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Block Grant Program – Farm Bill

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Preparing Viticulture for Climate Change: Cold Hardiness of Grape Cultivars in Response to Weather Events during Dormancy

Subrecipient
Agricultural Research Service, Dr. Krista Shellie

Project Summary
The purpose of this project was to measure the cold hardiness of multiple cultivars of winegrape, monitor the influence of weather events during winter months on cold hardiness, and create a web-based method to access the seasonal cold hardiness monitoring. Identifying cultivar differences in cold hardiness and their response to weather events is important because economic loss from cold injury in the Snake River Valley American Viticulture Area (AVA) can be extensive. If a trunk or cordon of a grapevine is severely damaged by cold, the above ground parts of the vine must be removed from the vineyard and new growth from the roots must be retrained to the vine trellis. The cost of labor and lost years of production must be absorbed by the grower. The cold hardiness data generated from this project will facilitate selection of cultivars best suited to particular macroclimates at different growing sites.

Climate change scenarios predict a future increase in incidence of extreme weather events. Cultivars best able to tolerate extreme weather events are most likely to exhibit sustained annual production. There currently is no published information or quantitative measurements available on the cold hardiness of winegrape cultivars grown in the Snake River Valley AVA. This SCBGP project was established to complement and enhance findings from a previously funded SCBGP project entitled "Adaptation of Lesser-known winegrape cultivars to climate features of the Snake River Valley AVA". In that project, new knowledge was generated regarding the adaptation of lesser-known winegrape cultivars to the Snake River Valley AVA and provided graduate student training in viticulture. Many of these lesser-known cultivars have never before been planted in regions where winter cold delimits the length of the growing season. The differences observed in production potential among the lesser-known winegrape cultivars in the previous SCBG were mainly attributed to cold sensitivity. This highlighted the importance of cold hardiness as a cultivar attribute for sustained production in the Snake River Valley AVA. The focus of the present SCBGP project was to use differential thermal analysis to monitor the cold hardiness of bud and cane tissue of the lesser-known cultivars evaluated in the previous SCBGP and of a collection of cultivars that are currently being grown commercially in the Snake River Valley AVA. Lethal cold temperatures in bud and cane tissue were monitored throughout the winter months and web-based public access to this information was created.

Project Approach
Activities during summer months of 2012 (April to October) were dedicated to managing vines at the two vineyard trial sites. The trial site at the Sawtooth vineyard in Nampa, Idaho was established in cooperation with Winemakers LLC, and contained the lesser-known cultivars evaluated in the previous SCBGP project. The lesser-known cultivar trial plot contained 13, red and white-skinned winegrape cultivars from production regions in Portugal, Spain, Austria, Italy and France that were planted in 2006 as 4-vine panels in a block design with six replications in north to south oriented

rows on a south-facing slope. The other trial site contained a collection of cultivars already grown commercially in the Snake River Valley AVA and was located at the University of Idaho Parma Research and Extension Center in Parma, Idaho. The commercial cultivar trial plot contained 13 red and white-skinned winegrape cultivars that were planted in 1997 as 8-vine panels in a block design with four replications in north to south oriented rows on a north facing slope. Dormant plant material was collected biweekly from November 2012 until March 2013 from each cultivar at each trial site and was used to measure cold hardiness by differential thermal analysis (DTA). The DTA analysis was performed in the laboratory inside a freezer programmed to cool from 40 to -40° F in I 0 hours using the cane tissue immediately after it was collected from the field. The USDA-ARS maintained operational the DTA data acquisition system and programmable freezer and provided training in its use to a University employee. Cultivar cold hardiness data was summarized by USDA-ARS after each testing interval. A report form was developed by USDA-ARS and sent to the Idaho Grape Growers and Wine Producers Commission as an electronic "pdf' file. The Commission posted the "pdf' file on their existing website http://wine.idaho.gov/ResourceRoom.aspx. The postings began in January of 2013 and were sent to the Idaho Wine Commission weekly through the end of February 2013. A comparison of bud viability was conducted on four cultivars from the Parma vineyard using a laboratory bioassay and DTA during spring 2013 to identify differences among cultivars in response to a late season cold event. Vines were pruned to a similar bud number in spring 2013 and bud fruitfulness and vine yield were measured at fruit maturity in September of 2013. Autumn bud acclimation was evaluated in October using DTA. A manuscript describing results from this research was accepted for publication in a peer reviewed scientific journal in December 2013.

Goals and Outcomes Achieved

The goal of this project was to monitor the dormant bud cold hardiness of multiple wine grape cultivars growing in the Snake River Valley AVA at intervals throughout the dormant season and to display this real-time information on an internet website as it was measured during the season. The cold hardiness of dormant buds, determined from their low temperature exotherms using differential thermal analysis, changed throughout the winter in response to environmental conditions and the stage of dormancy. There was no specific level of hardiness, but rather a dynamic range in hardiness throughout dormancy. The information from this project was presented at the Idaho Grape Growers and Wine Producers 2013 annual meeting held at the College of Idaho in Caldwell, Idaho. Attendees of the Annual meeting were shown how to access the cold hardiness information on the website and explained how to interpret the cold hardiness data. There were 50 to 75 people in the audience during this presentation. Enumeration of the number of visits to the website where the information was posted was not logistically possible. A copy of the web-based information is included in Appendix 1 and Appendix 3 shows the seasonal cold hardiness data collected throughout winter months in 2011 and 2012. Measurable outcomes were also met by submitting progress reports of Idaho trial data to members of the multistate NE-1020 Cultivar Evaluation project at annual meetings held in 2011 and 2012. This project generated the first cold hardiness data for winegrape cultivars grown in the Snake River Valley AVA and the new information was made available to the Idaho wine industry. Information was shared with the research community through publication in a peer-reviewed scientific journal (see additional information). Data from this

project was not presented at the 2013 American Society of Enology and Viticulture as projected, but it was submitted to a peer-reviewed, scientific journal for publication.

Beneficiaries

Results from this project benefitted the Idaho winegrape industry by providing information about the cold hardiness of cultivars grown commercially in the Snake River Valley AVA. Members of the Idaho wine industry, during a field day in July 2013 at the trial plot site, informally indicated that a notable amount of cold injury was apparent during spring 2013 and that cold hardiness was an important consideration in cultivar selection. The Idaho Wine Industry experienced a 17% growth rate in 2008 and had, in 2008, an estimated economic impact of $73 million. If one of the well-adapted, cold hardy lesser-known cultivars, such as Trousseau, were to be planted commercially in the Snake River Valley AVA, its potential economic impact could meet or exceed the current rate of $1200 per ton. Adoption of a more cold hardy cultivar identified through this project could enhance the competitiveness of the State's 57 farm entities and 47 wineries, with both growing and marketing their grape and grape products.

Lessons Learned

Winegrape cultivars varied in their level of maximum winter cold hardiness, their responsiveness to winter weather events, and their rates cold acclimation. Lesser-known cultivars with low production potential due to cold injury were 'Montepulciano', 'Tinto Cao', 'Aleatico' and 'Aglianico'. 'Grüner Veltliner', 'Sauvignon Gris' and 'Trousseau' cold acclimated early, had strong mid-winter cold hardiness, and yielded similar to or higher than the leading cultivars 'Merlot' and 'Cabernet Sauvignon'. The variability among cultivars observed in this study can be used to guide cultivar selection for growing sites differing in heat unit accumulation, frost susceptibility and cold winter temperature. An unexpected outcome of this study was an observed lack of correspondence between the lethal temperatures for cane tissue measured by DTA and the incidence visible injury to trunk and cane tissue in the spring of2013. According to the low temperature exotherms from DTA, phloem and xylem tissue was consistently more cold hardy than the coldest ambient temperature during the winter, yet there was a widespread incidence of trunk and cordon injury and many vines required complete removal and retraining. This raises a question about whether DTA is a useful predictive indicator of trunk and cordon cold injury.

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Additional Information

- Dr. Krista Shellie. Oral presentation at the annual meeting of the Idaho Grape Growers and Wine Producers Commission, Caldwell Idaho, February, 2013.
- Tour of Sawtooth vineyard trial plot July 26, 2013 as part of Idaho Wine Commission sponsored Vineyard Seminar. Dr. Krista Shellie.

- Shellie, K.C., J. Cragin, and M. Serpe. 2013. Lesser-known European Winegrape cultivars in southwestern Idaho: cold hardiness, berry maturity and yield. *In review by journal.*

Appendix 1. Grapevine Cold Hardiness Monitoring. This was available on the web at http://wine.idaho.gov/ResourceRoom.aspx

Appendix 2. Figure 1.2. Photos showing the Differential Thermal Analysis System and programmable freezer used to measure cold hardiness.

Appendix 3. Figures 1.5 and 1.7. Seasonal cold hardiness in response to weather events during the winter months of 2011 and 2012

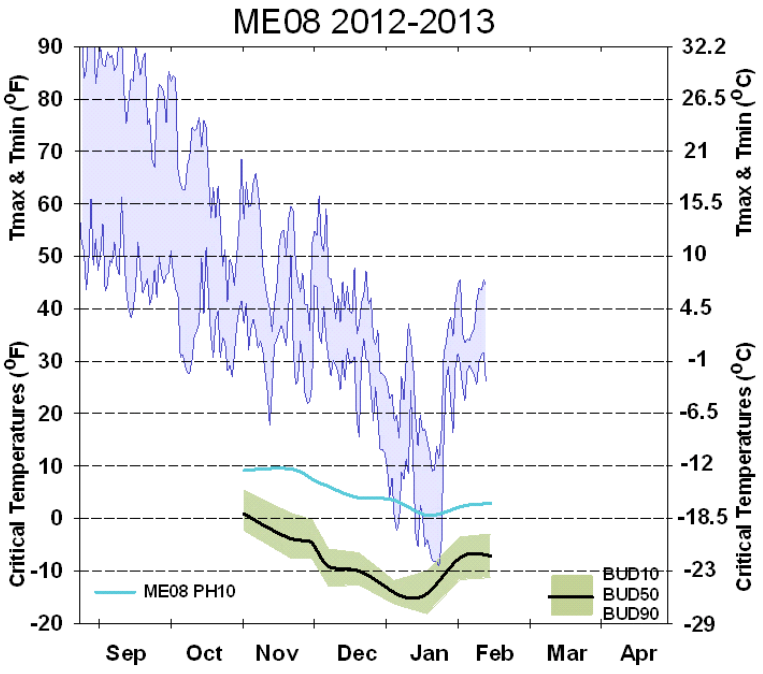
Grapevine Cold Hardiness Monitoring

Funding for this project is provided by a two-year USDA Specialty Crop Block Grant issued through the Idaho State Department of Agriculture to Winemakers, LLC and research conducted at the USDA-ARS Research laboratory in Parma, ID.

Lethal cold temperatures for wine grape (*Vitis vinifera* L.) primary bud and phloem (inner bark) tissue, as determined by differential thermal analysis (1), are presented in the table below. The numbers in the table indicate the temperature (°F) at which intracellular ice was detected in primary buds and cane tissue. BUD10, BUD50 and BUD90 are the temperatures (°F) at which ice formed in 10, 50, and 90% of buds. PH10 is the temperature at which ice formed in 10% of canes tested.

Cold hardiness changes in response to local weather. Temperatures in this table reflect the hardiness of mature vines (node positions 4-7) grown at the University of Idaho Parma Research and Extension Center in Parma, ID or Sawtooth Vineyard in Nampa, ID. *If temperatures in your vineyard have been colder than the vineyard test site, your grapevines could be more cold hardy than the stated temperatures. Likewise, if temperatures in your vineyard have been warmer than the vineyard test site, your grapevines could be less hardy.*

USDA-ARS is not responsible for any damage resulting from the use or misuse of the temperature data represented below.



Data will be updated periodically from mid-October through mid-April.

Date	Variety	Vineyard site	BUD10 °F	BUD50 °F	BUD90 °F	PH10 °F
2/12/13	Merlot	Parma, ID	-3.0	-7.0	-11.5	3.0
2/11/13	Cabernet Sauv	Parma, ID	-6.0	-11.5	-14.5	2.5
2/11/13	Chardonnay	Parma, ID	-10.0	-14.5	-16.0	1.0
2/7/13	Malbec	Parma, ID	-3.5	-8.0	-11.5	2.0
2/29/13	Merlot	Parma, ID	-3.5	-7.5	-11.5	2.0
2/28/13	Cabernet Sauv	Parma, ID	-8.0	-12.5	-15.5	-2.5
2/28/13	Chardonnay	Parma, ID	-11.0	-13.5	-15.5	-2.5
1/22/13	Malbec	Parma, ID	-8.5	-13.0	-18.0	0.0
1/17/13	Merlot	Parma, ID	-10.0	-14.5	-18.0	0.0
1/10/13	Nebiollo	Parma, ID	-14.5	-17.0	-18.5	4.5
1/10/13	Dolcetto	Parma, ID	-14.5	-16.0	-17.5	-1.0
1/10/13	Grenache	Parma, ID	-10.5	-13.0	-14.	-1.0
1/10/13	Lemberger	Parma, ID	-10	-15.5	-16.5	-0.5
1/10/13	Sangiovese	Parma, ID	-7.0	-9.5	-12.0	-1.0

Last updated 4:29 p.m. 2-15-13 by Alan Muir

- Mills, L., J. Ferguson, and M. Keller. 2006. Cold-hardiness evaluation of grapevine buds and cane tissues. Am. J. Enol. Vitic. 57:194-200.
- Ferguson, J.C., J.M. Tarara, L.J. Mills, G.G. Grove, and M. Keller. 2011. Dynamic thermal time model of cold hardiness for dormant grapevine buds. Annals of Botany 107:389-396.

Figure 1.2 The Evaluation of Cold Hardiness of Grapevines. (A) Field Samples were collected from the Field Site in Nampa, Idaho. (B) Four Trays containing 10 thermoelectric modules were loaded with Cane and Bud Tissue. (C) Trays were sealed with lids and loaded into a programmable freezer where the voltage ouput from each thermoelectric module was monitored with a data acquisition and logging system.

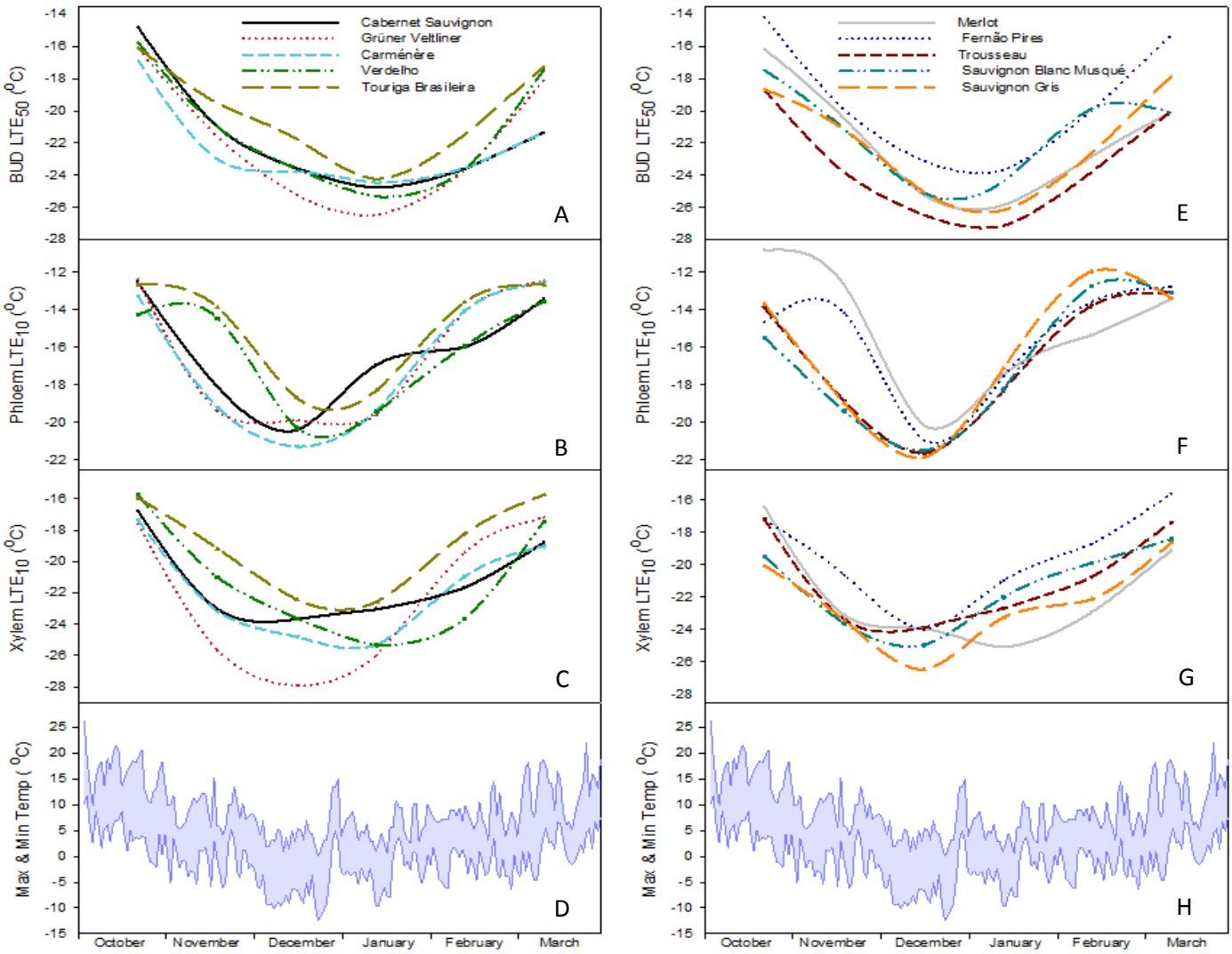


Figure 1.5 Cold Hardiness Values from October of 2011 to March of 2012 in Nampa, Idaho. Bud Cold Hardiness Based on LTE_{50} is Represented in (A) and (E) and BUD LTE50 were significant at $p \leq 0.05$ (n = 10) for All Dates Sampled. Cold Hardiness of Cane Tissue Based on LTE_{10} is Represented as Phloem Tissue in (B) and (F) with Xylem Tissue Represented in (C) and (G). Minimum and Maximum Temperatures in (D) and (H) are Equivalent.

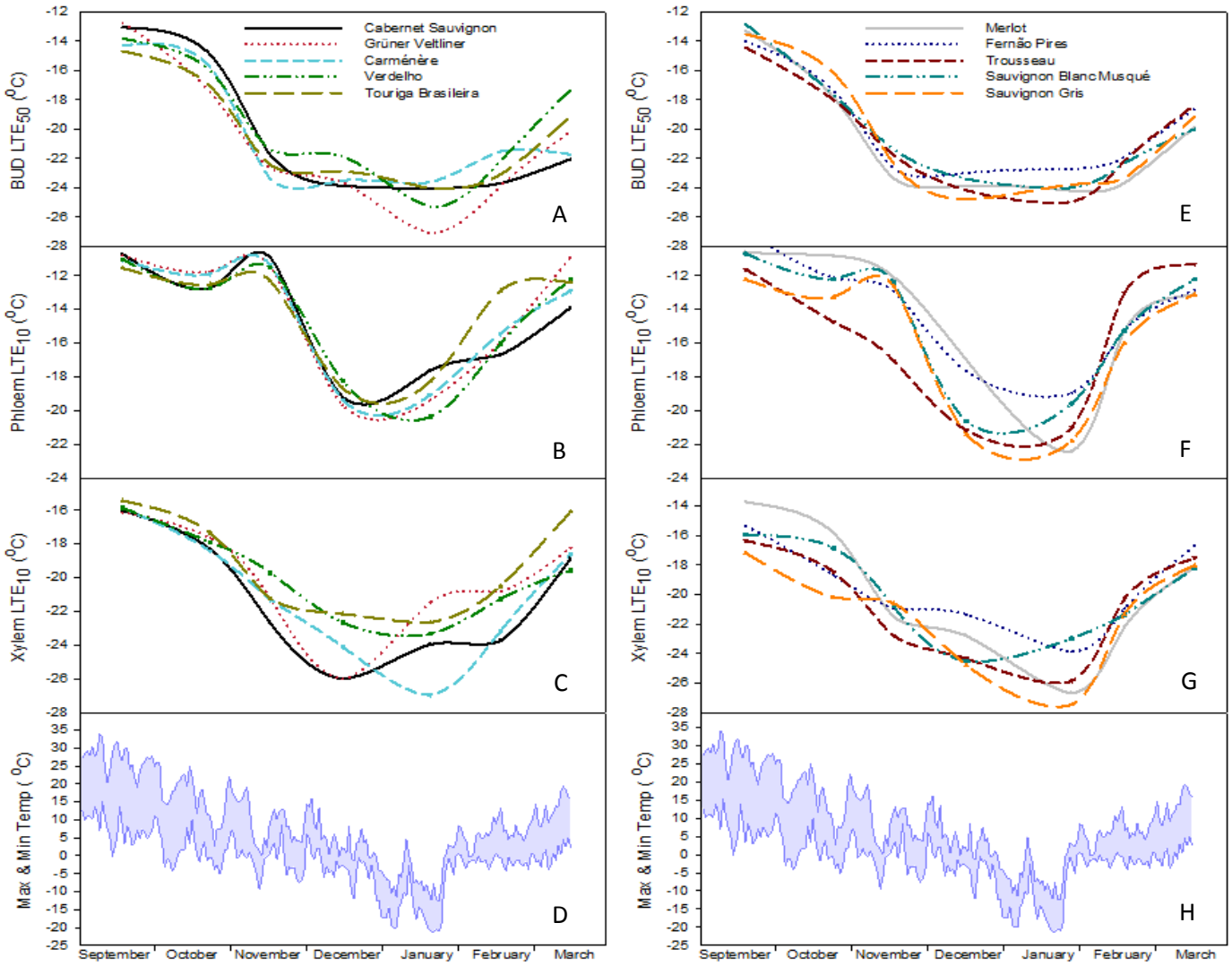


Figure 1.7 Cold Hardiness Values from September of 2012 to March of 2013 in Nampa, Idaho. Bud Cold Hardiness Based on LTE_{50} is Represented in (A) and (E) and BUD LTE50 were significant at $p \leq 0.05$ (n = 10) for All Dates Sampled. Cold Hardiness of Cane Tissue Based on LTE_{10} is Represented as Phloem Tissue in (B) and (F) with Xylem Tissue Represented in (C) and (G). Minimum and Maximum Temperatures in (D) and (H) are Equivalent.

Maximizing Production and Fruit Quality in Optimizing Mineral Nutrients in "Fuji"

Subrecipient
Idaho Apple Commission

Project Summary
Excellent climate and soil conditions make Southwestern Idaho an outstanding region for production of high quality apples. However, similar to most fruit-producing regions of the world, usable land is becoming scarce and considerable acreages of usable and fertile lands are being lost to urbanization as the population increases in Idaho. Idaho ranks fifth in apple production nationally, yet does not have the population to consume all its production locally. Thus, sustainability of this industry depends on the export market, and the global market is extremely competitive and demands high quality fruit. In this project, various new tree architectures were studied in combination with new dwarf rootstocks to enhance precocity and produce fruits with balanced mineral nutrients and increase yield and fruit quality of 'Aztec Fuji' apple. Rootstock affected leaf nutrient content. Trees on Nic 9 had significantly higher yield per tree than those on Bud 9 in 2012 but this difference was not significant in 2013 as trees reached closer to their full maturity. Fruit from trees on RN 29 (Nic 9) were significantly larger than those on Bud 9 in both 2012 and 2013. Fruit from trees on Bud 9 had significantly better color and higher soluble solids concentration. Fruits from trees on Bud 9 also had higher firmness than those on Nic 9. Trees with tall spindle training had significantly greater yield per tree, yield than those with 4-Leader in 2012, but the opposite was true in 2013, because trees with 4-Leader had young leaders with fewer fruit spurs than those tall spindle training while number of fruiting spurs exceeded those with tall spindle system in 2013. Averaging yield over 2012 and 2013 revealed that trees with tall spindle had higher yield than those with 4-Leader. Trees with tall spindle had an average of 40.3 Tons of fruit per hectare over 2012 and 2013. These trees were planted in 2010 and they were only 2 and 3 years old in 2012 and 2013, respectively. Thus, researchers are completely on their way to reach the goal of higher production when trees are mature. Fruits from trees with tall spindle architectures had smaller size (weight) than those with 4-Leader system in both 2012 and 2013. Fruit firmness and soluble solids concentration were greater in trees with a 4-Leader system in 2012 but the opposite was true in 2013. This fact indicates the transitional status of fruit quality as tree canopies go from juvenile into mature stage. Overall, it seems that a the use of Bud 9 with tall spindle training could result in optimum and early production of 'Fuji,' but this needs to be studied further when trees are fully mature.

Project Approach
Methodology, Data Collection and General Orchard Cultural Practices
The orchard soil was sandy loam with pH of about 7.6. Application of micronutrients, pesticides and herbicides and other cultural practices were similar to those in commercial orchards.

Throughout the time frame of this project, the focus was on data collection from the orchard and training methods of trees. University staff applied tree training treatments in 'Aztec Fuji'. Trees were trained into four different canopy architectures called Tall Spindle, 4-Leader, Tilted Wall and Straight Wall. These systems were established on Nic 29 and Bud 9 rootstocks. Two different orchards for this study were established at the University of Idaho Parma Research and Extension Center Pomology Program site. Trees in both orchards were irrigated with full drip and the volume of required water was calculated based of the evapotranspirartion data for the Parma Agrimet Weather system.

The experimental design in one of the orchards is randomized complete block split plot with rootstocks (RN29 and Bud9) as main effect, canopy architecture (Tall Spindle and 4-Leader) as sub-plot, each with 5 blocks of 20-tree plots. Each experimental tree row was guarded by two adjacent rows of 'Aztec' Fuji apples on the same rootstocks and tree architecture. It was necessary to establish this guarded system in order to eliminate any border effects on the actual treatments. In the other orchard, 'Aztec Fuji' on Bud 9 rootstock was used and the design was a randomized block design with Titled Wall and Straight Wall as the main effect and tree spacing (3 x 12 ft or 6 x 12 ft) as sub-plot, each with three 10-tree replications. Each experimental tree row was guarded by two adjacent rows of 'Aztec' Fuji apples.

Tall Spindle. The tall spindle system was established and trees were supported with strong posts and wire. The additional supporting system was installed during the period of this report. The trees were pruned minimally to remove branches that were thicker than 2 centimeters in diameter. Trees in this system produced fruits much faster (the second year after planting).

4-Leader. Trees in this system were topped at 36-inch height at planting and all side branches were removed to leave one or two buds. Then, only four main branches were remained permanently and the trees grew to 11 to 12.5 ft from the ground level during the period of this report. In March of 2012 and 2013, these trees were pruned to a 4-Leader and only four permanent side leaders remained on each tree. Any competing leader was removed.

Straight Wall. In this system, 'Fuji' apple on Bud 9 were planted straight at 3 x 12 or 6 x 12 ft spacing. The trees were supported by posts and wires as described for the Tall Spindle, and branches were trained to the wires.

Tilted Wall. In this system, trees were planted at a 30-degree angle (tilted) and branches arising from every 18 inches along the main trunk are tied to a wire, creating a total of 7 fruiting "lines" on each side. Thus, each side is now creating a uniform "wall of fruits" rather than single trees, and the two "tilted walls" are 60 degrees apart. These two walls of apples are producing a line of solid apple fruits at every 18 inches (total of 14 lines of fruits/two walls).

All measurement described in this project were made in 2012 and 2013. In each year the results were reported to apple growers during fruit tours and the Idaho State Horticultural Society Conference. Tree growth (growth in trunk cross sectional area), yield, time of terminal bud formation, and leaf and fruit mineral concentrations were measured annually. For leaf mineral analysis, 30 leaves per tree were be sampled randomly from the middle of the current-season's shoot in mid-August each year. Twenty fruits from each tree were picked randomly at commercial harvest time, and quality attributes (fruit color, firmness, soluble solids, starch pattern, and disorders) at harvest were determined. Analyses of variance were conducted by using SAS (SAS Institute, Cary, NC, USA), and means will be compared by least significant difference (LSD).

Goals and Outcomes Achieved

1. A traditional apple orchard with an old style of training and planting has about 494 trees per hectare and produces maximum of 25 tons/hectare of apples. However, based on preliminary experiments and selection of suitable dwarf rootstocks and tree spacing, as much as 40.3 tons per hectare has been produced in 2012 and an average of 37.8 to 39.1 tons of apples per hectare over 2012 and 2013 (Table 1). The level of production in this study at this early stage is approximately 50% greater than those in traditional orchards. These intensive orchard systems are expected to reduce water

consumption while producing much higher production per acre. This is a major outcome, and higher production is expected to be achieved when trees are fully mature. Thus, the goal of producing more apples than traditional orchards is in sight.

2. The cost of pruning was about 40 percent less by the use of Tall Spindle tree architecture in combination with Bud 9 rootstock was used.
3. Trees in all rootstocks and tree architecture treatments will be 4 years old by the end of 2014 and will enter into a mature stage. Therefore, considerable information will be available on tree growth, and development, yield and fruit quality in each treatment when trees reach complete maturity.
4. The Pomology Program at the University of Idaho worked closely with Idaho apple growers. Every step of this project was demonstrated during various educational tours to growers, several times a year. The new techniques and orchard architectures were presented to apple growers during five different educational tours and three seminars per year. During each of the five tours, between 45 to 86 fruit growers were in attendance. During each of the three seminars, between 80 to 110 people attended.
5. Idaho apple growers have been extremely pleased with performance of some of these treatments and are already establishing similar orchards with similar training and rootstocks. It is estimated that positive results from this study are already being applied by 80 percent of Idaho apple growers.

Beneficiaries

The Idaho apple industry with over 220 growers, their families, and thousands of Idaho workers who work in various sectors of apple production and fruit packing house businesses, as well as apple growers of the Pacific Northwest, will greatly benefit from the results of this project.

Lessons Learned

This project should be continued in order to learn more about these techniques as trees reach full maturity. However, results of this short-term project have been extremely informative. Based on current results, trees on Bud 9 are more precocious because they produce fruit spurs earlier than more vigorous rootstocks. It was also learned that tall spindle training results in earlier fruit production and sustainability of this type of training needs further study.

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Additional Information

Table 1. The influence of rootstock on yield and physical quality attributes in young 'Aztec Fuji' trees during 2012 and 2013.

Rootstock	Yield/Tree (kg)		Yield/Acre (Tons)		Yield/Hectare (Tons)			Avg. weight (g)		Color (1-5)[y]		Firmness (kg)	
Rootstock	2012[z]	2013	2012	2013	2012	2013	Avg.	2012	2013	2012	2013	2012	2013
Nic 9	16.3 a	15.3 a	16.3 a	15.3 a	40.3 a	37.8 a	39.1	349.4 a	302.3 a	3.7 b	4.3 b	7.9 a	8.0 b
Bud 9	14.9 b	15.3 a	14.9 b	15.3 a	36.8 b	37.8 a	37.3	320.6 b	276.1 b	4.2 a	4.4 a	7.9 a	8.4 a

[z] Mean separation within columns with Least Significant Difference (LSD) at 5% level. Each value represents the average value of four blocks, each with 8 trees.
[y] Fruit color rating: 1= green color, progressively to 5 = uniform red.

Table 2. The influence of rootstock on chemical and internal quality attributes in young 'Aztec Fuji' trees during 2012 and 2013.

	Soluble solids concentration		Starch (1-6)[y]		Bitter pit (%)		Sunburn (%)		Water core (%)	
Rootstock	**2012[z]**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Nic 9	15.5 b	14.5 b	5.3 a	4.1 a	0.3 a	3.0 a	14.8 b	5.7 b	33.3a	40.3 b
Bud 9	15.8 a	15.5 a	5.2 a	4.0 a	0.2 a	1.1 b	22.6 a	8.7 a	29.9 a	50.9 a

[z] Mean separation within columns with Least Significant Difference (LSD) at 5% level. Each value represents the average value of four blocks, each with 8 trees.
[y] Fruit Starch Degradation Pattern: 1= immature, progressively to 6 = completely ripe fruit.

Table 3. The influence of tree architectures (training) on yield and physical quality attributes in young 'Aztec Fuji' trees during 2012 and 2013.

Tree training	Yield/Tree (kg)		Yield/Acre (Tons)		Yield/Hectare (Tons)			Avg. weight (g)		Color (1-5)[y]		Firmness (kg)	
	2012[z]	**2013**	**2012**	**2013**	**2012**	**2013**	**Avg.**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Tall Spindle	19.7 a	12.9 b	19.7 a	12.9 b	48.7 a	31.9 b	40.3	329.6 b	289.5 a	4.1 a	4.3 a	7.7 b	8.3 a
4-Leader	11.4 b	17.4 a	11.4 b	17.4 a	28.2 b	43.0 a	35.6	339.7 a	289.8 a	4.1 a	4.4 a	8.0 a	8.1 b

[z] Mean separation within columns with Least Significant Difference (LSD) at 5% level. Each value represents the average value of four blocks, each with 8 trees.
[y] Fruit color rating: 1= green color, progressively to 5 = uniform red.

Table 4. The influence of tree architectures (training) on chemical and internal quality attributes in young 'Aztec Fuji' trees during 2012 and 2013.

	Soluble solids Conc. (^{o}Brix)		Starch (1-6)[y]		Bitter pit (%)		Sunburn (%)		Water core (%)	
Tree training	**2012[z]**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Tall Spindle	15.5 b	15.0 a	5.3 a	4.2 a	0.1 a	2.5 a	18.5 a	6.1 a	28.3 a	51.9 a
4-Leader	15.9 a	15.0 a	5.3 a	4.0 b	0.4 a	1.7 a	19.2 a	8.1 a	35.0 a	39.8 b

[z] Mean separation within columns with Least Significant Difference (LSD) at 5% level. Each value represents the average value of four blocks, each with 8 trees.
[y] Fruit Starch Degradation Pattern: 1= immature, progressively to 6 = completely ripe fruit.

Photo 1. 'Aztec Fuji' Apple on Bud 9 Rootstock with a Tall Spindle Training System at the University of Idaho, Parma, Idaho, 2013.

Photo 2. 'Aztec Fuji' Apple on Bud 9 Rootstock with a Straight Wall Training System at the University of Idaho, Parma, Idaho, 2013.

Development of Virus-Resistant Yellow Bean Seed for Domestic Sale and Export to Mexico

Subrecipient
Idaho Bean Commission (IBC)

Project Summary
Resistance to bean common mosaic and the related bean common mosaic necrosis viruses (BCMV and BCMNV, respectively) are routinely incorporated into dry bean cultivars that are grown in the United States. In addition, dry beans grown in the Pacific Northwest need beet curly top virus (BCTV) resistance. The Peruano or Mayocoba market class grown in Mexico is of interest to the Idaho dry bean industry for seed and domestic edible bean production. These types are susceptible to BCMV and BCTV, so a rapid backcrossing program was implemented using marker assisted selection to introgress resistance into the Peruano background. This project is a continuation of a previously funded Idaho Specialty Crop Block Grant (2010-2011), which allows introgression of virus resistance through three backcrosses into two Peruano backgrounds. At the end of the previous proposal, families were not necessarily fixed for resistance and were in need of further generation advance. During the current two year cycle (2011-2013), lead researchers advanced lines and identified a subset that was fixed for resistance. Seed increase was initiated for trialing and in anticipation of release of one or more lines.

Project Approach
During the summer of 2012, 14 backcrossed 3 derived families with I gene resistance and 12 with *bc-3* resistance were grown in Oregon and Idaho. Seed was harvested in the fall with larger quantities obtained in Idaho. Seed was cleaned and conditioned during the winter months prior to the 2013.

The four best lines with at least 5 pounds of seed were sent to Indio, California for a winter nursery increase. These were planted on January 25, 2013 into fairly cool soils and somewhat spotty stands were observed, but despite this, considerably more seed was received back than expected. Multiplication rates of 8.8 to 24x were obtained with seed amounts of 67 lbs for DBY24-2, 119 lbs for DBY28-1, 114 lbs for DBY54-1, and 44 lbs for DBY60-1. The seed was shipped back to Idaho for threshing and cleaning, and then shipped to Oregon for summer production.

Dr. Myers planted 1,120 square foot strips increase for each line at the OSU Vegetable Research Farm in 2013. Differences were noted in maturity with DBY60-1 being several days earlier than the other lines. This line was harvested before a heavy rain on September 29 and produced high quality seed. The other lines remained in the field during the rain and developed a heavy white mold (Sclerotinia sclerotiorum) infection which reduced yield and seed quality. Replicated plots were harvested from each strip to estimate yields. DBY60-1 yielded 22 Cwt/A whereas the other three lines (DBY 24-2, DBY28-1 and DBY 54-1) had yields that ranged from 11 – 13 Cwt/A. The yield difference among lines can mostly be accounted for by the white mold infection following rains and before beans were dry enough to harvest. Overall amounts of seed obtained were 137 lb for DBY 60-1, 64 lb for DBY 28-1, 81 lb for DBY 24-2 and 70 lb for DBY 54-1.

Plants were inspected for potential seed borne pathogens once during the growing season and once in the windrow by Oregon Department of Agriculture who issued a Field Inspection Certificate. A phytosanitary certificate was received for transfer of the seed from Oregon to Idaho, and of this writing, packing of seed is under way.

Taste tests conducted on a portion of the remnant seed from California revealed only minor differences among lines.

The four advanced lines were tested for the curly top resistance in the field at Kimberly, ID, station with the help of Dr. Carl Strausbaugh (USDA-ARS). Two lines, 28-2 and 54-1, exhibited the best levels of resistance and were closely followed by 24-2. Line 60-1 had an intermediate level of resistance.

All four lines, 28-1, 54-1, 24-2, and 60-1, were subjected to the virus challenge tests under greenhouse conditions at University of Idaho, with BCMNV-TN1 inoculum. Fifty plants per line were mechanically infected with the TN1 strain; all but 1 plant of the 60-1 line died exhibiting pronounced black root syndrome. The single line of 60-1 displayed local necrotic lesions on inoculated leaves but did not become systemically infected or succumbed to the black root syndrome. In all cases, the *I* gene was apparently present in the genetic background responding to the BCMNV challenge, and the lines were confirmed to carry the expected BCMV resistance genes.

The UI virology program tested the recently developed full-length infectious clones for BSCTV and BCTV for their host range on various bean cultivars. Both were found infecting beans of cultivar Topcrop, based on symptoms and laboratory analysis by ELISA and PCR. The purpose of this research is to create a tool for convenient screening of bean germplasm, without the use of leafhopper vectors for curly top inoculation. The work also continued on a series of BCMV isolates belonging to the RU1 strain, characterizing their reaction in a set of bean indicators carrying different resistance genes. The purpose of this research is to characterize genetic determinants of BCMV that interact with the *I* gene and with recessive genes, *bc-1*, *bc-2*, $bc\text{-}1^2$, and $bc\text{-}2^2$.

Goals and Outcomes Achieved

Breeding programs often require 10 years or more to complete, such that incremental progress is achieved in two year blocks. The first SCBGP allowed reasearchers to conduct a marker assisted backcrossing program to rapidly transfer virus resistance into the Peruano background. The current SCBGP met its objective of combining the characteristics of the Mayocoba market class with the resistance to two bean viruses by providing support to verify that resistance was present as predicted by the molecular markers, to identify lines that were fixed for resistance, and finally, to conduct preliminary evaluations of advanced lines and begin seed increase for yield trials, and eventual release to the Idaho dry bean industry.

The work plan sets a goal of releasing a new variety by fall of 2013. A release has not been pursued at present because there have not been sufficient trials to determine which of the four elite lines would be best for release. This should be possible after another field season of data to direct this decision. The 2013 SCBGP received by the Bean Commission will allow the completion of this project, including trials in Sinaloa, Mexico, the U.S., and the final selection and release of a new variety.

Beneficiaries

Beneficiaries are expected to be over 500 Idaho bean growers and 30 dealers who will be able to better meet market demand for this popular bean. Yellow beans are currently retailing for more than double pinto beans, Idaho's most dominant variety. Yellow beans hold great potential for increasing farm profitability. Mexican growers will also benefit from access to a yellow bean variety with BCMV and Curly Top resistance. Impact will be achieved after variety release, when the variety(s) have been placed in the hands of growers and dealers.

Lessons Learned

Researchers have gained experience with and have successfully applied a marker assisted backcrossing program. With dry beans, a time consuming bottleneck still remains with the requirement for multiple environments for testing and several seasons for seed multiplication. They have also learned that the actual virus challenge remains the key step in development of a virus resistant variety, because molecular markers may dissociate from the actual resistance trait, if not confirmed through virus challenge.

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Additional Information

Future Project Plans

Approximately 35 lbs of remnant Indio seed of each line will be used for evaluation in the National Cooperative Dry Bean Nurseries in 2014. It's expected that data from these trials will help narrow the number of selections for potential release. 100 pounds of DBY 60-1 and 50 pounds of each of the other lines will be shipped to the University of Idaho Foundation Seed Program at Kimberly for planting and further increase in 2014. Seed is also available for small yield and evaluation trials in Idaho and Mexico.

Plant Something: Awareness Campaign for Idaho-Grown Products

Subrecipient
Idaho Nursery and Landscape Association

Project Summary
The projects purpose was to encourage the use of Idaho-grown landscape plants. As overall markets and economic conditions improve, the need for such marketing efforts is critical to the recovery of the horticulture industry. With the opportunity to join other state associations and carry the same message, a unified marketing campaign was created that reached consumers nationwide. Educating the general public as to the proper use of locally-produced landscape plants is very important to the long-term success of the Idaho horticulture industry.

Project Approach
This marketing effort was in collaboration with the Arizona Nursery Association's (ANA) *Plant Something* Program. The ANA's program was funded through a Specialty Crop Grant in 2009-2010. Much of the cost of layout, design and production of the marketing and promotional materials was done by ANA, therefore there were very minimal costs incurred to adjust the materials to make them specific to Idaho. As material was developed, other states joined in the awareness campaign and allowed the use of products they had developed as well. Educating the public about the value of locally-produced landscape plants will have a significant impact on the long term success of the Idaho nursery industry.

The *Plant Something* program was first introduced in January 2012 to attendees of the Idaho Horticulture Expo (approx. 1,200 people). Businesses were able to order marketing material that targeted homeowners and promoted the benefits of purchasing and planting Idaho-grown, hardy plant material. The material was sent to them in early March. Those items included: posters, educational booklets, buttons, plant stakes, and banners. A flyer was sent out in February to all licensed nurseries in Idaho encouraging ordering of all promotional material at no charge (while supplies lasted).

Educational booklets, stickers and buttons were given out at home and garden shows throughout the state. Many of the University of Idaho County Extension offices gave out the educational booklets either at their office or during an event they held. The Idaho Botanical Garden and the Sawtooth Botanical garden also had the educational booklets available for their visitors.

An additional magazine was produced (with funding from the Idaho Nursery & Floral Research grant) with the same *Plant Something* message and distributed at all of the above-mentioned locations which also included a listing of retail garden center locations and landscape contractor contact information. An article on "Planting Idaho" was featured in the magazine along with "Choosing a Pro" and "Container Gardening; Use Your Imagination". The magazine can be viewed online at http://www.bluetoad.com/publication/?i=103668 .

A webpage was created from a template that one of the other state associations (MA) provided INLA. It is located at http://www.plantingidaho.org. Again, thousands of dollars were saved by collaborating with a *Plant Something* industry partner, which also made it possible to keep the general "look" of the

campaign the same. The Idaho website includes favorite links to articles on various plant related subjects, planting tips and a link to the INLA member retail garden centers and landscape/irrigation professional services.

INLA has a MOU with the Idaho Department of Lands to administer the Arbor Day grant program. *Plant Something* was the theme for each notification that was sent to Idaho communities this spring. Seventy five communities applied for the $300 grants and 45 were awarded. The Idaho Nursery and Landscape Association encouraged these communities to order *Plant Something* marketing materials to give out at their celebrations, and when in attendance at community events, INLA gave out stickers, educational brochures and displayed the banner.

The final approach to this campaign was to apply for another *Plant Something* Awareness Campaign grant and continue the effort through billboards, posters and other marketing material that will promote the health benefits that come from being outdoors and planting Idaho grown products.

Goals and Outcomes Achieved

Project goals included retail nurseries educating the public about proper plant choices, planting and placement of nursery stock, and the environmental benefits of trees. This was done through the use of marketing materials sent to them in early spring.

In August a survey was conducted among those who received the marketing materials. Below are the questions (in italic) and responses:

During the time you had your "Plant Something" marketing materials displayed in your nursery, what reactions/responses did you get from your customers to those materials?
Positive; it was a great reminder to them to keep them planting to improve the environment, material was passed along to tree committee members, very little, brochures were too generic – would have liked more information.

Suggestions to increase public awareness
Webpage; reasons to plant; more visibility in community; apparel for employees; TV, radio; continue with displays at home and garden shows; consistency and repetition; have retail ads use the slogan; focus on health reasons for planting; ask the experts for advice

All these components worked towards the benefits of the project which was to increase the long term sustainability of Idaho nursery growers while increasing sales of nursery stock at the local retail level. The INLA Executive Director talked personally at events and through phone calls to retail garden center members to ask what percentage their sales had increased or decreased from spring 2011 to spring of 2012. The responses ranged from a 1% to 20% increase in sales with no decreases for 2012 spring sales. Some attributed it to the *Plant Something* Awareness campaign and others to a slow rising economy. Many of the lawn care companies noted an even larger increase, as much as 50%.

A survey was also conducted at the Idaho Horticulture Expo in January in which the following questions (in italic) were asked to 78 respondents:

Before IHE had you heard of the Plant Something campaign?
81% said no
19% said yes

Have you ever seen the logo?
90% said no
10% said yes

Would you promote the campaign in your business?
26% said no (many of which were out of state or did not have a retail location)
74% said yes

In August the same IHE attendee respondents were surveyed and asked:
Did you see any of the Plant Something marketing materials at a garden center or nursery this summer?
14% said no
86% said yes

A survey at the Boise Flower & Garden show was done with attendees. One simple question was asked:
Have you heard the Plant Something slogan?
85% said no
15% said yes

In August the same BF&G attendee respondents were asked:
Did you see the Plant Something slogan at one of your local nurseries this year?
47% said no
53% said yes

Beneficiaries

All segments of Idaho's Green Industry benefited from the *Plant Something* awareness campaign. Growers were able to sell more plant material to the retail/garden centers and landscape contractors. Retail/garden centers and landscape contractors sold and installed more products to the consumer (general public). And those that care for and maintain landscapes were able to increase those services.

In the spring of 2011, marketing packets were sent to 56 retail/garden center businesses. Many of those businesses called INLA to request electronic files of the message "Don't Just Stand There – Plant Something," which were sent to them. Those electronic files were used in company newsletters, in advertising, and to produce other material given out to their customers. As a potential impact of the project, INLA was able to reach over 12,000 home and garden attendees throughout Idaho in the spring of 2011 with the Plant Something message through the magazine handed out at the events. To bring it into focus at a level of "workers on the ground" spreading the message, take the number of garden center employees of 2,000 and multiply it by the average number of customers they help on a daily basis (20), and this results in a 40,000 person outreach per day. As a potential economic impact, according to the same Idaho Green Industry survey, the sales of a retail garden center in Idaho were estimated at $103,552,316. Reported increases in sales ranged were from 5 – 20%, so if sales were

increased by an average of 10%, an additional $1 million was added to Idaho's economy to benefit specialty crops.

Lessons Learned

What was learned from this project is the enormous value that partnerships bring in a national campaign like this. Several people were available to brainstorm and collaborate, and no efforts were required to be duplicated, which in turn saved money and allowed the Specialty Crop grant funds to be spent very wisely. Lessons learned through this project include which other marketing products will be of value to this campaign in the future.

Distribution costs were more than anticipated due to the size of some of the materials. Free shipping boxes were available from USPS, but there was a larger postage expense to the size. Many of the items were hand delivered whenever someone from INLA was in a member's area, but geographically Idaho makes it a bit difficult to get around cost effectively.

One year is not long enough to really get the message to "stick". INLA is delighted to have received another Specialty Crop grant to further the *Plant Something* message. When the project began, there were five states involved, and now there are nine states and one province (British Columbia). Many other states have shown an interest in joining the *Plant Something* awareness campaign and Arizona continues to encourage them to participate.

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Development and Sustainable Production of New Potato Varieties for Idaho

Subrecipient
Idaho Potato Commission

Project Summary
The primary purpose of this project was to enhance competitiveness of the Idaho potato industry by developing new varieties that can be produced and utilized more efficiently than existing ones. These new varieties, combined with newly developed management guidelines designed to optimize pesticide, fertilizer water and energy inputs, will help address consumer demand for more sustainable production practices. Many of these new varieties will also benefit consumers through improved nutritive/health characteristics compared to standard varieties such as higher levels of nutrients and antioxidants, as well as lower acrylamide forming potential. This information was shared with producers, processors, fresh pack operators, buyers and consumers through a variety of seminars, workshops, and publications to promote implementation of sustainable potato production practices.

A primary motivation for this project was to respond to the recent implementation "Good Agricultural Practices" and "Sustainable Agricultural Practices" auditing programs by major buyers of potato products. These programs have been primarily aimed at ensuring food safety, but have recently targeted pesticide use, carbon footprints, water use efficiency and other environmental impacts. Potato producers in Idaho and other states already strive to optimize applications of inputs, but Russet Burbank and Russet Norkotah (the primary varieties grown for processing and fresh use in Idaho) are relatively input intensive due to low resistance to disease and environmental stress. One of the best ways to meet consumer demands for more sustainable potato production practices is through adoption of new potato varieties with increased pest and stress resistance.

This project is built upon a previously funded SCBGP and was designed to accelerate the development and release of more sustainable potato varieties and improve researchers' ability to evaluate and document improved efficiency. The 2011 project built upon the 2009 project by allowing the Commission and the University to more completely evaluate and define the relative water and nitrogen use efficiencies and disease resistances of the advanced potato lines that we were considering for release. As a direct result of this work, varieties were released including Teton Russet, Palisade Russet and Huckleberry Gold in 2011, each of which has superior fertilizer and water use efficiency than standard varieties as well as improved resistances to major diseases. The 2011 project also allowed the Commission and the University to generate the data necessary to release Payette Russet in 2015, which has excellent processing quality, high fertilizer use efficiency, and resistances to Verticillium wilt, late blight and potato virus Y. These combined assets will provide the potato industry with a new processing variety that will require substantially smaller amounts of nitrogen fertilizer, soil fumigants, fungicides and insecticides than current varieties.

Project Approach
The University of Idaho was contracted to develop new potato varieties with improved water and fertilizer use efficiency and increased disease resistance and conduct cultural management trials with these varieties to document the extent to which irrigation, fertilizer, and pesticide inputs could be reduced while maintaining or increasing economic returns. Results from these trials were then

incorporated into cultural management guides that were used to educate potato growers on best management practices for these varieties. The most significant results from the research trials are highlighted below.

Goals and Outcomes Achieved

Goal 1

Develop and release two new potato cultivars that provide significant advantages to the Idaho potato industry with regard to sustainability and nutritive quality. Create management guides, which document ways to reduce inputs and costs, while increasing sustainability.

Outcomes

Teton Russet, Palisade Russet and Huckleberry Gold, were released from the Idaho and Tri-State Potato Variety Development Programs during the project period. Teton Russet is a dual purpose cultivar with maturity similar to Russet Norkotah, but with better resistance to PVX, PLRV net necrosis, corky ringspot and tuber late blight infections. It has excellent Fusarium dry rot resistance, good early yield potential and excellent culinary qualities that are comparable to Russet Burbank. It also shows good potential for the early fresh market, with potential as a replacement for Russet Norkotah. Industry evaluations of processing quality for Teton Russet show that it has excellent potential for producing premium quality fries. In addition, Teton Russet has relatively low concentrations of asparagine, which is a key component in acrylamide formation. Palisade Russet has good processing quality and sugar end resistance as well as resistance to foliar and tuber late blight, Verticillium wilt, black dot, and pink rot, and a moderate level of resistance to tuber net necrosis, potato virus Y (PVY), and early blight of both the foliage and tuber. These disease resistances make it a good candidate for organic production, or for use by growers seeking reduced pesticide inputs. Huckleberry Gold is a medium-early maturing fresh variety with purple skin and yellow flesh and medium yield potential. It has potato cyst nematode resistance, which is very unique for a variety well adapted to Idaho, and also has *Potato virus X* resistance (*Nb* and *Rx1*). Merit ratings for fresh pack characteristics including postharvest evaluations for boiling, baking, and microwave characteristics were comparable to those for Yukon Gold. Huckleberry Gold tubers also have substantially higher antioxidant concentrations than Yukon Gold.
Management Guides have been developed for each of these new varieties and are posted on the Potato Variety Management Institute's (PVMI) website: *www.pvmi.org*.

Goal 2

Develop reports documenting end-use quality and processing and/or fresh pack performance of new variety releases.

Outcomes

Detailed processing quality evaluations have been conducted for all of the recent releases and advanced selections in collaboration with the JR Simplot as well as with McCain Foods and Lamb Weston. Teton Russet has excellent fry processing quality and has done well in early harvest commercial processing quality trials and looks good as a potential replacement for Shepody. An advanced selection that is nearing release later this year, A02507-2LB, also has excellent processing potential and long dormancy and looks good as a potential replacement for Russet Burbank for processing out of long-term storage. It also has resistance to a wide range of diseases including late blight, PVY, black dot and pink rot, making

it an excellent candidate for sustainable potato production.

Detailed reports documenting this information have been shared widely within the potato processing industry, including growers, processors and quick service restaurant quality managers.

Goal 3

Develop a report documenting biochemical and nutritional characteristics of advanced selections and new releases from the potato breeding program.

Outcomes

A report presenting concentrations of antioxidants, vitamin C, protein, sugars, asparagine and acrylamide has been published annually for all of the selections from the University's breeding program. It is posted on the USDA-ARS potato breeding website:
http://www.ars.usda.gov/Main/docs.htm?docid=21888.

Goals 4-6

Develop a report documenting responses of advanced selections and new releases to reduced amounts of irrigation, nitrogen fertilizer and fungicides. Relative resistances to major potato diseases will also be included in the report.

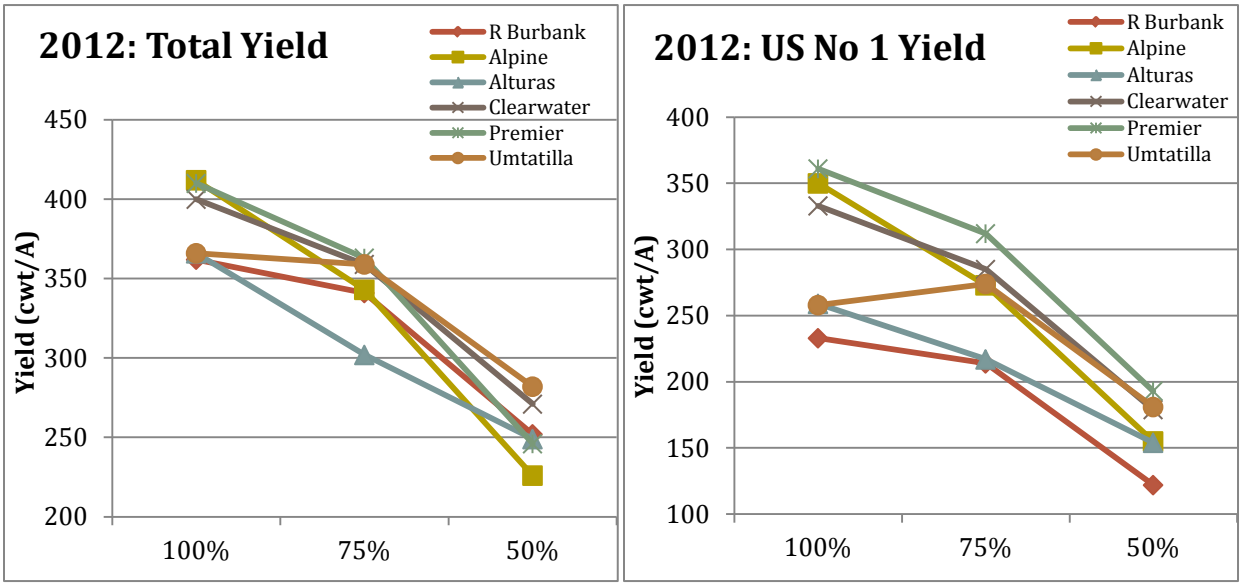
Outcomes

Water Use Efficiency

In 2012 Russet Burbank, Alpine Russet, Alturas, Clearwater Russet, Premier Russet, and Umatilla Russet were grown under 3 different irrigation regimes (100 % ET (20 inches), 75% ET (15 inches), and 50% ET (10 in), at the Aberdeen, Research & Extension Center. In 2013 the varieties/selections for this study included Russet Burbank, Classic Russet, Palisade Russet, Teton Russet, A01010-1 (aka, Binary) and A03158-2TE. Irrigation timing was identical for each treatment, with only the length of the irrigations differing to produce the three irrigation rates. The differential irrigation treatments were applied throughout the tuber initiation and bulking stages.

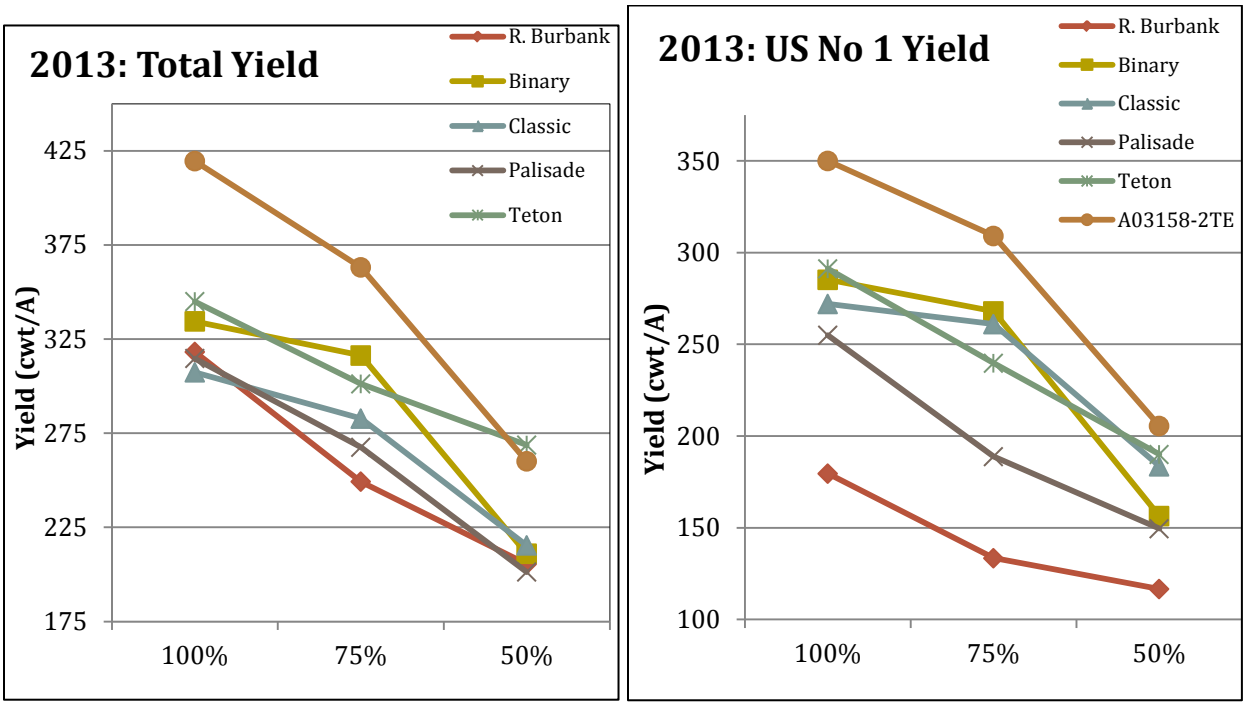
In 2012 trial, Premier Russet, Clearwater Russet and Umatilla Russet generally produced higher total yields than Russet Burbank across the wide range of irrigation levels (Fig.1), while Alturas produced lower total yields. However, all of the varieties used in this study with the exception of Alturas produced higher U.S. No. 1 yields than Russet Burbank at all irrigation levels.

Figure 1. Total and U.S. No 1 Yields for six potato varieties irrigated at 50, 75 and 100% ET in 2013.



In 2013 five new varieties/selections were compared with Russet Burbank across the same range of irrigation levels (Fig. 2.) A03158-2TE had significantly higher yield than any of the other varieties except Teton Russet for both total and U.S. No 1 yields at all irrigation levels. Teton Russet and A01010-1 (Binary) generally had higher total yields than Russet Burbank.

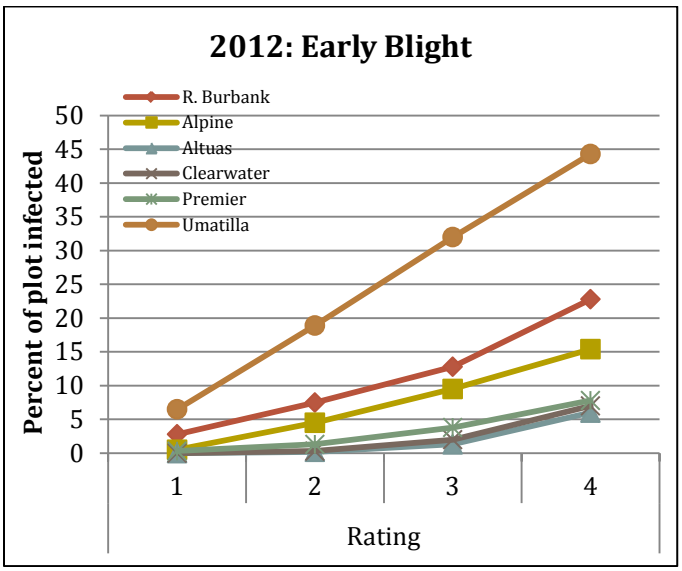
Figure 2. Total and U.S. No 1 Yields for six potato varieties/selections irrigated at 50, 75 and 100% ET in 2013.



These results show that the potential for improving water use efficiency through production of newer potato varieties is substantial. Improved water use efficiency would potentially provide an economic benefit to growers in terms of reduced pumping costs, but would also provide protection from major losses in yield and quality in years when snow pack conditions result in restrictions on water availability for irrigation.

Fungicide Use

Alpine, Alturas, Clearwater, Premier, Umatilla and Russet Burbank were planted in field trials at the University of Idaho Research & Extension Centers in Aberdeen and Parma during 2012 to evaluate responses of different varieties to the number of fungicide applications rates required to provide disease protection.



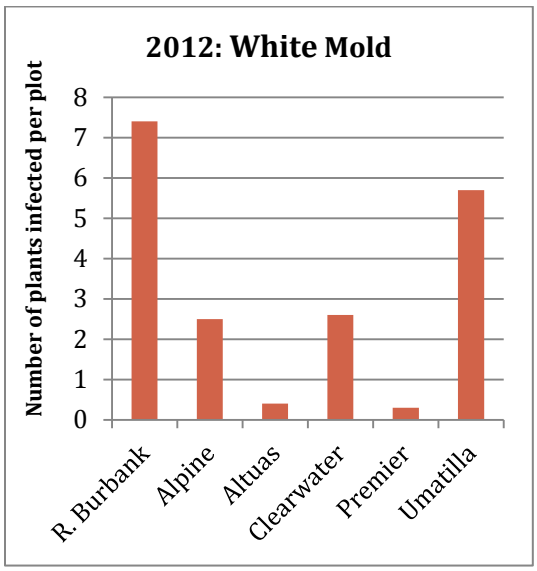
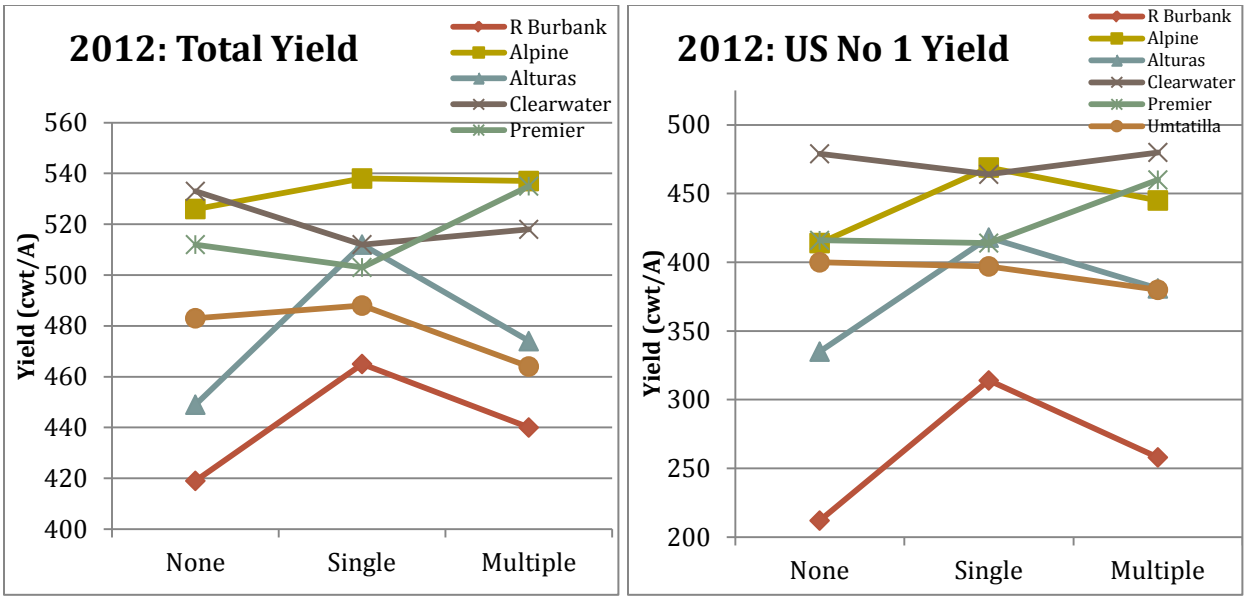


Figure 3a. Percent early blight infection on (1) Aug 27, (2) Sept. 3, (3) Sept. 10 and (4) Sept.18, 2012 of 6 potato cultivars

Figure 3b. White mold infection of 6 potato cultivars in 2012.

Alturas, Clearwater, and Premier all exhibited the greatest resistance to early blight having very similar ratings throughout the season (Fig. 3a). Also Alturas, Premier Russet, Alpine Russet and Clearwater Russet showed reduced amounts of white mold infection compared to Russet Burbank. Among the newer varieties, Umatilla had the highest level of foliar infection of early blight (Figure 3a) and white mold (Figure 3b).



Figures 4a and 4b. Effects of the number of fungicide spray applications on total and U.S. No. 1 yields (cwt/ac) of six potato varieties grown in 2012.

All of the new varieties produced higher Total and U.S. No. 1 yields than Russet Burbank at all levels of fungicide application (Fig. 5). Alpine, Clearwater and Premier were the least affected by the number of fungicide applications, indicating that growers could achieve significant savings by reducing the number of fungicide applications that they make to their crop when growing these new disease resistant varieties.

Economic Returns

Economic viability is a critical component of any sustainable potato production system. A processing (fry plant) contract model was used for the economic analysis in this study. Six metrics were compared to evaluate the relative economic efficiency of the newer varieties and advanced selections in comparison to Russet Burbank. These included: 1) Quality incentive-adjusted price, 2) Total value per acre, 3) Modified gross value per acre, 4) Average price received, 5) Cost of production, and 6) price received/unit of input. The results are illustrated here using the modified gross value per acre value since it takes into account changes in operating costs when inputs are reduced. Positive values indicate that the new variety is more economically efficient than Russet Burbank, while negative values indicate lower efficiency.

Table 1. Effect of irrigation level on modified gross value of five Tri-State potato varieties compared to Russet Burbank.

Irrigation Level (% of ET)	Alpine Russet	Alturas	Clearwater Russet	Umatilla Russet	Premier Russet
	----------$/acre ----------				
50	+438	+304	+451	+534	+565

75	+1,144	+793	+1,186	+1,092	+1,440
100	+1,405	+791	+888	+829	+1,430

Table 2. Effect of irrigation level on modified gross value of five recently released Tri-State potato varieties and advanced selections compared to Russet Burbank.

Irrigation Level (% of ET)	Classic Russet	Palisade Russet	Teton Russet	A01010-1	A03158-2TE
	----------$/acre----------				
50	+567	+384	+503	+283	+817
75	+1,097	+726	+867	+1,223	+1,652
100	+809	+827	+1,008	+1,080	+1,626

Table 3. Effect of N application rate on modified gross value of five potato varieties/selections compared to Russet Burbank.

Nitrogen Rate (lb N/acre)	Palisade Russet	A03158-2TE	A02507-2LB	A0073-2	A02138-2
	----------$/acre----------				
0	+ 130	+1,201	+730	+673	-309
60	+ 262	+1,335	+707	+474	+335
120	-27	+1,498	+714	-74	+365
180	+328	+1,350	+903	+227	+832
240	-76	+1,254	+497	+83	+1,003

The new varieties and selections all generated substantially more modified gross value per acre across a range of irrigation levels compared to Russet Burbank (Tables 1 and 2). Among the first group of varieties presented in Table 1, Premier Russet was the most economically efficient variety at all levels of irrigation applied, while Alturas was the least efficient. Alpine became more efficient as the amount of irrigation increased, but the efficiency of Clearwater Russet and Umatilla Russet decreased at the 100% ET level.

Among the recently released varieties and advanced selections (Table 2), all performed well compared to Russet Burbank, However, A03158-2TE was exceptional with regard to its economic return at all irrigation levels.

The new varieties and advanced selections also produced higher economic returns than Russet Burbank at nearly all nitrogen fertilizer rates (Table 3). A03158-2TE and A02507-2LB produced substantially higher returns across all N rates and show excellent promise for release in 2014.

Goal 7

Educate 200+ growers about optimum cultural practices for new potato cultivars by distributing the management guides at appropriate conferences and workshops. Information from the 2011 SCBG project was presented at Grower workshops held at the Idaho Potato Conference in January 2012 (42 attendees), January 2013 (39 attendees) and January 2014 (57 attendees). Additional variety management training sessions for growers and processors were held at the JR Simplot Technology Center in February 2012 (28 attendees) and the McCain Foods annual grower meeting in Burley, in March 2013 (73 attendees).

Outcomes: Cultural management guides for the new varieties were distributed to interested growers during workshops held at the Idaho Potato Conference in January 2012, January 2013 and January 2014. Additional variety management training sessions for growers and processors were held at the JR Simplot Technology Center in February 2012 and the McCain Foods annual grower meeting in Burley, in March 2013. Total grower attendance at these meetings was over 200.

Management guides for the new varieties were also posted on the following website:
Potato Variety Management Institute - *www.pvmi.org.*

Beneficiaries

This project benefited the estimated 100+ producers already growing newly released varieties by supplying management recommendations that will allow them to take advantage of potential reductions in pesticide, fertilizer and irrigation inputs. The resulting economic and environmental impacts could be substantial. The potential economic savings to Northwest growers attributed to that reduced nitrogen fertilizer use in 2013 was over $4.8 million. The reduced use of nitrogen should also significantly decrease the potential for nitrate-contaminated ground water in the region. The economic and environmental impacts of improved water and pesticide use efficiency should provide similar benefits.

Both the fresh pack and processing industries; and the associated buyers that are implementing sustainability initiatives should benefit from this project. The results provide quantifiable data as to the extent that fertilizer, water and pesticide input efficiencies can be improved by adoption of new varieties, and allow buyers to calculate the environmental impact on their business. This information also meets the demands of consumers interested in sustainable food production, and provides incentives for adoption of new varieties within the potato industry. In addition, the enhanced yield and quality of many of these new varieties and selections will also help to provide viable alternatives for production during years when water supplies are short.

Lessons Learned

This project clearly documents the improved efficiency of newly released potato varieties in terms of yield per unit of fertilizer, water and pesticide inputs compared to Russet Burbank. The magnitude to which production efficiencies can be improved was substantial. This clearly points to the need to continue current variety development efforts as a way to promote sustainable potato production in the future, as no other production system changes are likely to have this large of an impact.

Contact Persons

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Additional Information

None

International Market Development for Idaho Potatoes

Subrecipient
Idaho Potato Commission (IPC)

Project Summary
As Idaho continues to out-produce consumption of its famous potato domestically, IPC and shippers have turned to new markets overseas as an additional revenue stream. The Idaho Potato brand has been well established in the domestic market due in large part to educational activities and promotions. However, the Russet is not well known in many international markets. There is an apparent need for similar programs and activities to educate and inform new consumers in international markets and to promote the benefits and qualities of the Idaho potato as a premium brand.

The two-year program concentrated on developing and implementing educationally focused promotional programs in countries or regions designated as developing opportunities by the Idaho Potato Commission. The program included activities such as trade shows and technical training that educated and promoted Idaho fresh, dehydrated and processed potatoes to importers, distributors, food and beverage buyers, chefs and consumers in targeted markets.

Project Approach
IPC was able to participate in trade shows (MIDA and America's Food &Beverage (AFB)) servicing the Caribbean and Central and South American markets as well as HOFEX, the largest food and beverage oriented exhibition in Asia, and the PMA in Canada. These shows allowed IPC and Idaho companies traveling with the Commission to make personal contact with new wholesale and retail buyers, distributors, and foodservice decision makers, as well as reinforce relationships during pre-arranged meetings with current partners. The trade shows were a very effective way of finding new business partners and markets and promoting Idaho's fresh, dehydrated, frozen and processed potatoes through sampling, presentations and one-on-one conversations.

The Idaho Potato Commission had at least one booth at each of the above mentioned trade shows. It was a goal to sponsor at least one Idaho company in each of these shows to facilitate direct and immediate contact as well as sales. The presence of a booth alone drew the attention of hundreds of prospective consumers, buyers, distributors, and executives from the foodservice industry. Over 30 qualified leads have come out of these trade shows. From these leads new trade relationships have been established and have led up to 100-200% increase in shipments of potatoes and potato products into newer markets like Puerto Rico, Hong Kong, and Malaysia. At AFB in Miami, a demand for a particular frozen product was discovered, and as a result, a company that had not yet joined the export market is now supplying frozen bakers to the Latin American market.

This grant also enabled IPC to develop, produce, and implement a retail training program with the three largest retailers in their perspective markets: Cold Storage in Singapore, Giant in Malaysia and Wellcome in Hong Kong. The training program was tailored to each market and their varying cultural nuances. It provided handling, merchandising and storage presentations for produce executives, managers and

merchandisers in the region. Since the completion of this training all three retailers have ordered several containers of potatoes from Idaho shippers and continues to stock them regularly.

None of the trade shows or the training program would have been possible if it were not for IPC's partners and service agencies. Imalinx, Jaya Setia and Louis Ng are IPC's representatives in key foreign offices. They do much of the trade show booth organization on the ground and set up meetings between growers/shippers and in-region buyers. They facilitate contact with local organizations, distribution and media outlets, and provide market status updates for strategic planning. The Perishables Group was a key component in supporting the development and implementation of the Retail Training Program. With their already extensive knowledge and expertise in this area and their relationship with the U.S. Potato Board, they were able to assist with this project using data already collected and their extensive experience in the region for a reasonable fee.

Goals and Outcomes Achieved

IPC's goal was to achieve a minimum of 25% year-on-year growth in volume in each targeted market. Very early on in the program, Canada was excluded, as it is now being managed by IPC's national sales team. This enabled the Commission to focus on newer markets with great potential for the Idaho® potato. Successes in the Caribbean, Hong Kong/Macau, Malaysia and Singapore were significant.

Through the MIDA trade show in Puerto Rico, IPC was able to facilitate a new relationship between a third shipper and a new distributor for fresh exports to Puerto Rico and the Caribbean region. Work at the MIDA show and important follow-up also turned several new trade leads into real business for current shippers, resulting in new orders and consistent re-orders. Through these activities, sales volume in this region increased by over 90% in the last two years.

Two hugely successful reverse trade missions in Southeast Asia resulted in the addition of two of the largest retailers in SE Asia: Cold Storage and Giant. Both are shipping Idaho product consistently, and promotional activities were conducted by the local IPC representatives to support their launches. By the year 2013, volume increased in Malaysia by 40% and in Singapore by 150%. In Hong Kong the Commission was able to re-establish volumes with a new distributor and increased volumes by 100%.

Beneficiaries

Although not all Idaho growers, shippers, and processors choose to participate in markets outside of the U.S., all of Idaho's potato industry is positively impacted by internationally focused efforts. The greater the demand, the higher the grower return – which is critical to industry success and sustainability.

As a result of these initiatives, all segments of the Idaho potato industry including fresh, frozen, and dehydrated have expanded their opportunities outside the United States. From these missions and shows, they have identified new markets, increased their knowledge of the markets, developed new contacts and relationships, and in many cases directly increased overall international sales.

Lessons Learned

Although it was understood that trade shows and trade missions are the best tools to create awareness within the countries they are being conducted, it quickly became apparent that the strength the Idaho

brand and demand for Idaho-branded product is strong beyond the markets that have been targeted in the past.

On several different occasions, a trade show in one country (Singapore, Hong Kong, and even Miami) drew vendors from throughout the region, contact information was exchanged, and relationships were established that have resulted in exclusive distribution contracts of Idaho sealed product in China and in Malaysia, as well as new distribution channels in several countries in Latin America.

The retail trainings that IPC designed and implemented for the Asian market were also valuable in understanding of the varying cultures and markets. The best practice that came out of this event was to ensure that the produce merchandisers on the floor handling the product were present in the training. The hands-on training with the merchandisers provided much better results than training attended by higher lever management or buyers. In the future, IPC will insist that the actual produce merchandisers be invited to take part in any training provided.

There were two things that became very evident as both the trade missions and trade shows were being conducted. 1) It is absolutely imperative that a shipper/processor be present. IPC as a promotional organization cannot make a sale or draw up a contract. The funds from this grant allowed IPC to support representatives from Idaho companies to participate in these activities. 2) The efficiencies that a representative in the field provides are invaluable. Without someone in the region who speaks the language, understands the business, and already has relationships in the desired areas, IPC would not have known which shows to take part in, whom to meet with, or where best to focus time and efforts.

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Promoting Specialty Crops through Advertising and Channel Marketing

Subrecipient
Idaho Preferred

Project Summary
Idaho Preferred® is a program managed by the Market Development Division of ISDA to identify and promote Idaho food and agriculture products. The Idaho Preferred® program conducts television and radio advertising, retail and foodservice promotions, public relations activities, consumer events and educational programs to increase consumer awareness and demand for locally grown and produced products.

In 2010, the Idaho State Department of Agriculture conducted a specialty crop industry survey to identify needs and set priorities. The top priority as identified by the specialty crop industry was "Increasing Marketing and Promotion." Idaho Preferred® was well positioned to meet this need by expanding current marketing and promotion programs that had successfully increased consumer awareness of Idaho-grown products through an advertising campaign funded by previous Specialty Crop Block Grants.

The goal of 2011 Specialty Crop Block Grant was to continue this productive campaign through television and/or radio advertising. Specifically, this grant requested funding for 6 weeks of television and/or radio advertising to maintain current consumer awareness levels, and to allow the extension of a Specialty Crop grant-funded staff person to carry out retail and foodservice programs, as well as consumer and education events, designed to increase consumer demand for Idaho specialty crops. Ads produced featured only specialty crops: green beans, cherries, corn, dry beans, apples, potatoes, pears, and onions.

In order to be effective in the Idaho television market, a campaign should reach approximately 85% of consumers an average of 14 times in order to reach consumer awareness of 50%. This campaign strategy has proven successful, as research shows that consumer awareness of the ads has increased from 32% in 2007, to 41% in 2008 and to 66% awareness in 2010 – a dramatic increase in just 3 years! This grant requested support of 6 weeks of specialty crop specific television in 2013. This level of advertising was the minimum necessary to maintain the current levels of consumer awareness.

Television advertising is a call to action to affect immediate buying behaviors. In order to affect consumers' longer term demand for local specialty crop products, other information and education programs and events must occur. This grant also allowed for the continuation of a full time staff person to carry out demand building retail, foodservice, consumer education and school-related programs. These projects helped "connect growers to buyers" and "conduct consumer education" programs - identified as the third and seventh highest priorities in the 2010 Specialty Crop Industry Survey. Matching state funding and Idaho Preferred® participant fees supported the actual program costs. This

grant did not duplicate efforts of previous SCBG funds, but did extend and build upon previous advertising and marketing projects.

Project Approach

This grant included funding for 6 weeks of television advertising in 2013 based on advertising costs at the time of about $10,000/week. Due to the recessionary economy in 2011 when the proposal for this grant was written, television advertising rates were lower due to increased inventory as many companies reduced or eliminated marketing budgets. By 2013 when the ads were placed, the economy had rebounded, television ad inventory had tightened, and advertising prices had rebounded to over $14,500 per week. As a result, changes to the media plan were made to stay within budget and still meet the goals of the plan.

To promote the nursery industry, print, and online advertising replaced television ads in the spring of 2013. Print ads ran for the two weeks prior to Mother's Day (weeks of April 29 and May 6) in nine markets. A total of 16 ads ran in the Friday or Saturday edition of daily papers in Coeur d'Alene, Lewiston, Bonner County, Moscow, Idaho Falls, Pocatello, Twin Falls, Nampa and Boise. On-line ads were added during the same two week period to support the print campaign with banner ads running on the top rated website in Idaho, KTVB.com; and on the Yahoo Network. A total of just over $12,000 was spent on this nursery campaign.

The remaining advertising funds, approximately $51,000 were used to help fund 6 weeks of food-related specialty crop television commercials in August-September 2013. These 30-second ads were produced in 2011 and feature only specialty crop products including sweet corn, green beans, dry beans, cherries, potatoes, apples, pears, onions and summer squash. The ads ran the weeks of August 19 and 26, and September 2, 16, 23, and 30. Specialty crop television ads ran in Boise, Idaho Falls, Pocatello, Twin Falls, Lewiston, and North Idaho markets. Ads were strategically placed to reach a primary target audience of women 25-54 and included all dayparts and popular network programming including popular fall premiers such as 20/20, Dancing with the Stars, CSI, 48 Hours, Law & Order, Castle and Modern Family. Because stations matched each paid spot, it was possible to attain 1254 GRP's in each market. The cost of this television flight was approximately $87,000. Costs over the amount available through this grant were paid with subsequent Specialty Crop Block Grant funds.

The second component of this grant was funding of a staff person to carry out promotions for specialty crops through the Idaho Preferred program. Skylar Jett carried out a wide variety of consumer information programs to promote specialty crops, including a Farmer Chef Collaborative, Sun Valley Harvest Festival, Green Expo, Organic Week Celebration in 2012, A Locavores Night Out, Savor Idaho, and Dinner in the Orchard. She also recruited new specialty crop producers to take advantages of the many promotions conducted on their behalf and worked with new and existing retailers and restaurants to market specialty crops in Idaho.

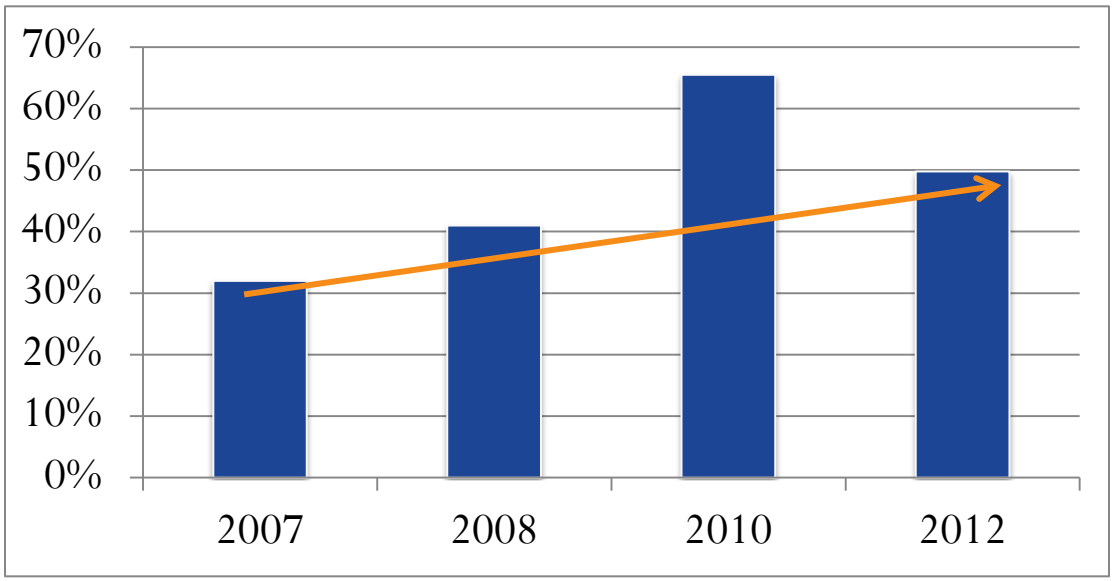
Goals and Outcomes Achieved

Television Campaign

Program evaluation is a significant part of the Idaho Preferred program. Statewide consumer market research has been conducted for 7 years to assess program performance. Consumer market research

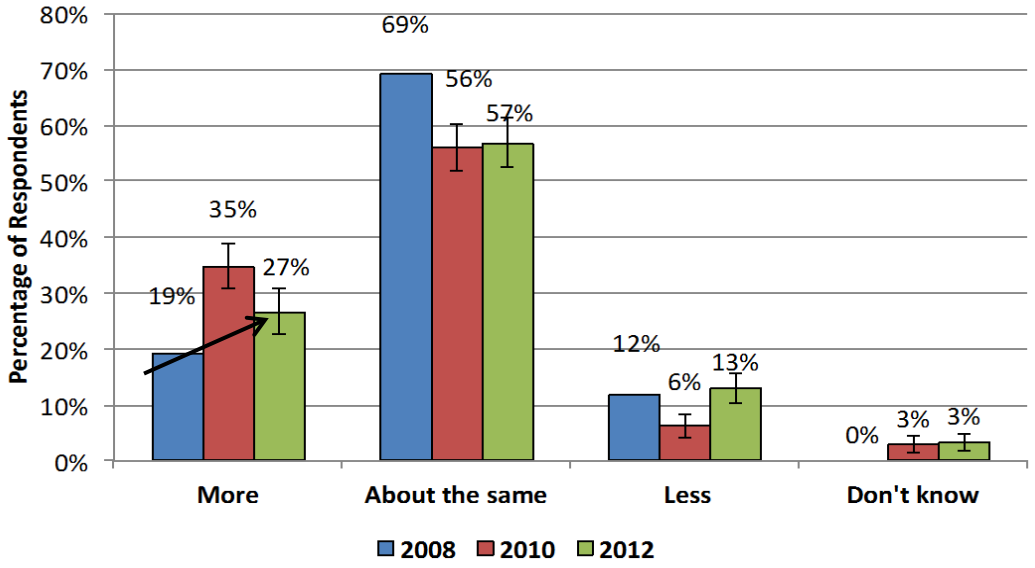
conducted in 2010 served as baseline data for this grant. Although originally planned for 2011, the data was not collected until fall of 2012 due to increased cost of conducting the research, limited funding and loss of a key research partner. As a result, the ads in this campaign ran after the 2012 research was conducted, and results will not be seen until the research is conducted in fall 2014. The research was NOT paid with this grant and is now conducted bi-annually. Below are results, original goals and explanations for 2012 results.

Chart 1: Research Findings - Awareness
"Have you heard or seen any advertising messages using the phrase Idaho Preferred or seen its logo, featuring a blue oval with a yellow sunrise behind the mountains?"



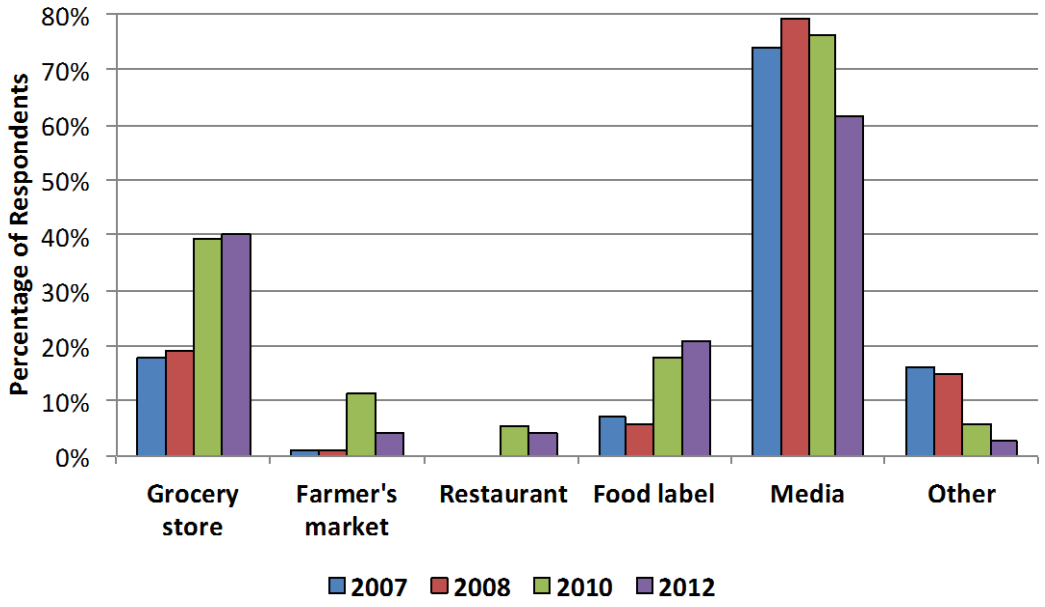
This graph depicts awareness of the Idaho Preferred logo and campaign in general. Although awareness fell from 2010 to 2012, the long term trend in awareness is upward. The goal for 2011 and 2013 as stated in the grant was 70% awareness. Obviously that goal was not reached in 2012 and data will not again be available until fall 2014 to assess effectiveness of the 2013 campaign. One of the possible reasons cited by the ad agency for the decline from 2010-2012 was the overall decline in the dollars spent for advertising in addition to the increased cost per ad resulting in fewer ads and fewer impressions. Prior year highs had been achieved with 12 weeks of advertising.

Chart 2: Research - Amount of local food purchased?
"On average, would you say you are buying more, about the same, or less local products than you used to?"



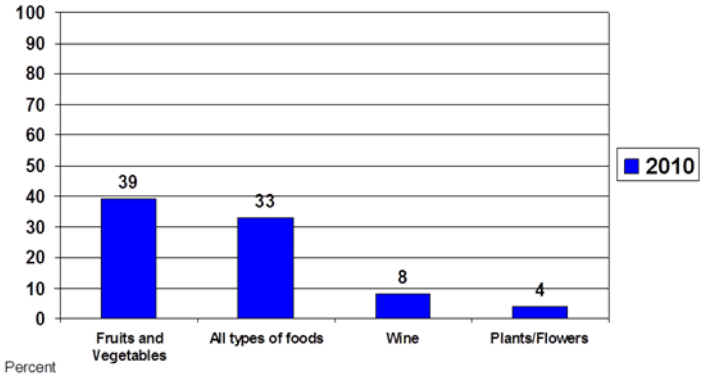
This graph reflects consumers reported buying behavior. 2010 data showed 35% of consumers reporting they were buying more local products. In 2012 that number fell to 27%, still a relatively strong number and above 2008 levels. However, the goal of 38% and 43% for 2011 and 2013 respectively were not met with 2012 data. Also disappointing was the increase in number of people reporting buying less local product. Because follow-up questions on why consumers were making these decisions was not a part of the research questionnaire design, reasons for these changes would only be speculative.

Chart 3: Research - Where is the message being seen?
"Where have you seen or heard this message or logo?"



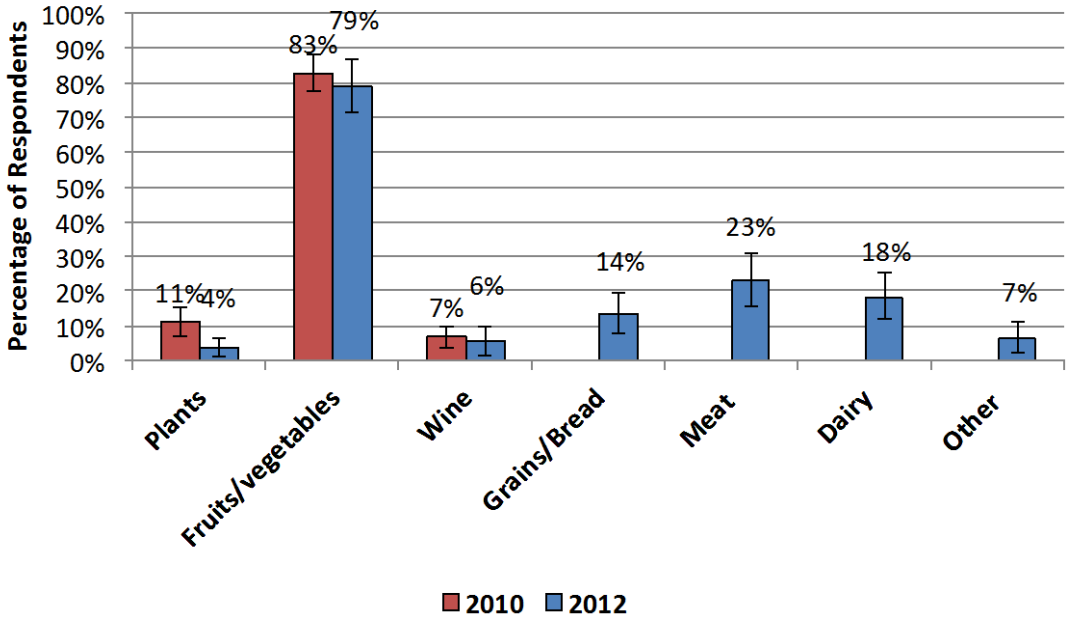
Although no objectives were set to see increases in any one area, Chart 3 shows that fewer people reported seeing the Idaho Preferred message in the media, not unexpected with fewer weeks on air, but more are identifying local products at the retail level and on packaging. This may be an indication of successful partnerships with retailers who are increasingly identifying local specialty crops with signage provided through the Idaho Preferred program (but not funded by this grant).

Chart 4: What images are recalled
"What images do you recall seeing in the Idaho Preferred TV ads?"



This question was not asked in 2012 due to the fact that a new TV commercial that only showed specialty crops was created in 2011 and was the only ad to air during the 2011 – 2013 campaigns.

Chart 5: Research - Types of local food purchased?
"What products would you say you are buying more of?"



The goal of the specialty crop advertising program is to increase purchase of specialty crops. This graph shows that fruits and vegetables are by far the most frequently reported foods that are being purchased locally. Questions about non-specialty crops were added to give perspective to purchases of specialty crops vs. non-specialty crops in reported buying behavior. The goals of maintaining levels of reported buying of fruits and vegetables was met as the slight decline is considered statistically insignificant.

However the goal of increasing reported nursery sales was not achieved in 2012. This may be due to the fact that nursery advertising was reduced to only two weeks of television advertising in 2011 and 2012 which makes it very difficult to achieve reach and frequency and affect buying behavior. The strategy of changing media plan to print and on-line for nursery products will be evaluated in 2014 research.

Staff

At the completion of the grant period, the following accomplishments had been achieved by staff:

- *Three Farmer Chef Collaboratives will be conducted by 2013 to connect growers to restaurants and chefs. (Spring 2012-13)*
    - Assisted University of Idaho to host a student-led collaborative in Moscow (December 2012)
    - North Idaho Farmer chef Collaborative (November 2012: 40 attendees)
    - Locavore's Night Out Industry Collaborative (April 2013: 400 attendees)

- *Three consumer events will be conducted to increase consumer awareness and provide opportunities to purchase specialty crop items directly from growers and processors.(Summer-Fall 2012-13)*
    - Sun Valley Harvest Festival (September 2012: 500 attendees)
    - Green Expo (June 2012: 6,000 attendees)
    - Organic Week Celebration that included (4 specialty crop producers) (June 2012: 200 attendees)
    - Victor's a Locavore's Night Out Consumer event(April 2012: 400 attendees)
    - Savor Idaho (June 2012 & June 2013: 900 attendees)
    - Dinner in the Orchard (July 2013: 60 attendees)

- *Ten new specialty crop producers will be recruited to take part in demand-building programs.*
    - Parma Ridge Vineyards – wine grapes
    - Giant Produce - Onions
    - YAH farms – Garden vegetables
    - Hells Canyon/Zhoo Zhoo Winery – Wine Grapes
    - Walton Farms – table grapes
    - Scott's Landing – table grapes
    - Snake River Winery - wine
    - Greenleaf Farms – table grapes
    - Fraser Vineyards – wine
    - Fresh Potato Co. - potatoes
    - Terra Nativa Vineyards – wine grapes
    - Cholmondeley Vineyards – table grapes
    - Silver Leaf Organics – organic table grapes
    - Benson Orchard – tree fruit
    - Jim's Year Round Produce - vegetables
    - Hamanishimi Farms – mint, onions, potatoes
    - Nielsen Brothers Vineyards – table grapes

- *Three new retailers will begin identifying local specialty crop items in their stores.*

- Boise Co-Op
- Rosauers - Meridian
- Barnucopia - Eagle
- Whole Foods - Boise

- *Five new restaurants will begin identifying local specialty crop items on their menus.*
  - Castle Rock Steakhouse - Boise
  - Riverside Hotel – Garden City
  - The Sandbar – Garden City
  - Natural Retreats South Fork Lodge – Swan Valley
  - Fork - Boise
  - Alavita - Boise

Beneficiaries

Data from the 2013 Idaho Agriculture Statistics bulletin estimates the value of specialty crops grown in Idaho at over $1.25 billion dollars. This estimate includes cash receipts from potatoes, fruits, vegetables, hops, honey, mint, and nursery crops. All producers engaged in the production of specialty crops in Idaho could potentially benefit from effective television advertising that increases consumers' awareness and intent to purchase Idaho fruits, vegetables, and nursery products. Unfortunately, as is the case with most perishable fresh products, it is very difficult to measure the effect of advertising on sales as all products will be sold at some price, and price becomes more a reflection of supply than of demand. However, awareness and intent or reported purchase of local products can be measured as seen above. In addition, consumer market research conducted in conjunction with this grant asked consumers if they were willing to pay more for local products. In spite of the sluggish economy between 2010 and 2012, still over 60% of consumers report they would be willing to pay more for local products as seen in Chart 6. Chart 7 shows that of those willing to pay more, most are only willing to pay up to 15% more – again perhaps reflective of a recessionary economy at the time. Consumers' willingness to pay more, as seen below, indicates that profitability could be enhanced for producers who identify their products as locally grown.

Chart 6: Research – Are consumers willing to pay more?

"Would you be willing to pay more for items identified as being produced or grown in Idaho than you would for comparable products that are either unlabeled or identified as being produced in another state or country?"

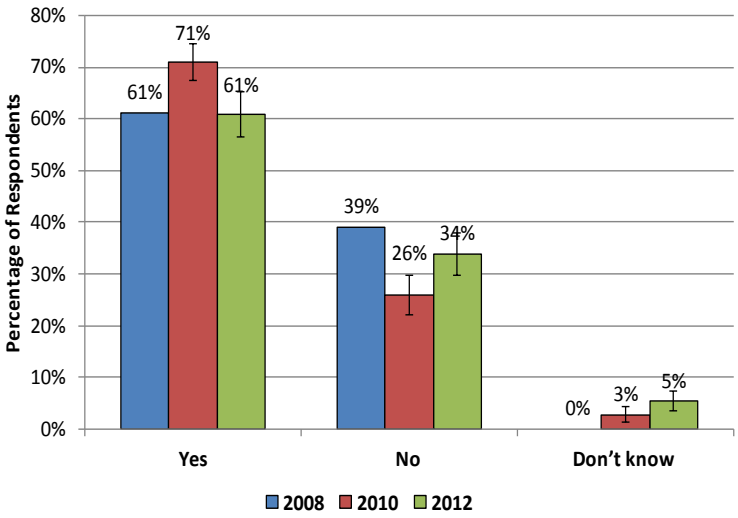
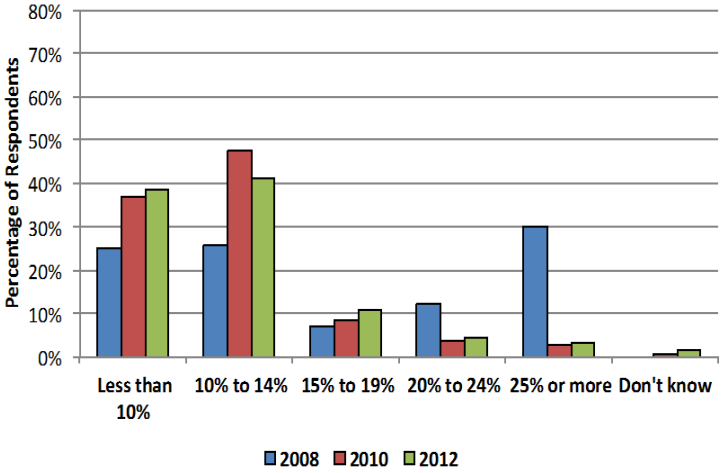


Chart 7: Research – How much more are willing to pay?

"How much more would you be willing to pay for products locally grown or produced in Idaho?"



Lessons Learned

Several lessons were learned during the administration of this grant. First, economic conditions greatly affect the cost of advertising. When the grant was written, the severity and the duration of the recession could not be predicted, nor could its effect on television advertising costs. Second, conducting market research is becoming extremely expensive in relation to the amount spent on advertising. In 2010, the market research was a joint effort with another partner paying for the majority of the cost of conducting the research, and Idaho Preferred just paying for additional questions. In 2011, no partners could be found to split the cost of research and there was not adequate budget to conduct the study independently so research was pushed back to 2012. In 2012, the research was budgeted for and conducted independently and it is the intent to continue to do research only on an every-other-year basis, partnering with other entities when possible. As a result of these research issues, the effectiveness of the 2013 ad campaign will not be assessed after the close of this grant in 2014.

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Additional Information

To view television commercials referenced in this report, go to www.idahopreferred.com.

Eradication of Necrotic Strains of Potato Virus Y in Idaho

Subrecipient
University of Idaho

Project Summary
Idaho is the largest producer of potatoes in the United States, with about one-third of the national production and more than 30% of the acreage in 2008; more than a quarter of U.S. potato processing capacity resides in Idaho. The potato industry contributes about $2.7B to the Idaho economy. In the past 3-5 years, *Potato virus Y* (PVY) has emerged as the most serious threat to Idaho potato production, both directly through yield reduction, and indirectly by affecting tuber quality and rendering tubers unmarketable. The emergence of PVY as a new threat is attributed to the high propensity of the virus to undergo genetic recombination, resulting in the development and spread of new strains of PVY, many of which can cause severe tuber necrosis. The necrotic damage caused by these new strains includes both internal and external symptoms on tubers. These new PVY strains have been tracked down through systematic typing of the PVY strains found during the winter grow-outs conducted by the various seed certification agencies. In order to eradicate these necrotic PVY strains, and devise a plan to control PVY in the State of Idaho, it was proposed to survey all seed potato lots that undergo winter testing in Idaho for prevalence of PVY strains with subsequent elimination of lots containing necrotic PVY from the seed potato system. This project continued a previously funded grant (2009-10) which started this systematic typing of PVY strains in Idaho. This project will lead to a comprehensive strategy to control PVY and eradicate necrotic PVY strains from the State.

Project Approach
The following activities were conducted:

Identification and segregation of PVY-positives from the winter grow-out testing
During 2011/12 and 2012/13 potato seed seasons, approximately 1,900 leaf samples were collected from Idaho potato seed lots submitted to the winter seed potato grow-out in Brawley, CA. The ELISA analysis was conducted concomitantly with immunocapture-PCR tests. All samples determined to be positive for PVY were subjected to RT-PCR tests for further typing to strain. Three samples with a new serological pattern were noted, this is AST-pattern MAb2-negative, 1F5-positive, SASA-N-negative. This serological pattern was not previously recorded in the U.S., but was found in Brazilian potato. All identified samples with AST-serology were inoculated to tobacco plants in the greenhouse for confirmation and further study. The AST-serology was not confirmed after testing all three samples infecting tobacco, serological profile turned out normal N serology, and NTN genotype.

Type all PVY-positives to strain using the RT-PCR technique.
In 2012, 735 samples were received from the 2011/12 winter grow-out tests, all were analyzed and the strain breakdown is presented in Table 1. A further drop was noted in the proportion of non-recombinant PVY^{O} strain relative to other, recombinant strains, both PVY^{NTN} and $PVY^{N:O}$, comparing to 2009-10 data. Recombinant strains represented 60% of all PVY-positive samples from Idaho seed potato tested in the winter grow-out. Tremendous clustering of recombinant PVY isolates was observed, especially PVY^{NTN}, with specific cultivars and producers. Hence, in 2012, producers with high proportion

of PVY^{NTN} in their lots were alterted. These attempts were successful – P. Nolte received a positive feedback from producers who removed their seed from the system.

Table 1. Summary of the 2012 winter grow-out testing.

1,021	Samples tested	100%
523	PVY-positive	51%
123	Typed PVY^{O}	24%
191	Typed $PVY^{N:O}$	37%
121	Typed PVY^{NTN}	23%
88	Typed as other/unclassif.	16%

Starting with the 2011/12 season, the University completely switched to the immunocupture (IC) RT-PCR methodology, and immediately increased the efficiency of PVY testing – the proportion of PVY-positives exceeded 50% for the first time. This reduced the number of samples subjected to the expensive RT-PCR analysis, and focused it only on PVY-positives.

In 2013, 868 samples were analyzed, received from Brawley, CA. All samples were subjected to an initial ELISA test, and of these only PVY-positives were further subjected to the RT-PCR typing technique (Lorenzen et al., 2006). All PVY positive samples have been typed to strain, logged into a master file, and are being grouped according to the lot of origin, cultivar submitted for re-certification, and the generation number. During 2012/13 season, University staff made another improvement in the PVY typing used for Brawley samples – another RT-PCR primer set developed by Dr. M. Chikh Ali (Chikh Ali et al., 2010, 2013) was added. With this new primer set, it was possible to expand the number of PVY strains that could be typed, which now included N-Wi and NE-11 types, among others (see Table 2). In fact, it was found that now that most of the N:O types identified with the Lorenzen set, are in fact N-Wi types, with actual N:O strain quite rare (1-2%).

Table 2. Summary of the 2013 winter grow-out testing.

868	Samples tested	100%
464	PVY-positive	53%
157	Typed PVY^{O}	34%
197	Typed $PVY^{N:O/Wi}$	43%
53	Typed PVY^{NTN}	11%
33	Typed as NE-11	7%
24	Typed mixed/unclassif.	5%

For the 2012 season, no further drop in the proportion of non-recombinant PVY^{O} strain relative to other, recombinant strains, both PVY^{NTN} and $PVY^{N:O}$, was noted comparing to the 2011 and 2010 data. Recombinant strains represented 61% of all PVY-positive samples from Idaho seed potato tested in the winter grow-out. For the first time in four years of observations a significant drop in PVY^{NTN} stain proportion was documented: 11% in 2012/13, versus approximately 20% between 2009 to 2011. Once again, the observation on clustering of recombinant PVY isolates, especially NE-11, with specific cultivars and producers was confirmed. For example, all thirty-tree NE-11 samples in 2012 came from a single producer. The University continued to alert producers having high proportion of PVY^{NTN} and other strains associated with tuber necrosis. These attempts were successful – P. Nolte received a positive feedback from producers who removed their seed from the system.

Goals and Outcomes Achieved

- The entire potato seed crop submitted for the Idaho winter grow-out test, over 600 seed lots in total, was subjected to testing for the PVY presence, and subsequent typing of the PVY-positives to type. The project sought to determine the incidence of the recombinant PVY strains in Idaho potato, and this objective was achieved.
- The longer-term objective of the project was to determine the dynamics of the recombinant PVY incidence, e.g. if and how the proportion of different recombinant strains circulating in Idaho potato may be changing over time. Based on this 2-year study the proportion of a non-recombinant O type was found stabilized at under 30%, with a proportion of the recombinant, PVY^{NTN} strain found decreasing to 11% (about half of the average in 2009-2010), and a recombinant N-Wi type found expanding. This registered drop in the proportion of the most damaging, tuber necrotic strain PVY^{NTN} is the most significant change observed and is certainly and encouraging news for the industry.
- This project (and the related previous project funded in 2009-2010) created the first comprehensive data set on PVY strain composition, their geographical and cultivar distribution, and their dynamic changes from year-to-year in Idaho seed potato.
- Typing data was presented at the Idaho Seed Potato Growers Seminars in 2012 (Jan 17) and 2013 (Jan 22); these events bring together approximately 100 seed potato growers from Idaho each year. The data were also presented at the Idaho Potato Conference in 2012 (Jan 19) and 2013 (Jan 23); the conference draws approximately 1,000 attendees from Idaho and other states: mainly growers, crop advisors, processors, and potato-related sales personnel, of which about 150 were present in the room for each presentation. These results were also presented and discussed at the annual meetings of the Idaho Association of Plant Protection in 2012 (Nov 7) and 2013 (Nov 5) which draw approximately 30 plant pathologists from Idaho. A database of all typing data for each year is maintained at University of Idaho's PSES Department and available for industry use.

Beneficiaries

Beneficiaries are expected to be Idaho potato seed growers, as well as all potato growers, and entire potato industry in the state. The total number of beneficiaries vary, but Idaho potato seed growers and potato growers are in the hundreds. Ultimately, consumers will benefit through more affordable prices and better quality of fresh market potato. Understanding of the PVY strain populations and circulation in the state will help in development of resistant varieties and guide growers in choices of grown cultivars.

Lessons Learned

- It is now known that the strain composition of PVY isolates circulating in Idaho seed potato is not static, and changes year-to-year. The drop in the non-recombinant PVY^{O} isolates observed for the past 4-5 years is of concern to the industry, since this is the traditional PVY type that can be effectively managed through potato seed certification.
- For the first time in 2012/13 season, University staff registered decrease in the proportion of necrotic PVY^{NTN} isolates. This is of course good news; however, the reasons behind this drop are unknown. Unfortunately, a drop in PVY^{NTN} isolates came with the rise in NE-11 isolates, so that the total proportion of PVY strains associated with tuber necrosis still stays at around 20%, similar with 2009-2010 seasons.
- It is now known that the strategy of alerting producers with PVYNTN in their seed lots works and the University plans to continue these eradication efforts targeting tuber necrotic strains of PVY.

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Additional Information

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