

Table 2. Whole-tuber sucrose and glucose concentrations and French-fry or chip acrylamide concentrations at each sampling time in 2011 at Becker and Inkster, for treatments receiving 120 – 240 lbs N/ac, for each cultivar. (Mean ± S.D., *min – max* for each; N = 6.)

	Sucrose				Glucose				Acrylamide			
	0 months	3 months	6 months	9 months	0 months	3 months	6 months	9 months	0 months	3 months	6 months	9 months
Alpine Russet	1.65±0.32 *1.3–2.22*	1.41±0.32 *0.92–1.78*	0.93±0.04 *0.89–0.98*	0.73±0.23 *0.38–1.11*	0.93±0.69 *0.22–3.34*	1.32±1.01 *0.23–2.64*	1.64±1.59 *0.10–3.48*	1.81±1.54 *0.40–3.80*	342±137 *205–532*	500±180 *302–824*	583±302 *287–1010*	723±590 *111–1520*
Dakota Trailblazer	1.38±0.21 *1.05–1.67*	0.97±0.45 *0.51–1.79*	0.57±0.38 *0.17–1.13*	0.64±0.43 *0.25–1.18*	0.49±0.16 *0.25–0.64*	0.80±0.35 *0.42–1.16*	0.50±0.21 *0.20–0.74*	0.82±0.19 *0.59–1.11*	169 ± 68 *85–263*	421 ±135 *254–663*	338 ± 206 *162–707*	351 ± 106 *192–459*
Russet Burbank	0.93±0.11 *0.78–1.08*	0.99±0.13 *0.85–1.22*	0.60±0.14 *0.42–0.76*	0.42±0.16 *0.23–0.60*	1.03±0.58 *0.40–1.76*	1.47±0.67 *0.64–2.42*	1.12±0.64 *0.49–1.98*	1.24±0.71 *0.60–2.24*	489±148 *355–760*	824±212 *575–1085*	766±218 *466–1118*	676±294 *288–996*
Ivory Crisp	1.14±0.46 *0.61–1.66*	0.64±0.07 *0.52–0.70*	0.82±0.23 *0.41–1.10*	0.96±0.19 *0.79–1.30*	0.18±0.03 *0.14–0.21*	0.22±0.07 *0.11–0.29*	0.32±0.30 *0.03–0.66*	0.52±0.36 *0.16–1.10*	2883±632 *1898–3615*	2097±869 *1219–3484*	1184±335 *936–1802*	1463±900 *661–2832*
Snowden	1.25±0.26 *0.95–1.67*	0.87±0.11 *0.67–0.96*	1.20±0.37 *0.83–1.87*	1.86±0.48 *1.22–2.67*	0.16±0.09 *0.06–0.30*	0.18±0.15 *0.67–0.96*	0.31±0.31 *0.03–0.77*	1.89±0.90 *0.63–2.93*	2622±532 *2084–3363*	1420±934 *636–3152*	1850±763 *1165–3035*	6830±3740 *3277–11632*

For potato chips made from tubers grown at the North Dakota site, mean chip color determined by the USDA Chip Color Chart or Agtron value across chip clones and nitrogen rate was not significantly different at 0 time. Snowden had higher Agtron values, while Ivory Crisp had a lower mean (data not presented). Similar results were obtained following three months storage. Agtron values declined following 6 months storage and the mean was below industry acceptable levels. Clone was significant for the nine month storage period, but not nitrogen rate. Mean Agtron value following 9 month storage was slightly higher than for the six month storage period; both clone and nitrogen rate were significant. Ivory Crisp had significantly better chip color values across nitrogen rates than Snowden.

Mean chip color was not significantly different (chart and Agtron values) across clones for nitrogen rate at 0 time. Following 3 months storage the Agtron value for the 150 nitrogen rate was lower than for the other rates. After 6 month storage chip color chart values were equal, however the Agtron values were significantly different and slightly darker for the 150, 210 and 270 lb. nitrogen rates. By the 9 month storage period, chip color chart values for the 150, 210 and 270 lb. nitrogen rates were higher than for the 0 and 90 lb. rate. The Agtron values also followed this pattern.

In Minnesota, plant stand two weeks after emergence was significantly lower for Alpine Russet (61.4% stand) than for Ivory Crisp (88.4% stand), which had significantly lower stand than the other three cultivars (all over 98.5% stand). The low stand for Alpine Russet was likely due to dry rot. Plant stand was not significantly related to the amount of nitrogen applied. The cultivars also differed significantly in their numbers of stems per plant three weeks post-emergence. Snowden (5.0 stems per plant) had significantly more than Russet Burbank (4.5 stems), which had significantly more than Ivory Crisp (3.6 stems) and Alpine Russet (3.5 stems), which had significantly more than Dakota Trailblazer (2.7 stems). The number of stems per plant was significantly related to nitrogen application rate for three cultivars, but the relationship was neither linear nor quadratic for Dakota Trailblazer (Table 6) and Ivory Crisp (Table 8). For Russet Burbank, the control treatment had significantly more stems per plant than the ESN-fertilized treatments.

Petiole nitrate increased significantly with increasing application of ESN for all combinations of cultivar and testing date (Table 4, Tables 5 – 9).

Petiole nitrate also varied significantly among cultivars in all four sampling periods (Table 4), but the rank-order of the five cultivars changed over time. On June 20, Alpine Russet plants had significantly higher petiole nitrate than all other cultivars, and on June 28, the same cultivar still had significantly higher nitrate than Russet Burbank or Snowden plants. On both July 11 and July 26, Russet Burbank plants had significantly higher petiole nitrate than any other cultivar, while Ivory Crisp plants had significantly lower nitrate than Snowden or Dakota Trailblazer.

Snowden had significantly greater total yield than Dakota Trailblazer, which had significantly greater yield than Ivory Crisp, which had significantly greater yield than Alpine Russet. Russet Burbank had total yield intermediate between and not significantly different from those of Dakota Trailblazer and Ivory Crisp. For yield U.S. No. 1 tubers and total marketable yield, Dakota Trailblazer had significantly higher yields than Snowden or Ivory Crisp, which had significantly higher yields than Russet Burbank, which had significantly higher yields than

Alpine Russet. The lower yield of Alpine Russet tubers was likely due to dry rot of the seed tubers.

For each variety, total and marketable yields and yields of U.S. No. 1 tubers peaked at a nitrogen application rate of 180 or 240 lbs N/ac (Tables 10-14), although, for Snowden, yields were similar for all treatments receiving 180 to 300 lbs N/ac. The yield of U.S. No. 2 tubers was low for all treatments for Dakota Trailblazer, Ivory Crisp, and Snowden. For Alpine Russet, yield of U.S. No. 2 tubers decreased with increasing application of nitrogen, while the opposite trend was seen in Russet Burbank (though the effect was not statistically significant).

Tuber size distributions shifted toward larger size classes with increasing nitrogen application rate, although this tendency was weak for Dakota Trailblazer. The percentage of yield in tubers over 6 or 10 ounces generally increased with increasing nitrogen application rate. This trend was not evident among ESN-fertilized treatments for Dakota Trailblazer tubers over 6 ounces (though it was for tubers over 10 ounces).

The ranks of the cultivars by tuber dry matter and specific gravity were Dakota Trailblazer > Snowden > Ivory Crisp > Russet Burbank > Alpine Russet. For tuber dry matter, each of these differences was statistically significant. For specific gravity, the difference between Snowden and Ivory Crisp was not significant.

Tuber dry matter increased with increasing rate of nitrogen application rate for all cultivars except Russet Burbank, for which there was not treatment effect (Tables 15-19). Tuber specific gravity was greater for all or most ESN-fertilized treatments than for the control for Russet Burbank and Ivory Crisp. There was no effect of nitrogen treatment on this trait for the other three cultivars.

The prevalences of hollow heart and brown center in Dakota Trailblazer were significantly greater than those in Alpine Russet, which were significantly greater than those in the other three cultivars. The prevalence of scab was significantly greater in Ivory Crisp than in any other variety, and significantly greater in Snowden than in Alpine Russet. The other two varieties had prevalences between, and not significantly different from, those of Snowden and Alpine Russet.

The prevalences of hollow heart and brown center increased with increasing nitrogen application rate for Dakota Trailblazer and Russet Burbank. These flaws were rare on not significantly related to nitrogen treatment for the other three cultivars. The prevalence of scab was not related to nitrogen treatment for any cultivar.

For all cultivars combined, tuber nitrogen concentration increased with increasing application of ESN (Tables 20-24). Alpine Russet tubers had significantly higher nitrogen concentration than Ivory Crisp tubers, which had significantly higher nitrogen concentration than Snowden or Russet Burbank tubers, which had significantly higher nitrogen concentration than Dakota Trailblazer tubers.

There was a treatment-by-cultivar interaction effect, attributable to differences in the strength of the response to nitrogen application rate. There was no relationship between treatment and tuber

nitrogen for Snowden, and Russet Burbank showed only a weak response to additional ESN above the rate of 120 lbs total N/ac, while the other cultivars showed a more consistent increase in tuber N with increasing application of nitrogen.

At harvest, Alpine Russet and Dakota Trailblazer had significantly higher whole-tuber sucrose concentrations than the other three cultivars, and Ivory Crisp had a significantly lower tuber sucrose concentration than any other cultivar. Three months later, Snowden and Ivory Crisp had significantly lower tuber sucrose concentrations than the other three cultivars, and Alpine Russet had a significantly higher tuber sucrose concentration than Russet Burbank. After six months in storage, Snowden tubers had significantly higher sucrose concentrations than those of any other cultivar, while Russet Burbank tubers had significantly lower sucrose concentrations than those of any other cultivar. A similar pattern was seen at nine months, except that Alpine Russet joined Russet Burbank in having a significantly lower sucrose concentration than the other cultivars. Overall, sucrose concentration tended to decline with storage time for the frying cultivars and increase for the chipping cultivars.

At harvest, Russet Burbank tubers had significantly higher glucose concentrations than Alpine Russet tubers, which had higher glucose concentrations than Dakota Trailblazer tubers, which had higher glucose concentrations than Snowden or Ivory Crisp tubers. After three months in storage, the glucose concentrations of Alpine Russet and Russet Burbank tubers were significantly higher than those of Dakota Trailblazer tubers, which were higher than those of Ivory Crisp and Snowden tubers. At six months, Alpine Russet tubers had significantly higher glucose concentrations than Russet Burbank tubers, which had higher glucose concentrations than any of the other three cultivars. After nine months in storage, Alpine Russet and Snowden tubers had significantly higher glucose concentrations than Russet Burbank tubers, which had higher glucose concentrations than Ivory Crisp or Dakota Trailblazer. Glucose concentration tended to increase with storage time for all cultivars.

There were no significant effects of nitrogen treatment on sucrose concentration for the frying cultivars or the chipping cultivars as groups, nor was there a significant treatment-by-cultivar interaction for either group (Table 4). In contrast, at all four sampling periods, glucose concentration decreased with increasing application of nitrogen, although this trend was not significant for chipping varieties at 6 and 9 months' storage. The treatment-by-cultivar interaction effect was significant for the frying varieties at all four sampling periods and for the chipping varieties at harvest (Table 4).

Among individual cultivars, nitrogen treatment only influenced whole-tuber sucrose concentration at harvest in Snowden (Tables 19-24), but the relationship was not linear or quadratic. Three months after harvest, nitrogen treatment was significantly related to sucrose concentration in Alpine Russet, Dakota Trailblazer, and Snowden. Sucrose concentration generally declined with increasing nitrogen application rate for Dakota Trailblazer and Snowden, but followed no simple pattern in Alpine Russet. At six months' storage, sucrose concentration was not related to fertilizer treatment for any cultivar. After nine months, sucrose concentration generally declined with increasing nitrogen application rate, except that the treatment receiving 120 lbs N/ac had a significantly lower tuber sucrose concentration than any other treatment.

Tuber glucose concentration at harvest generally declined with increasing nitrogen application rate for all cultivars except Dakota Trailblazer, though the effect was not statistically significant for Russet Burbank (Tables 19-24). The relationship between nitrogen application rate and glucose concentration at harvest for Dakota Trailblazer was not linear or quadratic. Three months after harvest, nitrogen treatment was significantly related to tuber glucose concentration for all varieties except Dakota Trailblazer. Glucose concentration generally declined with increasing nitrogen application rate for all varieties. At six months' storage, glucose concentration still tended to decline with increasing rate of nitrogen application for all five varieties, but the effect was only significant for Alpine Russet, for which the treatment receiving 300 lbs N/ac had a very low mean glucose concentration. After nine months in storage, there was no tendency for tuber glucose concentrations to decline with increasing nitrogen application rate in Dakota trailblazer, and in Snowden, the trend was only seen in a difference between the control group and the ESN-fertilized groups. For the other three varieties, tuber glucose did tend to decline with increasing nitrogen application rate, though this relationship was not significant for Russet Burbank.

Frying quality analysis was only performed for the chipping cultivars, Snowden and Ivory Crisp (Tables 25 and 26). There was no significant treatment by cultivar interaction effect at any sampling time (Table 4). For all treatments combined, there were significant effects of cultivar on both chip color and Agtron score at six and nine months' storage (Table 4). At both of these sampling times, chips made from Snowden tubers were darker than those made from Ivory Crisp, resulting in significantly higher chip color scores and lower Agtron scores. For both cultivars combined, nitrogen treatment only significantly affected chip color at nine months' storage (Table 4). At this time, the control treatment produced darker chips than the fertilized treatments.

Agtron scores were significantly related to treatment for Ivory Crisp at three and nine months' storage. At three months' storage, the treatment receiving 180 lbs N/ac had significantly darker chips than those receiving 240 or 300 lbs N/ac. After nine months, both Agtron scores and subjective chip color scores showed that ESN-fertilized treatments produced significantly darker chips than the control. This was the only case where subjective chip color was significantly related to treatment.

Potato chips had 3.5 to 8.3 times as much acrylamide (in ppb of fresh weight) as French fries. For that reason, the results for the frying cultivars and the chipping cultivars are considered separately.

For the frying cultivars as a group, nitrogen treatment had a marginally significant effect on the acrylamide concentrations of fries made soon after harvest, but the relationship was neither linear nor quadratic (Table 4). After three months in storage, nitrogen treatment was not significantly related to the acrylamide concentrations of fries. However, after six months in storage, there was a significant effect of nitrogen treatment, with the treatments receiving nitrogen at intermediate rates tending to have more acrylamide than those receiving extremely high or low rates. After nine months in storage, this pattern was weaker, so that the only significant difference between treatments was that the control treatment had significantly lower acrylamide than the treatment receiving 240 lbs N/ac.

The chipping cultivars showed significant responses of acrylamide concentration to nitrogen treatment at three and nine months' storage (Table 4). The response at three months was neither linear nor quadratic in shape. At nine months, acrylamide concentration declined steeply with increasing nitrogen application rate. This trend was also seen at six months, but it was not statistically significant.

There was a significant effect of tuber cultivar among both the frying cultivars and the chipping cultivars at each sampling period (Table 4). Fries made from Dakota Trailblazer had significantly lower acrylamide concentrations than those made from the other two cultivars at all four sampling periods. Alpine Russet fries had significantly lower acrylamide concentrations than Russet Burbank fries at harvest. Ivory Crisp chips had significantly higher acrylamide contents than Snowden chips at harvest and after three months in storage, but the relationship was reversed at six and nine months.

The frying cultivars showed significant treatment-by-cultivar interactions at harvest (Table 4). At harvest, the acrylamide contents of Russet Burbank fries varied significantly but unpredictably with nitrogen treatment (Table 29), while Alpine Russet showed a muted version of the same pattern (Table 27), and Dakota Trailblazer showed very little response (Table 28). There were no significant interaction effects at the other sampling times.

The chipping cultivars showed significant treatment-by-cultivar interaction effects at three and nine months' storage, the same sampling times when they showed significant responses to nitrogen treatment (Table 4). At three months, the two cultivars showed contrasting responses to nitrogen treatment (Tables 30 and 31). Neither response was linear or quadratic in form. Only Snowden's response was statistically significant; the treatment receiving 120 lbs N/ac produced more acrylamide than the others. At the nine-month sampling time, acrylamide concentrations decreased with increasing rate of nitrogen application. Both cultivars had this relationship, but while Snowden showed the effect between 180 and 300 lbs N/ac (Table 31), Ivory Crisp showed it between 30 and 240 lbs N/ac (Table 30).

For individual cultivars, the acrylamide concentrations of fries or chips were not significantly related to nitrogen treatment for most combinations of cultivar and sampling date, except that Snowden showed significant treatment effects at three, six, and nine months of storage (Tables 27-31). Significant results for the frying varieties tended to show an increase in acrylamide concentration with increasing rate of nitrogen application, while significant results for the chipping varieties tended to show the opposite effect. However, the linear component of the relationship between nitrogen application rate and acrylamide concentration was much cleaner for the chipping varieties.

Acrylamide concentration versus precursor concentrations:

To determine whether the acrylamide concentrations of fried potato products were related to the concentrations of acrylamide precursors in the raw tubers, we performed linear regressions of acrylamide concentration as a function of precursor concentrations. Because there were significant treatment-by-cultivar interactions for the concentrations of acrylamide and its

precursors, even when we considered the frying cultivars and chipping cultivars separately, we tested for relationships between acrylamide concentration and the concentrations of its precursors for each cultivar separately (Table 32).

Acrylamide concentrations in Alpine Russet fries made from freshly harvested tubers had a marginally significant positive relationship to whole-tuber sucrose concentrations, and acrylamide was positively related to tuber glucose concentration at six months' storage. Acrylamide concentrations for Dakota Trailblazer fries from freshly harvested tubers had a marginally significant negative relationship to tuber nitrogen concentration at harvest. The acrylamide concentration of Russet Burbank fries was significantly positively related to sucrose concentration at six months' storage. Acrylamide concentration in Ivory Crisp chips was significantly positively related to sucrose concentration at three months and glucose concentration at nine months in storage. Acrylamide concentration for this cultivar at nine months was also negatively related to tuber nitrogen concentration at harvest. Acrylamide concentration in Snowden chips showed a marginally significant positive relationship to tuber sucrose concentration at six months' storage and significant positive relationships to glucose concentration at three months and six months' storage. Snowden acrylamide concentration at three months' storage was also positively related to tuber nitrogen concentration at harvest.

Growers' potatoes:

Tubers from participating growers' farms often had somewhat different concentrations of sucrose and glucose (Table 33) than tubers of the same cultivar from our study site. Alpine Russet tubers from K+O tended to have high sucrose and low glucose concentrations relative to tubers of this cultivar from our study plots. Dakota Trailblazer tubers from Perham-Karsina had sugar levels similar to those found for this cultivar in our study plots. Russet Burbank tubers from K+O, Park Rapids Bliss, and Park Rapids HCBE initially had similar sucrose levels to those from our study sites, but did not exhibit the decline in sucrose in months six and nine that tubers from our site did. These growers' tubers also had lower glucose than Russet Burbank tubers from our study site throughout the storage period. Ivory Crisp tubers from Perham-RDO generally had high sucrose concentrations and low glucose concentrations relative to tubers of this cultivar from our study site. Snowden tubers from Goenners had glucose concentrations slightly lower than tubers of this cultivar from our study plots at all sampling times. They initially had similar sucrose concentrations to our study tubers, but their late-storage sucrose increase lagged behind that of the tubers from our study site. As sucrose concentrations began to rise in tubers from our study site at six months, the Goenner tubers retained steady, low sucrose concentrations. However, by nine months, even as sucrose concentrations continued to rise in Snowden tubers from our study site, the tubers from Goenners had converged again on similar concentrations.

Chips made from Ivory Crisp potatoes from Perham-RDO (Table 34) had similar chip color scores and AGT readings to chips of the same cultivar from fertilized treatments in our study site at all three sampling times for which we have data for the Perham-RDO chips. Chips from Snowden tubers grown by Goenners (Table 34) tended to have higher AGT scores (i.e., lighter color) than chips from Snowden tubers grown at our site, especially at harvest and after nine months in storage.

Acrylamide concentrations were also determined at each sampling period for fried products made from growers' tubers (Table 35). Acrylamide concentrations for fries made from K+O Alpine Russet tubers were similar to those found for this cultivar grown in our study site. Fries made from Dakota Trailblazer tubers grown at Perham-Karsina had higher acrylamide concentrations than those made from tubers grown at our site, except at three months' storage, when they had similar acrylamide concentrations. Fries made from Russet Burbank tubers from growers' farms had similar acrylamide levels to those found for our study site, except that K+O tubers had particularly high acrylamide levels after nine months in storage. Chips made from Ivory Crisp tubers grown at Perham-RDO had similar acrylamide levels to those found with tubers from our study site, except that the Perham-RDO tubers yielded slightly lower acrylamide levels at nine months' storage. Snowden tubers from Goenners yielded chips with lower acrylamide levels than found in Snowden chips from our study site tubers, except at nine months' storage, when the Goenner chips and our study site chips had similar acrylamide levels.

Problems and Delays

In North Dakota, unusual developments included the sampling of the materials prior to grading, thus, yield and grading data are not presented. This situation did not arise in 2012, as the potatoes were stored in Fargo at NDSU instead of the Potato Research Worksite. Additionally, the petiole analysis is not complete at this time. Thus, no correlation with high or residual nitrogen at harvest can be made with chip/French fry color, nor can recommendations be made regarding petiole nitrate levels for growers to use in season at this time. However, the results will be available and presented with the results and summary of the second year of the project (FY11 Specialty Crops Block Grant). Two years of data is always preferable to one when trying to make any type of recommendation for producers and will be very important given the extreme diversity of the two growing seasons of 2011 and 2012.

In Minnesota, data collection and analysis is currently on schedule. There was some delay in collecting data on acrylamide concentrations for French fries and chips made from tubers that had been in storage for 6 months, as many samples had undectably low levels. However, Bruce Witthuhn of the University of Minnesota Mass Spectrometry Laboratory discovered that these results were attributable to high accumulations of a (not yet identified) low-molecular-weight molecule not much smaller than acrylamide. He was able to correct for this, and acrylamide analysis is back on schedule.

Beneficiaries

Since this is a preliminary project (ie. a single year), beneficiaries will be more apt to receive benefits after a second year (and perhaps even a subsequent year) of trial results. Potato producers growing for the chip and frozen processing markets are potential beneficiaries. Additionally, based on yield and petiole information, not only will their product have potentially less acrylamide formation, but they may find that new cultivars are more sustainable from a production standpoint using less nitrogen to produce a high yield of a high quality crop. This may also positively impact the environment and consumers concerned about leaching. A second group of beneficiaries would include the potato processors. In North Dakota and Minnesota

potatoes grown by ND and MN growers are made into French fries and other frozen products at Simplot (Grand Forks, ND), Cavendish Farms (Jamestown, ND), and Lamb-Weston/ConAgra (Park Rapids, MN). Potatoes grown by MN and ND producers for chipping are processed at Barrel of Fun (Perham, MN), Old Dutch (Twin Cities area, MN), and also by Frito-Lay plants outside our states. These manufacturing sites benefit if the raw product has low levels of reducing sugars and asparagines, resulting in a finished product with reduced levels of acrylamide. Finally, consumers of frozen processed products including French fries, and snack foods containing potato, such as chips, benefit when acrylamide levels are reduced.

The results for the FY10 project was shared by the following methods:

1) Presented to the Northern Plains Potato Grower's Annual meeting on Feb 18. The presentation will soon be available on the NDSU potato management website: www.ag.ndsu.edu/potatoextension

2) Results were also provided to all growers on a CD given out at the meeting

3) A proceedings bulletin was also published by the Minnesota Area II Potato Research and Education Council and was handed out at the meeting on Feb. 18 and also will be handed out on March 4 at the Minnesota Area II meeting.

4) There were approximately 90 growers that attended the research reporting session on February 18 and there will be about 50 growers that attend the Area II meeting on March 4.

5) Total outreach with the CD and website will be approximately 200 growers and 5 Processors - Simplot, Black Gold, RD Offutt, Cavendish, Barrel O Fun.

Lessons Learned

North Dakota

Based on sampling of the 2011 yield, prior to grading, storage of raw product prior to sampling should occur where the materials can be monitored.

Based on a single year of evaluation, cultivar seems to play more of a role in acrylamide formation than nitrogen rate. The newer cultivar releases, Alpine Russet, Dakota Trailblazer, and Ivory Crisp, had lower levels, compared to the industry chip and French fry standards of Snowden and Russet Burbank, respectively. In previous research, Alpine Russet and Dakota Trialblazer have been shown to respond favorably in terms of yield, grade and French fry processing quality when produced at lower nitrogen levels than required for Russet Burbank. While generally not significant, across cultivars and storage time, nitrogen rate does tend to increase sucrose, glucose and acrylamide levels.

Minnesota

We have made substantial progress on establishing baseline values for sugar concentrations in mature tubers, chip color for chipping cultivars, and acrylamide concentrations for French fries and potato chips following 0, 3, 6, and 9 months in storage. Based on data from Becker, Inkster, and multiple growers, all of these characteristics show significant geographic variability. Furthermore, results for the 2012 season to date indicate a high degree of year-to-year variation, as well.

Nitrogen management had a limited effect on tuber sugar concentrations and the acrylamide concentrations of fried potato products. What effects we found differed between the North Dakota site and the Minnesota site. This does not support the hypothesis that the concentrations of tuber sugars and the concentration of acrylamide in fried products can be manipulated through nitrogen management in the field. However, nitrogen management did have a significant effect on tuber nitrogen concentration, and may therefore limit the accumulation of the acrylamide precursor asparagine in mature tubers. This may be significant in cases where the asparagine concentration limits the formation of acrylamide in fried potato products.

In the Minnesota site, acrylamide concentrations were not well predicted by the concentrations of sucrose, glucose, or nitrogen in raw tubers. This does not support the hypothesis that the acrylamide concentrations of French fries and potato chips can be controlled by manipulating the concentrations of acrylamide precursors in mature tubers. Acrylamide formation may have been limited by something other than the concentrations of acrylamide precursors in this system

Genetic approaches (e.g., cultivar selection, targeted breeding) are more likely to yield positive results in the effort to reduce acrylamide concentrations, based on this first year's data. Cultivars often varied significantly in the acrylamide concentrations of the French fries or chips produced from them, and some responded better than others did to long storage times. The Minnesota acrylamide results for cultivar were generally consistent with those reported by North Dakota

Future project plans

We have added this section because our project has received a second year of funding (FY11). A second field trial, petiole sampling, determination of yield and grade, sampling for determination of sugars, processing, and determination of acrylamide levels at 0, 3, 6, and 9 month storage periods has taken place. Sugars and acrylamide for the 0 time sampling have been determined. A second year of data will be significant in determining if our first year findings are consistent based on the protocol, or if environmental differences between growing seasons 2011 and 2012 resulted in significant differences.

The results for the 2011 growing season will be presented at the Northern Plains Potato Growers Association Research Reporting Session in Grand Fork, ND during the week of February 18.

Tubers from the second season, from both sites, are approaching 3 months' storage. Whole-tuber sucrose and glucose concentrations will be determined at 3, 6, and 9 months' storage, as will the acrylamide concentrations of French fries and potato chips made from these tubers. Statistical analyses will be conducted for both sites and both years, and the results will be reported the full results for both years will be reported to the Northern Plains Potato Growers

Association. Results will also be reported at the Potato Association of America annual meeting in 2013 or 2014.

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Development of Nitrogen Management Practices in MN & ND

Additional information available

Table 1. Clone means across nitrogen rates for sucrose, glucose and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F. The mean value is followed by significance (* = significant, ** = highly significant, ns = not significant) for clone.

Storage Time	Clone	Sucrose	Glucose	Acrylamide
		mg/g	mg/g	ng/g
0 Time	Alpine Russet	1.90	0.27	204.8
	Dakota Trailblazer	1.34	0.48	211.8
	Ivory Crisp	1.50	0.19	2682.2
	Russet Burbank	1.03	0.53	424.1
	Snowden	1.38	0.07	2131.4
	Mean	1.43**	0.31**	1138.0**
	LSD (α = 0.05)	0.17	0.09	324.2
3 Months	Alpine Russet	1.77	0.36	304.1
	Dakota Trailblazer	0.77	0.96	613.2
	Ivory Crisp	0.72	0.17	1808.6
	Russet Burbank	0.90	0.92	736.6
	Snowden	0.91	0.60	820.6
	Mean	1.02**	0.49**	856.6**
	LSD (α = 0.05)	0.11	0.22	272.6
6 Months	Alpine Russet	0.99	0.28	304.1

	Dakota Trailblazer	0.33	0.40	296.9
	Ivory Crisp	0.68	0.06	980.5
	Russet Burbank	0.78	0.55	666.0
	Snowden	0.98	0.04	1357.5
	Mean	0.75**	0.26**	725.3**
	LSD (α = 0.05)	0.12	0.18	74.1
9 Months	Alpine Russet	0.88	0.47	208.3
	Dakota Trailblazer	0.34	0.71	325.5
	Ivory Crisp	0.96	0.27	811.9
	Russet Burbank	0.59	0.72	404.3
	Snowden	1.78	0.98	3716.9
	Mean	0.91**	0.63**	1093.3**
	LSD (α = 0.05)	0.31	0.32	605.7

Table 2. Effect of nitrogen rate across clones on sucrose, glucose and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F. The mean value is followed by significance (* = significant, ** = highly significant, ns = not significant) for nitrogen rate.

Storage Time	Nitrogen Rate	Sucrose	Glucose	Acrylamide
		mg/g	mg/g	ng/g
0 Time	0	1.38	0.24	1159.2
	90	1.45	0.26	979.9
	150	1.44	0.37	1118.9
	210	1.44	0.37	1254.6
	270	1.45	0.32	1178.4
	Mean	1.43 ns	0.31**	1138.0 ns
	LSD (α = 0.05)	0.22	0.05	256.6
3 Months	0	1.00	0.42	584.9
	90	1.13	0.39	832.9
	150	1.07	0.56	769.5
	210	0.93	0.44	1036.6
	270	0.95	0.65	1059.2
	Mean	1.02 ns	0.49 ns	856.6*
	LSD (α = 0.05)	0.23	0.24	270.8
6 Months	0	0.75	0.19	691.7
	90	0.68	0.23	688.2
	150	0.77	0.23	768.9
	210	0.70	0.32	688.9

	270	0.87	0.36	791.0
	Mean	0.75 ns	0.26 ns	725.3 ns
	LSD (α = 0.05)	0.15	0.17	100.5
9 Months	0	0.83	0.61	1038.9
	90	0.94	0.55	1096.8
	150	0.87	0.62	1019.1
	210	0.81	0.51	1212.3
	270	1.094	0.86	1099.8
	Mean	0.91 ns	0.63 ns	1093.3 ns
	LSD (α = 0.05)	0.27	0.22	320.4

Table 3. Effect of nitrogen rate on sucrose, glucose and acrylamide level of five potato cultivars, Inkster, ND, 2011.

		suc0*	glu0	acryl0	suc3	glu3	acryl3	suc6	glu6	acryl6	suc9	glu9	acryl9
Clone	**N Rate**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Alpine Russet	**0**	2.06	0.14	86.5	2.04	0.24	125.4	1.10	0.10	281.9	1.04	0.21	86.8
	90	1.84	0.24	251.0	2.00	0.29	293.8	0.86	0.16	333.4	0.80	0.55	250.4
	150	1.60	0.32	248.7	1.78	0.53	386.6	0.90	0.36	349.7	0.66	0.40	190.4
	210	2.22	0.44	232.4	1.59	0.23	410.9	0.91	0.10	286.6	0.80	0.39	319.7
	270	1.78	0.22	205.3	1.45	0.52	303.8	1.19	0.66	269.1	1.11	0.79	194.2
Dakota Trailblazer	**0**	1.24	0.42	105.3	0.81	0.88	642.0	0.46	0.39	201.0	0.19	1.31	281.2
	90	1.47	0.32	137.9	0.94	0.59	753.0	0.39	0.26	161.6	0.54	0.28	360.7
	150	1.67	0.62	273.5	0.97	1.04	662.9	0.40	0.20	279.4	0.45	0.59	258.5
	210	1.29	0.64	280.8	0.51	1.14	371.3	0.17	0.74	353.7	0.25	0.68	385.2
	270	1.05	0.42	261.3	0.64	1.16	636.9	0.24	0.40	484.3	0.25	0.72	341.7
Ivory Crisp	**0**	1.31	0.20	2907.6	0.58	0.06	902.7	0.56	0.02	1000.6	0.51	0.16	602.3
	90	1.54	0.13	1898.0	0.78	0.07	1218.5	0.62	0.03	935.7	0.86	0.05	660.8
	150	1.55	0.17	2362.1	0.68	0.19	1330.5	0.76	0.03	955.8	0.91	0.16	922.6
	210	1.46	0.29	3206.6	0.70	0.11	2982.3	0.86	0.07	1050.6	0.78	0.19	993.3
	270	1.66	0.20	3036.7	0.86	0.41	2609.3	1.10	0.13	960.1	1.66	0.80	880.5
Russet Burbank	**0**	1.10	0.40	438.3	0.88	0.88	463.8	0.55	0.41	657.1	0.82	0.64	424.4
	90	1.05	0.59	528.8	0.81	0.97	1077.8	0.57	0.65	845.5	0.45	1.07	529.2
	150	1.05	0.66	371.8	0.98	0.98	575.4	0.76	0.49	641.4	0.54	0.60	447.0
	210	0.88	0.40	354.5	0.93	0.64	782.2	0.74	0.65	465.7	0.60	0.68	287.5
	270	1.08	0.63	430.7	0.91	1.11	783.8	0.81	0.56	720.3	0.55	0.61	333.3
Snowden	**0**	1.21	0.04	2078.1	0.71	0.06	790.5	1.09	0.05	1318.0	1.58	0.72	3799.8
	90	1.34	0.04	2083.7	1.12	0.04	821.4	0.96	0.03	1164.8	2.04	0.81	3683.1
	150	1.33	0.06	2338.6	0.94	0.04	892.4	1.04	0.06	1495.7	1.77	1.35	3276.9
	210	1.34	0.09	2198.9	0.90	0.09	636.3	0.83	0.03	1287.8	1.60	0.63	4075.8
	270	1.67	0.13	1957.9	0.89	0.07	962.2	0.99	0.03	1521.2	1.91	1.39	3749.2

*Sucrose abbreviated as suc (mg/g), glucose as glu (mg/g), acrylamide levels (ng/g) as acryl for 0, 3, 6 and 9 months storage times.

Table 4: Significance results of ANOVAs for each dependent variable as a function of nitrogen treatment, potato variety, and their interaction, for Becker, MN[1].

Dependent Variable	All varieties			Chipping varieties only			Frying varieties only		
	Treatment	Variety	Trt * Var	Treatment	Variety	Trt * Var	Treatment	Variety	Trt * Var
Plant % stand	NS	**	NS						
Stems/plant	NS	**	NS						
Petiole nitrate, June 20	**	**	NS						
Petiole nitrate, June 28	**	*	NS						
Petiole nitrate, July 11	**	**	++						
Petiole nitrate, July 26	**	**	++						
Yield, 0-3 oz	NS	**	**						
Yield, 3-6 oz	**	**	NS						
Yield, 6-10 oz	**	**	*						
Yield, 10-14 oz	**	**	++						
Yield, > 14 oz	**	**	++						
Yield, Total	**	**	NS						
Yield, #1s	**	**	NS						
Yield, #2s	NS	**	**						
Yield, Marketable	**	**	NS						
Yield, % > 6 oz	**	**	NS						
Yield, % > 10 oz	**	**	NS						
Hollow heart	**	**	**						
Brown center	**	**	**						
Scab	NS	**	NS						
Specific gravity	++	**	NS						
Dry matter	**	**	*						
AGT score, harvest				NS	NS	NS			
AGT score, 3 months				NS	NS	NS			
AGT score, 6 months				NS	*	NS			
AGT score, 9 months				*	**	NS			
Chip color, harvest				NS	NS	NS			
Chip color, 3 months				NS	NS	NS			
Chip color, 6 months				NS	*	NS			
Chip color, 9 months				**	**	NS			
Tuber nitrogen	**	**	**	**	++	**	**	**	++
Glucose, harvest	**	**	**	**	NS	++	**	**	**
Glucose, 3 months	**	**	*	**	NS	NS	**	**	++
Glucose, 6 months	**	**	*	NS	NS	NS	*	**	*
Glucose, 9 months	**	**	*	NS	**	NS	**	**	**
Sucrose, harvest	NS	**	NS	NS	**	++	NS	**	NS
Sucrose, 3 months	NS	**	NS	NS	**	**	**	**	NS
Sucrose, 6 months	NS	**	NS	NS	**	NS	NS	**	NS
Sucrose, 9 months	NS	**	NS	++	**	**	NS	**	NS
Acrylamide, harvest				NS	++	NS	**	**	**
Acrylamide, 3 months				*	**	++	NS	**	NS
Acrylamide, 6 months				NS	*	NS	**	**	NS
Acrylamide, 9 months				**	**	*	++	**	NS

NS: not significant. ++: $0.05 \leq P < 0.10$. *: $0.01 \leq P < 0.05$. **: $P < 0.01$. Blank cell: Not anaylyzed. (Agtron score and chip color were only determined for chipping varieties.

Table 5. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Alpine Russet potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	61.8	3.4	10197 b	1423 c	181 d	206 c
2	MAP + AMS, ESN	120	30, 90	61.8	3.5	20449 a	10819 b	2417 c	781 c
3	MAP + AMS, ESN	180	30, 150	67.4	3.5	21559 a	12151 b	3032 c	1329 c
4	MAP + AMS, ESN	240	30, 210	63.9	3.7	21206 a	19265 a	9571 b	3834 b
5	MAP + AMS, ESN	300	30, 270	52.1	3.6	22655 a	19594 a	14510 a	9299 a
			Significance[3]	NS	NS	*	**	**	**
			LSD (0.10)	--	--	5769	5653	1369	1199

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 6. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Dakota Trailblazer potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	99.3 a	2.6	8011 c	981 d	379 e	194 d
2	MAP + AMS, ESN	120	30, 90	95.8 b	2.5	17102 b	7813 c	3301 d	1092 cd
3	MAP + AMS, ESN	180	30, 150	100.0 a	2.9	18381 ab	10133 c	7121 c	2682 c
4	MAP + AMS, ESN	240	30, 210	99.3 a	2.8	20606 a	16080 b	9954 b	5071 b
5	MAP + AMS, ESN	300	30, 270	99.3 a	2.8	21556 a	20186 a	12828 a	7515 a
			Significance[3]	++	NS	**	**	**	**
			LSD (0.10)	2.8	--	3181	3594	1081	1652

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 7. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Russet Burbank potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	100.0	5.2 a	4415 c	689 e	333 e	112 e
2	MAP + AMS, ESN	120	30, 90	100.0	4.5 ab	14864 b	5353 d	2919 d	1600 d
3	MAP + AMS, ESN	180	30, 150	99.3	4.4 b	17714 a	10181 c	7442 c	4367 c
4	MAP + AMS, ESN	240	30, 210	100.0	4.1 b	19549 a	14070 b	12438 b	6683 b
5	MAP + AMS, ESN	300	30, 270	99.3	4.3 b	19893 a	17249 a	15501 a	9377 a
			Significance[3]	NS	++	**	**	**	**
			LSD (0.10)	--	0.8	2638	2177	1776	1313

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 8. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Ivory Crisp potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	88.2	3.7 ab	4032 c	346 d	160 d	100 c
2	MAP + AMS, ESN	120	30, 90	90.3	3.5 bc	16220 b	5157 c	937 d	275 c
3	MAP + AMS, ESN	180	30, 150	86.7	4.0 a	19321 ab	9918 b	4265 c	1721 bc
4	MAP + AMS, ESN	240	30, 210	88.2	3.5 bc	21115 a	16604 a	8705 b	3536 b
5	MAP + AMS, ESN	300	30, 270	88.9	3.4 c	22467 a	16943 a	14872 a	7478 a
			Significance[3]	NS	**	**	**	**	**
			LSD (0.10)	--	0.3	3467	3370	2654	2134

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 9. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Snowden potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	100.0	5.3	3556 c	573 d	260 e	306 d
2	MAP + AMS, ESN	120	30, 90	100.0	5.0	15618 b	6535 c	2766 d	1490 c
3	MAP + AMS, ESN	180	30, 150	99.3	5.2	20797 a	11989 b	6237 c	2561 b
4	MAP + AMS, ESN	240	30, 210	100.0	4.8	22039 a	16424 a	10604 b	6679 a
5	MAP + AMS, ESN	300	30, 270	99.3	5.0	20957 a	18960 a	14041 a	7535 a
			Significance[3]	NS	NS	**	**	**	**
			LSD (0.10)	--	--	3843	2691	1907	1003

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 10. Effect of nitrogen rate from ESN fertilizer on Alpine Russet tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	51.3	168.4 a	82.7 c	34.1 b	1.6 c	338.1 c	154.3 c	132.5 a	286.8 c	37.1 b	11.5 c
2	MAP + AMS, ESN	120	30, 90	42.5	150.5 a	140.1 ab	66.5 a	30.3 b	429.8 ab	293.6 ab	93.7 ab	387.3 ab	55.8 a	23.4 b
3	MAP + AMS, ESN	180	30, 150	50.7	150.3 a	154.1 a	75.7 a	42.5 b	473.3 a	339.7 a	82.9 b	422.5 a	57.8 a	25.2 b
4	MAP + AMS, ESN	240	30, 210	53.8	123.4 ab	128.8 ab	79.7 a	41.9 b	427.6 ab	286.4 b	87.4 b	373.8 ab	59.9 a	29.6 ab
5	MAP + AMS, ESN	300	30, 270	40.6	96.6 b	113.9 bc	56.5 ab	76.7 a	384.3 bc	266.7 b	77.0 b	343.7 b	64.7 a	35.1 a
			Significance[3]	NS	++	*	*	**	*	**	++	**	**	**
			LSD (0.10)	--	46.5	32.1	23.2	24.4	59.9	51.8	39.2	50.3	10.6	9.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 11. Effect of nitrogen rate from ESN fertilizer on Dakota Trailblazer tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	20.6 bc	162.7 a	213.6 bc	26.1 b	0.9 c	424.0 c	399.8 c	3.6	403.3 c	56.2 c	6.1 c
2	MAP + AMS, ESN	120	30, 90	19.5 c	121.9 bc	260.3 ab	88.8 a	21.7 b	512.1 ab	491.2 ab	1.4	492.6 ab	72.4 a	21.5 b
3	MAP + AMS, ESN	180	30, 150	29.1 a	135.4 ab	272.9 a	97.3 a	12.4 bc	547.0 a	516.4 a	1.4	517.8 a	69.8 ab	19.9 b
4	MAP + AMS, ESN	240	30, 210	27.8 ab	159.6 ab	196.1 c	115.9 a	24.4 ab	523.8 ab	496.0 ab	0.0	496.0 ab	64.1 b	26.2 ab
5	MAP + AMS, ESN	300	30, 270	32.1 a	94.1 c	213.4 bc	114.7 a	44.3 a	498.7 b	465.7 b	1.0	466.6 b	74.7 a	32.0 a
			Significance[3]	*	*	++	**	*	**	**	NS	**	**	**
			LSD (0.10)	7.7	38.6	57.2	27.8	20.1	41.9	46.0	--	46.2	7.1	6.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 12. Effect of nitrogen rate from ESN fertilizer on Russet Burbank tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	141.0 a	231.1	56.6	1.1 c	0.0 c	429.8 b	232.2	56.6	288.8 b	12.9 c	0.3 c
2	MAP + AMS, ESN	120	30, 90	112.2 b	234.3	135.5	7.6 c	5.0 bc	494.6 ab	320.2	62.1	382.4 a	30.2 b	2.6 c
3	MAP + AMS, ESN	180	30, 150	107.2 b	243.7	143.7	38.4 b	10.0 bc	543.0 a	363.2	72.6	435.8 a	35.4 ab	8.9 b
4	MAP + AMS, ESN	240	30, 210	102.4 bc	208.3	139.4	50.5 ab	14.4 ab	515.0 a	315.9	96.7	412.6 a	39.6 ab	12.6 b
5	MAP + AMS, ESN	300	30, 270	82.0 c	177.3	148.2	68.7 a	25.3 a	501.5 ab	304.0	115.5	419.5 a	48.1 a	19.3 a
			Significance[3]	*	NS	NS	**	*	++	NS	NS	*	**	**
			LSD (0.10)	24.8	--	--	20.7	12.7	77.2	--	--	79.1	14.3	6.3

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 13. Effect of nitrogen rate from ESN fertilizer on Ivory Crisp tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 - 3 oz (0 - 2.25")	3 - 6 oz (2.25 - 2.75")	6 - 10 oz (2.75 - 3.25")	10 - 14 oz (3.25 - 3.75")	> 14 oz (> 3.75")	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	41.6	147.1 a	135.6 d	36.2 c	7.6 c	368.1 c	326.4 c	0.0	326.4 c	47.8 b	11.4 c
2	MAP + AMS, ESN	120	30, 90	30.4	125.7 ab	215.4 b	80.2 bc	18.4 bc	470.1 b	438.9 b	0.8	439.7 b	66.1 a	20.0 bc
3	MAP + AMS, ESN	180	30, 150	33.6	137.2 ab	185.2 bc	108.7 ab	40.1 ab	504.8 ab	470.7 ab	0.5	471.2 ab	65.9 a	28.9 b
4	MAP + AMS, ESN	240	30, 210	26.4	118.4 bc	254.8 a	104.9 ab	41.5 ab	546.1 a	516.7 a	2.9	519.6 a	73.5 a	26.6 b
5	MAP + AMS, ESN	300	30, 270	25.5	89.9 c	176.9 c	128.6 a	67.0 a	487.9 b	461.6 ab	0.8	462.4 ab	76.3 a	40.2 a
			Significance[3]	NS	*	**	*	*	**	**	NS	**	**	**
			LSD (0.10)	--	28.7	35.3	47.4	30.6	53.3	59.6	--	59.7	11.0	10.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 14. Effect of nitrogen rate from ESN fertilizer on Snowden tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 - 3 oz (0 - 2.25")	3 - 6 oz (2.25 - 2.75")	6 - 10 oz (2.75 - 3.25")	10 - 14 oz (3.25 - 3.75")	> 14 oz (> 3.75")	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	76.1 bc	240.7	81.2 b	12.1 d	1.8 c	411.9 b	335.7 b	0.0	335.7 b	23.0 c	3.3 d
2	MAP + AMS, ESN	120	30, 90	72.8 c	275.8	164.8 a	25.2 cd	1.6 c	540.3 a	467.5 a	0.0	467.5 a	35.2 b	4.9 cd
3	MAP + AMS, ESN	180	30, 150	75.3 bc	243.8	203.2 a	32.5 c	5.1 bc	559.9 a	484.6 a	0.0	484.6 a	43.1 ab	6.7 c
4	MAP + AMS, ESN	240	30, 210	90.3 ab	231.5	181.2 a	48.3 b	13.3 ab	564.6 a	474.3 a	0.0	474.3 a	43.2 a	10.9 b
5	MAP + AMS, ESN	300	30, 270	96.4 a	210.7	173.1 a	64.9 a	16.9 a	562.0 a	464.0 a	1.6	465.6 a	44.9 a	14.5 a
			Significance[3]	*	NS	**	**	*	**	**	NS	**	**	**
			LSD (0.10)	16.0	--	47.5	14.8	8.9	53.1	53.2	--	53.5	8.0	2.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 15. Effect of nitrogen rate from ESN fertilizer on Alpine Russet tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	0.0	1.0802	17.6
2	MAP + AMS, ESN	120	30, 90	0.0	0.0	0.0	1.0725	19.5
3	MAP + AMS, ESN	180	30, 150	2.0	2.0	0.0	1.0758	20.0
4	MAP + AMS, ESN	240	30, 210	2.0	2.0	0.0	1.0765	19.8
5	MAP + AMS, ESN	300	30, 270	3.3	4.3	0.0	1.0798	20.7
			Significance[3]	NS	NS	--	NS	NS
			LSD (0.10)	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 16. Effect of nitrogen rate from ESN fertilizer on Dakota Trailblazer tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	4.3 c	4.3 c	0.0	1.0985	26.6 ab
2	MAP + AMS, ESN	120	30, 90	11.0 bc	11.0 bc	4.3	1.1074	26.3 b
3	MAP + AMS, ESN	180	30, 150	15.0 bc	15.0 bc	0.0	1.1045	27.3 a
4	MAP + AMS, ESN	240	30, 210	37.8 a	37.8 a	0.0	1.1057	26.7 ab
5	MAP + AMS, ESN	300	30, 270	22.3 b	22.3 b	0.0	1.1020	24.9 c
			Significance[3]	**	**	NS	NS	**
			LSD (0.10)	14.2	14.2	--	--	1.0

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 17. Effect of nitrogen rate from ESN fertilizer on Russet Burbank tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0 c	0.0 c	0.0	1.0758 c	20.0
2	MAP + AMS, ESN	120	30, 90	3.0 c	2.0 c	0.0	1.0839 a	19.7
3	MAP + AMS, ESN	180	30, 150	6.3 bc	6.3 bc	0.0	1.0823 ab	21.0
4	MAP + AMS, ESN	240	30, 210	19.0 a	19.0 a	3.0	1.0799 b	21.1
5	MAP + AMS, ESN	300	30, 270	18.3 ab	18.3 ab	0.0	1.0831 ab	20.8
			Significance[3]	*	++	NS	**	NS
			LSD (0.10)	12.7	12.4	--	0.0037	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 18. Effect of nitrogen rate from ESN fertilizer on Ivory Crisp tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	18.8	1.0758 c	18.9 d
2	MAP + AMS, ESN	120	30, 90	1.0	1.0	9.0	1.0851 b	20.9 c
3	MAP + AMS, ESN	180	30, 150	1.0	1.0	20.0	1.0864 ab	21.1 bc
4	MAP + AMS, ESN	240	30, 210	1.0	2.0	17.0	1.0880 ab	22.1 ab
5	MAP + AMS, ESN	300	30, 270	1.0	1.0	18.0	1.0894 a	22.5 a
			Significance[3]	NS	NS	NS	**	**
			LSD (0.10)	--	--	--	0.0038	1.1

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 19. Effect of nitrogen rate from ESN fertilizer on Snowden tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	1.0	1.0835	20.8 b
2	MAP + AMS, ESN	120	30, 90	0.0	0.0	12.0	1.0875	22.2 ab
3	MAP + AMS, ESN	180	30, 150	3.0	4.0	1.0	1.0893	22.8 a
4	MAP + AMS, ESN	240	30, 210	3.0	3.0	0.0	1.0871	22.4 ab
5	MAP + AMS, ESN	300	30, 270	6.0	6.0	4.3	1.0922	23.5 a
			Significance[3]	NS	NS	NS	NS	++
			LSD (0.10)	--	--	--	--	1.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 20. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Alpine Russet potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	1.16 c	1.52	2.02 a	1.30 ab	3.11 a	1.29	2.65 a	0.39	3.76 a
2	MAP + AMS, ESN	120	30, 90	1.29 bc	1.50	1.86 ab	1.57 a	2.17 b	0.93	3.48 a	0.30	3.13 a
3	MAP + AMS, ESN	180	30, 150	1.18 c	1.46	1.50 bc	0.92 c	2.64 ab	0.98	2.99 a	0.72	3.10 a
4	MAP + AMS, ESN	240	30, 210	1.43 ab	1.34	1.24 c	1.17 bc	1.81 b	0.89	2.75 a	0.38	1.96 b
5	MAP + AMS, ESN	300	30, 270	1.54 a	1.49	0.73 d	1.48 ab	1.74 b	0.86	1.40 b	0.29	1.38 b
			Significance[3]	**	NS	**	*	++	NS	*	NS	**
			LSD (0.05)	0.17	--	0.40	0.34	0.91	--	1.09	--	0.97

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 21. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Dakota Trailblazer potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.82 c	1.45	0.31 b	0.99 ab	0.55	0.47	0.90	0.67	0.62
2	MAP + AMS, ESN	120	30, 90	0.86 c	1.54	0.61 a	1.07 a	0.54	0.55	0.68	0.40	0.95
3	MAP + AMS, ESN	180	30, 150	0.98 b	1.39	0.41 ab	0.94 abc	0.51	0.63	0.60	0.74	0.85
4	MAP + AMS, ESN	240	30, 210	1.07 b	1.50	0.25 b	1.50 c	0.41	0.61	0.37	0.96	0.65
5	MAP + AMS, ESN	300	30, 270	1.19 a	1.38	0.48 ab	1.38 bc	0.48	0.50	0.65	0.75	0.89
			Significance[3]	**	NS	++	*	NS	NS	NS	NS	NS
			LSD (0.05)	0.12	--	0.26	0.16	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 22. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Russet Burbank potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.79 c	0.94	2.40	1.08	3.07 a	0.48	2.42	0.23	2.61
2	MAP + AMS, ESN	120	30, 90	1.06 b	0.78	1.49	1.22	2.42 ab	0.42	1.36	0.32	2.24
3	MAP + AMS, ESN	180	30, 150	1.12 ab	0.83	1.37	1.02	1.81 bc	0.49	1.98	0.23	1.81
4	MAP + AMS, ESN	240	30, 210	1.14 ab	0.95	1.76	0.85	1.88 bc	0.42	1.68	0.29	1.50
5	MAP + AMS, ESN	300	30, 270	1.23 a	1.24	1.56	1.27	1.58 c	0.60	1.52	0.13	1.67
			Significance[3]	**	NS	NS	NS	*	NS	NS	NS	NS
			LSD (0.05)	0.18	--	--	--	0.72	--	--	--	--

Table 23. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Ivory Crisp potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.96 d	0.37	0.61 a	0.48	0.45 a	0.55	0.98	0.33	1.10 a
2	MAP + AMS, ESN	120	30, 90	1.09 c	0.52	0.28 b	0.61	0.28 ab	0.41	0.60	0.40	1.10 a
3	MAP + AMS, ESN	180	30, 150	1.19 b	0.66	0.29 b	0.76	0.29 ab	0.95	0.66	0.40	0.72 b
4	MAP + AMS, ESN	240	30, 210	1.20 b	0.63	0.24 b	0.81	0.24 ab	0.86	0.53	0.92	0.56 b
5	MAP + AMS, ESN	300	30, 270	1.48 a	0.92	0.11 b	0.72	0.11 b	0.46	0.22	0.70	0.48 b
			Significance[3]	**	NS	*	NS	++	NS	NS	NS	**
			LSD (0.05)	0.08	--	0.21	--	0.21	--	--	--	0.30

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 24. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Snowden potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	1.11	1.18 a	0.29 a	0.91 a	0.42 a	1.43	0.65	2.36 a	3.41
2	MAP + AMS, ESN	120	30, 90	1.21	1.13 ab	0.30 a	0.87 a	0.23 b	1.17	0.53	1.22 c	2.48
3	MAP + AMS, ESN	180	30, 150	1.03	0.95 bc	0.16 b	0.68 b	0.23 b	1.33	0.77	1.98 ab	2.93
4	MAP + AMS, ESN	240	30, 210	1.14	1.05 abc	0.22 ab	0.67 b	0.20 b	1.32	0.42	1.86 ab	2.57
5	MAP + AMS, ESN	300	30, 270	1.16	0.91 c	0.12 b	0.73 ab	0.10 b	0.97	0.33	1.62 bc	2.82
			Significance[3]	NS	++	++	*	**	NS	NS	*	NS
			LSD (0.05)	--	0.20	0.12	0.19	0.15	--	--	0.63	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 25. Effect of nitrogen rate from ESN fertilizer on tuber frying quality of Ivory Crisp potato tubers in Becker, MN.

Nitrogen Treatments				Frying Quality							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score
1	MAP + AMS	30	30, 0	2.3	56.0	2.0	57.3 ab	2.0	56.0	3.0 a	50.3 b
2	MAP + AMS, ESN	120	30, 90	2.0	58.5	2.0	57.8 ab	2.0	57.5	2.3 b	57.0 a
3	MAP + AMS, ESN	180	30, 150	2.0	58.0	2.3	56.0 b	2.0	59.0	2.0 b	58.8 a
4	MAP + AMS, ESN	240	30, 210	2.3	58.0	2.0	59.0 a	2.0	58.0	2.0 b	59.5 a
5	MAP + AMS, ESN	300	30, 270	2.0	58.3	2.0	59.3 a	2.0	58.3	2.3 b	58.0 a
			Significance[3]	NS	NS	NS	++	--	NS	*	*
			LSD (0.10)	--	--	--	2.4	--	--	0.5	5.5

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

[4]Chip Color Score: 1 = light and 5 = dark.

Treatments that have the same letter within a column are not significantly different from each other.

Table 26. Effect of nitrogen rate from ESN fertilizer on frying quality of Snowden potato tubers in Becker, MN.

Nitrogen Treatments				Frying Quality							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score
1	MAP + AMS	30	30, 0	2.0	58.8	2.0	58.3	2.3	53.7	3.8	42.0
2	MAP + AMS, ESN	120	30, 90	2.0	57.8	2.0	58.8	2.5	54.8	3.8	43.0
3	MAP + AMS, ESN	180	30, 150	2.0	58.3	2.0	59.0	2.5	55.3	3.5	43.0
4	MAP + AMS, ESN	240	30, 210	2.0	58.8	2.0	57.8	2.0	57.8	3.0	46.8
5	MAP + AMS, ESN	300	30, 270	2.3	59.0	2.0	58.8	2.0	58.0	3.3	44.0
			Significance[3]	NS	NS	NA	NS	NS	NS	NS	NS
			LSD (0.10)	--	--	--	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

[4]Chip Color Score: 1 = light and 5 = dark.

Treatments that have the same letter within a column are not significantly different from each other.

Table 27. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Alpine Russet French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	420	629	543 cd	912
2	MAP + AMS, ESN	120	30, 90	359	824	705 bc	1071
3	MAP + AMS, ESN	180	30, 150	532	525	816 ab	1104
4	MAP + AMS, ESN	240	30, 210	476	113	1010 a	1128
5	MAP + AMS, ESN	300	30, 270	403	1021	478 d	756
			Significance[3]	NS	NS	**	NS
			LSD (0.05)	--	--	225	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 28. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Dakota Trailblazer French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	137	445	114	117 c
2	MAP + AMS, ESN	120	30, 90	144	254	312	192 bc
3	MAP + AMS, ESN	180	30, 150	85	126	192	449 a
4	MAP + AMS, ESN	240	30, 210	93	413	219	337 abc
5	MAP + AMS, ESN	300	30, 270	100	382	226	395 ab
			Significance[3]	NS	NS	NS	*
			LSD (0.05)	--	--	--	229

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 29. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Russet Burbank French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	407 b	491	408	564
2	MAP + AMS, ESN	120	30, 90	474 b	669	845	996
3	MAP + AMS, ESN	180	30, 150	760 a	918	1118	840
4	MAP + AMS, ESN	240	30, 210	443 b	755	788	955
5	MAP + AMS, ESN	300	30, 270	826 a	745	713	1016
			Significance[3]	**	NS	NS	NS
			LSD (0.05)	186	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 30. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Ivory Crisp potato chips in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	3533	2929	1400	4037 a
2	MAP + AMS, ESN	120	30, 90	3031	2737	1334	2832 b
3	MAP + AMS, ESN	180	30, 150	3615	3484	1024	2194 bc
4	MAP + AMS, ESN	240	30, 210	3187	1840	1351	1555 c
5	MAP + AMS, ESN	300	30, 270	3114	2861	1376	1727 c
			Significance[3]	NS	NS	NS	**
			LSD (0.05)	--	--	--	1094

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 31. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Snowden potato chips in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	2950	1697 b	2993 a	10044 ab
2	MAP + AMS, ESN	120	30, 90	3363	3152 a	2564 ab	10881 a
3	MAP + AMS, ESN	180	30, 150	2409	1725 b	3035 a	11632 a
4	MAP + AMS, ESN	240	30, 210	2568	1291 b	1553 b	7431 bc
5	MAP + AMS, ESN	300	30, 270	2643	1587 b	1620 b	5399 c
			Significance[3]	NS	**	*	*
			LSD (0.05)	--	816	1042	3433

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 32. Acrylamide contents of fries and chips vs. raw tuber sugar and nitrogen concentrations for Becker, MN[1].

	Acrylamide vs:	R^2	P	N	Direction
Alpine Russet	Sucrose, harvest	0.075	0.3223	15	0
	Sucrose, 3 months	0.099	0.2191	17	0
	Sucrose, 6 months	0.036	0.4672	17	0
	Sucrose, 9 months	0.115	0.2154	15	0
	Glucose, harvest	0.006	0.7796	15	0
	Glucose, 3 months	0.059	0.3468	17	0
	Glucose, 6 months	0.096	0.2263	17	0
	Glucose, 9 months	0.031	0.5309	15	0
	Nitrogen, harvest	<0.001	0.9887	15	0
	Nitrogen, 3 months	0.130	0.1550	17	0
	Nitrogen, 6 months	0.002	0.8725	17	0
	Nitrogen, 9 months	0.016	0.6509	15	0
Dakota Trailblazer	Sucrose, harvest	0.067	0.2994	18	0
	Sucrose, 3 months	0.183	0.1276	14	0
	Sucrose, 6 months	0.038	0.5073	14	0
	Sucrose, 9 months	0.063	0.3672	15	0
	Glucose, harvest	0.053	0.3561	18	0
	Glucose, 3 months	0.084	0.3145	14	0
	Glucose, 6 months	<0.001	0.9727	14	0
	Glucose, 9 months	<0.001	0.9564	15	0
	Nitrogen, harvest	0.055	0.3493	18	0
	Nitrogen, 3 months	<0.001	0.9492	14	0
	Nitrogen, 6 months	0.016	0.6638	14	0
	Nitrogen, 9 months	**0.321**	**0.0162**	**15**	**+**
Russet Burbank	Sucrose, harvest	0.075	0.2573	19	0
	Sucrose, 3 months	*0.229*	*0.0521*	*17*	-
	Sucrose, 6 months	0.109	0.2110	16	0
	Sucrose, 9 months	0.111	0.1768	18	0
	Glucose, harvest	0.032	0.4674	19	0
	Glucose, 3 months	0.002	0.8553	17	0
	Glucose, 6 months	0.014	0.6681	16	0
	Glucose, 9 months	0.047	0.3875	18	0
	Nitrogen, harvest	0.147	0.1050	19	0
	Nitrogen, 3 months	<0.001	0.9549	17	0
	Nitrogen, 6 months	0.029	0.5311	16	0
	Nitrogen, 9 months	*0.193*	*0.0680*	*18*	+

	Acrylamide vs:	R^2	P	N	Direction
Ivory Crisp	Sucrose, harvest	0.046	0.3936	18	0
	Sucrose, 3 months	**0.290**	**0.0470**	**14**	**+**
	Sucrose, 6 months	0.024	0.6147	13	0
	Sucrose, 9 months	0.095	0.2839	14	0
	Glucose, harvest	0.025	0.5328	18	0
	Glucose, 3 months	0.163	0.1517	14	0
	Glucose, 6 months	<0.001	0.9722	13	0
	Glucose, 9 months	*0.220*	*0.0517*	*14*	+
	Nitrogen, harvest	0.001	0.9046	18	0
	Nitrogen, 3 months	0.002	0.8971	14	0
	Nitrogen, 6 months	0.085	0.3337	13	0
	Nitrogen, 9 months	0.203	0.1059	14	-
Snowden	*Sucrose, harvest*	*0.207*	*0.0581*	*18*	+
	Sucrose, 3 months	0.094	0.2305	17	0
	Sucrose, 6 months	<0.001	0.9512	18	0
	Sucrose, 9 months	0.045	0.3993	18	0
	Glucose, harvest	**0.378**	**0.0067**	**18**	**+**
	Glucose, 3 months	0.012	0.6822	17	0
	Glucose, 6 months	**0.312**	**0.0160**	**18**	**+**
	Glucose, 9 months	0.107	0.1846	18	0
	Nitrogen, harvest	0.023	0.5450	18	0
	Nitrogen, 3 months	0.062	0.3371	17	0
	Nitrogen, 6 months	0.146	0.1179	18	0
	Nitrogen, 9 months	0.110	0.1778	18	0

[1]Linear regressions: Acrylamide content of fried potato product at each sampling period as a function of whole-tuber glucose or sucrose content in the same period or whole-tuber nitrogen content at harvest.

Table 33. Whole-tuber sugar concentrations of participating growers' potato plants in MN.

Grower	Variety	Preparation	Sugar Concentration (mg/g)							
			0 Months		3 Months		6 Months		9 Months	
			Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]
K+O	Alpine Russet	Fry	2.11 ± 0.74	0.82 ± 0.34	1.74 ± 0.44	0.97 ± 0.54	0.94 ± 0.10	0.73 ± 0.17	2.75 ± 2.74	1.90 ± 1.97
K+O	Russet Burbank	Fry	1.82 ± 0.84	0.95 ± 0.42	1.58 ± 0.57	1.05 ± 0.23	0.77 ± 0.33	0.71 ± 0.16	1.49 ± 0.85	1.22 ± 0.41
Park Rapids Bliss	Russet Burbank	Fry	0.89 ± 0.33	0.74 ± 0.30	1.03 ± 0.19	1.13 ± 0.36	0.73 ± 0.06	1.17 ± 0.21	0.90 ± 0.13	1.19 ± 0.50
Park Rapids HCBE	Russet Burbank	Fry	1.22 ± 0.12	1.02 ± 0.27	0.98 ± 0.22	1.16 ± 0.42	0.55 ± 0.08	0.91 ± 0.33	0.89 ± 0.14	0.74 ± 0.36
Perham-Karsina	Dakota Trailblazer	Fry	1.12 ± 0.15	0.58 ± 0.13	1.44 ± 0.05	0.90 ± 0.23	1.00 ± 0.28	0.57 ± 0.11	1.08 ± 0.09	0.45 ± 0.34
Perham-RDO	Ivory Crisp	Chip	1.75 ± 0.63	0.12 ± 0.04	1.28 ± 0.26	0.27 ± 0.15	0.72 ± 0.05	0.05 ± 0.03	1.66 ± 0.10	0.39 ± 0.20
Goenner	Snowden	Chip	0.81 ± 0.14	0.08 ± 0.04	0.61 ± 0.01	0.11 ± 0.03	0.83 ± 0.15	0.27 ± 0.19	2.69 ± 0.38	2.39 ± 0.78
		Significance[2]	*	**	**	**	NS	**	NS	NS
		LSD (0.10)	0.85	0.39	0.48	0.49	--	0.27	--	--

[1]Mean ± S.D.

[2]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Table 34. Tuber frying quality of participating growers' potato tubers in MN.

Grower	Variety	Preparation	Frying Quality							
			0 Months		3 Months		6 Months		9 Months	
			Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]
Perham-RDO	Ivory Crisp	Chip	2.0 ± 0.0	57.7 ± 3.1	2.0 ± 0.0	59.3 ± 2.1	-	-	2.0 ± 0.0	58.0 ± 1.7
Goenner	Snowden	Chip	2.0 ± 0.0	62.7 ± 1.2	2.0 ± 0.0	59.0 ± 1.0	2.0 ± 0.0	57.3 ± 1.2	3.0 ± 0.0	50.3 ± 3.2

[1]Mean ± S.D.

[2]Chip Color Score: 1 = light and 5 = dark.

Table 33. Acrylamide concentrations of French fries and chips from participating growers' potato plants in MN.

Grower	Variety	Preparation	Acrylamide Concentration[1] (ppb, fresh-weight basis)			
			0 Months	3 Months	6 Months	9 Months
K+O	Alpine Russet	Fry	409 ± 205	619 ± 34	633 ± 395	1291 ± 643
K+O	Russet Burbank	Fry	582 ± 281	802 ± 362	519 ± 219	1306 ± 249
Park Rapids Bliss	Russet Burbank	Fry	678 ± 220	717 ± 427	781 ± 91	788 ± 142
Park Rapids HCBE	Russet Burbank	Fry	493 ± 67	838 ± 321	681 ± 171	834 ± 116
Perham-Karsina	Dakota Trailblazer	Fry	554 ± 49	371 ± 243	584 ± 121	908 ± 363
Perham-RDO	Ivory Crisp	Chip	3510 ± 859	2020 ± 658	1056 ± 119	1469 ± 320
Goenner	Snowden	Chip	2197 ± 608	1311 ± 156	1908 ± 994	5930 ± 563

[1]Mean ± S.D.

PROJECT 6: Developing Sustainable, Effective, and Economical Weed Control Methods for Onion Production in North Dakota

Final Report

Project Summary

Weed control is the major obstacle for ND onion producers and weeds are most damaging to yield early in the growing season. While herbicides can be effective measures of weed control, they often cause injury to the onion crop, especially in the early stages of development. Ongoing research has shown that crop safety and somewhat consistent weed control can be achieved by applying multiple applications of post-emergent (POST) herbicides at reduced-rates (micro-rates) during early growth stages, or by applying pre-emergent (PRE) herbicides. However, the integration of these methods of weed control into an effective, yet economical system has yet to be investigated. The objectives of this project were to determine if PRE herbicide applications in combination with subsequent POST micro-rate herbicide applications could provide early-season weed control in onion. To achieve the objective, field experiments were conducted during the summer in 2010 at two locations near Oakes, ND and at Great Bend, ND, and in 2011 at two locations near Oakes, ND and Dawson, ND. Demonstration plots were also conducted at NDSU Research Extension Centers for field days. Weed control and onion yield data from these locations indicated that onion treated with bromoxynil provided 12.1% better weed control and 8.5 t/ha greater large-grade onion yield than onion treated with oxyfluorfen. Increasing herbicide rates increased weed control, decreased weed density, and increased large-grade onion yield. The inclusion of either methylated seed oil (MSO) or petroleum oil concentrate (POC) adjuvants with reduced-rate herbicide applications improved weed control approximately 28%. Weed density and onion stand were least and greatest, respectively, with the addition of MSO or POC to the reduced-rate herbicide application. Four or Five sequential reduce-rate applications provided approximately 16% better weed control than three applications. Tank-mixing several herbicides at reduced rates will broaden the weed control spectrum and increase onion yield in comparison to micro-rate applications with a single herbicide. Onion injury was too high when oxyfluorfen was utilized in the first micro-rate application, but is needed for common lambsquarters control. Applying a PRE herbicide at a reduced rate followed by micro-rate applications provided effective weed control, but did not provide significantly greater onion yields. Additional research is needed varying the PRE herbicide rate so that the best micro-rate combination can be incorporated. Further research should also evaluate the use of GDD-based or “as-needed” sequential herbicide applications with the onion micro-rate.

Project Approach

General Procedures

Herbicide micro-rate applications were made using a CO_2-pressurized backpack sprayer equipped with 8002[6] flat-fan nozzles spaced at 48 cm mounted on a 1.4-m-wide boom. Mid-season standard weed control treatments, in-season nitrogen, and grass control applications were made with a tractor mounted sprayer equipped with 8002 flat-fan nozzles spaced at 48 cm on a 10-m boom, except at Oakes where the boom length was 2.8 m. All applications were made with an operating pressure of 210 kPa, a speed of 5.5 km/h, and a spray volume of 190 L/ha. Reduced application volumes were chosen based on the research of Schumacher and Hatterman-Valenti (2007) in onion.

Best management practices were used for planting[7, 8], fertility, irrigation, and pest control at each location. 'Teton' onion was seeded in four, paired-rows at 543,000 seeds/ha. Nitrogen (28% UAN) was applied in-season at two-wk intervals (beginning when onion was between the 2- to 3-leaf stage) and did not total greater than 133 kg/ha. Grass weeds were controlled as needed with clethodim at 140 g ai/ha plus petroleum oil concentrate (POC) at 1% vol/vol or fluazifop-P at 210 to 280 g ai/ha plus a nonionic surfactant[9] at 0.5% vol/vol. Late-season broadleaf weeds were controlled with a standard POST applications of bromoxynil and oxyfluorfen at 280 g /ha and 1120 g /ha during the 2- to- 5-leaf stage.

Onion yields were obtained by harvesting 1.5 m of the middle two rows in each four-row plot (total plot length was generally 6 m) and grading according to USDA standards by size and quality (USDA 1997). Prior to grading, onion was allowed to cure for at least 2 wk in a well-ventilated storage room. Grades were determined by bulb diameter: cull (< 2.5 cm); small (2.5 to 5.7 cm); medium (5.7 to 7.6 cm); and large (> 7.6 cm). Split and diseased bulbs were graded as culls regardless of diameter.

Common lambsquarters was the first broadleaf weed to emerge each season and was the dominant broadleaf weed species at each location with a mean density of 118 plants/m^2. Other broadleaf species including redroot pigweed (*Amaranthus retroflexus* L.), hairy nightshade *(Solanum sarrachoides* S.), kochia (*Kochia scoparia* L.), and common purslane (*Portulaca oleracea* L.) were either not present or had low densities across each location. Common lambsquarters control was representative of the other minor weeds controlled and will be the focus of this discussion.

Visual evaluations were used to assess overall early season broadleaf weed control after all herbicide applications were made. These evaluations were taken approximately 3 wk after the fourth micro-rate application for the adjuvant efficacy field experiment or 2 wk after the fifth micro-rate application for the sequential application field experiment using a 0 to 100% scale, where 0 was no visible injury or no control and 100 was plant death. In each plot, weed densities were counted in a 0.1 m^2 quadrate 3 wk after the fourth micro-rate application for the adjuvant efficacy field experiment or 2 wk after the fifth micro-rate application for the sequential application field experiment. These weed counts were later equated to a full m^2 for discussion

purposes. At the same time, stand counts were taken of a 1-m section of one middle paired-row to evaluate onion injury.

Adjuvant Efficacy Field Experiment and Sequential Application Field Experiment.

Adjuvant efficacy field experiments evaluated the use of methylated seed oil[4] (MSO) or petroleum oil concentrate[4] (POC) with bromoxynil or oxyfluorfen (aqueous capsule suspension[2]) applied in multiple sequential applications at reduced-rates (micro-rates) for weed control and onion safety. Sequential application field experiments evaluated the most effective number of consecutive micro-rate herbicide applications for weed control during establishment.

Herbicides were applied at 0.25X, 0.13X, and 0.06X, where "X" was the lowest labeled herbicide rate, with four sequential applications. Herbicide micro-rate treatments included bromoxynil at 70, 35, and 18 g ae/ha and oxyfluorfen at 70, 35, and 18 g ai/ha. These herbicides were selected based on the results of previous field research (Loken and Hatterman-Valenti 2010). Herbicide applications began in the field when weeds reached the cotyledon stage with sequential applications every 7 d. Two checks were used in this experiment for comparison to the micro-rate, a hand-weeded check and a weedy check (untreated).

Sequential Application Field Experiment.

Herbicides were applied at 0.13X (bromoxynil and oxyfluorfen at 35 g/ha), where "X" was the lowest labeled herbicide rate, with three, four, or five sequential applications. The 0.13X rate was chosen to emphasize the sequential application effect, rather than the herbicide rate. Previous onion weed control research concluded that three micro-rate applications provided better weed control than two, so two sequential applications was not included as a treatment (Loken and Hatterman-Valenti 2010). Herbicide applications began in the field when weeds reached the cotyledon stage with sequential applications every 7 d (Table 3). Two checks were used in this experiment for comparison to the micro-rate, a hand-weeded check and weedy check (untreated).

Micro-rate System Field Experiment.

Micro-rate system field experiments evaluated the use of PRE applications of pendimethalin and/or glyphosate followed by POST micro-rate applications including tank-mixes of bromoxynil, oxyfluorfen, clethodim, and MSO for weed control and onion safety.

Preemergence herbicide treatments included pendimethalin at 1.1 kg ai/ha as an early-PRE, glyphosate at 1.1 kg ae/ha as a late-PRE, and pendimethalin plus glyphosate as a late PRE. DCPA (11.2 kg ai/ha) was applied as an early-PRE for the conventional standard check. A no-PRE control was also included for comparison. Early-PRE applications were made shortly after planting and late-PRE applications were made just prior to onion emergence to maximize residual duration with pendimethalin and emerged weed control with glyphosate. Postemergence

herbicide treatments included tank-mixes of three different micro-rates. The "high" micro-rate was bromoxynil plus oxyfluorfen plus clethodim at 70 plus 70 plus 35 g/ha with MSO at 0.5% v/v; the "medium" micro-rate of the same herbicides was 70 plus 35 plus 35 with MSO at 0.5% v/v; the "low" micro-rate was of the same herbicides 35 plus 35 plus 35 with MSO at 0.5% v/v. Herbicide applications began in the field when weeds reached the cotyledon stage with sequential applications every 7 d. Five checks were used in this experiment for comparison to the PRE plus micro-rate treatments; a bromoxynil micro-rate check, an oxyfluorfen micro-rate check, a conventional herbicide standard check, a hand-weeded check, and a weedy check (untreated).

Statistical Evaluation

The experimental design at each location was a randomized complete block (RCBD) with four replications and a factorial arrangement of micro-rate and PRE or a factorial arrangement of herbicide, rate, and adjuvant. Data were also analyzed as a RCBD without factorial arrangement for comparison to the checks. Environments were considered random effects, while herbicide, rate, and adjuvant were considered fixed effects. Each environment was first analyzed separately to test for homogeneity of mean square error among environments using SAS[10]. Data with mean square errors within a factor of 10 were considered homogeneous and were pooled across environments. Mean squares were equated to expected mean squares to determine the proper denominators for *F*-tests. Treatment means were separated where appropriate using Fisher's protected LSD at the 0.05 level of significance unless otherwise specified.

Goals and Outcomes Achieved

Adjuvant Efficacy Field Experiment.

Bromoxynil (71.2%) provided better control of common lambsquarters than oxyfluorfen (59.1) when averaged across rate and adjuvant (Table 1). Large-grade onion yield confirmed these results as onion treated with bromoxynil (26.8 t/ha) had greater yields than onion treated with oxyfluorfen (18.3 t/ha). Bromoxynil has demonstrated similar effectiveness for control of common lambsquarters and other broadleaf weeds in other studies evaluating reduced-rates. Bromoxynil applied at 140 g/ha provided 88% control of 6-leaf common lambsquarters 4 wk after treatment (WAT) and this control was not different from the 280 g/ha rate (97%) (Brown et al. 2007). Bromoxynil applied at 70 g/ha resulted in 95% and 93% control of seedling common lambsquarters and redroot pigweed, respectively during a midseason evaluation (Loken and Hatterman-Valenti 2010). In contrast, droughty conditions resulted in poor 4- leaf common sunflower (*Helianthus* annuus) and ragweed parthenium (*Parathenium hysterophorus*) control 4 WAT (51 and 53%, respectively) with bromoxynil applied at 240 g/ha (Rosales-Robles et al. 2005), emphasizing the need to improve herbicide efficacy, possibly with adjuvants. Adjuvants were not used with bromoxynil in any of the research above.

Table 1. Effect of herbicide, averaged across rate and adjuvant, on percent common lambsquarters control and large-grade onion yield in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications.

Herbicide	Common lambsquarters	Large-grade yield
	% control	t/ha
Oxyfluorfen	59.1	18.3
Bromoxynil	71.2	26.8
LSD (0.05)	10.3	5.6

Oxyfluorfen has also been evaluated at reduced rates in other studies for common lambsquarters and broadleaf weed control. Oxyfluorfen was applied with POC at 2.3 L/ha to evaluate rate and (70 and 140 g/ha) and carrier volume (47 or 190 L/ha) (Zandstra and Wallace 1989). Resulting control of common lambsquarters, onion injury, and onion yield did not differ with application with rate or carrier volume during two evaluation years, with the exception of better common lambsquarters control with the greater application volume (190 L/ha) in one of the years. Overall common lambsquarters control was considered poor to fair, but common lambsquarters were, on average, 10 to 25 cm tall because applications were made at the onion 3- to 4-leaf stage. In comparison, micro-rate applications in this study were made to small weeds in the cotyledon stage (1-2 cm tall) and some individual treatments with oxyfluorfen provided acceptable weed control (Table 4).

Greater herbicide rates resulted in better weed control and reduced common lambsquarters density (Table 2). Common lambsquarters density was least (28.6 plants/m^2) when herbicides were applied at 70 g/ha. Densities were greatest when herbicides were applied at 18 or 35 g/ha (85.5 and 60.2 plants/m^2, respectively). Large-grade onion yield supported weed control and weed density results as herbicides applied at 35 or 70 g/ha resulted in greater yields than the 18 g/ha rate.

Table 2. Effect of rate, averaged across herbicide and adjuvant, on common lambsquarters control and density and large-grade onion yield in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications.

Herbicide rate[a]	Common lambsquarters		Large-grade yield
g/ha	% control	density/m^2	t/ha
18	47.1	85.5	14.6

35	66.7	60.2	23.1
70	81.4	28.6	30.0
LSD (0.05)	10.1	30.8	8.4

[a] bromoxynil rates expressed as g ae/ha; oxyfluorfen rates expressed as g ai/ha.

The use of either MSO or POC, averaged across herbicide and rate, increased common lambsquarters control, decreased common lambsquarters density, and tended to increase onion stand (Table 3). Resulting large-grade and total onion yield were also greater when either MSO or POC were used as a part of the treatment. Similarly, reduced sugarbeet injury, increased sugarbeet yield, and 86% control of the weed population were reported with micro-rate applications of desmedipham plus phenmedipham plus triflusulfuron plus clopyralid plus MSO (45 + 45 + 4.5 + 20 g/ha + 1.5% v/v, respectively) compared to the non-treated check (Wilson et al. 2005). In another study, the addition of POC at 0.25% v/v to a bromoxynil plus oxyfluorfen tank mix (280 + 140 g/ha, respectively) did not increase onion injury (2-leaf) compared to the same herbicide application without POC (Cudney and Orloff 1988). Russian thistle (*Salsola iberica*) control and fresh weight (percent of control) also increased (72 to 85% and 82 to 94%, respectively) with the addition of POC.

Table 3. Effect of adjuvant, averaged across herbicide and rate, on common lambsquarters control and density, onion stand, and large-grade and total onion yield in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications.

					Yield	
Adjuvant[a]	Rate	Common lambsquarters		Onion	Large-grade	Total
		% control	density/m^2	plants/m	---------- t/ha	----------
MSO	0.5% v/v	78.3	39.8	9.1	28.6	46.6
POC	1.2 L/ha	70.4	56.6	8.5	25.2	43.6
None	0	46.4	77.9	7.4	13.9	29.6
LSD (0.05)		11.8	22.4	1.2	8.5	9.8

[a] MSO, methylated seed oil; POC, petroleum oil concentrate.

Bromoxynil applied at 18, 35, or 70 g/ha did not reduce onion stand (Pr > F = 0.06) (Figure 1), and no visual injury observations were recorded. Bromoxynil also has demonstrated onion safety in other studies. Onion injury 1 WAT and height 3 WAT were not different than the untreated check with bromoxynil (80 or 340 g/ha) applied at the onion 1-leaf stage (Schumacher and Hatterman-Valenti 2007). Approximately 5% onion injury from bromoxynil (70 g/ha) was observed in a previous micro-rate study (Loken and Hatterman-Valenti 2010). However, bromoxynil at 280 g/ha (lowest current labeled rate) has injured 2-leaf onion when applications are made during low light intensity and high relative humidity (Menges and Tamez 1981).

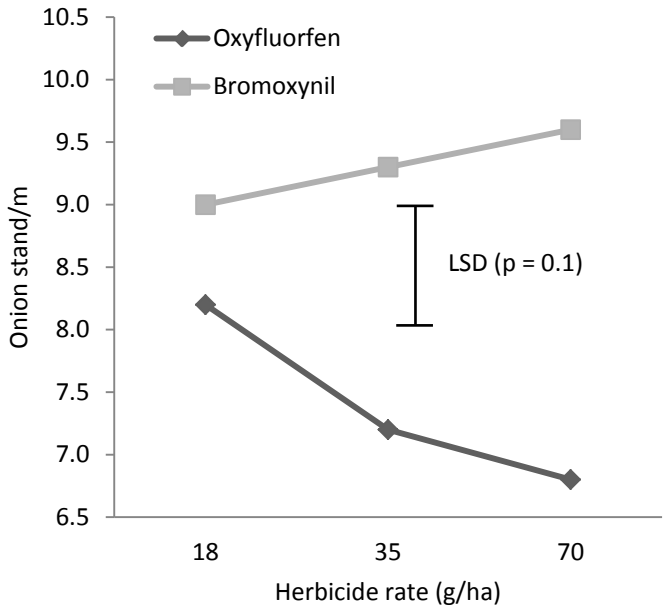

Figure 1. Effect of herbicide-by-rate interaction, averaged across adjuvants, on onion stand in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications. Oxyfluorfen rates expressed as g ai/ha and bromoxynil rates expressed as g ae/ha.

The magnitude of stand reduction was greatest with oxyfluorfen applied at 35 or 70 g/ha (Figure 1), supporting onion injury and stand reduction observations with oxyfluorfen at higher rates. Onion treated with higher oxyfluorfen rates commonly had constricted leaves near the soil surface. Additional micro-rate applications caused plant death and subsequent stand reduction. Similarly, a single oxyfluorfen dose (1-leaf onion) applied at 30 or 110 g/ha also injured onion (26 and 38%, respectively) 1 WAT (Schumacher and Hatterman-Valenti 2007). However, the injury symptoms caused by the single reduced herbicide dose did not impose any long-term effects and onion quickly recovered 3 WAT. Onion safety to oxyfluorfen at greater single dose rates (1200, 134, and 2500 g/ha) has been reported when applications were made to more mature, 3- to 4-leaf onion (Ghosheh 2004; Norsworthy et al. 2007; Qasem 2005). Maturity coupled with

warmer temperatures at application, may have allowed for greater onion cuticle thickness and reduced oxyfluorfen absorption, imparting selectivity.

Herbicide and herbicide rate interacted to effect total onion yield (Figure 2). Onion treated with bromoxynil had greater total yield than onion treated with oxyfluorfen at each rate. As rates increased, so did yield of onion treated with bromoxynil. The magnitude of the total yield difference between oxyfluorfen and bromoxynil increased at the 70 g/ha rate because onion treated with oxyfluorfen did not differ from 35 to 70 g/ha. This magnitude increase is attributed to increased onion injury and subsequent stand reduction from the 70 g/ha oxyfluorfen rate.

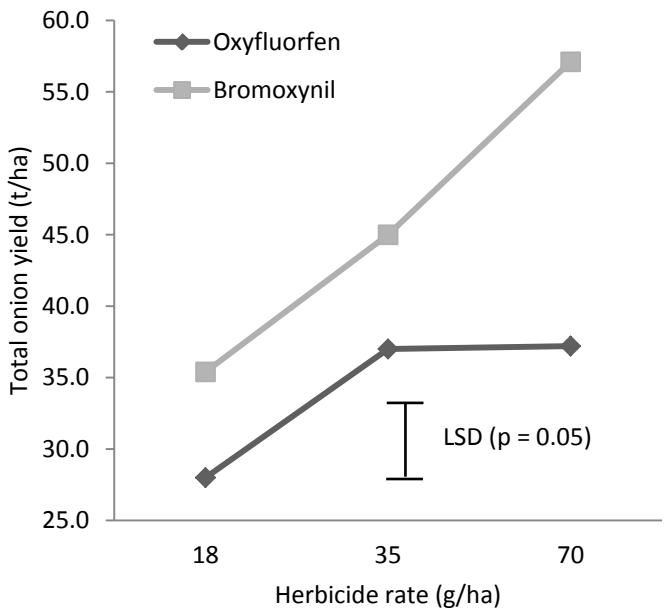

Figure 2. Effect of herbicide-by-rate interaction, averaged across adjuvants, on total onion yield in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications. Oxyfluorfen rates expressed as g ai/ha and bromoxynil rates expressed as g ae/ha.

The treatment analysis with checks confirmed the findings of the factorial analysis (Table 4). Common lambsquarters control and density tended to be greatest and least, respectively, with increasing bromoxynil rates plus MSO or POC, and was similar to the hand-weeded check. Oxyfluorfen at 70 g/ha plus MSO also provide similar common lambsquarters control and density reduction to the hand-weeded check, but reduced onion stand to levels as low as the weedy check. Onion stand reduction tended to be greatest with oxyfluorfen applied at 35 or 70 g/ha with MSO, POC, or no adjuvant. Stand reduction tended to be least with bromoxynil plus MSO or POC. Subsequent large-grade and total onion yield were greatest with bromoxynil applied at 35 or 70 g/ha plus MSO or POC, and with bromoxynil applied at 70 g/ha without an

adjuvant. These yields were greater than the hand-weeded check, possibly due damaged onion roots from the hand weeding process. Onion treated with oxyfluorfen tended to produce large-grade and total yields that were less than those treated with bromoxynil at 35 or 70 g/ha plus MSO or POC.

Table 4. Effect of herbicide + adjuvant treatment on common lambsquarters control and density, onion stand, and large-grade and total onion yield in adjuvant efficacy field experiments 3 wk after four sequential herbicide applications.

Herbicide	Adjuvant [a]	Herbicide + adjuvant rate	Common lambsquarters		Onion	Yield	
						Large-grade	Total
			% control	density/m^2	plants/m	---------- t/ha ----------	
Oxyfluorfen	MSO	70 g ai/ha+ 0.5 % v/v	89.3	27.6	7.3	33.2	46.1
Oxyfluorfen	MSO	35 g ai/ha + 0.5 % v/v	69.1	67.3	8.2	22.4	42.3
Oxyfluorfen	MSO	17 g ai/ha + 0.5 % v/v	59.4	58.5	9.4	16.2	34.9
Oxyfluorfen	POC	70 g ai/ha+ 1.2 L/ha	77.2	49.1	6.6	24.0	36.0
Oxyfluorfen	POC	35 g ai/ha + 1.2 L/ha	66.6	68.0	7.1	25.6	42.8
Oxyfluorfen	POC	17 g ai/ha + 1.2 L/ha	42.8	103.6	8.7	9.5	26.4
Oxyfluorfen	None	70 g ai/ha	52.5	53.8	6.4	12.2	29.3
Oxyfluorfen	None	35 g ai/ha	76.6	86.5	6.4	12.4	25.7
Oxyfluorfen	None	17 g ai/ha	28.1	93.5	6.6	9.3	22.6
Bromoxynil	MSO	70 g ae/ha+ 0.5 % v/v	93.3	0	10.1	37.4	56.6
Bromoxynil	MSO	35 g ae/ha + 0.5 % v/v	92.8	14.8	9.4	36.1	53.9
Bromoxynil	MSO	17 g ae/ha + 0.5 % v/v	65.9	70.6	10.0	26.1	46.0

Bromoxynil	POC	70 g ae/ha+ 1.2 L/ha	96.9	4.7	10.3	39.6	60.1
Bromoxynil	POC	35 g ae/ha + 1.2 L/ha	82.7	31.6	10.3	32.8	56.0
Bromoxynil	POC	17 g ae/ha + 1.2 L/ha	56.6	82.7	8.3	19.9	40.1
Bromoxynil	None	70 g ae/ha	78.3	36.3	8.3	33.7	54.5
Bromoxynil	None	35 g ae/ha	42.5	96.2	8.3	9.1	25.0
Bromoxynil	None	17 g ae/ha	28.1	104.3	8.6	6.7	20.2
Hand-weeded check	none	--	95.9	3.4	8.9	16.5	39.0
Weedy check	none	--	0	118.4	6.9	8.8	18.2
LSD (0.05)			16.2	47.3	2.4	12.5	18.2

[a] MSO, methylated seed oil; POC, petroleum oil concentrate.

Sequential Application Field Experiment.

Four or five sequential herbicide applications provided better common lambsquarters control than three sequential herbicide applications (Table 5). These results confirm weed emergence observations from 2008 and 2009 when it was noted that another common lambsquarters flush came after the third herbicide application. This flush was controlled in treatments with four or five herbicide applications, but plots receiving only three herbicide applications had poorer weed control. Increasing the number of sequential applications did not reduce onion stands.

Table 5. Effect of sequential herbicide applications, averaged across herbicide, on common lambsquarters control and onion stand with oxyfluorfen[a] and bromoxynil applied at 35 g/ha + MSO[b] at 0.5% v/v in sequential application field experiments.

No. of sequential applications	Common lambsquarters	Onion
	% control	plants/m
5	83.8	10.0
4	78.3	9.8
3	64.4	8.8
LSD (0.05)	13.3	ns

[a] Oxyfluorfen rates expressed as g ai/ha; bromoxynil rates expressed as g ae/ha.

[b] MSO, methylated seed oil.

Common lambsquarters control with bromoxynil applied four or five times was similar to the hand-weeded check (Table 6). Common lambsquarters control with oxyfluorfen applied four or five times was not different than bromoxynil applied three, four, or five times. Common lambsquarters densities tended to be inversely proportionate to the weed control ratings. Subsequent large-grade and total yield of onion treated with either bromoxynil or oxyfluorfen were not different from the hand-weeded check, with the exception of the large-grade hand-weed check yield which was less than onion treated with bromoxynil or oxyfluorfen. This reduction in large-grade yield was probably due to root injury incurred by the hand-weeding process.

Table 6. Effect of sequential herbicide applications on common lambsquarters control and density and large-grade and total onion yield with oxyfluorfen[a] and bromoxynil applied at 35 g/ha + MSO[b] at 0.5% v/v in sequential application field experiments.

Herbicide	No. of sequential applications	Common lambsquarters		Yield	
				Large-grade	Total
		% control	density/m^2	---------- t/ha ----------	
Bromoxynil	3	68.4	6.9	28.5	43.3
Bromoxynil	4	85.3	1.6	35.8	55.6
Bromoxynil	5	90.4	2.0	28.9	49.4
Oxyfluorfen	3	60.3	3.6	24.6	42.0
Oxyfluorfen	4	71.3	5.8	23.8	41.9
Oxyfluorfen	5	77.1	5.8	27.6	47.1
Hand-weeded check		100.0	0	14.7	38.0
Weedy check		0	10.6	6.6	13.7
LSD (0.05)		22.1	6.3	13.6	18.0

[a] Oxyfluorfen rates expressed as g ai/ha; bromoxynil rates expressed as g ae/ha.

[b] MSO, methylated seed oil.

Sequential herbicide applications were made at approximate 7 d intervals, weather permitting. Often times when applications were made, no weeds were present. A farmer would be better served, both agronomically and economically, to use the micro-rate for weed control when weeds are present, as illustrated by the poorer weed control with only 3 subsequent applications. In a similar study comparing sequential calendar day (7 d) micro-rate applications with micro-rate applications based on growing degree days (GDD) as predictive tool for weed emergence and micro-rate applications “as-needed” (herbicide applications based on the physical appearance of cotyledon-stage weeds) in sugarbeet, weed control and sugarbeet injury were not different and reduced, respectively, by spraying “as-needed” or according to GDD (Dale and Renner 2005).

Micro-rate System Field Experiment.

Broadleaf weed control with high, medium, or low micro-rates was 80% or better when a PRE application of glyphosate, pendimethilan, or the combination of the two was made at all locations, except the medium micro-rate with glyphosate at location A (63.8% overall control) and the low micro-rate with glyphosate at location B (62.5% overall control) (data not shown). This control was generally similar to the DCPA standard check, but poorer than the hand-weeded check. These results were confirmed in the factorial analysis. Overall weed control tended to be greater with glyphosate, pendimethalin, or a combination of the two than when no PRE was included in the weed control system. High and medium micro-rates provided better weed control than low micro-rates. Split applications of bromoxynil plus oxyfluorfen at 110 and 110 g/ha have also been shown to provide superior Venice mallow (*Hibiscus trionum*) control than when the same herbicides were applied singly (Westra et al. 1990). No weed control differences were detected for PRE or micro-rate factors.

Onion stands were severely reduced by PRE and micro-rate applications (Table 7 and 8). Palczynski et al. (2001) reported no onion injury when POST applications of bromoxynil plus oxyfluorfen were made to 2- to 3-leaf onion at full labeled rates. Slight injury was reported when bromoxynil was applied with oxyfluorfen in two or three applications at full labeled rates starting at the two leaf stage with DCPA applied PRE, but this injury did not factor to reduce yield (Boydston and Seymour 2002). In contrast, micro-rate applications in this study were made when onion were in the seedling stages and had already had PRE applications. Initial onion stands at the Oakes location were poor including untreated checks. Stands experienced greater initial reduction at Oakes because of herbicide carryover from the previous year, and remaining onion stand were further reduced by herbicide treatments. When glyphosate was applied as a late-PRE, onion stand reduction occurred due to uneven emergence and our inability to make timely applications given the distance of the trials from Fargo (Table 4). The late-PRE applications were intended to be made just prior to onion emergence, however at Oakes, Hample, and Great Bend some onion had already emerged (10%, 25%, and 5%, respectively) at the time of application, causing the nonselective activity of glyphosate to kill most emerged onion. Stand reduction at Great Bend from PRE or micro-rate applications was not as severe as at Oakes or Hample, but was still considered unacceptable (Table 8). Onion plots that did not receive a PRE application averaged 42.9 and 20.4% injury at Hample and Great Bend, respectively, indicating other environmental effects reduced onion stand. The effect of micro-rate on stand reduction was only significant at Oakes where greater herbicide rates per micro-rate caused greater stand reduction. Marketable and total yields corresponded to stand reduction and were generally low at each environment (data not shown).

The safe application of glyphosate, pendimethalin, or a combination of the two followed shortly by micro-rates of bromoxynil plus oxyfluorfen plus clethodim plus MSO cannot be recommended at this time due to severe onion stand reduction. Further research is necessary to evaluate different combinations and rates of bromoxynil, oxyfluorfen, clethodim, and MSO when

compared to these herbicides applied singly. Research should also evaluate onion safety when differing micro-rates are applied at differing onion growth stages.

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Table 7. Effect of herbicide treatments on onion stand 2 wk after the first micro-rate application at Oakes, Hample, and Great Bend, ND.

Herbicide treatments[a]				Stand reduction		
PRE	Rate[b]	Micro-rate[c]	Rate	Oakes	Hample	Great Bend
	g/ha		g/ha	---------- % ----------		
Gly	1100	Brom + oxy + cleth + MSO	70 + 70 +35 + 0.5% v/v	86.2	67.5	71.2
Pend	1100	Brom + oxy + cleth + MSO	70 + 70 +35 + 0.5% v/v	73.7	27.5	26.2
Gly + pend	1100 + 1100	Brom + oxy + cleth + MSO	70 + 70 +35 + 0.5% v/v	86.2	56.2	31.2
None	-	Brom + oxy + cleth + MSO	70 + 70 +35 + 0.5% v/v	76.2	36.2	28.7
Gly	1100	Brom + oxy + cleth + MSO	70 + 35 +35 + 0.5% v/v	86.2	70.0	38.7
Pend	1100	Brom + oxy + cleth + MSO	70 + 35 +35 + 0.5% v/v	71.2	17.5	36.2
Gly + pend	1100 + 1100	Brom + oxy + cleth + MSO	70 + 35 +35 + 0.5% v/v	82.5	71.2	30.0
None	-	Brom + oxy + cleth + MSO	70 + 35 +35 + 0.5% v/v	58.7	52.5	16.2
Gly	1100	Brom + oxy + cleth + MSO	35 + 35 +35 + 0.5% v/v	72.5	78.7	46.2
Pend	1100	Brom + oxy + cleth + MSO	35 + 35 +35 + 0.5% v/v	63.7	18.7	28.7
Gly + pend	1100 + 1100	Brom + oxy + cleth + MSO	35 + 35 +35 + 0.5% v/v	83.4	55.0	38.7
None	-	Brom + oxy + cleth + MSO	35 + 35 +35 + 0.5% v/v	53.7	40.0	16.2

Checks						
None	-	Brom + cleth + MSO	70 + 35 + 0.5% v/v	50.0	21.2	28.7
None	-	Oxy + cleth + MSO	70 + 35 + 0.5% v/v	56.2	18.7	11.2
DCPA[d]	11200	Brom + oxy	280 + 140	36.2	15.0	11.2
Hand-weeded	-	-	-	20.0	21.2	7.5
Weedy	-	-	-	15.0	5.0	7.5
LSD (0.05)				12.7	19.3	21.1

[a] Abbreviations: Gly, glyphosate; Pend, pendamethalin; Brom, bromoxynil; Oxy, oxyfluorfen; Cleth, clethodim; MSO, methylated seed oil.

[b] Glyphosate and bromoxynil rates expressed as g ae/ha.

[c] Micro-rate applications were applied four times.

[d] Conventional Standard Check, PRE application of DCPA followed by a single POST application at the 2- to 5-leaf stage.

Table 8. Effect of preemergence herbicide and postemergence micro-rate applications on onion stand 2 wk after the first micro-rate application and overall weed control 6 wk after the first micro-rate application at Oakes, Hample, and Great Bend, ND.

	Oakes		Hample		Great Bend	
Herbicide timing	Stand reduction	Overall control[a]	Stand reduction	Overall control	Stand reduction	Overall control
	%					

PRE[b]						
gly[c]	81.7	85.4	72.1	75.8	42.1	86.7
pend[d]	69.6	81.3	21.2	84.2	30.4	95.0
gly + pend	84.2	86.7	60.8	84.6	33.3	96.7
none	62.9	77.9	42.9	82.1	20.4	71.3
LSD (0.05)	6.8	5.8	10.7	ns	13.9	10.3
Micro-rate[e]						
High	81.6	87.8	46.9	85.0	31.9	97.5
Medium	74.7	83.4	52.8	78.4	30.3	91.6
Low	68.4	77.2	48.1	81.6	32.5	73.1
LSD (0.05)	5.9	5.0	ns	ns	ns	8.9

[a] Visually evaluated control of all weedy species per experimental unit.

[b] Preemergence herbicide application.

[c] Glyphosate at 1.1 kg ae/ha.

[d] Pendimethalin at 1.1 kg ai/ha.

[e] High, bromoxynil + oxyfluorfen + clethodim + MSO (70 g ae/ha + 70 g ai/ha +35 g ai/ha + 0.5% v/v); Medium, bromoxynil + oxyfluorfen + clethodim + MSO (70 g ae/ha + 35 g ai/ha +35 g ai/ha + 0.5% v/v); Low, bromoxynil + oxyfluorfen + clethodim + MSO (35 g ae/ha + 35 g ai/ha +35 g ai/ha + 0.5% v/v).

Beneficiaries

Any grower in North Dakota would benefit by crop diversification. Soil benefit from crop rotation have been shown repeatedly, however realistically, only those producers that are familiar with the management requirements of most specialty crops will be interested with the addition of onion to diversify their cropping system. The integration of PRE herbicides coupled with POST micro-rate applications into a system should provide producers an effective and consistent weed control tool for emerging annual broadleaf weeds. The fledgling ND onion industry has been dealing with crop failure due to lack of weed control on an annual basis. The information provided by this research is extremely important for ND onion producers (approximately 200 ha (500 acre) in 2009) because onions cannot overcome injury and insufficient weed control to produce a marketable yield with current inconsistent weed control options. The economic implications of this research are substantial, as onion production in ND is a potential multi-million dollar industry. For example, when onion prices were high in 2006, ND onion producers with a marketable crop had a potential net return on investment of approximately $8600/ha ($3500/acre). However, until the weed control issues are addressed, onion production in ND will not increase, and potential growers will be wary to assume the financial risk for a crop with limited and uncertain weed control options.

The field research was included in the NDSU Field Day, held at the Oakes Research Extension Center on July 26, 2011. Approximately 100 growers attended the field day and saw the early-season weed control with micro-rate system. All but one of the onion growers in North Dakota have incorporated part of the micro-rate system on some of their onions as they try to become more familiar with the micro-rate system and find ways to control early-season broadleaf weeds in onions.

Results from the field trials will also be made available to growers through the North Dakota Weed Control Research publication. This publication is available free online at http://www.ag.ndsu.edu/weeds/nd-weed-control-research.

Lessons Learned

The goal of this project was to address the need for reliable early season weed control in ND onion production. Several field experiments were designed to accomplish this goal. The experiments were located in grower fields as well as at NDSU REC's in order to provide outreach and demonstrate potential weed control options.

The benchmark for weed control and yield measurements described above may vary based on environmental conditions at each location. However, the controls used in this experiment provide an adequate means of comparison for each PRE/micro-rate treatment. The addition of MSO or POC to the reduced-rate herbicide application resulted in the lowest weed density and highest onion stand. Using four or five sequential micro-rate applications provided

better early-season and overall weed control compared to three micro-rate applications. Tank-mixing several herbicides at reduced rates will broaden the weed control spectrum and increase onion yield in comparison to micro-rate applications using a single herbicide. Onion injury was too high when oxyfluorfen was utilized in the first micro-rate application, but is needed for common lambsquarters control in this cropping system. Applying a PRE herbicide at a reduced rate followed by micro-rate applications provided effective weed control, but did not provide significantly greater onion yields. Additional research is needed with varied PRE herbicide rates so that the best micro-rate combination can be incorporated. Further research should also evaluate the use of GDD-based or "as-needed" sequential herbicide applications with the onion micro-rate.

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Additional information available (e.g. publications, web sites)

Presentations at Professional Meeting

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PROJECT 7: Strengthening Management of New Late Blight Genotypes for Quality Potato Production in North Dakota and Minnesota

Final Report

Project Summary

Because of the resurgence of late blight by new genotypes of *Phytophthora infestans* in the US and Canada, and our region, we requested and received funding from the Specialty Crop Block Grant to strengthen and improve our regional late blight management program. Potatoes are an important crop in our region. In 2009, ND planted 83,000 acres of potatoes with a value of 175 million dollars; MN planted 47,000 acres or potatoes with a value of 160 million dollars. Late blight has been present the past two years, and has the potential to cause widespread and severe losses in the field and in storage, and requires a concerted and integrated education and management plan for the industry in our region. Unexpectedly in 2009, three new genotypes of Pi – US22, US23 and US24 were discovered throughout the US and our region, including ND, MN, and MB. The program we implemented for control of these new genotypes was conducted in cooperation with the potato commodity groups of ND, MN, MB, the state governments of ND and MN, and the entire potato industry of ND, MN and MB - growers, processors, allied industries. The overall objective of this project is to evaluate the impact of these new genotypes in our region and strengthen our management plan for control of late blight.

Project Approach

Our 2011 management plan was an integrated approach with multiple components:

1. Grower and industry education

2. Early detection

3. Late blight forecasting

4. Fungicide trials

5. Development of late blight resistant varieties

1. Grower/industry education. Meetings were held to educate growers about the understanding and management of late blight.

2. Early detection. Sentinel plots, small plantings of untreated potatoes with no fungicide were planted early to act as a biological trap of any late blight in the area in order to provide an early warning to potato growers. Ten locations in ND including Potato Research Farm, NDSU campus, consultant offices and field sites, fungicide distributor sites, grower fields, were planted with the late blight susceptible variety Red LaSoda. The sites were planted early and monitored

frequently. If and when late blight found, potato plants are destroyed and late blight reported on the NDSU Blightline. A retired extension potato specialist (Duane Preston) was hired to monitor sentinel plots, to monitor retail tomato plants for late blight at big box retail stores, and to scout fields for late blight.

3. Late blight forecasting. The NDSU Blightline in operated June 1 – August 30 to forecast weather conditions favorable for late blight, forecast presence of late blight in the field, and to make fungicide recommendations. The Blightline uses data from 29 NDAWN weather stations to forecast late blight severity and favorability. A new report is issued every Monday, Wednesday, and Friday with late blight locations and disease control recommendations. Reports are available to growers and allied industries by phone, email, NDSU website, and published by Northern Plains Potato Growers Association weekly website Potato Bytes.

4. Fungicide trials. Fungicide trials were planted at the NDSU Prosper research station near Fargo. Inoculum of current late blight genotypes was prepared to inoculate the trials. Parallel trials were planned in the Manitoba production area. Fungicide treatments included 5-10 "real life" grower fungicide programs, experimental fungicides and biological fungicides. Both foliar and tuber late blight infection are rated in the trials. A non-field late blight seed treatment trial was conducted. Cut seed of Red LaSoda (LB susceptible) was tumbled with late blight infected seed and lab prepared inoculum. The trial consisted of 18 treatments designed as 4 replications with 25 seed pieces/replication. After inoculation and treatment, the seed was stored four weeks in paper bags at 12°C, and evaluated for late blight.

5. Development of late blight resistant varieties. As part of the NDSU potato breeding program, headed by Dr. Susie Thompson, a dedicated crossing block with late blight resistant parents was established to develop late blight resistant varieties. In 2011, approximately 9000 seedlings from 90 crosses were tested using a detached leaf assay procedure in the new NDSU greenhouse. From each cross, 100 seedlings are tested to identify families with high levels of late blight resistance for field selection. Selections are made in the field based on agronomic traits from families with highest levels of resistance. We continued to search for new late blight resistant parents to use in this program in future years; an example is the Patagonia variety from Chile, which may have a new source of resistance. Field trials were planted at the NDSU Prosper site for new and advanced selections from the NDSU potato breeding program to evaluate late blight resistance, and the National Late Blight Trial to test advanced selections from multiple US potato breeding programs for resistance to late blight.

Goals and Outcomes Achieved

OUTCOME 1: The PI Secor spoke at the Manitoba Potato Days January 26, coordinated a late blight symposium at the International Crop Expo in Grand Forks, ND February 17, spoke at the MN Area II Potato Growers meeting March 1, and at a grower only meeting April 21 in Hoople, ND. A late blight update was given at the NPPGA field day meetings August 25. In concert with

the Departments of Agriculture in ND and MN and NDSU, we wrote and distributed electronically a Plant Disease Alert for organic growers, home gardeners and farmer markets entitled "Late Blight: A Plant Disease That Impacts the Community". Approximately 40 samples of late blight were received from growers, agronomists and consultants. Approximately 100 phone calls were received to answer questions about late blight and to provide management recommendations.

OUTCOME 2: No late blight was found in either the sentinel plots or retail tomato plants in big box stores in the region during the period from May 1 – July 31.

OUTCOME3: The NDSU Blightline was delivered to target audiences as planned. Based informal grower surveys, the Blightline is widely used and read and is the main source of late blight information to growers in our region. This year most growers began spraying fungicides early before threshold severity value reached and continued on a 5-7 day regular schedule. Early fungicide application was due to several factors, including a high threat of late blight, seed borne late blight, favorable weather, large acreages that take several days to spray, and because growers do not want to get behind if late blight appears. Because we have few resistant varieties, frequent fungicide applications are necessary.

OUTCOME 4: Fungicide field trials were planted and inoculum planted, but the field trials were lost to flooding due to excessive rain. Differences between seed treatment fungicides for control of seed-borne late blight were found, and the results communicated to the industry. It is anticipated that these trials will be continued, as there is great interests in this trial. New late blight seed treatment trials will be conducted in 2012, and

OUTCOME 5: Overall, about 5% of families with >6o% of the seedlings with resistance to late blight were identified in greenhouse detached leaf assays. Seedlings from the resistant families will planted in 2012 and selections made based on agronomic traits. Due to excessive flooding, the field trials were lost in 2011. New genotypes affect cultivar resistance, and continuous screening will be necessary to develop resistant varieties.

OVERALL OUTCOME. The work done from this proposal established a complete late blight management plan that will be followed in subsequent years.

Beneficiaries

The primary beneficiaries of this project work are the potato commodity groups of ND (Northern Plains Potato Growers Association, approximately 500 growers), MN (Minnesota Area II Potato Council, approximately 50 growers). Secondary beneficiaries are the state governments of ND and MN, and the allied potato industries that include processors (Simplot, Lamb-Weston, Cavendish), consultants, fungicide dealers, wash plants, and seed growers. It is estimated that this group comprises approximately 1500 persons. The specific components of the late blight management plan will be adopted by all beneficiaries for late blight management. Presentation of

results from this work at grower meetings in 2012 will be used by growers to reduce late blight in their fields and storages, resulting in increased economic benefit. The authors of this work have established communication opportunities with the industry in our region and will monitor success of our work by personal visits, educational presentations, and field visits. Implementation of the plan reduced late blight losses in 2011 and should continue to do so in future years as growers continue to use data and findings from this work.

Lessons Learned

Despite a coordinated and strengthened late blight management plan, the disease was still present in our region, but losses were limited. Without such a plan in place, losses to late blight would have been much greater. Late blight is a serious and continuing disease and finds a way to cause disease despite integrated management strategies and tactics we develop. Continued development of resistant varieties will be necessary to reduce losses. Using this grant as a pattern, we anticipate continuing to actively manage late blight in future years to collectively reduce losses in our region. Good news is that late blight was not found on imported tomato or nursery plant in commercial “big box” stores. The program we proposed was implemented as planned, but due to excessive rain, fungicide trial and germplasm resistance trials were lost. These trials will be repeated in 2012 with separate funding.

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Additional information available (e.g. publications, web sites)

http://www.ndsu.edu/potato_pathology/

http://www.ag.ndsu.edu/pubs/plantsci/hortcrop/pp1565.pdf

PROJECT 8: Extrusion Processing of Beans: Texturized Protein and Puffed Products Development

Final Report

Project Summary

The use of extrusion processing is a viable technology to produce dry bean extruded products (snacks and cereals) and texturized vegetable proteins. In particular, foods for the gluten free, diabetic market and high protein markets can be created from beans. There is currently a lack of knowledge in developing non-traditional foods using beans. Therefore, the goal of this study was to develop processing protocol that can be used to create non-traditional products from beans. Beans were fractionated into starch and protein ingredients using air classification. The bean flours were milled to 100μ particle size or smaller and then aspired to separate the particles into a starch-rich fraction and protein-rich fraction. The protein fraction was made into texturized vegetable protein.

The extrudate from the protein fraction was composed of 39.2% (dry basis, d.b.) protein, 2.44% d.b. starch, and 7.2% d.b. ash. These values were similar to the raw bean flour indicating that minimal nutrient degradation during processing. Water adsorption of 3.1 g/g extrudate and water soluble index of 30.9% were lower in the extruded protein than the non-processed protein fraction. The extrusion did promote the browning of the extrudate and thus the extrudates were of darker color than the original protein fraction. The texturized protein required 20 minutes of cooking suggesting that smaller particles would help maintain quality of the texturized products. The texturized protein was evaluated as meat extenders in processed meat products. However, the products produced were of lower quality compared to the control or all meat products. However, the water holding capacity was slightly better for the bean fortified products. This indicated that additional research is needed to optimize formulations.

The fractionated starch ingredient was processed into puffed snack products. The puffed products were evaluated as non-flavored and cheese-flavored puffed snacks. Sensory evaluation indicated that the beaniness characteristic was slightly but not significantly lower in the puffed product prepared from the starch fraction compared to the puffed product made from whole bean flours. However, the rating for stickiness was not different between the fractionated starch and whole bean flour extrudates. The presence of fiber in the extrudate likely contributed to the stickiness of the extrudate. The stickiness of the products fell in the moderately sticky range of the sensory scale. Coating of the product reduced the stickiness but did not eliminate this attribute. Beany flavor dropped from an average score of 2.7 in the non-coated sample to 1.5 for the coated samples. This indicates that coat was an effective method for reducing the beaniness of the puffed products. Extrusion of the bean starch enhanced water solubility and water absorption properties of the starch.

The protein will find application as a texturized vegetable protein while the starch fraction has the potential to be used in puffed products or noodles. Future work in the extrusion and functionality of bean fractions should focus on optimization of the texturization process and the meat formulation optimization. The work focused on dry fractionation of the protein and

starch and thus a wet fractionation should be considered in the future. Comparison between dry fractionated and wet fractionated protein will further allow for the development of beans as ingredients in food products.

Project Approach

The project was broken into three phases. Phase 1 include the milling and fractionation of the beans, phase 2 involved processing of the bean fractions and phase 3 involved products application studies. In all three phases, both navy and pinto beans will be evaluated.

Beans were obtained from local bean suppliers. Navy and pinto beans were milled to an average particle size of 100 μm using a hammer mill. This served as the control flour. The remaining flour was air classified into protein and starch fractions. This was completed at Particle Control Milling Company (Albertville, MN) in July 2011. The flours were shipped immediately and stored at the Northern Crops Institute until processed.

Bean flours and protein fraction were extruded into a texturized protein. However, due to the difficulty in texturizing whole flour, our focus shifted to texturizing the protein fractions only. Extrusion conditions will include a barrel length of 130 cm, twin 5.25 cm diameter screws (co-rotating), a screw rotation of 300 rpm. A proprietary screw profile was used to texture the protein. Moisture content of approximately 11% moisture was evaluated. Texturizing was completed in September 2011 at the Northern Crops Institute (NCI; Fargo, ND). The texturized protein product was rehydrated and texture measured on a Brookfield Texture Analyzer.

The whole flour and the starch fraction were extruded into a puffed shape resembling a Cheetos, crisp (e.g. Rice Krispy), and corn balls. Extrusion conditions included the above barrel information but used a screw rotation of 320-380 rpm. Moisture content of 18% moisture was used during extrusion. The temperature in the extruder zone ranged from 40 to 100 C. The product was flavored with cheese and sensory evaluation completed. This will be completed at the School of Food Systems during October and November of 2011.

Sensory evaluation was completed using an attribute rating and hedonic scale for semi-trained panelists and consumer acceptance testing, respectively. Approximately 50 panelists participated in each of the sensory tests. The evaluations of the beany and stickiness attributes were completed on both a non-coated and cheese-coated extrudates. Overall acceptability was evaluated only in the cheese coated products because the commercial products would likely be flavored or coated; thus, the cheese coating represents a real world scenario. The texturized protein was ground with meat, mixed with sausage spices, and then smoked in a smokehouse following established methods in the meat science lab at NDSU. Sensory evaluation was completed by our meat scientist on the sausage product made with texturized bean protein.

Goals and Outcomes Achieved

Objective 1. Fractionate the starch and protein from pinto and navy beans.

Particle Control Milling Company (Albertville, MN) completed the separation of the protein and starch following a confidential protocol they use in their business operation. However, the basic separation included milling the beans to 100μ particle size or smaller and then aspiration to separate the particles. These fractions were then used in objective 2.

Protein fraction was composed of 44% (dry basis, d.b.) protein, 1.3% d.b. starch, and 6.4% d.b. ash. These results were similar to result obtained by Zbigniew et al (1993) for pin-milled and air-classified pinto beans. Thus, the commercial separation was comparable to a lab prepared method suggesting the feasibility of using dry fractionation to prepare commercial source of bean protein. The starch fraction was approximately 48% d.b. starch, and 2.4% d.b. ash. The remaining composition included fiber.

Objective 2. To extrude the protein fraction into a texturized product.

The protein fraction from objective one was used in the texturization process. Extrusion was done using a co-rotating Wenger TX52 twin screw extruder with a 90 kg/hr capacity. The extrusion conditions that produced a texturized product included a screw speed of 300 rpm, a material feed rate of 64 kg/hr, extrusion moisture of 11.6 % and specific mechanical energy of 7.18. Temperature profile in zone 1 through 9 ranged from 40 to 100 C. Under these conditions, the textured pieces had water adsorption of 3.1 g/g extrudate and water soluble index of 30.9%. Both values were lower than the raw bean protein fraction, which had values of 3.6 g/g and 39.6% for water absorption and water soluble indexes, respectively. These observations support the increased water holding capacity of the extruded bean protein and suggest that processing is essential for improving functionality. It did take the texturized protein extrudate 20 minutes to cook as indicated by a fully cooked product. However, the particles tested were larger than a typical texturized protein particle thus providing a cooking time that is longer than average. Due to limited availability of protein, multiple forms or shapes were not investigated and therefore cooking time could be reduced by modifying the shape into smaller particles. Smaller pieces could be used to make hydrated fibers for application in ground meat products.

The extrudate from the protein fraction was composed of 39.2% (dry basis, d.b.) protein, 2.44% d.b. starch, and 7.2% d.b. ash. These values were close to those of the raw protein fraction indicating limited breakdown of the components during the texturization process. However, the lower level of protein suggests that texturization could be improved by increasing protein content in the protein fraction. The texturization process did affect the color of the extrudate. The lightness value decreased from 86.1 in the protein fraction to 71.6 in the extruded protein fraction. The redness and greenness values increased. This indicated that the color of the extrudate increased in brownness. This was more apparent in the pinto extrudates than in the navy bean extrudates. The increased brownness favors its incorporation into products such as a hamburger or processed meat having a brown color.

Objective 3. To produce extruded snack products from dry bean starch fraction and assess the sensory properties of these extruded bean snack products.

Extrusion of the starch fraction from objective one resulted in a product that expanded between 2.7 and 3.3 times the die (port whereby the extrudate exits during extrusion) for curl type (e.g.

Cheetos) and 3.0-3.3 times the die in a ball type extrudate (e.g. breakfast cereal). Whole bean flours expansion was approximately 1.5 times indicating that starch purification (i.e. starch fraction) enhanced the extrudability of the bean flour. The higher starch content in the starch fraction compared to whole bean flour likely contributed to the enhanced puffing properties. Extrusion was done using a co-rotating Wenger TX52 twin screw extruder with a 90 kg/hr capacity. Feed rates of material, steam and water were 13 kg/hr, 7.02 kg/hr and 0.098 kg/hr, respectively. Temperature profile in zone 1 through 9 ranged from 40 to 90 C. Under these conditions, the starch pieces had water adsorption of 4.13 g/g extrudate and water soluble index of 39.9%. Both values were higher than the raw bean starch fraction, which had values of 2.53 g/g and 13.6% for water absorption and water soluble indexes, respectively. The starch fraction was approximately 54% d.b. starch, and 2.6% d.b. ash. These values were higher in the extrudates than in the raw starch fraction. This indicates that extrusion modified the starch to one that is more water soluble. The increased solubility may have impacted the sensory characteristics.

Sensory evaluation of the bean extrudate using a 5-point attribute rating scale and 9-point hedonic scale indicated a trend to improving sensory characteristics when using the starch fractions compared to the whole bean. The extrudates from starch fractions were deemed to have the same beany flavor as compared to the extrudates from the whole bean flour. However, difference in stickiness was observed between the starch extrudate and whole bean flour extrudate. The stickiness property may have been related to the fiber content since fiber had been reported to contribute to the stickiness of other types of extrudates. The fiber content was a significant component of the starch fraction and thus likely contributed to the observed stickiness of the starch fraction extrudate. However, the panelists rated the stickiness character between the slightly sticky to moderately sticky range of the sensory scale. No attempt was made to eliminate the stickiness characteristic in the extrudate. However, cheese coating of the starch fraction extrudate did reduce some of the stickiness indicating that addition of food additives could minimize this characteristic. In general, addition to cheese coating to any of the extrudate reduced the stickiness closer to the slightly sticky part of the sensory scale. In contrast, the cheese coating reduced the beany characteristic from a moderately beany level found in the non-coated samples to a trace to slight beany level in the cheese coated samples. Overall acceptability of the cheese coated samples fell into the like slightly to like moderately part of the sensory scale. In both cases, the cheese coated puffs from the starch fractions were deemed to be better than the puffs made with the whole bean flour.

The analytical measurement of hardness indicated that extrudates made from the starch fraction were harder than extrudates made with whole bean flour. For example, hardness value of 2203 and 769 grams for navy bean extrudates made from the starch fraction and whole bean flour, respectively. This indicates that the protein present in the whole beans may have altered the starch interactions resulting in a softer texture.

Objective 4. To utilize textured protein as an ingredient in meat products such as sausage and as a meat extender in hamburger.

The texturized protein was evaluated as meat extenders in processed meat products. However, the products produced were of lower quality compared to the control or all meat products. However, the water holding capacity was slightly better for the bean fortified products. The initial formulations did not utilize sufficient water thus resulting in products that were dry and crumbly. Attempts to modify the water addition levels in light of the greater water holding improved the quality of the products but as of the end of the study optimal conditions were yet to be identified. This indicated that the application of the texturized proteins were feasible for the sausage like products but additional requirements such as processing and ingredient additions may be required for optimizing formulations.

Two articles were planned to be published. One manuscript was submitted but rejected. The review indicated that several additional tests were needed. We are currently completing these tests. A second paper is currently being written that will be submitted in 2013. Time constraints have delayed submission.

Beneficiaries

The food ingredient manufactures and the food industry in general are the beneficiaries of this research. There are close to 100 companies worldwide that produce texturized soy protein, and approximately 10 of those companies would legitimately consider using beans as a protein source. The research completed demonstrated the feasibility of using fractionated bean as ingredients in puffed and texturized products. General processing protocols were identified that can serve as the basis for optimizing processing conditions suitable to food ingredient manufactures. The producer of beans benefit because alternative market for their beans beyond as an ingredient in canned or soup products could be developed by the food ingredient market. The estimated usage of the navy and pinto beans is 57,000 acres according to the National Agriculture Statistics Service. NASS indicates that the average farm size in North Dakota is 1,200 acres, so a minimum of 47 producers would be required to produce the beans provided they plant the full 1,200 acres. Since not all of the producers would plant all of their acres into beans, a more likely scenario would be that half of their acres would be beans and would double the producers benefited to 94.

The results of the research have been presented at one pulse short course (25 participants), two trade groups (approximately 10 people/group) interested in pulse utilization, and three private communications with food manufacturing companies. In addition, the results were presented at three meetings listed below. One manuscript was submitted but rejected. The review indicated that several additional tests were needed. We are currently completing these tests.

- Composition and properties of pinto bean flour subjected to air classification and extrusion. *Oral presentation* at AACC International Conference, Hollywood, Fl. October 2012. Approximately 50 people attended this presentation.
- Texturized pinto bean protein optimization in straight dough bread formulation. *Poster presentation* at Institute of Food Technologists (IFT) Conference, Las Vegas, NV. June 2012. Approximately 75 people attended this presentation.

- Properties of edible bean flours and their application in food processing. *Oral presentation* at the 9th Canadian pulse research workshop, Ontario, Canada, November 2012. Approximately 120 people attended this presentation.

Lessons Learned

The most significant lessons learned dealt with two aspects of the project, namely the fractionation and texturization process. The fractionation of the beans into protein and starch fractions could be improved through improving dry fractionation protocols. A future direction could include wet fractionation of the beans to enhance further the purity of the protein and starch fractions. The starch fraction puffed more during extrusion, which had been expected, however the sensory qualities of the starch puffed product were not substantially different from the whole bean flour puffed product. However, cheese coating improved sensory qualities indicating that food manufactures can use bean starches as ingredients in puffed products such as snacks and breakfast cereals using appropriate flavor systems to mask the bean flavor characteristic. The fundamental texturization process was identified; however, the small amount of starch did cause processing issues using published vegetable protein texturization processing protocols. As a result, we had to modify the texturization processing parameters to suit the raw material. In the end, we did make the texturized bean product with the protein fraction obtained from the dry fractionation process. Therefore, the processing parameters identified may require small changes to make acceptable texturized products. The final lesson learned was that the application in processed meat products was possible. However, we did meet the goal to optimize the formulations. The major obstacle was that the water holding capacity of the texturized bean protein flours was significantly different from the meat; thus the level of appropriate water addition was never quite identified by the end of the study. The use of the texturized bean protein flour indicated that it was possible to use the protein to extend meat but the formulation attempted resulted in drier than expected products. Future research should be aimed at enhancing protein levels in the protein fraction and characterize the water holding capacity of the texturized protein as a means to optimized its use in meat products.

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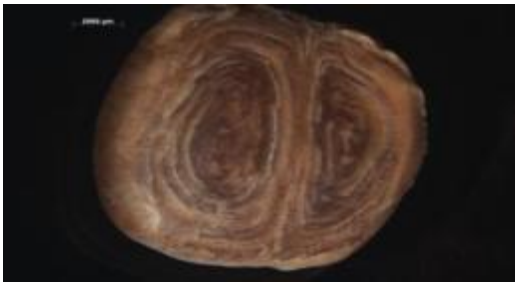
Additional information available (e.g. publications, web sites)



Protein extrudate obtained from the texturization process.

Cheese coated starch extrudate (curls, puffed balls, crisps) obtained from the puffing process.

Reference

Zbigniew, C., Gujska, E and Khan, K. 1993. Extrusion of pinto bean high protein fraction Pre-treated with papain and cellulose enzymes. *Journal of food Science* 58 (2): 395-398, 404

PROJECT 9: Helping Hands Community Garden Project

Final Report

Project Summary

This project was designed to provide classroom and hands-on educational gardening activities to youth, families, and elders in Sioux County and Standing Rock Indian Reservation. Recipients received education and training to develop and implement locally-grown, culturally relevant, sustainable food production systems, utilizing specialty crops that are adapted to this area. This project included training to market their production at a farmers market or local grocery store, and/or to process and prepare locally-grown foods for local consumption.

This project originated due to obesity, heart disease, diabetes, and other related health problems have a direct impact on longevity and quality of life. These health problems are on the increase in this area, especially in the Native American communities. One of the commonalities with these diseases is poor quality diet. The average diet of many consumers in this area is typically lacking in recommended amounts of fruits and vegetables.

Much of the produce for local consumption came from producers and suppliers who are located a considerable distance from the marketplace. Several of our small communities do not have a local grocery store, so the lack of local providers limited access to fresh fruits and vegetables. The fruits and vegetables provided for this area of the country are typically not vine-ripened before they are harvested. There is also added expense for transportation and middlemen costs as compared to locally-grown produce.

Many residents did not have knowledge and skills related to producing, consuming, and/or marketing locally-grown foods. There was a need for more educational outreach and hands-on mentorship for students and residents to receive training on how to raise, process, prepare, and serve nutritious foods, and how to integrate them into a balanced, healthy diet.

Through this grant we were able to:

- Provided hands-on information and education to over 1500 people of the area on nutrition and how to grow and plant fresh fruits and vegetables.
- Constructed garden demonstration learning sites in two communities on Standing Rock Indian Reservation.
- Promoted and assisted in starting 27 new box gardens for families to plant their own fresh vegetables.
- Developed and recruited 25 vendors for a weekly Farmer’s Market which provided opportunity for the purchase of locally grown fruits and vegetables for community residents. Over 80% of the vouchers distributed were used at the Farmer’s Market.
- Provided more than $34,000 in sales from the Farmer’s Market of fresh produce to the community and donated approximately $10,000 worth of produce to the local schools for their hot lunch program and the community Soup Kitchen from the project garden produce.

- Introduced nutrition and preparation tips in the local grocery each month on various locally-grown produce.

Project Approach

The following activities were performed for the "Helping Hands Community Garden Project":

First quarter of 2011:

By January, of 2011, members of various community groups and organizations were asked to be part of the "Helping Hands Community Garden Project" and serve as the project oversight committee. February 16, 2011, the Specialty Crop Ad Hoc project oversight committee was assembled. We met in the church building that had been rented for the project at a reduced rate. The committee consists of: RC&D, Extension, NRCS, SCD District, County, Cedar Soil, Sitting Bull College, and Faith Community representatives.

In January, 2011, discussion began on how to develop the plan for the garden project with the various partners. A plan for the garden plot was developed. Sitting Bull College and NDSU Extension developed the curriculum for the workshops.

During the first quarter of the project the High Tunnel, soil supplies, plants, etc. were purchased along with other supplies for the workshops and activities of the project. In addition, promotion of the project was developed and has been ongoing throughout the project year.

In March a Community kick-off meeting was held with various partners in the community to let these partners know of the project and the details for developing the activities.

Second Quarter of 2011:

Due to the weather in 2011 progress was slowed down of the construction of the High Tunnel. We took advantage of this quarter to plan workshop agendas, promotion and purchase additional supplies needed for the project. Development of the garden and some planting was done by volunteers from the community. In addition an intern was hired to assist with and maintain the garden.

Third Quarter of 2011:

The third quarter of 2011 was extremely busy as in July wood structures were constructed for the garden site. A new High Tunnel was purchased and put up end of June and replanting done in July. A trial garden was established in August to determine how far to carry plants into the season utilizing the High Tunnel. Cool weather root & herb crops were successful. Also, another trial was conducted utilizing Arikara & Hidasta bean. These were heirloom seed donated by Three Affiliated Tribes. The plants bloomed, but bore no fruit.

Farmers Markets were held every Wednesday beginning in June through October. Unsold produce from the garden was available for purchase during the week. Also, each week, a garden

product would be the featured produce of the week where that product is used in a prepared dish for people to sample and give ideas on how it can be used and prepared.

- Approximately 20 vendors participated in the Farmer's Market in 2011. Vendors were recruited through participants in the Farmer's Market Training seminars, advertising in the local area through Extension and other agency emails, etc., direct contact and word of mouth from other vendors, attendees, and Extension staff.
- The actual number of "Farmer's Market Vouchers" redeemed in 2011 through the Senior Farmers Market Nutrition Program was 2,307. Each voucher is in the amount of $5 for a total amount redeemed for fresh produce of for 2011 was $11,535.

Throughout the project in 2011:

In 2011 a Farmers Market Training was held with approximately 150 adults received information and education on various topics each year. 13 sessions of classroom and hands-on sessions were given on various topics that included seed selection, plant breeding, soil health, soil prep, what can grow and what traditional crops can be planted, No-till gardening, vermiculture, composting, high tunnels and container gardening techniques.

Fourth Quarter of 2011:

During the last quarter of the project we reviewed the project and identified the problems and delays of the project. Weather from the longer than usual winter, and flooding, being the biggest factors for the delay of the project in 2011. We discussed possible options for the project with the ND Department of Agriculture. We asked for an extension for this project based on the problems and delays and we were granted a one year extension.

First Quarter 2012:

In 2012 use of the 2011 garden site was not available for the project. The garden was moved to a permanent location, on County owned land, on the lot with the Sioux County Extension office. Construction of two 16x24 high tunnels, and one 16x24 high tunnels were completed.

Second Quarter 2012:

In 2012 a small orchard was added that included two Canadian Cherry bushes. A variety of winter onions were also added. The garden was planted and 27 box gardens were constructed.

Third Quarter 2012:

In 2012 a 20x40 Community Garden was constructed and planted in the community of Cannon Ball by volunteers from the community. Fans, water and solar panels were added to the Fort Yates Garden site. An additional 30x44 high tunnel was constructed and a nutrition education workshop was done.

In 2012 a composting was added to be utilized by this project for the next season to help improve soil health in the garden. Compost comes from the garden and the Community Soup Kitchen. Data from the reservation which includes both ND and SD area indicates that 250 gardens were tilled.

Farmers Markets were held every Wednesday beginning in June through October. Unsold produce from the garden was available for purchase during the week. Also, each week, a garden product would be the featured produce of the week where that product is used in a prepared dish for people to sample and give ideas on how it can be used and prepared.

- In 2012 five new vendors participated in this project which met our target of 25.
- In 2012 2560 vouchers were redeemed for a total amount of $12,800. Our target for this project was 2500 vouchers.
- Approximately 5000 pounds of produce was donated to the community's Soup Kitchen and schools.

Ongoing throughout the Project:

Since this project originated each year 264 Jr. Master Gardener Program to 3rd-6th grade students of Standing Rock and Cannon Ball Schools:

- 11 sessions per week (44 sessions per month) were presented to 3rd through 6th grade in Standing Rock and Cannon Ball Schools for a total of 264 sessions presented during this reporting period.
- 200 Student per week were provided information and education on the Jr. Master Gardener Program. This included 120 from Standing Rock School (Grades 4 & 5) plus 80 students from Cannon Ball School (Grades 3-6).

Nutrition, gardening and marketing classes were taught to the eight schools, totaling nearly 700 students, on the North Dakota side of Standing Rock Indian Reservation.

In 2012 several new topics were introduced to 520 people to include traditional culturally relevant aspects of garden plants, nutrition, soil health, seed selection, general garden maintenance, and marketing.

Speakers included: Frank Kutka, Abrey Sky, Paul Blackcloud, William Thompson, Jeramy Maher, Sue Isbell, Austin Lang, Corey Lund, Bob Waliser, and Wayne Markegard.

- 7 classroom sessions conducted with approximately 10 -12 adult participants per session.
- 6 sessions were conducted in the garden (hands on) with approximately 10-15 adult participants per session.

New in 2012 was Midnight Madness at the local grocery store. Extension staff would choose one produce item per month to provide information on nutritional value and preparation tips.

The project was featured in the Bismarck Tribune and Extension staff was invited to mentor United Tribes, in Bismarck, on their garden project.

Performance monitoring, project tracking, and data collection was reviewed quarterly or more often. At least quarterly, or more often, the staff of extension and the RC&D staff were in contact with each other in regard to the progress of the project. The project moved along very well considering a few obstacles of weather, employee, and partner turnover which are outlined in the Problems and Delays section of our annual report.

Last Quarter 2012:

During this last quarter of 2012 a Fall Harvest Results Workshop was held. We met with partners to determine the project outcomes and how the project could be improved and/or expanded.

The RC&D and Extension staff met to close out the project. The unique partnership with Sioux County Extension staff was instrumental in the success of this project. They helped to develop, promote and implement a local Farmer's Market in Fort Yates. They work with area vendors to coordinate this weekly event. The Standing Rock Nutrition for the Elderly Program and its Nutrition Services provided vouchers to the elderly that they can redeem for produce at the Farmer's Market. These vouchers can only be used for locally grown fruits and vegetables. 80% of the vouchers in 2012 were given out were used at the Farmer's Market, which was the direct results of the Sioux County Extension staff's promotion of the project. The Sioux County Extension staff knows the people in their communities and have the partnerships needed, from various community agencies and groups, to get this project done. Sue Isbell, Sioux County Extension Agent, will accomplish what she set out to do.

Goals and Outcomes Achieved

There were three keys of this project: Awareness – Sustainability – Buy-in from the Community that addressed the goals of the program for Nutrition and a healthy diet.

The following are the goals outlined in our project proposal:

1. Provide hands-on education to 750 youth, families and elders in the production, processing and marketing/utilization of locally-grown, culturally relevant specialty crops (fruits, vegetables, native medicinal herbs) during the life of this project. **Outcome: Over 1500 people of the area served by this grant received education over the course of this project.**
2. Add 8 new venders (new businesses) who market locally-grown produce at the community farmers market, within the next two years. **Outcome: This goal was achieved. *Note: In 2012 there were a few vendors that did not return and new vendors were added.**
3. Within the life of this project, increase:
    - **a.** The number of garden plots that produce local fruits and vegetables. **Outcome: Our target was 10 new garden plots. There were 27 new box gardens added which exceeded our goal.**
    - **b.** The number of "Farmers Market Vouchers" utilized to purchase locally-raised produce in the community. **Outcome: Our target was 2500 vouchers to be**

used to purchase locally grown fruits and vegetables. Over the two years the total vouchers used was 4867. *Note 2011 was a short season due to weather and flooding issues. In 2012 80% of the vouchers used were used at the Farmer's Market.

c. The value of fruits and vegetables marked locally. **Outcome: Our target was $15,000 of locally-grown fruits and vegetable being sold. Over the two years $34,335 was sold, and approximately $10,000 of produce donated to the local schools for their hot lunch program and to the community Soup Kitchen.**

4. Introduce locally-grown production of specialty crops into the local grocery store food offering. **Outcome: Extension staff created Midnight Madness at the local grocery store each month which features a different produce prepared for shoppers to sample and receive nutrition and preparation tips.**

Beneficiaries

Beneficiaries of this project include:

- Approximately 900 students and 970 adults received: a) Hands-on training at sponsor/partner sites including greenhouses, outdoor gardens, and classroom facilities.
- Over 400 family and community members, including tribal members and elders who are looking for training and resources to become established in fruits and vegetable production. This included: a) Hands-on training in the greenhouses, at the garden sites and classroom facilities; b) Mentorship opportunities to assist new and inexperienced growers.
- Over 1,000 residents of recipient communities who will gain access to more locally-grown fresh fruits and vegetables.
- As a result of this project, beneficiaries gained:
    - A broad-based knowledge and hands-on understanding of: a) How to utilize available natural and community resources to grow, process, and consume locally-grown foods to improve nutrition and health, and provide economic opportunity and family sustainability; b) How to establish and succeed in a specialty crops farm-to-table business.
    - Access to a dependable and consistent supply of locally-grown fresh fruits and vegetables.
    - Incentive to become new venders/businesses marketing their products to the community.

Potential economic impact from this project was realized by those vendors participating in the Farmer's Market from the production and sale of specialty crops in our area. In addition, over $10,000 worth of produce were donated to the local schools Hot Lunch Program and the community Soup Kitchen. The County building, located next door to the Fort Yates garden site saw first-hand the impact this project had on this project and have committed to assist in a continued project.

Lessons Learned

Insights from the project:

This project suffered a few delays at the startup of the project in 2011. The following were issues you that you may want to consider in future projects.

- The weather was the biggest factor. With the late spring and planting, the program had a very late start.
- Flooding issues the Community dealt with also was another delaying factor.
- The second major unexpected delay was a major partner in the project pulled out after construction of the first high tunnel was completed. The partner provided the first High Tunnel and when they pulled out of the project the High Tunnel was removed. The project had to start over with the purchase and construction of a new High Tunnel and planting.
- Employee turnover.

Weather and flooding were not easy to overcome. Some of the plants and educational activities were conducted and project plans were scaled back for the year.

Actions taken to address these delays included purchase of a new high tunnel and two smaller tunnels which were constructed by the Community members. The plants and high tunnels were in place by the end of June, first part of July. Some plants and education projects were not possible.

Sustainability and Staff: We found we needed to replace the intern with a Garden Director. We found we needed someone to oversee the project on a day to day basis. Also, the amount to sustain a project should include a higher budget for salary to be able to keep people staffed for the project.

Vandalism was another issue that we had to deal with. Sioux County Commission paid to have a fence installed that surrounded the garden site.

Lessons Learned/Recommendations:

- Regulation of temperatures to maintain soil moisture and soil health.
- Growing atmosphere needed to be maintained especially, with vining produce.
- Management of pests in the high tunnel structure. With fining plants there was more ground cover that promoted mice and mold.
- How structural support for various produce (i.e. tomatoes) is needed in a high tunnel structure.
- Regulate extended growing season. In a high tunnel the growing season begins in March.
- Short turn-around time on green cabbage. It is best to plan for a fall production harvest on cabbage.
- Tomato plants produced fewer fruit in the high tunnel than traditional growing methods. They tended to get overgrown in the high-tunnel.
- We found we need to incorporate a drip irrigation system in the high tunnels. It does not work to water overhead as it promoted mold growth.

Unexpected Results:

- Elders loved coming to the Community Garden to assist with garden activities.
- People enjoyed the pick and pay at the Farmer's Market. They were given the choice of choosing and purchasing produce picked by the garden staff and volunteers, or pick their own produce.
- Youth assisted in picking produce and assisted Elders at the Farmer's Market. Farmer's Market Day turned out to be a family day event with inter-generational community involvement.
- The Bismarck Tribune did an article on the project creating more awareness of the project.
- The project called attention to the need of fresh produce in the community. After staff from Great Plains Food Bank visited the Farmer's Market in Fort Yates, 14,000 pounds of produce was donated and distributed in the community.

Contact

For additional information on this project, please contact:
Mary Stevens at 701-250-4222, or by email at: dakotaprairiesrcd@gmail.com

Additional Information

Project photos on file with Mary Stevens at the contact information above, or, Sue Isbell at sue.isbell@ndsu.edu.

Project Photo Album on file with Emily Edlund, of the ND Department of Agriculture, at edlund@nd.gov

Link to Bismarck Tribune Article on the Helping Hands Community Garden Project:
http://bismarcktribune.com/hoops-and-boxes-grow-food-for-standing-rock/article_4191ebb0-d825-11e1-80d0-001a4bcf887a.htm

HELPING HANDS
COMMUNITY GARDEN
NRCS
North Dakota
Department of
Agriculture
Cedar
Soil
Conservation
District
NDSU
Extension Service

PROJECT 10: Local Foods Initiative

Final Report

Project Summary

The North Dakota Department of Agriculture (NDDA) began promoting specialty crops as local foods in August of 2008 through the Going Local North Dakota local foods initiative. We have seen an increased interest in buying fruits and vegetables from farmers; and growing more specialty crops on small to mid-sized family farms.

Increased interest in local foods and building up the economy could not be overstated. With the economic downturn and local foods movement, more and more people are looking to "local" as a lifestyle. With creativity and support, the potential for an agriculture state like North Dakota to cultivate new enterprises surrounding fruit orchards, vegetable production is limitless. You can see the interest in local growing through the number of donations from gardeners to the Hunger Free North Dakota Garden project; the interactions with our social networking communities; the implementation of farm-to-school programs in local schools, the increase in the number of school garden grant applications and awardees; the increase in CSA programs, farmers markets and community gardens; and the increased requests for information about direct marketing to our office.

Funding from the SCBGP is helping the NDDA achieve the following goals:

1. Increase the number Farm to Cafeteria (Farm to School) programs.
2. Distribute and implement "Go Wild for Fruits and Veggies" curriculum.
3. Increase participation in North Dakota's local foods summit.
4. Increase participation in the social networking.
5. Document vegetable and fruit production in the state through the Hunger Free ND Garden project.
6. Provide technical assistance to communities working their local foods strategic plans.
7. Create a how to manual for bolstering fruit production in the state.

Project Approach

The going local initiative utilized grant money to connect with North Dakota communities, large and small, and assist them in growing, consuming and supporting local products. We worked with education facilities, civic organizations, groups, associations, businesses, etc. to reach our goals and objectives for this grant. By bringing groups like this together we opened communication lines and helped show the strength in teamwork.

To make sure the grant money is used to solely enhance the competitiveness of specialty crops, the Department employs four marketing specialists. One specialist, funded through this grant, works solely on specialty crop promotions and production and is able to track time on the Local Foods Initiative. The other three marketing specialists work on non-specialty crop aspects of the Local Foods Initiative and are funded through the North Dakota Department of Agriculture.

Goals and Outcomes Achieved

- Increased the number Farm to School programs. At the beginning of the grant program North Dakota documented three schools working with this program. Our goal was to document 10 schools involved with the Farm to School program, and we have currently have over ten schools working to bring local foods to their lunch programs which affects thousands of students from k-12. Staff took time to visit several schools over the course of this grant and talk about the many successes and problems that come with sourcing food locally. While there are many challenges with the Farm to School program, the opportunity is there as well.

  The North Dakota Governor proclaimed September 18-24 Farm to School Week in ND. The event was held in September to coincide with the harvest season. The state had at least seven schools held special Farm to School events which includes 14,000 students. The Local Foods Initiative also worked with the Pride of Dakota program to promote October 4th as Pride of Dakota School Lunch Day. Poster and information identifying specialty crops were distributed to over 85 schools reaching over 30,000 students. See Addendum A/B for poster samples and menus we distributed to the schools.

  We also worked with the National Farm to School program to designate October 2011 as Farm to School month. During this month schools were encouraged to provide meals with local foods and stress "know your farmer; know your food".

- Distribution and implementation "Go Wild for Fruits and Veggies" curriculum in partnership with NDSU Extension Service and Dr. Abby Gold. The curriculum was developed and piloted throughout the state during 2011-2012.

  Go Wild with Fruits & Vegetables is a curriculum for 3rd - 5th grade students. It is a seven week program teaching all the color groups of fruits and vegetables and each week covers a different color group of fruits and vegetables (red, orange/yellow, blue/purple, tan/white & green). They learn ways to incorporate the different colored fruits and vegetables into their daily meals, the benefits of eating different colors, etc. Along with learning about the color groups, there is an animal character who serves as the "champion" for that color. Each week focuses on Farmer's Markets, growing your own fruits and vegetables, etc.

  "The Go Wild for Fruits and Veggies Curriculum was tested in a randomized control trial during the Fall of school year 2011-2012. Participant selection was accomplished by randomly placing Extension county agents into either an intervention (n=12 and 14 schools) or delayed intervention (n=12 and 12 schools) condition. The intervention agents delivered the curriculum to third grade students and collected pre and post data with the students and their parents. The delayed intervention was not given the curriculum and only collected pre and post data with the third grade students and their parents. Delayed intervention agents were given the curriculum after the intervention agents completed their trial so they could teach the curriculum during the Spring of school year 2011-2012.

In all, approximately 380 students participated in the intervention group and 370 students participated in the delayed intervention group."

We have some impressions from the agents, but the data for outcomes has not been analyzed yet. See Addendum C

- Increased participation in the local foods Summit. The local foods summit was held February of 2011 with the title *Dakota Grown – A local foods conference*. We had speakers from NDSU Extension, University of Minnesota Extension, and area businesses and growers. We worked closely with the North Dakota Farmers Market & Growers Association and FARRMS to coordinate the summit.

  The 2011 summit was held in Bismarck, ND and drew attendees from across the state, and region including Montana, South Dakota and Minnesota. We held two full days of sessions including tracks on hoop house discussions, marketing and production for specialty crop production.

  Our attendance was down just a few from the previous year, with 145 people in attendance, but the survey results and networking opportunity within the state was valuable. We feel the main reason for drop in attendance was the North Dakota blizzard and below average temperatures that hit the region the two days of the conference.

  We conducted post conference surveys to collect data and help shape our 2012 conference. See Addendum D-F

- Increase participation in the social networking .ning site. The social networking site, www.goinglocalnd.ning.com, started the grant cycle with roughly 300 members. We are currently at 360 active members and feel this is a successful social media outlet. However, as the trends in social networking continue to shift and change, we have added a Facebook fan page to help promote and connect with local foods in the region www.facebook.com/goinglocalnorthdakota . Our fan page has gained popularity with over 500 fans, and we are able to utilize it to send people to the .ning site where they can generate more intimate conversations. In addition to Facebook we've created a ND Local Foods Twitter account to connect with Twitter users.

- Document vegetable and fruit production in the state through the Hunger Free ND Garden Project. The Hunger Free ND Garden project had an interesting year in 2011. While we received wonderful marketing opportunities and project promotion, a year of statewide flooding and poor farming conditions lead to decreased number of produce donations for the project.

  The program kicked off the year with a press conference and Fargo-Moorhead Redhawks baseball game in Fargo, ND. The Agriculture Commissioner announced a request for donations at the Great Plains Food Bank and followed the press conference by throwing the first pitch at the "Homerun for Hunger" baseball game at Newman Outdoor Field.

We followed the press conference with an invitation to food pantries across the state to become a part of the project and provide the program with locations and best times for farmers to drop off produce. We received over 65 interested organizations which was up 20 participants from 2010.

In addition to the pantries getting on board and encouraging growers to donate fresh produce, ND received a visit from the BBC requesting to do a story on the Hunger Free ND Garden project. The story was released online, on radio and in print. The BBC coverage provided us wonderful feedback from across the nation; people looking to start similar projects in their neighborhoods and areas.

While we didn't reach our goal of 500, 000 pounds we did end up documenting over 260,000 pounds of produce donations and we learned valuable information to assist the program in 2012. We are still providing surveys to participants and collecting data to help us coordinate next year's efforts.

1 in 11 North Dakotans utilize charitable food organizations across the state. Those over 36,000 individuals are benefiting from the program with the access to fresh produce to meet nutritional needs. We also assisted over 65 community organizations; food pantries, soup kitchens, churches, senior centers, etc., provide fresh local foods to their clients. See Addendum G - H

- Building Capacity for Local Foods Infrastructure Development:
  The Local Foods Marketing Specialist spent time across the state working with communities to promote local foods and drive the efforts in schools and rural communities to increase the consumption and production of specialty crops. Activities included utilizing the mobile food processing unit to produce product, educate and promote local foods. We assisted with over 15 community and individual projects. See Addendum I

  State leaders and educators have taken a critical role in the region's local foods movement. A group of individuals, including the NDDA's Local Foods Marketing Specialist worked together to host a "Scaling Up Local Foods Research Symposium" in May of 2011. The event brought over 60 participants together to discuss our food systems and helped generate many ideas for how NDSU and other groups working in the local foods arena could help locate best practices and develop new innovations.

  There are many challenges working with communities and their local foods plans. Our goal was to continue to create strategic plans for communities, but we've been focusing on increasing awareness through projects and events to get communities committed to the work that goes into strategic planning. We feel the work we've done creates an incentive to look at more local foods opportunities in the future.

- Community – School Orchard Grants: The Local Foods grant received an extension and amendment to provide additional funds for an orchard grant opportunity for the region. The orchard grants were advertised in January and winners were awarded in April 2012.

We saw a huge interest in orchards with an astounding 27 applications submitted. Only five communities were chosen, but we see significant growth opportunities in the project.

The dollars were awarded to:

1. *Aneta Specialty Crop Group – Create a community orchard & garden for the city of Aneta. This partnership project involves the Aneta Homemaker's Club, Jolly Haymakers 4-H Club, Aneta Booster Club and the Aneta Specialty Crop Group made up of Bill Miller, Janice Mills, Fred Lukens, Jane Lukens, Randy Johnson and Donna Schaeffer. The project will work with Nelson County Food Bank, Parkview Health Center and Dakota Prairie School for food security, school nutrition and education. The orchard will also be utilized as a community activity center and is walking distance from town. $7,000 Population 220*

2. *City of Sheyenne Tree Board – The Sheyenne Town and County Civic Association, Trail Riders 4-H and Sheyenne-Oberon Area Ministries have partnered with the Horizon Program's G.R.I.T. (growth renewal, imagination, teamwork) community group to bring a community orchard to Sheyenne. This orchard grant will help grow the Hunger Free ND Garden Project the community has been working on for the past two years. By incorporating fruit trees they will ensure long-term sustainability and a fruit-filled future for Sheyenne. $5,400 Population 205*

3. *Elgin/New Leipzig Public School (Marie Klein) – The grant money will be used to build additional boxes to establish apple trees, strawberries, raspberries and rhubarb at the existing O.W.L.S. Tree Project located at the Elgin Public School. The area provides educational opportunities for the community and school with plans of donating a portion of the orchard harvest to help provide healthy, low cost food at the school's Eating Wise Program. $800 Student enrollment: 145*

4. *Cankdeska Cikana Community College Land Grant Program (CCCC) – Funding from the Orchard Grant will help CCC integrate fruit trees and bushed into the campus environment. The edible landscape will serve as an outdoor classroom for youth programs, college curriculum, and community workshops. Community members will learn about the cultural significance of fruits and how they can be used to encourage healthy eating habits. $4,000 Enrollment: 250*

5. *North Dakota State University – The Orchard Grant will benefit the Dragonfly Garden in Bismarck. The Dragonfly Garden is a 1.5 acre outdoor classroom located at United Tribes Technical College in Bismarck where families can learn how to grow healthy food and enjoy the beauty of nature. Educational programs are conducted in the garden and via mass media to demonstrate science-based, sustainable practices. The goal of the project is to have the most diverse collection of fruit trees/bushes/berries in the state. $2,500 Bismarck population: 63,000*

Beneficiaries

The beneficiaries for the local foods initiative includes a very diverse crowd of school systems, farmers, small businesses, community organizations, under-privileged communities, and citizens. We feel we've reached around 120 schools, 45,142 students, 200 farmers and small businesses,

85 community organizations, over 36,000 under-privileged individuals, and around 65,000 citizens from across the region.

Lessons Learned

One item we've learned is that the interest in local foods, farming, CSAs, farmers markets and direct marketing continues to grow and reach new audiences in the state. Not only are consumers looking to connect with local foods, but more and more producers are seeing the potential to grow and sell specialty crops. With this influx of new market potential and new growers, we've seen the need to continue to educate growers on farming practices, regulations, business trends and business opportunities to help provide an adequate number of growers for the state's demand.

With that in mind one of the biggest lessons we've learned is that we don't have a large enough selection of growers to meet the demands for local foods. One prime example is a meeting we had with a VERY large retailer in the Bismarck community. They are interested in brining local fruits and vegetable into their store to sell in large quantities to the consumers; there is a huge consumer demand. At this time, we can't make that work in the state. We have several small fruit and vegetable producers, but not many looking to scale their business up a level or they don't have the means or knowledge to take their business to the next level. Through education, communication, and continued work we are confident North Dakota will work through these issues.

After seeing the need to scale up local foods production, the NDDA continues to connect the growers and consumers, but we are making an effort to provide information and assistance to growing the scale and number of specialty crop farmers. This includes helping with items like a local food co-ops, working on materials geared to regulation, business practices and business opportunities to help farmers market from their farm to shelves/plates.

Additional lessons include:

- The great deal of interest in community orchards. As a way to strengthen communities and provide fresh fruit to rural areas, this program is an exciting step in the right direction

- The Hunger Free ND Garden Project is a wonderful addition to the state. We've received world-wide attention for the program and we're excited to see our program serve as a pilot project for many cities and communities across the nation. We did learn that capturing the amounts of produce donated serves as an area of constant thought and challenges. We worked with the Great Plains Food Bank to institute a system to collect poundage donated through their member agencies; however, we need to keep working on our system to capture the donated amounts of food.

- At the Scaling Up conference, we learned of support of local foods from many entities across the state including the NDSU Extension Service, membership groups such as FARRMS and the Northern Plains Sustainable Agriculture Society, individual producers, farmers market and CSA producers, nutrition groups and individuals. NDSU shared its support for identifying and carrying out research needs. In order to scale up the production of local foods for direct sales or regional markets, however, there needs to be

one group that provides the leadership and support for bringing these diverse groups together, planning and helping groups move forward in a unified direction. With additional personnel and a small amount of administrative support, the North Dakota Department of Agriculture could fulfill this role.

- North Dakota is not participating in federal programs including the WIC Farmers Market Nutrition Program, the Senior Farmers Market Nutrition Program; and only a handful of growers/markets participate in the SNAP farmers market nutrition program. As the local foods programs continue to build momentum work in this field could benefit producers by increasing their sales and to benefit recipients who could have increased access to locally-grown produce.

Contact

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Local Foods Marketing Specialist
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Additional Information

Please see the following pages for addendums supporting this project

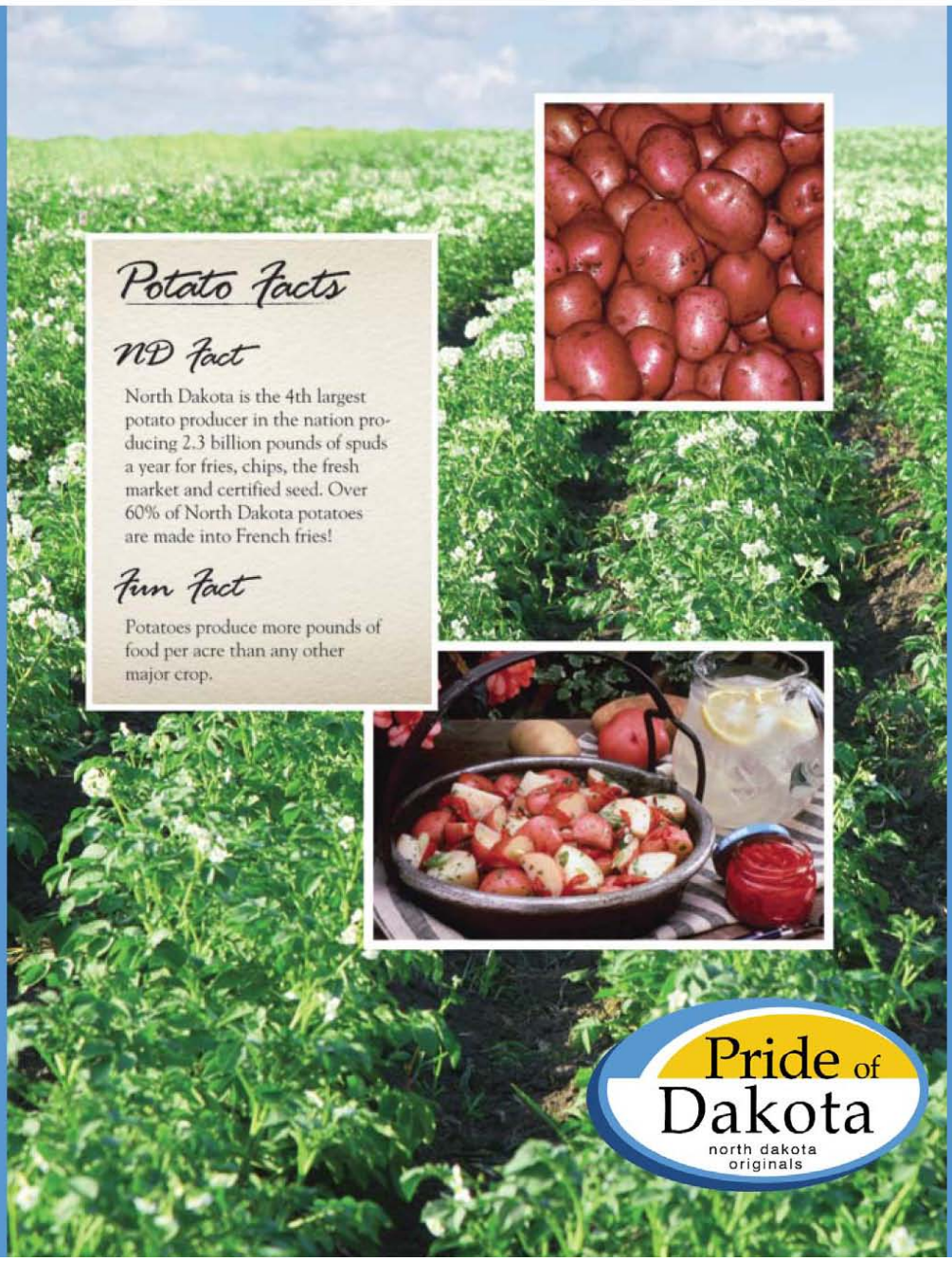
ADDENDUM A – PRIDE OF DAKOTA SCHOOL LUNCH DAY POSTERS

— Pride of Dakota —

Support North Dakota Agriculture and Products

Visit www.prideofdakota.com

Potatoes


Potato Facts
ND Fact
North Dakota is the 4th largest potato producer in the nation producing 2.3 billion pounds of spuds a year for fries, chips, the fresh market and certified seed. Over 60% of North Dakota potatoes are made into French fries!
Fun Fact
Potatoes produce more pounds of food per acre than any other major crop.
Pride of Dakota
north dakota originals

Local Foods

Support North Dakota Agriculture and Products

Visit www.prideofdakota.com

Honey

Honey Facts

ND Fact

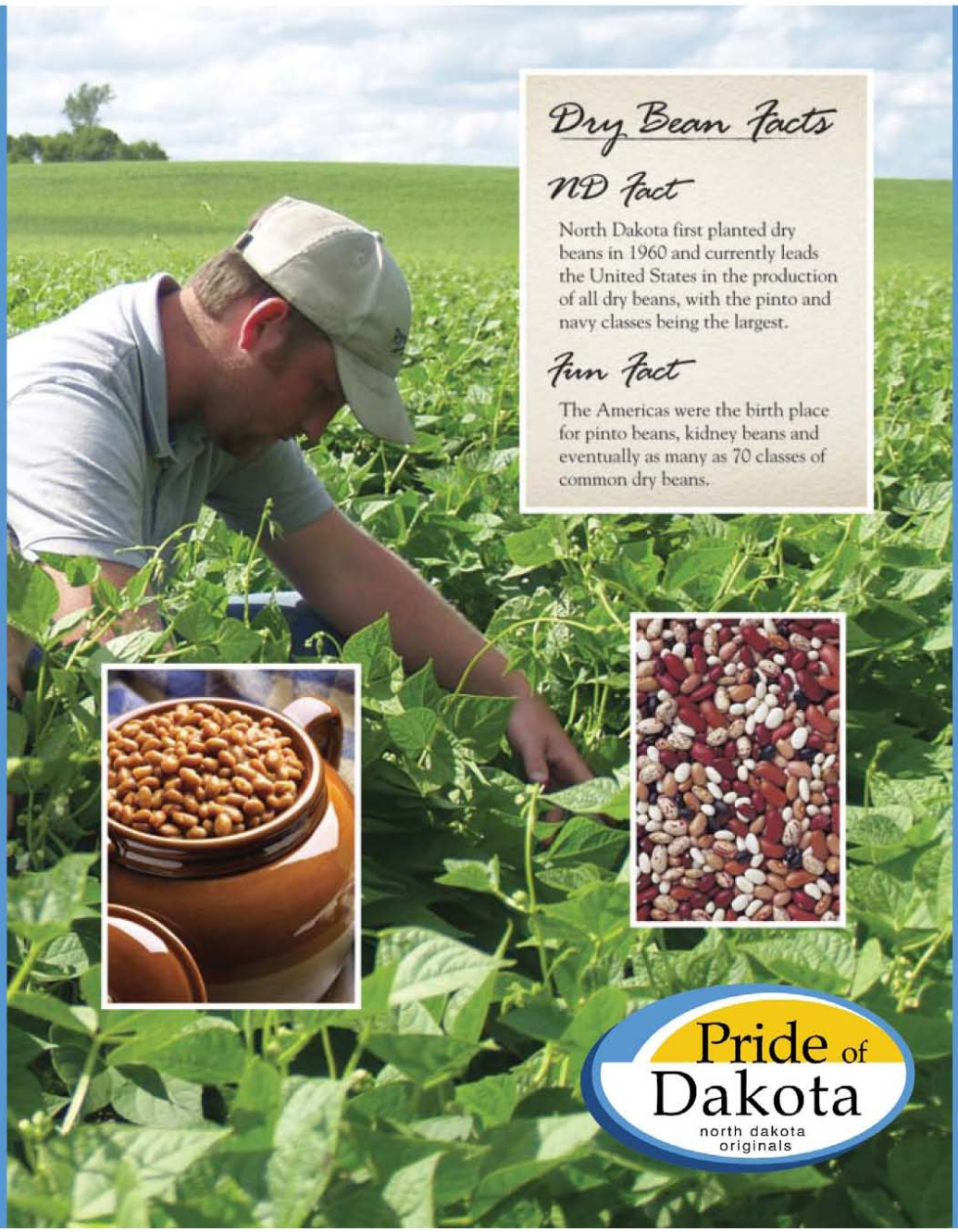
Major honey producing crops in North Dakota include white and yellow sweet clover, alfalfa, sunflowers, buckwheat and canola.

Fun Fact

To make one pound of honey, bees must collect nectar from approximately 2 million flowers.

Pride of Dakota
north dakota originals

Dry Beans


Dry Bean Facts
ND Fact
North Dakota first planted dry beans in 1960 and currently leads the United States in the production of all dry beans, with the pinto and navy classes being the largest.
Fun Fact
The Americas were the birth place for pinto beans, kidney beans and eventually as many as 70 classes of common dry beans.
Pride of Dakota
north dakota originals

ADDENDUM B – PRIDE OF DAKOTA SCHOOL LUNCH DAY MENU

Pride of Dakota
School Lunch Day
Tuesday, October 4, 2011

Sample Menu 1	Portion Size
• Cloverdale Ham *on*	2 oz
• Baker Boy Whole Wheat Bun	2 oz
• Baked Potato Half, Red River Valley	4.5 oz
• Sour Cream, Reduced Fat	2 Tbsp
• Corn, Whole Kernel	¼ cup
• Italian Pasta Salad	3/8 cup
• Cheese Slice	1 oz
• Butter	2 tsp
• Milk, Chocolate Skim	1 cup

Sample Menu 2	Portion Size
• Chili with Pinto Beans	1 cup
• Crackers	4 each
• Baker Boy Breadstick or Dinner Roll	1.5 oz
• Honey	1 Tbsp
• Carrots and Celery	¼ cup
• Ranch, (Lite Dressing, Buttermilk)	1 oz
• Apple Half, Fresh	½ each
• Sunbutter Cookies	1 cookie
• Milk, 1% Lowfat	1 cup

Sample Menu 3	Portion Size
French Dip Roast Beef Sandwich	
• Roast Beef, Thin Sliced *on*	2 -3 oz
• Baker Boy Steak Bun	2.5 oz
• Au Jus	2 oz
• Oven-Baked Natural Potato Wedges	3.5 oz
• Carrots and Celery	¼ cup
• Roasted Soy Nuts	1 oz
• Ranch, (Lite Dressing, Buttermilk)	1 oz
• Ketchup (condiment)	2 T
• Milk, Chocolate Skim	1 cup

For additional menus
using products you may want to purchase locally, call or email
Deb Egeland, degeland@nd.gov
North Dakota Department of Public Instruction
701-328-3718 or 1-888-338-3663

Child Nutrition & Food Distribution Programs

ADDENDUM C – GO WILD WITH FRUITS & VEGETABLES FOR GRADES 3 - 5

NDSU EXTENSION SERVICE | Making a difference

NORTH DAKOTA STATE UNIVERSITY

Go Wild with Fruits and Veggies!

The Situation

According to the 2007 National Survey of Children's Health, 25.7% of North Dakota children are considered either overweight or obese. To prevent obesity, children should eat a well-balanced diet that includes the recommended amount of fruits and vegetables and get 60 minutes of physical activity every day. It is especially important for limited resource families to be introduced to the health benefits of eating different colored fruits and vegetables to fight obesity.

Extension Response

Go Wild with Fruits and Veggies! is an exciting curriculum designed to spark students' knowledge and interest in fruits and vegetables. This program encourages children to eat more fruits and vegetables and increase their physical activity. Third graders at Lake Agassiz Elementary School participated in this educational opportunity. The lessons feature Go Wild animal characters, such as Tomas Turkey, to represent the different color groups of fruits and vegetables.
During the six weekly lessons, students learned facts about wildlife, nutrition, food safety and the importance of physical activity. The school's Child Nutrition Program provided a fruit or vegetable snack to go with each featured color group.

Impacts

An evaluation was given to the students after the six lessons. Seventy-three of the eighty students completed the evaluation.

- Seventy-seven percent of the students said they exercise more after attending the lessons.
- Fifty-eight percent of the students said they eat more vegetables after attending the lessons.
- Sixty-six percent of the students said they eat more fruit after attending the lessons.
- Seventy -four percent of the students reported they want to try more new fruits and vegetables after attending the lessons.
- Eighty percent of the students said they eat more colorful fruits after attending the lessons.
- Fifty-six percent of the students said they eat more colorful vegetables after attending the lessons.

Feedback

My favorite part was how the students remember all of the information from week to week. 3rd Grade Teacher

My favorite part was how the animal facts fit perfectly with our science curriculum. 3rd Grade Teacher

I liked getting to know what foods do for you, like red fruits and vegetables heal you. 3rd Grader

My favorite part of the lesson was learning how to read labels and how much sodium and fat you should have a day. 3rd Grader

I tried pomegranate. It was sour, I did not like it but it was fun to try. 3rd Grader

I liked meeting all the characters, they should have a fish. 3rd Grader

Contact

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Family Nutrition Program

Carrie Knutson, MS
Extension Agent 4-H Youth Development

Donna Bernhardt, MS LRD
Nutrition, Food Safety and Health

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ADDENDUM D – 2011 LOCAL FOODS CONFERENCE

Welcome to the Dakota Grown local foods conference

FRIDAY, FEBRUARY 18

8:30 – 9 a.m.	Welcome and introductions
9 – 11 a.m.	Keynote speaker - **Michelle Wall, Dale Carnegie**
11 - 11:15 a.m.	Break with refreshments
11:15 a.m. - 1 p.m.	Lunch - The mobile food processing unit and your community in 2011 ND local Food Initiative update and plans for 2011

SESSION	HOOP HOUSES	GROWING YOUR BUSINESS
1:15 – 2:30 p.m.	Hoop house I - construction **Terry Nennich - U of Minnesota**	Funding, development and how to start a business **Glenn Muske, NDSU Extension**
2:30 p.m.	Break with refreshments	Break with refreshments
2:45 – 3:45 p.m.	Hoop house II - weeds and insects **Terry Nennich - U of Minnesota**	Marketing alternative products panel **Patty Patrie, Bowdon; Kristi Wirrenga, Adrian; and Tracie Thompson, Antler**
4 – 5 p.m.	Hoop house III - water/fertility **Terry Nennich - U of Minnesota**	Product pricing **Holly Mawby, Entrepreneurial Center for Horticulture**

5:15 – 6 p.m.	ND Farmers Market and Growers Association business meeting
6 – 6:30 p.m.	Social
6:30 p.m.	Dinner and keynote speaker - **Chris Young, The Rainmaker Group -** committed to helping those we serve make their difference in the world

SATURDAY, FEBRUARY 19

7:30 – 8:30 a.m.	NDFMGA board meeting and breakfast
8 – 9 a.m.	Breakfast - Report on local foods strategic planning in communities: **Bruce Smith - Montana update**
9 – 9:15 a.m.	A word from Karen Gehrig, NDFMGA president

SESSION	ROOTS & STEMS	GROWING YOUR BUSINESS
9:30 – 10:30 a.m.	Heirloom seeds **Theresa Podoll, Fullerton**	CSA I - types of CSAs **Jay Basquiat, Mandan and Annie Carlson, Cleveland**
10:45 – 11:45 a.m.	Plants and seeds – How many plants do I need? Seed supply companies and varieties that do well here **Tom Kalb, NDSU, Bismarck**	"Why should I care about local food?" **Lisa Kyes - Urban Harvest, Bismarck**
12 – 1 p.m.	Lunch - **Bruce Smith - Ag Marketing Cooperative**	
1:15 – 2:15 p.m.	Mulching and composting What is a no-till garden? **Marvin Baker, Carpio**	School garden panel – Farm to School **Sue Balcom - regional Farm to School team, Mandan** **Monica Cox and Lenore Kuntz, YCC-Mandan**
2:30 p.m.	Break with refreshments	Break with refreshments
2:45 – 3:45 p.m.	Natural and non-toxic insect control **Brian McGinness, Mandan**	CSA II - how to build a CSA **Jay Basquiat and Annie Carlson**
3:45 p.m.	Conference wrap -up	

Please remember to leave your evaluation forms and name tags at the registration table

Have a safe trip home.... see you next year.

ADDENDUM E – LOCAL FOODS CONFERENCE REGISTRATION

Don't delay... register today for

DAKOTA GROWN -

A LOCAL FOODS CONFERENCE
at the Doublewood Inn
1400 E Interchange Avenue, Bismarck, ND

A block of 50 standard sleeping rooms has been reserved for February 17 and 18 at a rate of $75.00 (plus tax). These rooms will be held until February 3.
For reservations phone: 701-258-7000

BOOK EXCHANGE: FARRMS will host a reading room at this year's conference. Bring your local foods or sustainable farming book donations; leave one and take one and then be sure and PASS IT ON...

The vision of Going Local ND is to create a food system in North Dakota that is abundant in locally produced foods to foster the betterment of our health, economic well-being and the self-reliance of our citizens.

BE VOCAL - ASK FOR LOCAL!

Contact the NDFMGA at:
Dakota College at Bottineau
Attn: Stacy Baldus
stacy.baldus@dakotacollege.edu
Phone: 701-228-5400

Sponsored by the North Dakota Department of Agriculture
600 East Blvd. Ave, #602, Bismarck, ND 58505-0020
DOUG GOEHRING AGRICULTURE COMMISSIONER
TOLL-FREE: 1-800-242-7535

The North Dakota Farmers Market and Growers Association, Inc.
Dakota Grown
IT'S ALL GOOD

LOCAL FOODS CONFERENCE

Friday and Saturday
February 18-19
at the
Doublewood Inn
Bismarck

LOCAL FOOD - HEIRLOOM SEEDS - PRODUCT PRICING - FARM TO SCHOOL - MARKETING YOUR FARM - CSA - SEASON EXTENSION - NETWORKING - MULCH - FUNDING OPPORTUNITIES - COMPOST - INSECTS - AND MORE...

Schedule of events

FRIDAY, FEBRUARY 18

8:30 – 9 a.m.	Welcome and introductions
9 – 10:45 a.m.	Keynote speaker - **Michelle Wall, Dale Carnegie** - focused on giving you the opportunity to sharpen your life skills in order to build positive, steady, and profitable results in business and life
10:45 – 11 a.m.	Break
11 – 11:30 a.m.	Question and answer session with Michelle Wall
11:30 a.m. – 1 p.m.	Lunch with North Dakota Local Food Initiative update and 2010 project wrap-up

SESSION	HOOP HOUSES	GROWING YOUR BUSINESS
1:15 – 2:30 p.m.	Hoop house I - construction **Terry Nennich - U of Minnesota**	Funding, development and how to start a business **Glenn Muske, NDSU Extension**
2:30 p.m.	Break with snack	Break with snack
2:45 – 3:45 p.m.	Hoop house II - weeds and insects **Terry Nennich - U of Minnesota**	Marketing alternative products panel **Patty Patrie, Bowdon; Kristi Wirrenga, Adrian; and Tracie Thompson, Antler**
4 – 5 p.m.	Hoop house III - water/fertility **Terry Nennich - U of Minnesota**	Product pricing **Holly Mawby, Entrepreneurial Center for Horticulture**

5:15 – 6 p.m.	ND Farmers Market and Growers Association business meeting
6 – 6:30 p.m.	Social
6:30 p.m.	Dinner and keynote speaker - **Chris Young, The Rainmaker Group** - committed to helping those we serve make their difference in the world

SATURDAY, FEBRUARY 19

7:30 – 8:30 a.m.	NDFMGA board meeting and breakfast
8 – 9 a.m.	Breakfast - Report on Local Foods Strategic Planning in communities (speaker pending)
9 – 9:15 a.m.	A word from Karen Gehrig, NDFMGA president

SESSION	ROOTS & STEMS	GROWING YOUR BUSINESS
9:30 – 10:30 a.m.	Heirloom seeds **Theresa Podoll, Fullerton**	CSA I - types of CSAs **Jay Basquiat, Mandan and Annie Carlson, Cleveland**
10:45 – 11:45 a.m.	Plants and seeds – How many plants do I need? Seed supply companies and varieties that do well here **Tom Kalb, NDSU, Bismarck**	"Why should I care about local food?" **Lisa Kyes - Urban Harvest, Bismarck**
12 a.m. – 1 p.m.	Lunch (speaker pending)	Lunch (speaker pending)
1:15 – 2:15 p.m.	Mulching and composting What is a no till garden? **Marvin Baker, Carpio**	School garden panel – Farm to School **Sue Balcom - regional Farm to School team, Mandan** **Monica Cox and Lenore Kuntz, YCC-Mandan**
2:30 p.m.	Break with snack	Break with snack
2:45 – 3:45	Natural and non-toxic insect control **Brian McGinness, Mandan**	CSA II - how to build a CSA **Jay Basquiat and Annie Carlson**
3:45 p.m.	Conference wrap-up	

Register today

Local Food Conference - Feb. 18-19
Doublewood Inn, Bismarck

Name: _____

Address: _____

City, State, Zip: _____

Email: _____

Phone: _____

I'm registering a friend, or two:

Name: _____

Name: _____

Meals are included in the registration price; for planning purposes we will be attending:

Friday lunch: No.____
Friday evening banquet: No.____
Saturday lunch: No.____

Please note any special considerations for you or a member of your party.

REGISTRATION $40 x ____ persons = _____

Enclosed is my check for $ _____

Checks should be payable to NFMGA.
Registrations should be mailed before Feb. 11 to: FARRMS, 301 Fifth Ave. SE, Medina ND 58467.

The North Dakota Farmers Market
Dakota Grown
IT'S ALL GOOD
and Growers Association, Inc.

A local foods conference

Friday and Saturday
February 18-19
at the
Doublewood Inn
Bismarck

Save the date!

Friday-Saturday, Feb. 18-19, 2011

Local foods tops the list of eating trends for 2011, so don't miss an opportunity to learn about:

- The care and keeping of hoop houses
- How to start a growing business
- Farm-to-School
- Product pricing
- CSAs
- Small fruits
- Mulching
- Natural pest control

Mark your calendars!

Networking opportunities, good food and more...

Send your contact information to info@farrms.org to receive details as they unfold.

ADDENDUM F – LOCAL FOODS CONFERENCE SPEAKER BIOS

TOM KALB

Dr. Tom Kalb is the NDSU Extension Horticulturist for Western North Dakota. Tom was raised on a family farm in Minnesota and received his Ph.D. in horticulture from Virginia Tech. He has worked as an educator with the University of Wisconsin and as the head of training at the world's leading center for international vegetable research, called The World Vegetable Center, located in Taiwan.

Tom established and coordinates the North Dakota Home Garden Variety Trial Program. Over the past two years, he has worked with 500 families to test vegetable varieties in their gardens and farms—this is the largest program of its kind in the USA. Today Tom will speak about planning your garden, including working with the best seed companies and sowing the best varieties in North Dakota.

LENORE KUNTZ

I've been at the school (YCC) for 25 years being a FACS teacher by trade. Initially, my job was to provide the classwork for the Welding, Auto and Building Trades shops. I now do Health, FACS and tutoring.
We received a grant through our state Ag Dept. the first year of our garden. We're on year three and it's been an adventure—and learning experience. As a lifetime gardener, I enjoy growing things but also want to impart to students the environment impact we have on our world. The classes I teach lend themselves well to our garden project.

I am married with 5 grown and I (almost grown) daughters, all of whom have had to pull weeds at one time or another. My mission is to provide, for our students, some exposure to "another world".

LISA KYES

Lisa Kyes is a past Associate Director for Urban Harvest, handling market operation and PR for the past 2 seasons. She has facilitated the past two spring Urban Harvest book clubs series, which focused solely on local foods issues. Lisa is a member of Slow Food USA, actively supports local foods issues in Bismarck/Mandan, and is a member of the ND SARE group. She lives in Bismarck with her husband and 2 children, and is also the Store Manager of Barnes & Noble.

JAY BASQUIAT

Jay Basquiat started Baskets of Plenty, the first Community Supported Agriculture program in Bismarck-Mandan, in 2008, after completing the FARRMS program called "Organic 101." He rents land west of Mandan and strives to create an enduring, sustainable farming practice. This will be his fourth year of operation and his CSA is capped at 60 shareholders. Basquiat also teaches English and Philosophy at Bismarck State College, serves on the board of the North Dakota Humanities Council, and spends the rest of his time enjoying the great outdoors, great food, and great friends.

THERESA PODOLL

Theresa Podoll farms with her husband, Dan and extended family as part of Prairie Road Organic Farm in Fullerton, North Dakota, producing certified organic garden seeds under contract with seed catalog companies.
She most recently served as the Interim Manager of the Family Farmers Seed Cooperative, a farmer-owned marketing cooperative, formed in 2008 with eight founding members in Colorado, New Mexico, Oregon,

Washington, and North Dakota. FFSC's mission is to foster the development and improvement of open-pollinated vegetable varieties suitable to organic production systems, producing and distributing high quality, open-pollinated, certified organic seed. Theresa holds a Master's degree in Community Development and serves as Vice President of the Board of the Organic Farming Research Foundation.

BRUCE SMITH

Bruce Smith was born in Williston and raised in northeastern Montana on a diversified farm and ranch. The family farm corporation raised cattle, hogs, sheep, poultry, dryland and irrigated small grain crops and hay. Bruce graduated from Montana State University with a degree in Ag Production/Animal Science and another in Ag Business and received a Masters Degree in Business Administration from Cal Poly – San Luis Obispo. He worked eight years managing food manufacturing plants making frozen vegetables, margarine, and French fries in California, Illinois and Idaho for three of the world's 12 largest food companies. Bruce became an MSU Extension Agent in 1994 and moved back to eastern Montana where he has been active in community, economic, and rural leadership development, value-added agriculture, and the development of local food systems.

Bruce's background and experience in value-added agriculture, food manufacturing, and business management have given him a different perspective on the region's agricultural future. Bruce's current projects include the Farm-to-Table Project; developing a culinary arts program at the local community college; a regional food and agriculture development center; a small food manufacturing business that uses local foods; a local foods restaurant and microbrewery; a community garden; a local foods store; a Farmers Market; a high tunnel production and demonstration project; and an ag marketing cooperative.

Introduction biography of Mrs. Holly Mawby

Holly Mawby currently serves as the Director of the Entrepreneurial Center for Horticulture at Dakota College at Bottineau. She is also so the Executive Director for the North Dakota Farmers Market and Growers Association. Originally from Minot, Holly has worked for 20 years in the higher education system. She has a degree in Horticulture and Landscaping from the University of Minnesota, Waseca and a BA in Business and Industry Education from Valley City State University. Holly and her husband Barry own gardendwellers FARM in Churchs Ferry, ND, which is a producer of culinary herbs for farmers markets, grocery stores and restaurants.

MICHELLE J. WALL

Area Manager 701.255.8476 | 800.255.1091 | mwall@eidebailly.com

Knowledge and Expertise

• Partners strategically with companies to increase their capacity to drive and execute business results.

• Works with individuals, teams, and organizations to enhance skills, facilitate change, and improve quality critical to strong business results.

• Improves their performance in areas such as leadership, management, communication, presentations, human relations, sales, and teamwork development.

• Provides tailored business solutions for organizations by conducting business and employee development assessments and organizational analysis.

• Frequent presenter at conferences, seminars, and workshops.

Professional Memberships and Accomplishments

• ND YP Network – Success Strategies Columnist

• Bismarck-Mandan Young Professionals – Great Plains Summit Program Committee

• Bismarck-Mandan, Minot, Dickinson & Williston Chambers of Commerce Member

• Southwest Area & Minot Area Human Resource Associations

• NDSU Sigma Alpha Alumni Association

- Professional Organization for Women in Agriculture
- National Outstanding Alumni Award

Accreditation

• Certified Dale Carnegie Performance Coach

Education

• Bachelor of Science, Communications and Agriculture, Minor in Marketing - North Dakota State University, Fargo

Agricultural Background

• Grew up on a small grains and purebred cattle operation near Mercer, ND.
• American FFA Degree
• Past coordinator of KFYR Radio Agri-International Stock & Trade Show

CHRIS YOUNG

Chris Young is a North Dakotan who has an undergrad in Economics and masters in Agricultural Economics from NDSU. He has worked for Pillsbury Foods, Continental Grain, and in economic development for the Department of Commerce. In 2000, Chris founded The Rainmaker Group – a professional consultancy focused on helping people and organizations Maximize their Possibility. One of Chris' passions is helping organizations shape the mindset of their team members and their Customers.

Chris lives in Bismarck with his wife Sandy of 19 years and his two children Gracynn (13) and Macauley (10).

TERRY NENNICH

Terry Nennich is a University of Minnesota Extension Professor, who throughout his career has specialized in vegetable and small fruit production and marketing. For the past ten years he has lead the University of Minnesota high tunnel research and development team. He is co- author of the 'Minnesota High Tunnel Production Manual for Commercial Growers".

Terry also works with farmers market development and recently co-authored the "Minnesota Farmers Market Manual for Management and Vendors. Terry and his wife Loralee own and operate Ter-Lee Gardens, a fruit and vegetable operation which sells its produce pick-your-own and directly at a farmers market. His lifelong agriculture production experience helps him maintain a strong perspective of the revolutionary changes occurring in direct-to-consumer marketing and local foods movement.

ANNIE CARLSON

Annie Carlson is the executive director of FARRMS, the foundation for sustainability in Medina, ND.
Annie and her husband, John, own and operate Morning Joy Farm, a vegetable CSA (Community Supported Agriculture) with her husband near Cleveland, ND. Previously, she worked a trainer for Coventry Health Care in Bismarck, a science teacher for the Bismarck Public Schools and an adjunct professor for BSC. Carlson is originally from Mercer, ND and graduated from Turtle Lake-Mercer High School and NDSU.

SUE BALCOM

Sue Balcom is the marketing and outreach coordinator for FARRMS in Medina. Sue also serves as the regional farm to school lead for the Midwest region representing North Dakota.
For the past two years Balcom has worked as the local foods marketing specialist at the North Dakota Department of Agriculture. Prior to that she edited the Mandan News for more than seven years.

III. FOOD DISTRIBUTION PARTNERSHIPS

❶ Hunger-Free North Dakota Gardens Project

ND Department of Agriculture | North Dakota
http://www.agdepartment.com/Programs/LocalFoodsInfo.htm

Opportunity
One in 12 North Dakota residents seeks charitable food assistance every year. Demand for charitable food assistance grew by nearly 20% in 2009 alone. At the same time, many North Dakota residents grow excess produce or have the ability to grow and donate excess produce to charitable organizations.

Program Description
Started in 2010, the Hunger-Free North Dakota Gardens Project encourages North Dakota farmers and growers to plant and donate extra produce to the state's hunger relief organizations. The Garden Project is a small initiative of the North Dakota Department of Agriculture (NDDA) and the Great Plains Food Bank, through which locally-grown produce make it into the hands of low-income and food insecure North Dakota residents. The Gardens Project is part of NDDA's broader Local Foods Initiative.

The project's stated goals are to (1) grow and distribute 500,000 pounds of fresh produce to North Dakota's 244 food pantries, shelters and charitable organizations; (2) build a distribution system to supply North Dakota with fresh and healthy produce; (3) recognize the quantities of fruits and vegetables grown in the state; (4) improve local diets through donation and education of local foods; and (5) connect local produce to communities through farmers and gardeners.

North Dakota gardeners and farmers are encouraged to plant an extra row of produce to donate or glean and donate excess crops to the Garden Project. Participants leave their donations at organizations publicized on the NDDA website, including area pantries, soup kitchens, churches, domestic violence shelters, and senior programs. These organizations, having pre-registered with NDDA, weigh and report to NDDA the amount of produce they receive each year.

The project engenders secondary local partnerships. For example, The Bismarck Community Garden, organized by a group of volunteers on land provided by the Bismarck Parks and Recreation Department, offers garden plots at no charge if all produce is donated to the initiative. Burleigh County Soil Conservation District donated land in Menoken, ND, and volunteers from First Presbyterian Church of Bismarck are planting and tending the field in order to donate all the produce to the Garden Project.

Outcomes
In 2010, 41 food pantries and organizations reported 361,500 pounds of fresh, local produce donations across the state. The project is operating in its second year, and North Dakota Department of Agriculture staff report that over 65 organizations are registered to received donated produce.

Partners & Funding

The Hunger Free ND Gardens Project is a partnership between the ***North Dakota Department of Agriculture***, the ***Great Plains Food Bank***, a number of ***state and local associations and coalitions***, and North Dakota growers and gardeners. The Department of Agriculture provides funding for one employee to coordinate the program and a small budget to cover the costs of promotional materials and correspondence. Great Plains Food Bank coordinates and transports large produce donations to organizations across the state. Associations and coalitions assist with public outreach and donate space and resources for Hunger Gardens.

In the Statehouse

States can provide funding for one-time efforts that show promise of being self-sustaining in the future, including pilots and expansions of programs that have shown proof of concept. For example, in January 2009, North Dakota passed SB NO. 2231, providing a one-time grant of $350,000 to the state department of human services to contract with the Great Plains Food Bank to expand their network into rural, underserved areas in the state.

Contact

Dana Pritschet
Local Foods Marketing Specialist
ND Department of Agriculture
(701) 328-4763
pritschet@nd.gov

ADDENDUM H – BBC ARTICLE BY PAUL ADAMS - HUNGER GARDEN

http://www.bbc.co.uk/news/world-us-canada-14022795

North Dakota: Feeding the hungry in a land of plenty

By Paul Adams BBC News, Bismarck, North Dakota

North Dakotans like to think they feed the world. But right now they are being encouraged to feed themselves.

Aided by its recent oil boom, North Dakota has weathered the recession better than many other states. But government officials say one in 11 of the population does not have enough to eat. Many of these people are children.

In response, the state is promoting the Hunger Free North Dakota Garden Project, urging farmers and gardeners to grow and donate fruit and vegetables to food pantries and community programmes.

"Over 95% of our land is given over to fields, ranches, crops and animal production," says Karen Ehrens, a dietician and consultant to North Dakota's Department of Agriculture, which is helping to co-ordinate the project."

"And even here in our own state there were people not getting enough to eat, which was a great irony."

The scheme is in its second year. In 2011 it brought in 350,000lb (160,000kg) of fresh produce. This year, the target is 500,000lb.

Reap what they sow

The race to produce is infectious.

"It's becoming kind of a challenge between two of us sets of husbands and wives," says retired office supplies store owner Bob Schauer, as he and his wife Donna water seedlings on municipal ground in downtown Bismarck, the state capital.

The Schauers donated 350lb of produce last year but are now tending three plots, each measuring 20ft by 20ft (6m by 6m), and so hope to triple their record.

A hard winter and a long, wet spring have caused delays, but the they rattle off an impressive list of some 25 different fruits and vegetables they have in the ground, including cucumbers, tomatoes, potatoes and corn.

The city provides the plots and the water. Participants do the rest.

"It's up to you to furnish the seed, to maintain the garden, to water it, to weed it, to care for it," says Donna. "Then to reap the harvest and distribute it among the many charities that are on the list."

At a nearby plot, children are busy checking for weeds and bugs. Many of the plots are sporting brightly-coloured signs announcing "I'm growing a hunger free North Dakota garden."

Once harvested, some of the food grown will be used by charities feeding those in need

At the Ruth Meiers Hospitality House, a food pantry and homeless shelter on Broadway Avenue, executive director Susan Martin says the arrival of fresh produce at harvest time is a welcome addition to the canned and packaged goods that make up the bulk of donations. For the residents, it can seem almost miraculous.

"Last summer we had a lady bring in fresh strawberries," she says. "And they were just delighted because they hadn't had fresh strawberries for years."

But if growing food is deep within North Dakota's DNA, Agriculture Commissioner Doug Goehring, himself a farmer, says Dakotans are slowly forgetting their roots.

"It's amazing how disconnected we are from production agriculture," Mr. Goehring says. “The Hunger Free Garden project, he says, is designed so that people can "reconnect with the land".

It certainly seems to be working for Bob Schauer, who was raised on a farm before moving to the city.

"That's where I came from," he says. "You can never take the boy away from the farm."

Clockwise: Above- Growing a Hunger Garden at Bismarck Community Gardens; Haycreek 4H kids donate over 500 lbs of their harvest to local organizations; Valley City State students help harvest two acres of squash for the Hunger Garden Project– 57,423 lbs.; Hunger Garden Plot

ADDENDUM I:

Community Local Foods Projects utilizing the Mobile Food Processing Unit included:

	Date	Event	Comments
1.	January 21-25, 2011	Northern Pulse Growers Convention, Minot Holiday Inn	Taste testing pulse products
2.	February 18 – 19, 2011	Local Foods Conference	Farmers market vendors
3.	May 31 – June 8, 2011	Giant Snacks, Wahpeton	Market Development - sunflowers
4.	June 27 – 28, 2011	Northern Pulse Growers	Williston Research Center – taste testing at research tour
5.	July 6 – 7, 2011	Gardendwellers Herb Farm, Devils Lake area	Local foods education event/local foods meal
6.	July 8 -16, 2011	Red River Valley Fair	Pride of Dakota vendors serving local foods
7.	July 23, 2011	Farmers Market at the Capitol	Bismarck capitol grounds – local foods event
8.	July 26 – 29, 2011	Honey Lover's processing, Shields	Ice cream topping made out of North Dakota honey
9.	August 10 – 11, 2011	LaMoure Farmers Market	Local foods taste testing
10.	September 3, 2011	Capital Farmers Market, Bismarck	Local foods cooking demonstration by Chef Duane Ehrens
11.	September 13, 2011	United Tribes Technical College, Bismarck	Tree planting event at orchard, local foods meal served
12.	September 2011	Riverbound Farm, CSA south of Mandan	Slow Food Event
13.	September 30 – October 3, 2011	Honey Lover's processing, Shields	*Visited by legislator and Under Secretary Avalos* Ice cream topping made out of ND honey
14.	October 21 – 22, 2011	UND Tailgating Event	Served at tailgating –served specialty crops including pulses, dry beans & local foods
15.	October 28 – 29, 2011	NDSU Tailgating Event	Harvest Bowl - Served at tailgating –served specialty crops including pulses, dry beans & local foods