FY2014 Specialty Crop Block Grant Program – Farm Bill

Idaho State Department of Agriculture

Submitted by: **Laura Johnson,** Bureau Chief, Division of Marketing & Development

AMS Agreement: 14-SCBGP-ID-0016

Final Performance Report

Submitted: April 2, 2018

Table of Contents

Boise State University
Protocol to Improve the Efficiency and Quality of Fried Potato Products 4

Boise State University
Sunnyslope Soils Analysis (SSSA) 16

Idaho Apple Commission
The Impact of Tree Architecture and Girdling at Full Maturity in a Modern Super High Density Orchard on Yield Efficiency, Fruit Quality, Mineral Partitioning and Postharvest Physiology of Apples in Idaho and Promotion 20

Idaho Bean Commission
Developing season-long integrated weed control systems in Idaho dry beans 25

Idaho Bean Commission
Developing the Bean Seed Market in Costa Rica..... 28

Idaho Grape Growers and Wine Producers Commission
Increase Quality, Awareness, and Sales of Idaho Wine 33

Idaho Hop Commission
Evaluating Experimental Hop Selections in Unique Idaho Terrior Conditions..... 46

Idaho Nursery & Landscape Association
Idaho Wholesale Nursery Map and Consumer Plant Something Magazine 48

Idaho Nursery & Landscape Association
Media Plant Something Marketing Campaign 50

Idaho Potato Commission
Identification of potato genes conferring resistance to NTN and N-Wilga recombinants of Potato Virus Y 53

Idaho Potato Commission
International Development for Idaho Potatoes - 2014..... 57

Idaho Preferred
Promoting Specialty Crops through Advertising and Retail Promotions..... 63

Idaho-Eastern Oregon Onion Committee
Developing Awareness of Idaho-E. Oregon Onions and Building International Markets in Mexico and Central America through In-store Promotions and Trade Missions 69

Northwest Nazarene University
Expanding the Application of the Crop Monitoring and Assessment Platform 72

University of Idaho
Identification and exploitation of resistance to Zebra chip disease in potato 77

University of Idaho
Studying Adaptation, Introduction, and Quality of Alternative Fruits to Enhance Profitability of Small Businesses and Public Health in Idaho 80

USA Dry Pea & Lentil Council
Enhancing domestic trade of dry peas, lentils and chickpeas by educating the food/foodservices industry about the benefits of utilizing pulses as ingredients..... 85

USDA, Agricultural Research Service
Deciphering the effects of grapevine virus on Idaho grape/wine quality 89

USDA, Agricultural Research Service
Method Development for Automated, Real-time Monitoring of Wine Grape Vine Water Stress for Use in Wireless Sensor-based Irrigation Networks 92

Protocol to Improve the Efficiency and Quality of Fried Potato Products

Subrecipient
Boise State University (BSU)

Project Summary

The aim of this project was to develop a method for accurate and rapid determination of the quality and identity of fryer oil degradation products that are generated during processing of potato products. High oil temperatures and the high moisture content foods result in chemical modifications of triacylglycerides (TAGs) in the formation of oxidation products and polymerized TAGs, which have direct impacts on the quality of fried products.[1] The nature and extent of this chemistry is very complex, and reaching a better understanding of this chemistry will allow food processors to provide more stringent food quality assurances through controls of processing operations.[2,3] The objective of this proposal was to develop a rapid protocol employing near infrared spectrophotometry (NIR) to establish more precise control parameters for monitoring the quality of fryer oil throughout the time the oil is used for food processing. Improved in-line processing controls can be implemented to provide rapid adjustments of frying conditions to prevent unacceptably degraded oil. The significance of this project is that implementation of such monitoring and control measures will ensure food quality and safety by preventing contamination of fried products associated with degraded fryer oil.

Idaho, Washington, and Oregon produce over 16 billion lbs of fried potato products annually. During the processing of fried potatoes, fryer oil is consistently filtered in order to maintain oil and food quality. Filtered oil may look acceptable and produce fried products with appropriate sensory quality, but the nutritional value of the food can be compromised by oil that has been hydrolyzed, polymerized, oxidized and/or thermally degraded. A major factor is the loss of the more healthful mono- and polyunsaturated fatty acids over time, and adverse health effects have been correlated with the polar compounds formed during the frying process.[4,5] Additionally, highly degraded oils can contain potentially unhealthy compounds such as acrolein. As the fryer oil degrades, the ability to control the temperature can be affected, where over cooking potatoes can lead to the production of acrylamide.[6] When the oil degradation leads to out-of-grade products, these products must then be discarded, which increases the economic burden to the company and the consumer. The removal of depleted and unusable oil in food fryers, and the subsequent cleaning and sanitizing, are significant operational costs to the business. To maintain the appropriate quality of frying oil during a production cycle, processors need to balance blending of fresh oil with used oil while accounting for the oil removed by the food products. Therefore, a rapid monitoring process to detect the identity and quantity of potentially unhealthful materials is highly desirable for both food consumer and processor.

FT-NIR has been demonstrated in the literature to be a reliable method for rapid, non-destructive analytical technique capable of providing accurate measurements of oil quality indicators, as well as quality measures in other food and drink products, such as wine and dairy.[7-13] There are many advantages of NIR technology including limited or no required sample preparation, accurate and rapid measurements, and the nondestructive nature of NIR radiation, which allows for the implementation of in-line monitoring and chemical analysis. The NIR region of the electromagnetic spectrum is considered to cover the wavelength range of 0.75 to 3 µm, or approximately 3300 to 13,000 cm^{-1} , lying between the visible and mid-infrared regions (Figure 1). The chemical information obtained in this spectral region consists of molecular vibrational overtone and combination bands. The weak absorption cross-sections of these vibrational transitions permits the measurement of concentrated materials through long path lengths. Thus, pure oil samples can be measured through a 1-cm path length, with no dilutions, chemical modifications, or any other preparation of the samples. A NIR spectrum of soybean oil used in potato processing is shown in Figure 2. Notable spectral regions and the molecular vibrations giving rise to the NIR absorption bands in these regions are indicated. Monitoring changes in the absorption profiles of fryer oils sampled during potato processing can provide information regarding alterations in chemical composition of the fryer oils and the generation of oxidation products.

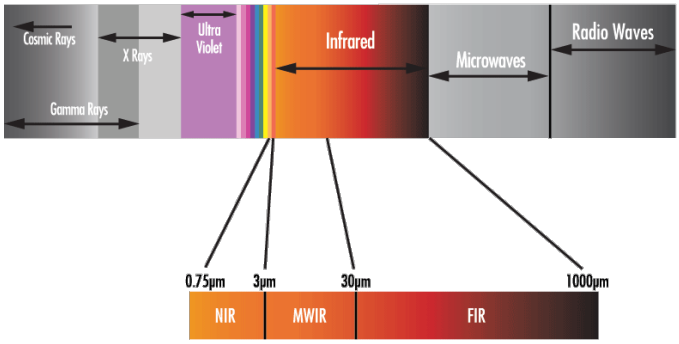


Figure 1. Electromagnetic spectrum showing the narrow near-infrared (NIR) region.

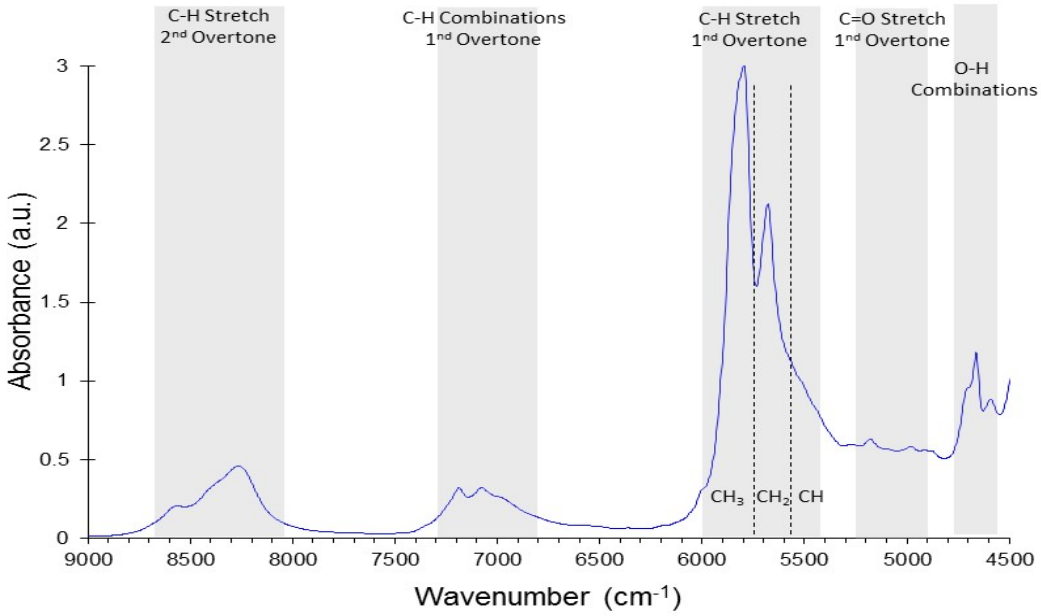


Figure 2. FT-NIR spectrum of soybean oil obtained from a potato processing facility.

Project Approach

A Fourier transform-near infrared (FT-NIR) spectrophotometer (Bruker MPA) equipped with quantitative analysis software and standard oil degradation testing methods was purchased and installed at Boise State University. The instrument was used to develop and test NIR spectrophotometric methods for the analysis of oil quality measures including total polar materials, anisidine values, polymerized TAGs, and free fatty acid contents. In addition, NIR calibration methods for oil analysis generated and supplied by Bruker were evaluated.

For the FT-NIR analyses, fryer oils consisting of soybean and soybean-canola blends were obtained from various potato processing facilities. FT-NIR calibrations were generated for the measurement of oil quality indicators of total polar materials (TPM), anisidine values (AnV), free fatty acids (FFA), and polymerized triacylglycerides (TAGs). The FT-NIR calibrations required an internal multivariate calibration entailing the correlation between observed changes in the measured FT-NIR spectra and the 'true' value measured by standard laboratory methods for a set of oils samples. A flow diagram of the cross-validation (internal standard) calibration procedure is outlined in Figure 3. Briefly, a set of M FT-NIR spectra are collected. A matrix is constructed containing the spectral intensities at each wavenumber data point. A second matrix is constructed containing the known concentrations of the component of interest, i.e. AnV, FFA, etc., These matrices are then factoralized using a partial least-squares regression to determine a calibration function, b, such that $\mathrm{Y} = \mathrm{X} \cdot \mathrm{b}$. Once the calibration function for a component is determined, its concentration Y in an unknown sample can be easily calculated based on the subtle changes observed in the collected NIR spectrum.

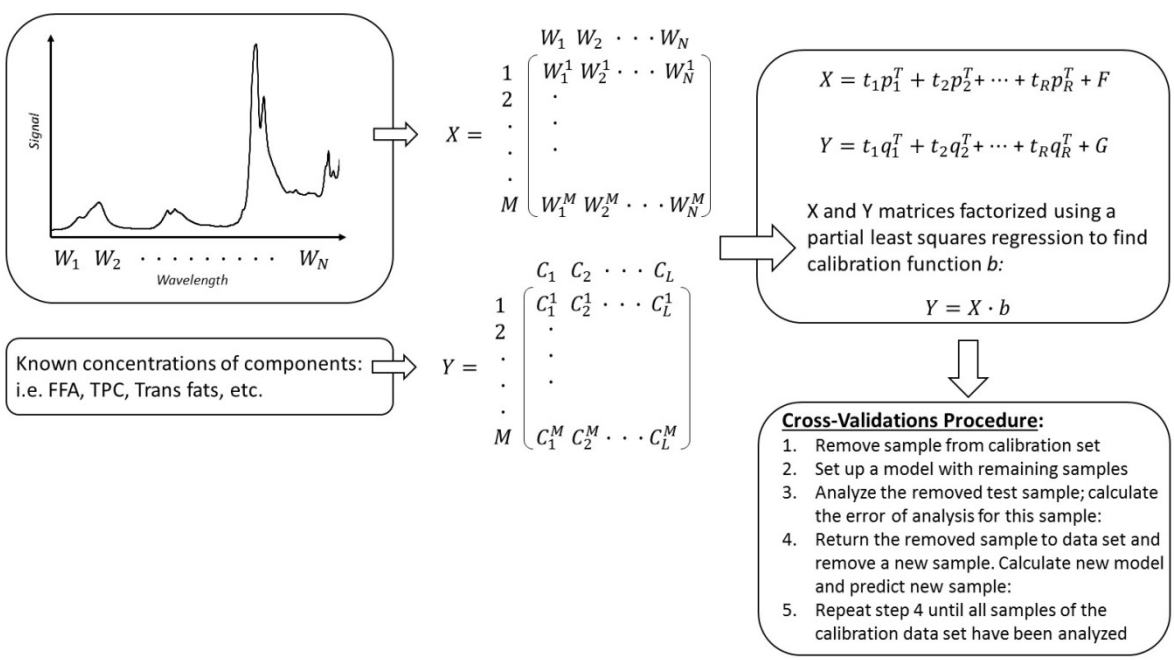


Figure 3. Outline of FT-NIR multivariate calibration using a cross-validation, or internal standard, method.

Initially, the spectral regions indicative of the desired measurements were identified. Molecular vibrational overtones observed in the NIR spectral region arise from distinct molecular functional groups. For instance, C-H vibrational motions of methylene groups occur at a fundamental frequency of ~2850 cm^{-1}. This means that the first vibrational overtone will be observed at ~5700 cm^{-1}, corresponding to a quantum-mechanically 'forbidden' $v_0 \rightarrow v_2$ transition (2 × the fundamental frequency), while the

second overtone will occur at 8550 cm^{-1} (3 × the fundamental frequency), and so on, with each successive transition decreasing significantly in absorption strength given its reduce probability. The NIR spectral regions identified for measured oil-quality indicators, the associated contributing molecular vibrational overtone, and the standard laboratory analysis method accepted by the American Oil Chemists Society (AOCS) and the International Union of Pure and Applied Chemistry (IUPAC) used to quantify the reference values are provide in Table 1.[14,15] The methods of developing the NIR calibration methods are briefly described below.

Table 1. Spectral region used to identify components of interest, and the associated molecular vibrational contribution to the spectra.

	Spectral Region (cm^{-1})	**Vibrational Overtone**	**Testing Method**
TPM	4600 - 5600	1st Overtones: C=O stretches Combination bands: C–O–H	Testo 270
AnV	4600 - 5050	1st Overtone: C=O stretches	AOCS Cd 18-90
FFA	5000 - 5600	1st Overtone: C–O stretches	AOCS Ca 5a-40
Polymerized	5500 - 7500	1st and 2nd Overtones: C–H, CH_2 stretches	IUPAC 2.508

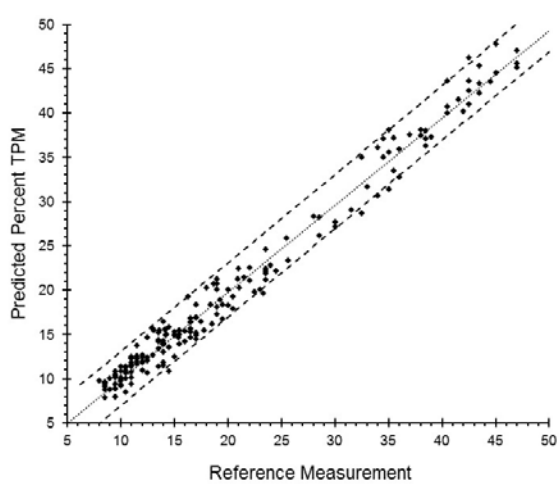
Pre-processing of the NIR spectra through vector normalization and calculation of the first derivative of the spectra improved the sensitivity of the multivariate calibrations. Pre-processing allows for the enhanced detection of subtle changes in the spectral intensity in the region of interest. Vector normalization negates absorption intensity, which is important when measuring samples with varying scattering properties, i.e. the sample may contain residual particulates left over from the potato product which scatter transmitted NIR radiation, thereby reducing the overall transmission intensity. Using the first derivative of the spectrum after vector normalization, as opposed to using the normalized absorption intensity, provides an enhancement of small changes in absorption strength, particularly when overlapping vibrational bands are present. Increased variability in the spectra used as input for multivariate calibration methods greatly reduces the error of measurements.

Goals and Outcomes Achieved

FT-NIR Calibrations of Oil Quality Indicators

Total Polar Materials

The measurement of TPM in used fryer oil is an indicator of oxidative degradation of the oil during the frying process. Polar materials are due to the generation of primary (peroxides, free fatty acids, dienes) and secondary oxidation products (aldehydes, ketones, trienes). The sample analysis of TPM used for the NIR multivariate calibration was provided by Simplot. Laboratory measurement of TPM was achieved using a Testo 270, which measures TPM by potentiometry with an accuracy of +/- 2%. Figure 4 shows the results of the calibration of the NIR data against the laboratory measurements. A coefficient of



determination, or R^2 value, of 0.9812 was achieved over a range of 6-47% TPM. The root-mean-squared error of cross-validation (RMSECV) was found to be 1.53.

Anisidine Value

AnV is a measure of the secondary oxidation products α,β,-unsaturated aldehydes in used fryer oils. The oxidation products result in oil rancidity, negatively affecting the flavor and odor of fried potato products. AnV used for generating the NIR calibrations were determined by laboratory methods using the AOCS Method Cd 18-90. Briefly, oil samples were dissolved in isooctane and mixed with an acidic p-anisidine solution. The p-anisidine will form a UV-absorbing complex with any accessible aldehyde functional groups. The sample is measured using a UV spectrometer at 350 nm in order to quantify the presence of complexed p-anisidine, thereby providing a measure of the extent of secondary oxidation. NIR measurements were calibrated against laboratory measurements, with the results of the calibration shown in Figure 5. From the correlation, an R^2 value of 0.9801 was achieved over an AnV range of 55-240. The root-mean-squared error of cross-validation (RMSECV) was found to be 7.36.

Figure 4. Multivariate calibration for the measurement of total polar material by FT-NIR. Center dotted line indicates the best-fit linear regression. The dashed lines indicate the 95% confidence interval of prediction.

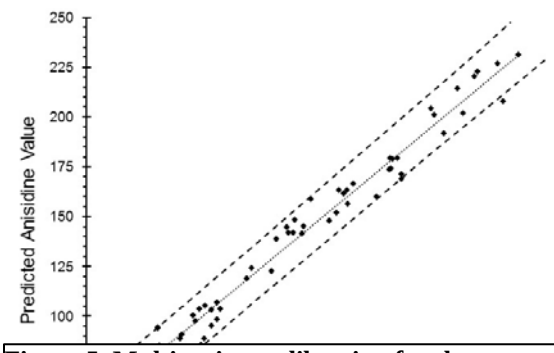
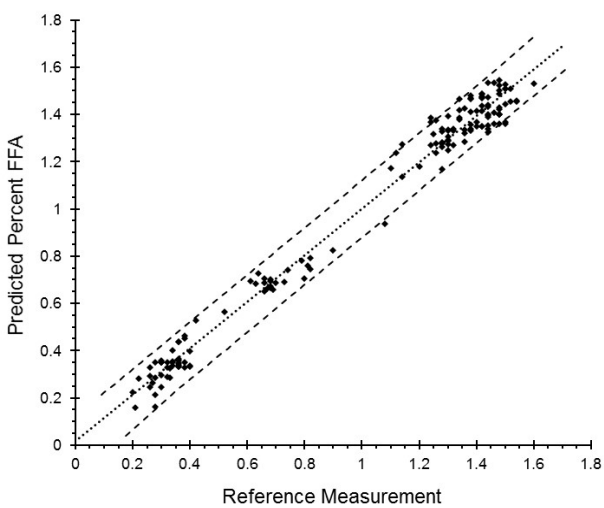


Figure 5. Multivariate calibration for the measurement of anisidine values by FT-NIR. Center dotted line indicates the best-fit linear regression. The dashed lines indicate the 95% confidence interval of prediction.

Free Fatty Acids



Free fatty acids are a primary oxidation product generated during the frying process by the hydrolysis of fatty acids from the oil triacylglycerides in the presence of heat and water. FFAs generated during the potato frying process leads to degradation of product quality and create operational concerns with the generation of foams. Laboratory analysis of FFA contents in used fryer oils was achieved by a standard acid-base titration by AOCS Method Ca 5a-40. Briefly, commercial oil samples were titrated with 0.0005 M sodium hydroxide. For each titration, a phenolphthalein indicator was added to approximately one gram of sample. The volume of NaOH used and the mass of the sample titrated were used to calculate the percent of free fatty acid by

mass in each. The near infrared spectrum of each sample was collected and was correlated to the measured percent FFA.

The NIR calibration shown in Figure 6 was generated by multivariate calibration against laboratory FFA measurements. The calibration spans a FFA content of 0.2 – 1.6%. The coefficient of determination from the calibration was 0.9836, with an RMSECV of 0.06%.

Figure 6. Multivariate calibration for the measurement of free fatty acids by FT-NIR.

Polymerized Triacylglycerides

Polymerized oils generated during the potato frying process introduce food quality and operational concerns. Dimers and higher polymers alter the heat transfer properties of the oil, thereby directly influencing the quality of fried product. Laboratory measures of polymerized TAGs used for the NIR calibrations were performed using IUPAC method 2.508. This method involves separations of TAGs, dimers, and higher polymers using high-performance size exclusion chromatography (HPSEC). The method deviated from the standard IUPAC method in that charged aerosol detection (CAD) was used in place of refractive index detection. Figure 7 shows a representative spectrum obtained from the HPLC analysis of used fryer oil, allowing for quantification of relative polymer contents. The NIR calibration of polymerized oils is provided in Figure 8. Polymerized oil content available for constructing the calibration curve ranged from 2 to 32%. A R2 value of 0.8935 was achieved, with a RMSECV of 2.45%.

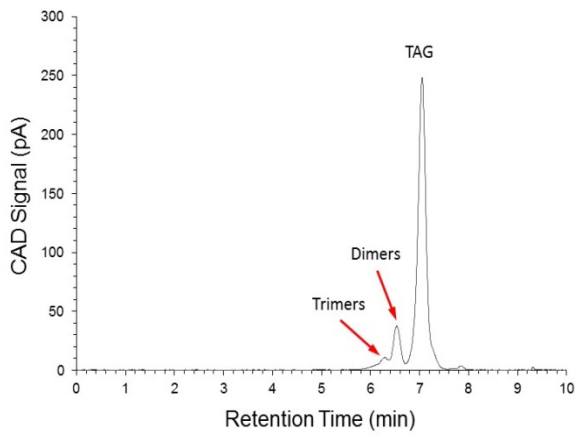


Figure 7. HPSEC-CAD chromatogram of TAG and polymerized TAG.

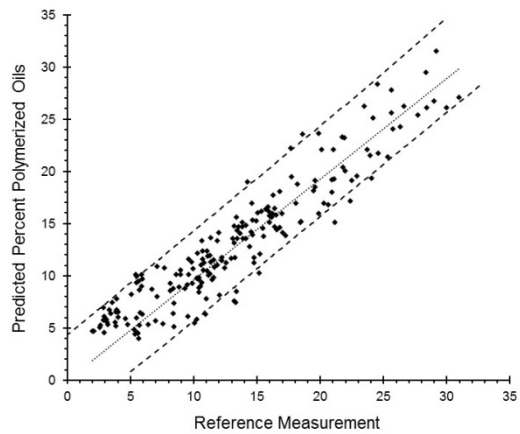


Figure 8. Multivariate calibration for polymerized triacylglycerides by FT-NIR.

Tabl

e 2. Summary of FT-NIR cross-validation multivariate calibrations.

	R^2	RMSECV	n	outliers
TPM	0.9812	1.53	222	13
AnV	0.9801	7.36	98	4
FFA	0.9836	0.06	165	9
Poly	0.8935	2.45	222	11

External Validation of NIR Calibrations

An external sample set of fryer oil samples were used to validate the multivariate calibrations shown above. Of the four oil quality measures, validations for total polar material, anisidine value, and polymerized TAGs produced results within the calibration parameters supplied by the internal calibration. However, measurements of free fatty acids produced results that were not consistent with the initial calibration. To further investigate the validity of the FFA multivariate calibration, the initial calibration was compared with that provided by Bruker (Figure 9). The overlay of the two calibrations clearly indicate differences in calibration parameters used to produce the two individual calibrations. This indicates that the free fatty acid concentrations cannot be reliable determined by the NIR calibrations even though the initial calibration appeared to be quite accurate.

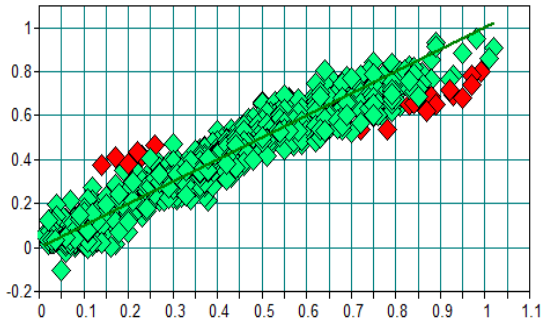


Figure 9. Two overlaid multivariate calibrations for the measurement of free fatty acids by FT-

This demonstrates the necessity for validation of NIR calibrations using an external sample set (samples not used in the internal multivariate calibration). The likely reasoning for the apparent high quality of the internal validation is due to the differences in the concentrations of multiple components in the oils samples that influence the same NIR spectral region. With an increase in free fatty acid concentrations due to oil degradation, there is also an increase in total polar materials. Both of these components effect the region of the NIR spectrum where the 1st overtone of the carboxyl stretching frequency occurs. Since the concentrations of total polar materials is much greater than the free fatty acid contents, the multivariate calibration for free fatty acids is actually more heavily influenced by the changes in total polar materials, thus the failure in measuring FFA contents in the external validation set.

Fatty Acid Analysis

Trans Fat Analysis

Oils were extracted from three different collections of commercial products, two of which were available from two separate production lots, giving a total of five products sampled. The samples included thin-cut fries (in duplicate), steak fries, and battered fries (in duplicate) Each product sample was collected at various time intervals throughout the production process, providing additional information into the internal measurements of the oil quality during the collection period. Each of the product samples was fried at 350 °F for three minutes in fresh, medium, and heavily used soybean oils obtained from commercial fryers. This was followed by the immediate extraction of oils for analysis.

For the efficient extraction of oils from commercial fried potato products, the samples were first pulverized by mortar and pestle. The products were then placed in 50 mL of n-hexane and stirred for 30 minutes. The hexane was removed by rotary evaporation to yield the extracted oil. To the residual oil, approximately 2 mL of hexane was placed in the flask to allow the transfer of the oil to a small vial. The vial was then placed under a gentle stream of nitrogen to evaporate the hexane, leaving only the extracted oils.

The oil extracts were analyzed by gas chromatography (GC) with flame ionization detection (FID). The oils were first subjected to a base-catalyzed hydrolysis to convert the triacylglycerides to methylated fatty acids (fatty acid methyl esters, FAMES). The derivatized oils and FAME standard mix were run on GC-FID (Figure 10). The relative fatty acid concentrations of the oil extracts were determined by relative peak intensities observed in the chromatograms.

The results of the GC-FID analysis of fatty acid contents are summarized in Table 3. There was a general trend of decreased relative concentrations of unsaturated fatty acids as oil quality decreased. This is likely due to the degradation of unsaturated fatty acids, as these chemical structures are susceptible to oxidative and thermal breakdown. Unsaturations in the fatty acid chains can also facilitate the polymerization of TAGs during the frying process. However, the overall changes in the saturated/unsaturated fatty acid contents did not change significantly across the different grades of frying oil. The was a notably higher concentration of saturated fatty acids in the pre-fried french fries than from the oils recovered after frying in each of the oils. Interestingly, very small quantities of trans fatty acids were detected in any of the samples, with no correlation observed between oil quality and trans fat concentrations.

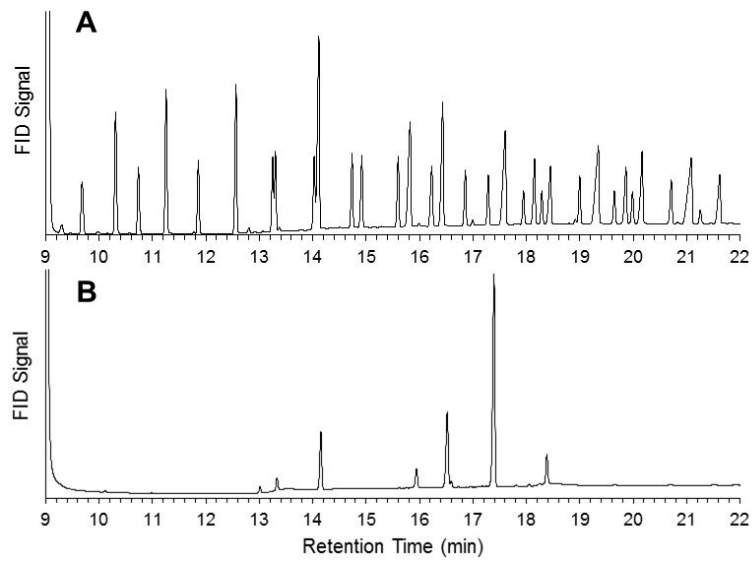


Figure 10. GC-FID chromatograms of the A) FAME standard mixture and B) derivatized oil extract.

The low concentrations of trans fatty acids suggests that cis unsaturated fatty acids are more prone to degradation through oxidative and polymerization processes than to cis-trans conversions. This is supported by the observation of unidentified peaks in the chromatograms, most notable in the steak fries, which did not correspond to the retention time of any component within the standard FAME mixture. These are expected to be oxidation products of unsaturated fatty acids generated during the frying process.

Table 3. GC-FID analysis of total fatty acid contents for five French fry samples (three product lines) fried in clean (**C**), medium (**M**), and heavily used (**H**) soybean oils. (**P** = pre-fried)

		Thin Cut #1				**Thin Cut #2**				**Steak**			
FAME	**Ret. Time**	**P**	**C**	**M**	**H**	**P**	**C**	**M**	**H**	**P**	**C**	**M**	**H**
	12.40										0.06		
	12.82												0.01

	13.08					1.96	0.45				0.82	0.84	0.71
C14:0	13.44	0.61		0.13	0.57	4.07	1.99	0.19	0.31	2.30	1.50	1.64	1.32
C16:0	14.55	14.55	5.72	12.95	19.22	12.62	12.71	13.26	11.06	12.64	10.73	13.27	10.97
	15.47												0.18
C18:1 t	16.01												0.01
C18:0	16.57	1.67	0.32	1.59	2.17	4.47	4.48	1.58	1.05	16.26	3.71	4.29	2.60
C18:1 c	16.85	19.17	7.70	22.56	7.83	18.88	17.09	22.34	45.90	20.42	41.80	21.08	44.61
C18:2 t	17.37										0.01		
C18:2 c	17.71	57.21	75.36	56.14	68.25	51.46	54.28	55.14	38.04	43.94	37.93	52.21	39.59
C18:3 t	18.56											0.20	
C18:3 c	18.65	6.79	10.89	6.63	1.96	6.56	9.00	7.49	3.64	4.43	3.44	6.47	

		Battered #1				**Battered #2**			
FAME	**Ret. Time**	**P**	**C**	**M**	**H**	**P**	**C**	**M**	**H**
	12.40								
	12.82	0.81							
	13.08	6.13		1.29	2.14				
C14:0	13.44	21.37	0.89	2.85	4.14	6.03	1.97		0.32
C16:0	14.55	11.98	4.35	0.11		20.66	7.49	0.81	1.17
	15.47	3.95		0.02					
C18:1 t	16.01								
C18:0	16.57	3.41	1.76	1.54	3.87	4.67	0.63	5.79	4.16
C18:1	16.8	16.2	19.3	59.7	46.4	20.2	9.27	25.5	50.0

c	5	2	3	4	8	1		4	0
C18:2 t	17.37								
C18:2 c	17.71	33.17	64.28	30.12	42.25	43.93	70.78	60.15	40.86
C18:3 t	18.56								
C18:3 c	18.65	2.96	9.39	4.33	1.13	4.50	9.86	7.70	3.49

Sensory Analysis

Sensory analysis of the fried potato products was conducted from the same commercial lot in the different qualities of soybean oil. The products were placed in the three different qualities of oil and fried for three minutes. Eight individuals voluntarily participated in the sensory analysis. All volunteers signed consent forms prior to consumption of any products. The participants were seated in the same room, at the same time when the products were consumed. Participants were told to try the fried products that were numbered 1, 2, and 3; these numbers corresponded to the quality of oil. As participants consumed the products from each of the numbered plates, they were instructed to document the texture, taste, color, and crispness of the product.

Reponses of all the participants signified that they could usually taste the difference between oil qualities. This was more obvious between fries cook in lightly used oil versus the heavily used oil. Fries from the lightly used oil fryer were found to have better crispiness, texture and taste than that of the heavily used oil. Heavily used oil received comments such as, “fishy tasting”, “least crispy”, “very squishy and most oily”. This wasn’t really the case between the medium used oil and the lightly used oil. Comments about which one was more variable varied with the participants. In summary, participants could distinctly identify the difference in taste, texture, and color between the lightly used and medium used oil as compared to the heavily used oil.

The proposed work involved the use of NIR to improve the efficiency and quality of fried potato products. An offshoot of this effort resulted in the determination of glycoalkaloid content in potatoes and potato products using microwave assisted extraction methods. The results of this later study were disseminated via publication in the American Journal of Potato Research. Citation: Kondamudi, N.; Smith, J. K.; McDougal, O. M. (2017) Determination of Glycoalkaloids in Potatoes and Potato Products by Microwave Assisted Extraction. Am. J. Potato Res. DOI 10.1007/s12230-016-9558-9. The results of this work on potatoes were also presented as a poster by Jacob Smith, an undergraduate student in the Department of Chemistry and Biochemistry at Boise State University, at the annual Undergraduate Student Research Conference on the Boise State campus April 2016.

Beneficiaries

The results found in these studies have the potential to greatly benefit producers of fried potato and other food products locally and nationally. FT-NIR spectrophotometry proved to be a reliable method for the accurate measurement of the oil quality indicators in used fryer oils of total polar materials, anisidine value, and polymerized triacylglycerides. The implementation of NIR technology for near real-time monitoring of fryer oils in processing facilities could have a significant impact on potato product

quality by allowing for more stringent control of operations.

The USDA/ISDA report from the NIR project was presented to approximately 27 research scientists at J.R. Simplot Co. Based on the analysis performed using NIR spectrometry, a request was made to perform additional data collection specific to the food products produced by J.R. Simplot Co. The project initiated by the USDA/ISDA proposal was deemed to be of interest and value for further exploration of fryer oil monitoring by NIR and extrapolation to food safety. While the broader scope of the project is not currently known, the potential economic impact of the project has generated enough interest for student financial support to continue in an effort to vet the NIR technology. At this point in time, the project is ongoing and has led to industry support. Potentially, the results have the ability to positively affect the economic situation of over 200 potato farmers in Idaho.

Lessons Learned

FT-NIR spectrophotometry was capable of accurate measurements of the oil quality indicators in used fryer oils of total polar materials, anisidine value, and polymerized triacylglycerides. From the sample sets, high correlations were observed in the multivariate calibrations of each, producing coefficients of determination of 0.98, 0.98 and 0.90, and errors of prediction of 1.53%, 7.36%, and 2.45%, respectively. External validation produced results that were consistent with the initial internal cross-validation calibration procedure. Importantly, measurement of free fatty acid contents in used fryer oils was not possible in the range observed in the samples (0.1 - 1.2%). This is of potential concern for industrial implementation of FT-NIR since one of the current oil-quality indicators that is routinely monitored in FFA contents. However, as more is learned from this and other studies correlating oil quality to product quality, FFA content does not seem to be the primary component of used oils that negatively impact the quality of the product.

It was found that the quality of fryer oil had negligible impact of trans fats concentrations in fried potato products. There was, however, a notable decrease in mono- and polyunsaturated fatty acids, and an increase in oxidation products as oil quality was degraded. These oil quality indicators could be correlated to sensory quality of the products. Texture, consistency, flavor, and color were all noted to be more unfavorable in potato product fried in heavily used oils due to the increased concentrations of polar materials and polymerized oils, which directly contribute to the reduction in consumer product quality.

Contact Person

Owen McDougal
(208) 426-3964
owenmcdougal@boisestate.edu

Additional Information

References

1. Chen, W.-A.; Chiu, C. P.; Cheng, W.-C. ; Hsu, C.-K. ; Kuo, M.-I. (2013) Total Polar Compounds and Acid Values of Repeatedly used Frying Oils Measured by Standard and Rapid Methods. J. Food Drug Anal. 21(1), 58-65.

2. Bomgardner, M. M. (2012) Replacing Trans Fat. Chemical and Engineering News 90(11), 30-32.

3. Stein, R. F. (2007) Ensuring the Safety and Quality of Fried Foods. Food Safety Magazine (http://www.foodsafetymagazine.com/magazine-archive1/junejuly-2007/ensuring-the-safety-and-quality-of-fried-foods/) June/July 2007 (Accessed June 2014).

4. Boatella-Riera, J.; Codony, R.; Rafecas, M.; Guardiola, F. (2000) Recycled Cooking Oils: Assessment of Risks for Public Health. European Parliament. PE 289.889/Fin. St.

5. Romero, A. ; Bastida, S. ; Sanchez-Muniz, F. J. (2006) Cyclic Fatty Acid Monomer Formation in Domestic Frying of Frozen Foods in Sunflower Oil and High Oleic Acid Sunflower Oil without Oil Replenishment. Food Chem. Toxicol. 44, 1647-1681.

6. Bethke, P.; Bussan, A.J. (2013). Acrylamide in Processed Potato Products. Amer. J. Potato Res. 90(5):403-424.

7. Gertz, C.; Hans-Jochen, F.; Hancock, J. N. S. (2013) FT-near Infrared (NIR) Spectroscopy – Screening Analysis of Used Frying Fats and Oils for Rapid Determination of Polar Compounds, Polymerzied Triacylglycerols, Acid Value, and Aniside Value. Eur. J. Lipid Sci. Technol. 115, 1193-1197.

8. Gertz, C.; Behmer, D. (2014) Application of FT-NIR spectroscopy in assessment of used frying fats and oils. Eur. J. Lipid Sci. Technol. 116, 756-762.

9. Du, R.; Lai, K.; Xiao, Z.; Shen, Y.; Wang, X.; Huang, Y. (2012) Evaluation of the quality of deep frying oils with Fourier transform near-infrared and mid-infrared spectroscopy. J. Food. Sci. 77, 261-266.

10. Ng, C.L.; Wehling, R.L.; Cuppett, S.L. (2009) Method for determining frying oil degradation by near-infrared spectroscopy. J. Agric. Food Chem. 55, 593-597.

11. Paradkar, M.M.; Irudayaraj, J. (2002) Determination of cholesterol in dairy products by infrared techniques: 2. FT-NIR method. Int. J. Dairy Technol. 55, 133-138.

12. Wu, Z.; Long, J.; Xu, E.; Wu, C.; Wang, F.; Xu, X.; Jin, X.; Jiao, A. (2015) Application of FT-NIR spectroscopy and FT-IR spectroscopy to Chinese rice wine for rapid determination of fermentation process parameters. **Anal. Methods 7**, 2726-2737.

13. Ye, M.; Gao, Z.; Li, Z.; Yuan, Y.; Yue, T. (2016) Rapid detection of volatile compounds in apple wines using FT-NIR spectroscopy. Food Chem. 190, 701-708.

14. Official Methods and Recommended Practices of the AOCS, 6th ed. Firestone, D. Ed. American Oil Chemists Society. Rev. 2011.

15. Standard Methods for Analysis of Oils, Fats and Derivatives, 7th ed. Dieffenbacher, A.; Pocklington, W.D., Eds. International Union of Pure and Applied Chemistry, Commission on Oils, Fats and Derivatives, Blackwell Scientific Publications, London, 1991.

Sunnyslope Soils Analysis (SSSA)

Subrecipient
Boise State University (BSU)

Project Summary
The term "terroir" is used to describe or quantify the distinctive characteristics, including topography (elevation, slope, and aspect), climate, and soils of a vineyard site that play a role in growing wine grapes. While wine grape and wine production in the Snake River Valley American Viticultural Area (SRVAVA) was mapped in 2007 and again in 2010-12, the characteristics of the terroir, notably the soils and climate that define the wine districts, were absent.

The Sunnyslope Wine District was selected for study because it is the largest region of wine grape production in Idaho. The Sunnyslope Soils Analysis project was proposed to develop a foundation of high-resolution (both spatial and temporal) data on physical parameters that could inform current and, with a goal of promoting growth of the Idaho wine grape industry, future growers.

Understanding the diversity of soil characteristics and climate factors in the established as well as potential sites is needed to inform current and future growers on selection of cultivars (varietals, clones) to plant. The proper soils and weather data can also help growers manage applications of irrigation as well as treatments by providing critical information in a timely fashion.

This project fills a data gap in the Sunnyslope wine district, the largest producing region of wine grapes in Idaho, through creation of a climate data repository and public weather data website of weather stations and soil moisture sensors at 10 vineyard sites in the district. It also provides a broad analysis of soil characteristics at current and planned vineyard sites in the district

This project does not build on any previous SCBG funded projects.

Project Goals and Outcomes Achieved
Goal 1. Soils examination and analyses. The project activities included examination and sampling of soils at 17 established and planned vineyard sites in the district. Soils were examined in situ through excavation of pits to depths of up to two meters. All told, 73 samples were collected, packaged, and submitted to a local lab for textural, nutrient, and chemical analysis.

Outcome 1. Most of the soils are Aridic Entisols, formed under very limited precipitation regimes. Profiles record complexity in both diversity of parent material ranging from single source to contrasting materials and depositional environments. Additionally, several pits contained restrictive layers such as lime-cemented petrocalcic horizons. Texture analysis of the soil samples documented that about 90% of the soil horizons in the 17 soils have sandy loam,

loamy sand, sand, or silt loam textures and therefore are well drained to excessively well drained.

Soil profiles in the vineyard soil pits were compared with the descriptions of the mapped soils from the USDA NRCS Soil Web. While the soil mapped units suggested that 11 of the sites would be uniform with no restrictive layers at depth, we found 8 of those 11 to have significant restrictive layers. This finding underscores the need for vineyard developers to investigate soils on potential sites to better understand soil heterogeneity and its implications for vineyard planting and irrigation management.

Goal 2. Placement of environmental measurement sensors. Ten vineyard sites in the Sunnyslope district (spread from Kuna to southwest of Parma) were identified, providing a broad suite of topographic and soil terroir characteristics. At each site, we placed a suite of weather instruments (temperature, precipitation, wind, solar radiation, humidity, vapor pressure) and three to five soil moisture and temperature sensors at different depths. The data were to be recorded and transmitted by cellular service to a central server (Decagon, in Pullman, WA).

Outcome 2. Nine of the ten sites are currently in full operation, measuring and recording data hourly and transmitting data three times daily to the server. The data logger at one site (Patterson) has experienced difficulty transmitting weather data, even though it has recorded data without interruption, and is in the process of being repaired by the instrument distributor.

Goal 3. Presentation of data at scientific venue. The plan was to present the results of the study, in both oral and written formats, to a scientific audience.

Outcome 3. In June, 2016, we presented results of the soil analyses and the first full growing season weather results at the International Terroir Congress in McMinnville, OR. Attending the conference were 225 terroir research scientists from 20+ countries – of the attendees, ~150 were international. The paper and copy of the poster are linked under the "Additional Information" section of this report.

Goal 4. Creation of data repository and website. As we began implementing goals 1 and 2, we recognized a third, easily obtainable and logical extension. All the sensors are recorded using data loggers that use cellular service to transmit the data three times a day to the central server, but that server is password protected and the data are not easily downloaded beyond a two-week window. This third objective was to develop an easy to access and navigate website interface that provided anyone (current growers, potential vineyard investors, researchers) access to the soil moisture and climate data for the ten sites. The plan was to make the data available through a public web repository for both viewing and downloading. This objective would insure continuity of the data beyond the end of the project's funding.

Outcome 4. Through a no-cost extension as well as supplemental funding provided our project, we created a website and created a program that connects our website to the primary data server at Decagon. The website provides graphs as well as downloadable data for user-defined

intervals of time. A link to the website is provided in the "Additional Information" section as Appendix C.

Additionally, the Department of Geosciences at Boise State University is paying for continuing the cellular data service through the Decagon server. This commitment is based on recognition that the data are valuable for continued research and should be maintained.

We also developed a script providing derived data through the site. That is, in addition to the raw weather data, the website also provides growing-degree days, wind run, frost-free days, and modeled evapotranspiration. These parameters are essential to growers to track fruit development and to inform varietal selection between sites.

Daily data summaries are available through an email subscription service – anyone can subscribe to receive a morning email (by 0630 MT) of the previous day's weather and soil statistics for any or all of the weather sites. A sample email summary is provided as Appendix D.

Beneficiaries

In numerous ad hoc interviews with wine grape producers and wineries in the Sunnyslope district and elsewhere in the state, they have stated their satisfaction of having easily accessed climate and soils data. The data are providing utility to their decision making for irrigation timing and amount, as well as applications of pest and mildew treatments to their vineyards. It also has provided data as to identifying cold-damage prone sites, particularly during the intense freeze in January 2017.

Through our presentations to the annual meetings of the Idaho Wine Grape Growers and Wine Producers Commission (IWC), other wine grape growing districts (Eagle Hills, Lewis-Clark Valley) have expressed interest in developing similar data generating capabilities.

The IWC has plans to mirror our website to help disseminate the data. Their current website and server is planned for a major upgrade and is currently not able to support managing our data.

The weather and soil moisture stations in the Sunnyslope District directly benefit 10 growers/vineyard owners. There are also parallel benefits to vineyard managers adjacent or proximal to the weather stations (n=5) who can take advantage of and use the weather data for managing their own vineyard stocks. Finally, because many of the vineyards produce wine grapes for other wineries (n=~15), the benefit from information the weather and soil data provide those end users of the grapes with expands to those winemakers who rely on the data to monitor progression of fruit ripening. The economic value provided from the new data availability is difficult to derive on such a short time frame, but will be recognized in better and more efficient management strategies and future vineyard development going forward.

Lessons Learned

As a result of this project, we've learned to communicate with vested stakeholders (producers) to best identify and work to meet their needs so that the project can best meet its ultimate goal of improving wine grape production.

A corollary to that is to also keep an open ear and remain aware of easily achieved and logical goals that can be added to a project. Clearly, if we'd recognized fully the implications of having such a rich data stream generated by our weather and soil stations, we would have included a plan for data dissemination in the original project proposal.

We also have learned to coordinate future research plans with the IWC. Improved communications will allow us to better gage both their interest in being involved as well as allow them to integrate the projects in their plans.

Contact Person

Dr. David Wilkins
Boise State University
208.426.2390
dwilkins@boisestate.edu

Additional Information

Link to paper and poster presented at 2016 International Terroir Congress, McMinnville, Oregon:

https://www.dropbox.com/sh/8x1w8nalqu55c3h/AACONxcD9JcL7z51JKKJQIEKa?dl=0

Link to weather and soil data website:

http://sunnyslope.boisestate.edu/

The Impact of Tree Architecture and Girdling at Full Maturity in a Modern Super High Density Orchard on Yield Efficiency, Fruit Quality, Mineral Partitioning and Postharvest Physiology of Apples in Idaho

Subrecipient
Idaho Apple Commission (IAC)

Project Summary

Excellent climate and soil conditions make southwestern Idaho an outstanding region for production of high quality apples. Idaho apple industry depends on the export market, while this global market is extremely competitive and demands high quality fruit.

Suitable land and water for fruit production is decreasing as world population is increasing, and this trend mandates a more efficient use of orchard lands. Production of 'Fuji' apples with desirable quality attributes is extremely important and challenging for the apple growers of Idaho and the Pacific Northwest in today's competitive global market, because most of their fruits are produced for export marketability. The use of efficient size-controlling rootstocks meshed with new orchard architectures can result in precocity and production of higher yield with better fruit quality in apples, but there is no information on the impact of these two components (rootstock and tree architectures) on sustainability of production and fruit quality when trees reach full maturity.

Consumer acceptance of apples is determined by fruit color, size, eating quality and texture. Nevertheless, poor color can drastically reduce apple values even if they have acceptable fruit size. Acceptable commercial fruit color development, yield, and fruit size at harvest is often a major problem for 'Fuji' apple growers in the Intermountain west region of the USA, including Idaho. Formation of red color in apple is influenced by light, temperature, and mineral nutrients, particularly nitrogen. Rootstock and tree architecture can influence light penetration, orchard temperature, and mineral nutrient uptake, and thus photosynthesis, fruit quality and yield in apples.

Increasing yield is usually associated with a decline in fruit quality in fruit crops, particularly apples. However, with the use of a desirable tree architecture and suitable rootstock, a close-spacing orchard system could be produced in which both yield and fruit quality would be much improved over the traditional systems. Tall Spindle and Vertical Axis training systems are new methods that are currently being evaluated in New York. Also, Bud 9 and RN 29 are two new and popular apple rootstocks. Sustainability of yield per tree, yield efficiency (yield/tree size), fruit quality, and mineral uptake change as apple trees reach full maturity, and these subjects have never been studied in any of the western states in the USA. Our main objective in this research was to increase the apple yield from 25 Tons/hectare to at least 80 Tons/hectare (an increase of 400%) in fully mature trees while also keeping the fruit quality high, with the selection of a suitable tree architecture and rootstock. Also, bark girdling may result in accumulation of carbohydrates in the upper parts of the tree and thus increase yield.

The main objective of this research was to find an appropriate training and rootstock to increase productivity and fruit quality of 'Fuji' apples for Idaho growers.

Project Approach

The experimental orchards were located at the University of Idaho Parma Research and Extension Center, Parma Idaho. 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. The experimental design in one of the orchards was randomized complete block split plot with rootstocks (RN29 and Bud 9) as main effect, canopy architecture (Tall Spindle and Vertical Axis) as sub-plot, each with 5 blocks of 20-tree plots. Each experimental tree row is guarded by two adjacent rows of 'Aztec' Fuji apples on the same rootstocks and tree architecture. We needed to establish this guarded system 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 wa guarded by two adjacent rows of 'Aztec' Fuji apples.

During this period, trees had reached their complete maturity, and we were able to collect data that represented fully-grown and mature apple trees. Side branches in all trees with different tree architectures were bended down and leaders were tied to the wires. Branches in the straight and tilted wall systems were trained at 90 degrees in relation to the main leader. Tall Spindle, Vertical Axis, Straight Wall and Tilted Wall architecture tree architectures were formed according to the protocol.

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. We needed slightly less training as trees had reached complete maturity.

For leaf mineral analysis, 30 leaves per tree were sampled randomly from the middle of the current-season's shoot in mid-August every year of this project. Leaves were washed and dried and percent dry weight was calculated during the period of this report. Dried leaves were ground to pass a 40-mesh screen. In leaf tissue, nitrogen was determined using a LECO Protein/Nitrogen Analyzer, and potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) were measured by dry ashing at 500°C, digestion, and atomic absorption spectrophotometery.

Three girdling practices were conducted in this orchard during June 2015. And 2016. In one treatment, a 2-mm ring was completely removed from the bark of each tree from about 8 inches above the bud union. In the second treatment, the same area of the bark was scored with a simple knife in a spiral pattern. The third set of trees remained un-girdled. Trunk cross sectional area from below and above the girdling areas was measured twice during this period. A leaf chlorophyll meter was purchased and chlorophyll index of leaves in this experiment was measured twice during this season.

In October of every year, fruit samples were taken for quality and fruit quality measurements. Analyses of variance were conducted by using SAS (SAS Institute, Cary, NC, USA), and means were compared by least significant difference (LSD).

Results of each year were reported to apple growers during fruit tours and the Idaho State Horticultural Society Conference. During the period of this research, we offered five tours for Idaho apple growers.

Goals and Outcomes Achieved

In this research, we studied the influence of rootstocks and orchard architectures with two girdling practices on different characteristics of apples, including tree growth, nutrient partitioning, fruit size, color, soluble solids concentration (SSC), starch index, and firmness. Our objectives in this project were as follows:

1. Evaluate the effect of four new tree architecture systems (Tall Spindle, Vertical Axis, Straight Wall, and Tilted Wall) in close- to- ultra close tree spacing (super density and high density) orchard systems on tree growth, yield, and fruit quality of 'Aztec Fuji' apples when trees are completely mature.
2. Study effects of two size-controlling rootstocks on precocity, yield, and fruit quality attributes at harvest and after storage in 'Aztec Fuji' when trees are completely mature.
3. Study effects of the tree architecture systems (in Objective 1) and two size-controlling rootstocks on mineral nutrient partitioning and determine the optimum nutrient balance for a high density 'Fuji' apple system when trees are completely mature.
4. Effects of two tree spacing with Wall and Straight Wall architectures on yield, fruit quality and mineral nutrient partition in 'Aztec Fuji' apples on Bud 9 rootstock when trees are completely mature.
5. The impact of three types of trunk girdling, two training systems, and two rootstocks on yield, fruit quality, and mineral partitioning of 'Aztec Fuji' when trees are completely mature.

During the period of this project, we studied various new tree architectures and girdling practices in combination with new dwarf rootstocks to enhance precocity, yield, and to improve fruit quality attributes and mineral nutrients in 'Aztec Fuji' apple. Rootstock affected leaf nutrient concentrations. Trees on Bud 9 had higher leaf calcium but lower potassium. Trees on Nic 9 always were significantly more vigorous, and in some years, higher yield per tree than those on Bud 9. Fruit from trees on Bud 9 had 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 than those with 4-Leader in some years but the opposite was true in other years, because different numbers of spurs produced in each year. Fruit size was also affected by the canopy architectures. Trees with higher yield had smaller fruit size and vice versa in any combination of canopy architectures any rootstock. Trees from tilted wall with 6 ft spacing had larger fruit than those with 3 ft spacing. Fruit production in trees with Bud.9 rootstock with a tall spindle training was over 85 tons per hectare. A complete girdling increased fruit size in different systems. We have completely reached of goal to have higher production when trees were mature.

Rootstock effects. Trees on RN 29 rootstock were significantly more vigorous than those on Bud 9. Thus, trees on RN 29 needed significantly more sever pruning than those on Bud 9 rootstocks every year. Each tree on RN 29 sometimes needed three times longer time to prune than those on Bud 9 and this practice added to the over-all expenses of orchard operation. Therefore, Bud 9 is preferred over RN 29 for training and pruning.

Rootstock significantly affected yield, fruit quality attributes and mineral nutrients. Trees on Nic 9 had higher yield per tree than those on Bud 9 but the difference was not always significant as trees reached closer to their full maturity (Table 1). Fruit from trees on RN 29 (Nic 9) were significantly larger than those on Bud 9 every year, because of the presence of higher leaf-to-fruit ratio in trees with RN 29 rootstock. Fruit from trees on Bud 9 had significantly better color and higher soluble solids concentration. This could be due to smaller size, smaller tree canopy, and thus better light penetration

in fruit on Bud 9 rootstock, resulting in more soluble solids concentration and better color. Fruits from trees on Bud 9 also had higher firmness than those on Nic 9, due to their smaller size (Table 1).

Fruits from trees on Bud 9 had a higher percentage of sunburn because of their smaller canopy size and thus, less protection of the fruit. Leaves from tree on Bud 9 had lower potassium but higher calcium than those on RN 29.

Canopy architectures effects. We found that it was much easier to form the tree canopy to either central leader or tall spindle, and easier to train workers how to create fruitful side branches when Bud 9 rootstock was used. It is noteworthy that trees with tall spindle had an average of 40.3 Tons of fruit per hectare when trees were 2 or 3 years old. But, these trees were averaging about 85 tons per hectare during the period that trees were completely mature. Therefore, we are completely on the target to reach the goal of having higher production when trees are mature.

What this project built (complimented) on a previously funded project. This project built upon a 2011 grant "Maximizing Production and Fruit Quality and Optimizing Mineral Nutrients in "Fuji". Trees on Bud 9 appeared to be more vigorous when a tall spindle system was used as compared to a "tilted wall". Yield from trees with a tilted wall system was greater than those with straight wall training. Fruit from straight wall had earlier and more uniform color than did those with tilted wall. When a tilted wall architecture system was used, trees with 6 ft spacing had larger fruit with better color than those with 3 ft spacing. In general, we conclude that a combination of Bud 9 rootstock with tall spindle training provided better canopy structure with more light penetration, more fruit color, and easier tree management that other rootstock- training combinations.

Measurable Outcomes:

This project had several measurable outcomes including those described below:

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 our preliminary experiments and by selection of suitable dwarf rootstocks and tree spacing, we have produced as much as 40.3 tons per hectare in early years and over 85 tons per acre when trees were mature. The level of production in our study was approximately 1.6 times higher when trees were young and about 3.4 times greater than those in traditional orchards. These intensive orchard systems reduce water consumption while producing much higher production per acre. Thus, we have reached our goal of producing more apples than traditional orchards.
2. The cost of pruning was about 40% less using tall spindle tree architecture in combination with Bud 9 rootstock was used.
3. We could improve fruit quality attributes and increase saleable apples at least by 80% over the traditional technique.
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 five times a year and at the Idaho State Horticultural Society conferences once a year. We discussed and educated apple growers in Idaho, Washington, and Colorado about these new techniques and orchard architectures during four to five different educational tours and three seminars per year.
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.

Work with cooperators:
We worked with our cooperators, including Symms Frit Ranch, Hanggeler Packing House, and Kelly's orchards. They have used some of the promising tree architectures and rootstocks and their orchards with great preliminary results. These cooperators have been following the progress in every step of our experiment and we have closely cooperated with their pilot studies. We expect a larger scale of application of these techniques within the next few years.

Beneficiaries

Apple growers of Idaho and Pacific Northwest and many other growers are benefitting from the results of this project. We estimate that our positive results are already being applied by 90% of Idaho apple growers. At least 70 fruit growers in Idaho and 30 in Utah, 25 in Colorado, and many in other states including Washington have been positively impacted by the results of this project.

Lessons Learned

Results of this project have been extremely informative. Based on our results:

1. Trees on Bud 9 are more precocious because they produce fruit spurs earlier than more vigorous rootstocks.
2. We have also learned that tall spindle training results in earlier fruit production and this production was sustainable when tree matured.
3. The use of Bud 9 rootstock with a tall spindle training is recommended over using other architectures and rootstock systems.

Contact Person

Dr. Esmaeil "Essie" Fallahi
Professor and Director of Pomology Program
University of Idaho, Parma Research and Extension Center
29603 U of I lane, Parma, Idaho 83660
Tel: 208-722-6701 Ext 225 OR 208-880-8088
efallahi@uidaho.edu

Developing season-long integrated weed control systems in Idaho dry beans

Subrecipient
Idaho Bean Commission (IBC)

Project Summary
The purpose of this project was to develop effective integrated weed control strategies in sprinkler and furrow irrigated beans that would enable Idaho bean growers to improve their bean yield and quality by reducing losses due to weeds like hairy nightshade, common lambsquarters, redroot pigweed and other species. Three field experiments were repeated over a three-year period to address growers concerns in response to a survey conducted by the Idaho Bean Commission. In the survey, growers clearly identified weeds, including hairy nightshade, as their top production challenge. The difference in soil-active herbicide behavior between furrow-irrigated and sprinkler irrigated necessitated establishing studies in both irrigation systems.

This project was funded for one year by the Idaho Bean Commission. This enabled getting three years of data with funding from the Specialty Crops Block Grant Program.

Project Approach
The objective of this project was to develop improved weed management strategies in dry bean production through three uniquely different field experiments. Multiple weed control strategies will be combined in each experiment to determine the most effective, economical and environmentally sound methods to control hairy nightshade and other broadleaf and grass weeds in dry beans. Currently, growers are spending $68/acre, on average, for the control of hairy nightshade in beans. Measurable outcomes from the field experiments will show that using integrated weed control strategies will reduce weed control costs to less than $50/acre.

Field study descriptions
Wide versus narrow row spacing- This study was conducted in 2014, 2015 and 2016. The first-year study was funded by the Idaho Bean Commission, which was a significant contributor to the ability to conduct this study for three years. The experimental design for this study was a 2 by 2 by 6 factorial randomized complete block design. The factors were 2 row widths (7.5 and 22 inches), 2 pinto bean varieties with different plant architectures (upright and viny), and 6 weed control treatments, that included a weedy control and a handweeded control. The weed competition was reduced in the narrow rows in combination with postemergence sequential herbicide applications. It also was reduced in the wide row beans, but with the added cost of cultivation. The beans grown in narrow rows generally yielded higher than the beans grown in wide rows for both varieties. The implications of this study are that pinto beans can be grown on narrow rows with equal or better yields compared to growing beans on wide rows. Narrow row bean production also eliminates the cost of cultivation, but does not allow using less herbicides for weed control.

Weed control in furrow-irrigated dry bean-
Weed control in furrow-irrigated dry bean is a different challenge compared to sprinkler irrigated dry bean production. The reason for this difference is because soil-active herbicides can be easily activated to control germinating weeds with 0.5 to 0.7 inches of overhead irrigation applied. In furrow-irrigation

beans, activation of soil-applied herbicides is not easily accomplished unless a timely rain follows the herbicide application. In the high desert environment of southern Idaho and eastern Oregon, a timely rain is cannot be relied upon. For the growers who use furrow-irrigation, a common weed control practice is to apply soil-active herbicides before planting and mechanically incorporate the herbicides into the soil. Ethalfluralin, pendimethalin, dimethenamid and EPTC were all applied as 2-herbicide tank mix combinations. Each of these was followed by bentazon alone or bentazon + one of the soil-active herbicides. The results from these studies showed that the addition of bentazon with methylated seed oil (MSO) and ammonium sulfate (AMS) was sufficient for optimizing season-long weed control in at least one of the three years of the experiment. The problem was with the consistency of bentazon applied postemergence for weed control. In the arid climate of the Intermountain West, bentazon has not been very consistent. Exactly why it is inconsistent is thought to be due to the much drier climate in the west compared to the Midwest, where bentazon is more effective.

Influence of time of day and application method on bentazon

In this field experiment, the objective was to determine the influence that time of day and the application method had on the effectiveness of a postemergence bentazon herbicide application in dry beans. Bentazon is the only postemergence herbicide registered for use in dry bean that doesn't have restrictions to rotating to potatoes and sugar beets; both of which are important rotational crops with dry beans. The experimental design was a randomized complete block with four replications. Individual plots were four rows by 30 ft. For the time of day treatments, bentazon + MSO + AMS was applied at 6 AM, 9 AM, 12 PM, 3 PM, 6 PM and 9 PM two times at the 1st trifoliate leaf and 3rd trifoliate leaf growth stage. The application method treatments consisted of applying bentazon + MSO + AMS at the same two growth stages, but with different spray nozzles and application volumes. The spray nozzles tested were Spraying System TeeJet 11001 flan fan (FF) and 11001 air induction (AI) nozzles. Each of these nozzles were tested with 10, 15, and 20 gallons per acre (GPA) application volumes.

Over the two years that time of day application was compared, there was not a clear-cut advantage to applying at a particular time. However, slightly more crop injury was observed when bentazon was applied at 6 or 9 AM than any of the other times. It is believed that environmental conditions have more influence on crop tolerance and weed control than time of day. However, early morning applications have the greatest chance for higher humidity conditions than any other time of day. Humidity is one environmental factor that has been attributed to bentazon efficacy in the Midwest. There was no yield advantage from applying bentazon at any of the applications times. With regard to application spray volume and spray nozzle type, spray volume seemed to have some influence on controlling certain weeds like common lambsquarters and hairy nightshade. Higher spray volumes (15 and 20 GPA) usually provided slightly better weed control than 10 GPA, but not always. There were no apparent differences in weed control between the FF and AI nozzles in our studies and there was no benefit to dry bean yield.

The support of the Idaho Bean Commission and the Idaho bean growers who provided first year funding and feedback during this research is greatly appreciated. Without their support and interest, these field studies would not have been done or completed.

Goals and Outcomes Achieved

A graduate student, Michael Thornton, completed his M.S. degree based on the work he did in this project. His focus was on the wide row versus narrow row spacing and weed control study, but he also was responsible for the other two studies that were funded for this project. The results from these studies were presented at four field days, the UI Bean School, and at a professional society meeting. A manuscript from the row spacing study is nearing the final stages for submission for publication in a

refereed journal. As a result of this research project, some growers in Idaho are now planting dry beans in narrow rows.

One of the other goals of this project was to help farmers reduce their weed management costs in dry bean production. Unfortunately, not as great of reduction in cost was achieved as hoped. By growing dry beans in narrow rows, cultivation is eliminated because the closer spacing of the beans helped make them a bit more competitive with weeds. More work is being done to determine optimum bean density in narrow planted rows.

Idaho dry bean growers, estimated around 500 along with the local bean warehouses, will benefit from this research project. Although we were unable to answer all of the questions that led to this research, we have made several strides to be able to advise growers with better weed management information. This is particularly true for the furrow-irrigated dry bean growers. They have a better understanding of the importance of postemergence application timing regarding the size of the weeds.

IBC's graduate student completed his M.S. degree. IBC will analyze the data from this year and combine the data from the two previous years to see how all three years compared, and plans to have all of the data analyzed from the multiple years by the end of 2016 and a final report written by spring 2017.

Beneficiaries

Idaho dry bean growers, estimated around 500 along with the local bean warehouses, will benefit from this research project.

Lessons Learned

One aspect of dry bean production that challenges the idea of growing pinto beans in narrow rows, is the difficulty in harvesting the beans without losing or damaging the pods during harvest. This is because the pods of pinto beans tend to hand close to the ground, especially those with a viny plant architecture, but also for the upright varieties. This is in contrast to some other classes of beans, such as navy beans whose pods are naturally higher off the ground making them more conducive to direct harvest instead of having to cut the beans before harvesting. Thus, it is important to select an upright pinto bean variety with pods higher off the ground to facilitate direct-harvest without losing yield because the pods are not being harvested.

An important aspect of weed control in dry beans planted in narrow-rows that was learned from this project is irrigation management. To get the most out of the soil-active herbicides, it is important to be able to apply a 0.5-inch irrigation shortly after applying the herbicide so that it is activated to control germinating weeds.

Contact person

Andi Woolf Weibye
Executive Director
Idaho Bean Commission
208.334.3520, bean@bean.idaho.gov

Developing the Bean Seed Market in Costa Rica

Subrecipient
Idaho Bean Commission (IBC)

Project Summary
The purpose of this project was to demonstrate the value of investing in certified disease free Idaho seed in Costa Rica. In order for this mission to be accomplished, it was imperative that the local Costa Rican growers see the benefit of Idaho seed and relationships needed to be built with the corporations contracting for the beans.

The Commission had 2 pounds of Costa Rican red beans that we were able to obtain after joining the Governor's Trade Mission in February 2014. We learned that the Costa Ricans prefer this local variety as it has a very specific texture when cooked and there was not a suitable U.S. variety that held up to their native cooking techniques. This small sample of seed was to be planted in 2014 and increased for use in this project in 2015. Since many Costa Rican farmers save and replant their bean seed, the disease pressure is very high and yields are low. It was the commission's hope that by eliminating the seed borne diseases through Idaho's strict certification process, yield potential will increase significantly and making the investment for certified seed worth the cost. The Commission also identified that there were also many black seeds grown and consumed in the area. And that portion of the market still needs more base line research, but should also be explored.

This project was very timely as Idaho bean growers and producers are always looking for new markets to be able to expand upon for the superior seed product we are uniquely able to grow here. The 2014 Trade Mission identified some areas of the Caribbean that would potentially fit for both them and us, and Costa Rica was the most suitable. Growers in that area have the capabilities to invest in seed, have the flexibility to be able to alter their growing practices if necessary, and finally the cost of doing business between both locations isn't cost prohibitive. It is incredibly timely for Costa Rica particularly because they do not appreciate dealing with their current trade partners, most notably being Nicaragua. There also has been some interesting economic change in the country for the last 35 years as prior to that, Costa Rica was a net exporter of beans, and currently they import almost all of them. The citizens also enjoy purchasing products produced in their own country, which again, is incredibly pertinent for this project.

Project Approach
The objective of this project was to develop a new premium market for Idaho produced bean seed. To accomplish this goal we started before the grant officially began by taking about most of our 2 pounds of Costa Rican red bean seed and planting in a trial field near Twin Falls, Idaho. Unfortunately right after the plants had pod set, a very late hail storm hit the area and damaged the crop so badly that there were holes in the leaves and as a result, there were absolutely no beans that were formed for harvesting in October 2014.

Fortunately we still had enough seed left to go ahead and plant them successfully in the greenhouse in February 2015. Yields were 10.8 pounds and were enough that we were then able to do a second field grow out in May 2015. This field trial was likely the most successful and least eventful weather wise, than any field trials related to this project. Results below:

Designation	No. Rows	cl. wt.	Yield/row	Comments
Red Flag:	298	193 lbs	.65 lbs	later maturity; more foliage
White Flag:	107	84	.79	very early maturity; less foliage
Pink Flag:	234	216	.92	very early maturity; less foliage
Blue Flag	18	6.5	.36	No anthocyanin. Seed has poor appearance/quality.
Total:	657	499.5 lbs		

As you can see; our yield increase from 10.8 pounds in the greenhouse to 499.5 pounds in the May 2015 trial, was way more than the 15% we had set out to accomplish at the beginning of this project.

In the middle of the prior mentioned two growing events, we took our first visit to Costa Rica to further some of the initial contacts and build upon the relationships established in the previous year. For this trip, the Commission also collaborated with International Business students from Boise State University to prepare a marketing plan structure for Costa Rica as well as identify any potential issues we might face. During the trip, we met with USDA, Foreign Agricultural Services, the Ministry of Agriculture, Merica Group, Global Partners, Wal-Mart, Corporacion Frijol Cinco Mil and toured some bean fields in Los Chiles with a grower organization Camara de productroes de Granos Basicos. All of the meetings were extremely productive and the trip as a whole really helped prove our capabilities to the existing contacts and helped show them how enthusiastic we are about this project.

We then engaged in another Idaho field trial in May 2016 that was once again plagued with hail. This time the hail happened earlier in the growing season and right as the plants were emerging. It basically pushed the plants right back into the ground and restarted the entire growing process. After the crop started to reemerge we had an incredibly wet late summer-early fall and one of the latest harvest seasons ever on record. As a result we did still get a crop out, but the quality and yield were not impressive due to the extremely unusual weather situation. Because the trial basically re-started itself, the positive thing about it was that the plots were still actively growing when we hosted some of the key Costa Rican contacts in September 2016 and they were able to really see the difference in the Idaho bean stands versus their native Costa Rican for themselves, which they would not have likely been able to do if things had been on a more regular schedule, as most of our fields would have already been actively harvesting or already harvested.

As mentioned above, the Commission hosted 4 key people from the Costa Rican bean industry (2 importers/dealers and 2 growers) in Idaho on Sept. 13-16. We started the tour by taking them to visit the red bean seed that we would be sending over during their next growing season. We then visited our bean trials going on at the Kimberly Research and Extension Center, where we also were able to sit down and have some great discussions on the bean market in Costa Rica. Afterwards, we visited some local farms in the Magic Valley. The following day, we toured ISDA's office and were able to educate them on our incredible certification program. We also toured bean fields in the Treasure Valley, visited a bean warehouse and introduced the gentleman to some bean harvesting equipment that they did not have in Costa Rica. Overall the trip was extremely well received! It really made a difference for us to be able to have them here and for them to be able to see the difference in our quality as opposed to us being down there and telling them how wonderful we think we are. After their visit there was a lot more excitement on the Costa Rican's end and promptness of correspondence than was ever

experienced. The Commission believes that in any future new market development efforts, hosting the trade partners in Idaho is key to keeping the project on task and moving forward.

Image 1. Jose-Mario in a black bean field in Parma, ID

Image 2. All 4 Costa Ricans inspecting bean plants in Twin Falls, ID

Shortly after the Costa Ricans left Idaho, we finally got to work on harvest. And although it was a long and more arduous process than usual, we were able to get the bean seed into Costa Rica by November 2016. The contractor we were working with assured us that although this is later in the season, the ground was still too wet to plant so that we would still be able to get the beans planted in conjunction with the rest of their native beans.

On March 15-19 three IBC board members and the executive director visited the bean trials currently going in Costa Rica near San Carlos and Los Chiles. During this time we were able to talk directly with the growers of the two trials, and other bean growers from the area. We had a lot of other growers express interest in continuing trials with us in the future. The growers seemed very excited about our work and our progress and for the possibility of them having a better Costa Rican red bean crop which, in turn, means better options for their crop rotations in the future. We were also able to hold a field day on the 16th with these growers and talk about what they would like to see in the future. There was a vast difference in the appearance of our Idaho red bean crop and their current native red bean crop. The impression given to us by their growers was that they could actually identify the benefit and the health of our newer red bean variety with their own eyes which, if nothing else, has strengthened our efforts in the country. While in Costa Rica, the Commission toured Frijole Cinco Mil, a bean facility that has been very actively engaged in this project. They have made significant investments in equipment in order to be able to package and store more beans, as they anticipate our Idaho red beans energizing the market and for this opportunity to really take off. They even created a new bag for beans 2lbs and above with handles that is very nicely put together. They can identify the bags being used by people for other things after they are done with their beans, and local Costa Ricans have commented to their grocers that they buy the beans specifically for the bag!

The biggest problem in the entirety of the project that we ran into was Hurricane Otto which hit landfall in Costa Rica in November 2016. Unfortunately the fields were so wet, that it delayed planting a lot longer than anyone expected.

Goals and Outcomes Achieved

Idaho dry bean growers, estimated to be around 500, along with the local bean warehouses, are the beneficiaries from this research project. We did accomplish our goal of 15% more yield in the growing season from 2015 to 2016. These results were shared with the growers and dealers at our Annual Bean Schools in January 2017. They were also presented to the Costa Rican growers during the field day that we held while we visited our trials in March 2017.

Unfortunately due to Hurricane Otto, we were not able to tell if our black beans were able to outperform their local Costa Rican varieties, as the plants had their supply of water turned off too soon and unfortunately the bean plants were not able to pod set, and this occurred to both their native varieties as well as our Idaho varieties, so there was nothing left to harvest and measure. This is still a venture that the Commission is very devoted to and we will continue to move forward in our pursuit of this knowledge and market development.

Beneficiaries

Idaho dry bean growers, estimated to be around 500, along with the local bean warehouses, are the beneficiaries from this research project.

Lessons Learned

We learned a great deal from this project! Unfortunately one of the biggest lessons is that Mother Nature is never predictable. We had four separate major weather events that effected three growing seasons. While occasionally an event, or maybe two, can occur with projects like these, but we have never experienced the sheer number or severity on a project like this before. And most unfortunately of all; there is nothing that can be done to really stave off these types of events as they were completely beyond standard weather hazards. In fact, our Idaho contractor has only had 4 hail events on his ground in nearly 40 years of growing, 2 of them happened with this project. One exceedingly major event that happened during this project was when Hurricane Otto crossed over Costa Rica in November 2016 thus delaying planting for our beans. This was the first time a hurricane has ever passed over Costa Rica since record keeping began in 1851. Like I mentioned before, there's no way for us to be able to plan for events like this, all we can do is learn to be patient. As well as make sure to plan ahead such as setting aside beans that might need to be used for a second grow out if the first one is plagued with a weather event and thus deemed unsuccessful.

The second lesson we learned from this project was that people from the Caribbean area conduct relationships in a much different manner than people from the United States. In fact, it was explained to us that it is almost exactly opposite. People from the U.S. typically build trust by observing how another person performs. We might ask them to do a small but manageable task, and if they do it to our satisfaction; then we build confidence in them and learn to value their attributes such as their work ethic, and in turn give them bigger or more important tasks as we trust them more and more. With people from the Caribbean, they need to get to know you as a person first, before they will entrust you with a task. As they get to know your character and if they feel you are a good fit for their personality (or the personality fitting for their business) then they tend to move forward with business type transactions. This is important for us specifically because although we are so eager to get this project moving at warp speed, it can get rather frustrating when we feel that people from the Caribbean aren't as enthusiastic as we are so we tend to wonder if we are doing something wrong, or maybe they aren't feeling the excitement for the project in the same way that we are. When in reality, we are both looking

forward to the same goal with similar enthusiasm; we just have different paths in mind on how to achieve that goal.

The final lesson we learned was how imperative this project really is because around 35 years ago, Costa Rica was a next exporter of beans. Due to their obvious location in the Caribbean, beans are an important part of their cuisine and their culture, so they are eager to be able to produce their own local cultivars of beans. Since they now import nearly all their consumed beans, compiled with the national push to purchase native Costa Rican produced products, this project couldn't be timed any better! Below are photos sent to us by our Costa Rican Contractor in Los Chiles in February 2017, a month before the Commission's visit. You can clearly see with the two fields that were adjacent to each other, the difference between their currently grown native varieties (left) juxtaposed to our Idaho grown red bean variety (left) just how much of a difference clean genetics makes!

Image 3. Costa Rican Native Red Beans adjacent field to Image 4. Image 4. Idaho Grown red bean seed adjacent field to Image 3.

Contact Person

Andi Woolf Weibye
Executive Director
Idaho Bean Commission
208.334.3520
bean@bean.idaho.gov

Increase Quality, Awareness, and Sales of Idaho Wine

Subrecipient
Idaho Grape Growers and Wine Producers Commission (IWC)

Project Summary
As an agency tasked with providing, marketing and educational resources for the Idaho wine industry, the Idaho Grape Growers and Wine Producers Commission (IWC) sought to deliver these resources while aiding in the increase of quality, awareness and sales of Idaho wine. With a focus on local Idahoans, the IWC set a goal to reach more consumers within the state, as well as expand exposure to other markets and consumers by connecting across neighboring boarders. Through many elements such as advertising, educational training, event marketing, media outreach, collateral items and research, the IWC has been able to improve the quality of Idaho wines while raising both awareness and sales of products throughout the state.

Project Approach
Prior to implementing any project components, the IWC mapped out a detailed plan of action with Red Sky PR, a public relations agency contracted through the State of Idaho, and Rizen Creative, a marketing agency contracted through the State of Idaho. Red Sky PR was initially contracted for the work completion and assisted in completing projects early on, however with the contract coming to a close, the IWC went through the RFP process with the State of Idaho Division of Purchasing again to select Fahlgren Mortine as the new public relations firm. The IWC reviewed the project goals and plan with Fahlgren Mortine in order to stay on track in completing the mission of the grant project. Each of these organizations were selected through the State of Idaho's Division of Purchasing to be contracted by the IWC for general objectives throughout the year. Because of this, they were also the selected agencies for all grant project components to be completed.

The first objectives derived from this plan was to target specific journalists to visit Idaho. These journalists were selected based on professional qualifications, interest in visiting Idaho, and connection to the national wine industry. In February 2015, Michael Veseth, and Eric Degerman both traveled to Idaho during the IWC's annual meeting. Veseth is a writer who has written books such as Wine Wars, and The Wine Economist, while Degerman is co-founder of Great Northwest Wine and a freelance writer for Treasure Valley Magazine, Wine Press Northwest and The Idaho Statesman. These gentlemen were the first of 12 journalists to visit Idaho during 2015-2016. Over the course of these two years, the IWC used grant funds to help host Mattie Bamman, freelance writer for Northwest Travel Magazine, Mike Dunn, Sacramento Bee, Bren Herrera, Today, CNN, Parade, Cathy Huyghe, Forbes, Tina Caputo, Sonoma Magazine, Zester Daily, Tara Morgan, SIP Northwest Magazine, Linda Murphy, Lanee Lee Neil, Wine Enthusiast, John Vankat, Arizona Daily Sun, Wendy Van Diver, Touring and Tasting Magazine and W. Blake Gray, freelance writer and blogger with The Gray Report. The initial goal of the grant application was to host 5 journalists, however with additional assistance from partnering agencies, the IWC was able to more than double that number. To date there have been 9 articles total written regarding the trips to Idaho from this group of journalists and they are continuing to come in.

Although the IWC hosted several more journalists than the initial goal set, there were still many influential media individuals who were not able to travel to Idaho. Because of this, the IWC worked with a public relations firm, Watershed Communications, that specializes in the collaboration of agencies to build media boxes with products, collateral materials and digital elements that strive to most fully

encompass the essence of Idaho without physically visiting Idaho. Through this the IWC reached 20 journalists with the story of Idaho wine and the products produced here. Throughout the full grant project, the IWC saved funding on different project elements such as advertising and the wine quality initiative. With those cost savings, the Best Case Scenario was extended to push the project to a broader reach of journalists. This resulted in a total of 36 journalists receiving the package and 15 stories targeting the industry and boosting awareness. Articles were written in the following national publications; Northwest Travel Magazine, Sacramento Bee, Wine Searcher Magazine, Elixir Vitae, SIP Northwest Magazine, Travel + Leisure, Great Northwest Wine, Sunset Magazine, Atlanta Journal, Vinography and Terroirist. Digital articles are posted through the IWC website: http://www.idahowines.org/News. The IWC was also asked to participate in a large media tour with tourism agencies throughout Southern Idaho and United Dairymen of Idaho. With many journalists approached to learn more about the Idaho wine industry and tour the region, the IWC worked closely with Red Sky PR and Fahlgren Mortine to choose the highest quality and most influential journalists for invitations. These contractual expenses were handled by the IWC as matching funds for the grant project.

In addition to targeting journalists and educating them on the quality of Idaho's wine products, the IWC participated in events targeting and educating consumers. The events were selected based on website traffic and traveling history by location to Idaho wineries. These events included the Seattle Wine and Food Experience (February 22nd, 2,000 media and consumers in attendance) and Vintage Spokane (July 19th, 2,000 attendance) in Washington State. With funds from the grant, the IWC was able to procure a marketing package with Salt Lake Magazine that allowed us to place a full-page advertisement in their magazine, (an $8,500 value), and an event booth registration/participation. For the price of the ad, the IWC was able to attend TasteMakers in Salt Lake City, UT on May 28-29, representing the industry and pouring wine for 7 Idaho wineries to a crowd of 1,500 general admission attendees and 250 VIP attendees. The IWC partnered with the Division of Tourism and Southwest Idaho Tourism Association (SWITA) to help cover the additional expenses for the Salt Lake Magazine package which gave a full travel experience to those looking to visit wineries in Idaho, and two events hosted by Sunset Magazine in conjunction with an advertising package. The Sunset Events were Celebration Weekend (June 6-7, 20,000 attendance), and Savor the Central Coast (September 26-27, 30,000 attendance). At each of these events, the IWC and its members were able to tell the story of Idaho's wine industry, describe what makes Idaho's wine and wine region ideal for growing winegrapes and sample the resulting product. Each participant of these events walked away seeing Idaho wine becoming more well-known and individuals who have neither heard nor tasted Idaho wine becoming more rare. This is a successful measure for the industry as the word and quality of taste have spread.

The IWC staff attended several conferences between November 2014 and March 2015, educating the public on the Idaho wine industry. These conferences gave the staff an excellent avenue to find new speakers, educators and ideas that can be brought to Idaho. IWC staff attended the Seattle Wine and Food Experience, Unified Grape and Wine Symposium, LIVE Conference, WineAmerica Spring Conference and LA Grill n' Chill presented by Sunset Magazine, which came up as an additional opportunity with no booth registration cost. From April 2015 through September 2015, the IWC participated in several other events promoting Idaho wines and providing opportunities to educate the public on the industry. These events included Sunset's Celebration Weekend and Savor the Central Coast, Vintage Spokane, and TasteMakers Utah. Due to substantial cost savings in several areas of the grant and event registrations, the IWC was able to team up with Idaho's United Dairymen to host a group of 14 food, travel and lifestyle journalists, tour them around Idaho and educate them on Idaho wine. The IWC had originally intended on participating in the Sun Valley Wine Auction and the Festival at

Sandpoint, however Idaho wineries have chosen to attend these events representing themselves. Since the wineries are choosing to attend these events themselves, it was deemed unnecessary for the IWC to attend. This shows the IWC there is a positive shift of wineries growing to the point of sustaining their individual booths, and there is enough demand for their wines at events for them to do so.

Other elements created with the assistance of this specialty crop block grant were to help increase the exposure, awareness and sales of Idaho wine. This included many informative marketing pieces. With Rizen Creative, the IWC was able to update the website to include a directory, historical information, and current and future events for wineries. Also with Rizen Creative, the IWC was able to film a second consumer-focused Idaho wine video featuring the character Ted, a potato farmer who had never tried Idaho wine. The second video was developed to show the evolution of a person who has fallen in love with Idaho wine. The video launched in June 2015 and was a huge success. It received an honorable mention from Wine Spectator in their video competition and had 838 views on YouTube alone in the first month. It is available for viewing on the IWC website and Wine Spectator's website, as well as each staff members' email signature. To date it has received 1,063 views through YouTube. The final project element that Rizen Creative worked with the IWC on was a redesign of the industry tour brochure that IWC prints annually. While the tour brochure gets printed each year, the information changes with the wineries and activities taking place in the coming year. To make sure consumers are seeing the newest version, the IWC worked to update the layout and images showcasing new photography and information. Upon completion, 25,000 brochures were printed and distributed among all Idaho wineries, chambers, hotels, wine retail outlets, and individual requests through the IWC website. The IWC partnered with The Boise Weekly, inserting 3,000 copies directly into the publication. The IWC used this opportunity as matching funds with the printing. Lastly, 169 street banners were hung throughout the state for Idaho Wine Month. 143 of these banners were placed throughout downtown Boise, with 14 hung in Lewiston and 12 in Caldwell. The distribution was based on available locations and interest from wineries. Banners were located on main streets in each city.

Along with these marketing initiatives, there were a number of different advertisements placed throughout Idaho and the Pacific Northwest, highlighting the region and attracting travelers to the quality Idaho has to offer. The IWC placed advertisements with both grant funds and matching funds in publications such as Wine Press Northwest (14,000 Circulation), Alaska Air (2.06 Million Circulation) The Idaho Statesman (46,521 Circulation), Salt Lake City Weekly (55,000 Circulation) Great Northwest Wine (13,100 Monthly Visitors), The Spokesman Review (65,074 Circulation), Touring and Tasting Magazine (660,000 Circulation) Idaho Business Review (3,500 Circulation), Boise Weekly (35,000 Circulation), Cumulus Radio (131,400 Weekly Listeners), and social media advertising. Through these efforts, the IWC believes there was a connection with the increase in traffic to the IWC website and social media sites. Due to negotiated rates for banners and advertising packages, the IWC was able to extend the use of funds for additional advertisements through September and October 2015.

In addition to the several journalists who visited Idaho, the IWC was host to select educational seminars. They benefited the members and assisted in improving the quality of the product, as well as the experience for consumers visiting the tasting rooms. The initial quote for the tasting room training was higher than the final result, as was the expenses for the Wine Quality Initiative. Therefore, the IWC was able to use the remaining funding to offer an extension of the Wine Quality Initiative training. In the search to provide a well-tailored and qualified tasting room seminar for the Idaho wine industry members, the IWC reached out to several secret shopper/tasting room training companies to conduct the educational opportunities and found that WISE Academy best suited the needs. The IWC negotiated the original quote, reducing the cost for the seminar. The secret shopping results and tasting room

training was presented at the 2015 Idaho Wine Annual Meeting and received overwhelmingly positive feedback and was found to be beneficial to the members of the industry.

The IWC was able to handle the expenses for the website critiques in another manner and therefore redirected those funds to host an educational sensory seminar for its members at the IWC Annual Meeting in February 2016. Because the wine quality was not as expensive, we were able to extend projects and host a wine chemistry expert. Dr. Charles Edwards from Washington State University attended and presented at the 2015 Idaho Wine Commission Annual Meeting. By combining these additional seminars with the Annual Meeting, it is estimated more than twice the number of attendees were able to partake in the seminars. With more funds remaining after the additional seminars, the IWC sought to extend the wine quality project into the vineyard. With this new direction, the IWC found a member of the industry, Meredith Smith winemaker for Sawtooth Winery, who was interested in collecting samples for certain varietals from many different vineyards throughout Idaho to determine changes in pH levels and the best management of them. In doing so, the changes in management can alter the quality of the winegrapes and winemakers will begin with a superior product.

Goals and Outcomes Achieved

- Increase in Idaho wine's market share
- Increase in website traffic
- Increase quality of Idaho wine
- Increase in social media traffic

From year to year the IWC tracks certain measurable goals to evaluate the growth of the industry as well as the effectiveness of its efforts. These measurables have been applied to the project elements supported by the specialty crop block grant in order to see the changes created through these works.

Each Idaho winery is required to file quarterly tax reports to the Idaho State Tax Commission. These reports break down the sales by Idaho wineries within the state of Idaho, out of state and to distributors. By using these numbers from the Tax Commission, the IWC is able to track the changing market share number for Idaho wine sold within the state of Idaho. The IWC calculates the market share number based on how much total Idaho wine is sold within the state from all outlets, versus all other wine sold through these outlets. This number is only based on Idaho wine sold within the state and does not factor in Idaho wine sold in other states by distributors or direct to consumer. With the initial goals set to increase Idaho wine sold in the state of Idaho to 190,000 gallons by the end of 2014 and to 200,000 by the end of 2015, exceeding both goals by the end of 2014 with 301,352 gallons sold was a success. The new goal was determined to repeat sales from 2014 as it was an outstanding year, and at the end of 2015, a total of 358,347 gallons of Idaho wine had been sold within the state. Not only did this exceed the goal again, it also resulted in Idaho wines having a 10.35% market share within the state. With only the first two quarters of 2016 available, there have been 167,242 gallons of Idaho wine sold in the state, reaching a market share percentage of 12.6%. The growth of this measurable has surpassed the expectations of the IWC and is on track to continue on this path.

All digital and print advertisements call attention to the IWC website in order to find more information. This is a very valuable tool that the majority of IWC members take advantage of when posting their most up-to-date information and events. By the end of 2013, there was an average of 5,498 total unique

visitors per month to the IWC website. The IWC set out to increase this average to 6,000 total visitors per month in 2014 and to 6,500 total visitors per month in 2015. Due to a difference in website analytical tracking between Google Analytics and the State of Idaho, these goals were adjusted to reflect a more realistic number gauged from the reporting. After reaching an average of 4,628 unique monthly visitors by the end of 2015, the goal was adjusted to 5,000 by the end of 2016. As of the end of September 2016, the average unique monthly visitor number came to 5,582 for 2016. This exceeds the revised goal set and the IWC is pleased with the outcome since the numbers continue to climb as more awareness is created.

With a difficult obstacle to overcome, one of the important initiatives of this grant project was to improve the quality of Idaho's wine and make the public aware of this change. In August of 2013, the IWC hosted two wine experts who evaluated Idaho wines on a number of different criteria. These initial results were used as a starting point to gauge the change over a two-year interval in the quality of wine produced in Idaho. To measure improvement, the IWC looked to get direct feedback from the same experts who evaluated the wines in 2013. Although the IWC wanted to have a percentage change in the amount of faults found in wines over the course of the two years, it was not attainable after receiving the feedback from these experts. The IWC was looking to see a decrease in wines with faults such as oxidation, tired/stewed fruit characteristics, and high wood content. After reviewing the new vintage of wines that had been given a chance for improvements, wine expert, Bob Betz from Washington State, revealed that, "Serious steps have been taken since my last review: there are more wines with balance, expression and character, fewer wines with microbial flaws. There is more energy, knowledge and ability in the community versus two years ago. " Since the findings for each winery were kept confidential, Betz was asked to provide an overall synopsis of his findings and offer a comparison to the 2013 evaluations, allowing the IWC to see the growth in quality of the industry's product, pinpoint improvements and also see where improvements can continually be made. The IWC believes this reveals a goal met in the increase in the quality of Idaho wines and the project was successful. Member testimony provides confirmation the guidance Betz gave has been put into practice, resulted in improved quality and a more desirable wine from the winemaker's perspective.

Social media outlets have become major focuses for the IWC to directly connect with consumers and those who have opted-in for supporting the industry. The IWC set a goal of increasing followers on its social media channels to 2,000 followers on Facebook and 3,000 followers on Twitter by the end of 2015. Since both of these goals were surpassed, the IWC reevaluated the goal to reach 3,500 Facebook followers and 5,200 Twitter followers by the end of 2015. The second Facebook goal was slightly short with a final list of followers at 3,371 at the end of 2015. With this being the second goal set, the IWC still feels there was successful growth in the amount of consumers interested in receiving the latest information about the Idaho wine industry. By September 2016, there were 3,962 followers of the IWC Facebook page and 5,718 followers of the IWC Twitter account. 5,200 Twitter followers was ultimately the third goal set after having surpassed the first two before the end of 2015, and by the end of the year the IWC Twitter account had reached 5,148 followers. This was extremely close to the third goal set and is also viewed as a success from where the ideal reach had started. The numbers continue to grow as more and more consumers are becoming interested in Idaho wines and the third goals were passed prior to the official end of the grant project.

Beneficiaries

The IWC's mission is to market and promote all Idaho wineries and vineyards while providing education to its members and consumers. With that mission in mind, the 51 licensed wineries and over 1,300 acres of vineyards in Idaho who compile the membership of the IWC, were the focus of these initiatives to increase quality, awareness and sales of Idaho wine. In 2014, the IWC commissioned an economic impact study to reveal important factors of where the industry stands. At the time Stonebridge Research Group completed the report, the Idaho wine industry held an impact of more than $169 million in 2013 which was nearly $100 million more than 2008. Since economic impact studies take an extreme amount of time and money, they are not conducted every year, however with the growth between 2008 and 2013 for an economic impact in dollars and the case production growth between 2013 and 2015, it shows a noticeable growth pattern. While wineries continue to grow and generate revenue for the state, this directly correlates to a need for growth in the vineyards as well. In order for this product to continue to be made with Idaho winegrapes, the vineyards need to continue to grow and build up the agriculture community with them. With consumers continuing to increase the supply and demand need, the supply and demand need for planted vineyards is on the rise.

The purpose of this specialty crop grant was to further expose the quality and potential of this Idaho product to help grow the industry for both wineries and vineyards. As the industry is on the path of continued growth, each of these members are benefiting in their respective areas.

Lessons Learned

Although things went smoothly and the grant funding was extended to expand on projects outlined in the application, it also extended the initial timeline. The goals and mission behind the project remained the same, however being able to adapt to changes that allowed for a larger impact to the industry was an adjustment. The original mission was seen through with excellent outcomes. With the unexpected changes in lower expenses and need to modify the original plan, it did call for some flexibility and new potential that wasn't visible at the time of applying for the specialty crop block grant. This ability to see opportunity and cultivate it to meet the best possible outcome was a lesson well learned and taken into practice through other aspects of the IWC's dealings.

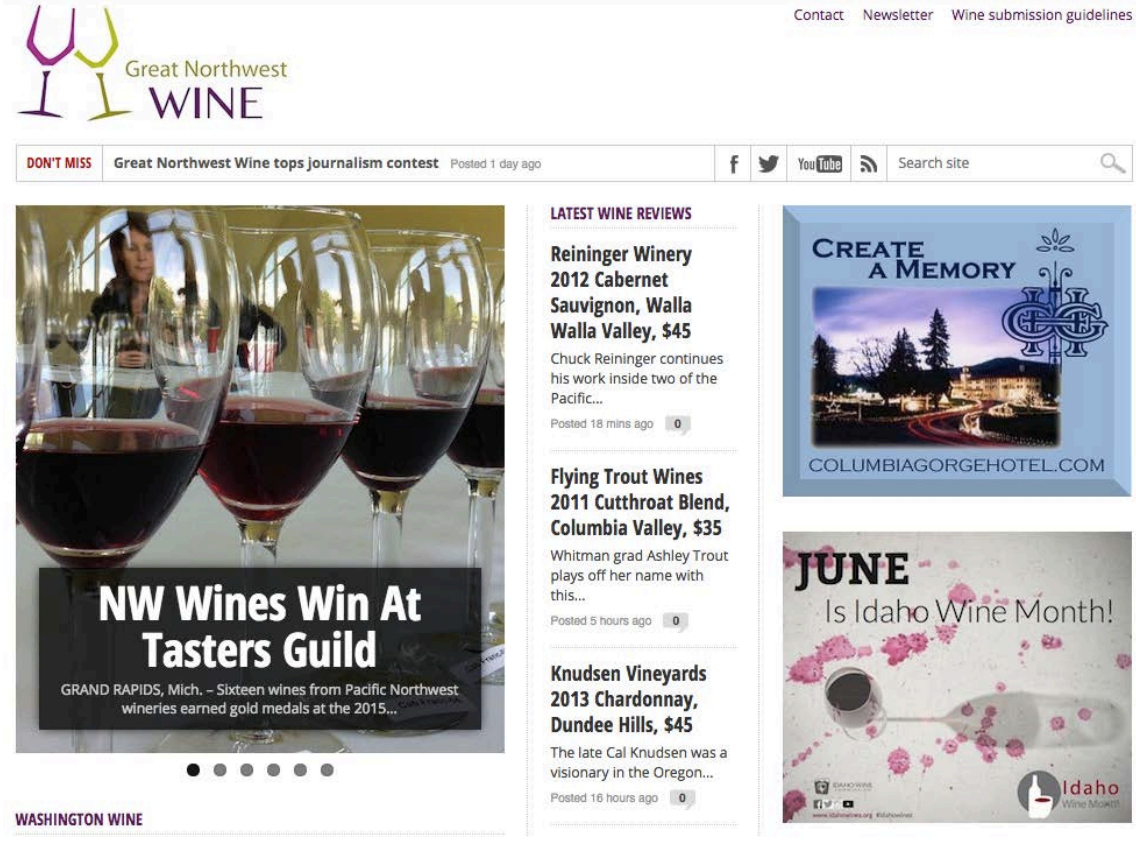
In regards to matching funds, the IWC was able to use personnel, contractual and other advertising funds to support the efforts of the grant project. Previous grant projects, showed the IWC there are possible overlapping fiscal cycles, and managing these in regards to applying for matching funds was a lesson taken into consideration. Because of this, it was easier for the IWC to reach the matching funds goal within the proposed categories. In all aspects there is room for improvement with each new project. Learning this will allow the IWC to maximize future opportunities.

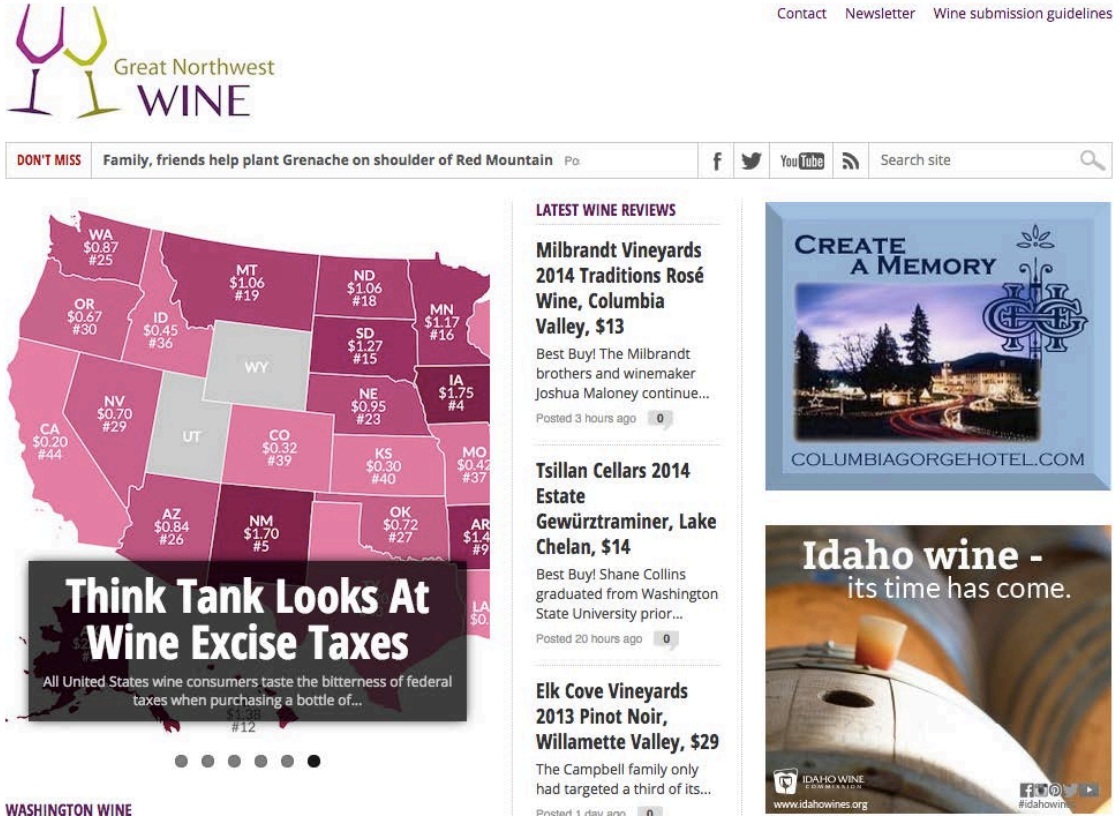
Contact Person

Moya Dolsby
(208) 332-1538
moya@idahowines.org

Additional Information

*The IWC and ISDA Specialty Crop Grant only paid for Idaho wine related advertising and projects. The below images reflect ad placement and additional ads on the pages are not related to or paid for by the IWC.

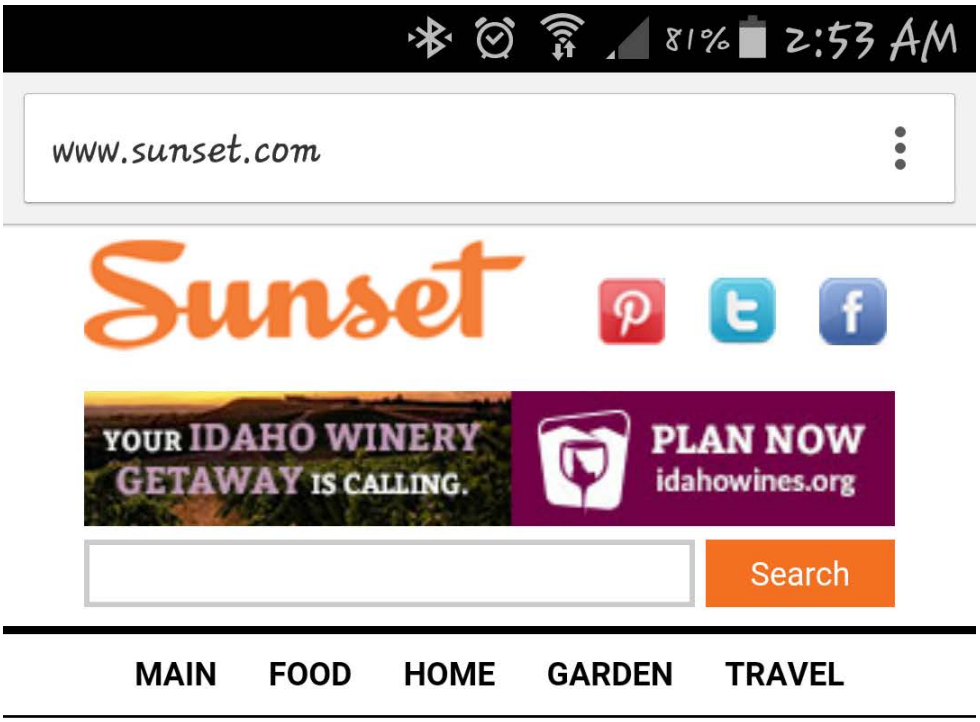

Contact Newsletter Wine submission guidelines
Great Northwest WINE
DON'T MISS
Great Northwest Wine tops journalism contest Posted 1 day ago
Search site
NW Wines Win At Tasters Guild
GRAND RAPIDS, Mich. – Sixteen wines from Pacific Northwest wineries earned gold medals at the 2015...
LATEST WINE REVIEWS
Reininger Winery 2012 Cabernet Sauvignon, Walla Walla Valley, $45
Chuck Reininger continues his work inside two of the Pacific...
Posted 18 mins ago 0
Flying Trout Wines 2011 Cutthroat Blend, Columbia Valley, $35
Whitman grad Ashley Trout plays off her name with this...
Posted 5 hours ago 0
Knudsen Vineyards 2013 Chardonnay, Dundee Hills, $45
The late Cal Knudsen was a visionary in the Oregon...
Posted 16 hours ago 0
CREATE A MEMORY
COLUMBIAGORGEHOTEL.COM
JUNE
Is Idaho Wine Month!
Idaho
WASHINGTON WINE


Contact Newsletter Wine submission guidelines
Great Northwest WINE
DON'T MISS
Family, friends help plant Grenache on shoulder of Red Mountain
Search site
WA $0.87 #25
OR $0.67 #30
ID $0.45 #36
MT $1.06 #19
ND $1.06 #18
MN $1.17 #16
SD $1.27 #15
WY
NV $0.70 #29
NE $0.95 #23
IA $1.75 #4
CA $0.20 #44
UT
CO $0.32 #39
KS $0.30 #40
AZ $0.84 #26
NM $1.70 #5
OK $0.72 #27
Think Tank Looks At Wine Excise Taxes
All United States wine consumers taste the bitterness of federal taxes when purchasing a bottle of...
LATEST WINE REVIEWS
Milbrandt Vineyards 2014 Traditions Rosé Wine, Columbia Valley, $13
Best Buy! The Milbrandt brothers and winemaker Joshua Maloney continue...
Posted 3 hours ago 0
Tsillan Cellars 2014 Estate Gewürztraminer, Lake Chelan, $14
Best Buy! Shane Collins graduated from Washington State University prior...
Posted 20 hours ago 0
Elk Cove Vineyards 2013 Pinot Noir, Willamette Valley, $29
The Campbell family only had targeted a third of its...
CREATE A MEMORY
COLUMBIAGORGEHOTEL.COM
Idaho wine - its time has come.
IDAHO WINE COMMISSION
www.idahowines.org
WASHINGTON WINE

ALL ROADS
LEAD TO SAVOR
SEPT. 24-27, 2015
VOLVO
presents
Sunset
SAVOR THE CENTRAL COAST
California's Premier
FOOD • WINE
AND LIFESTYLE EVENT
Event Program
SAVORCENTRALCOAST.COM

MARKETPLACE
Take a grand tour of living in the West as you taste wines and delicacies from California's Central Coast and beyond. Sample artisanal foods and outstanding wines as you wander through rows of more than 100 wineries, restaurants, and food purveyors. Take a bit of Sunset style home with you as you shop for regional delicacies, including locally produced olive oil, cookies, and almonds.
Maiser Ranch Vineyards
hatterranch.com
Paso Robles, CA
Hammersky LLC
hammersky.com
Paso Robles, CA
Hearst Ranch Winery
hearstranchwinery.com
San Simeon, CA
Hope Family Wines
hopefamilywines.com
Paso Robles, CA
Idaho Wine Commission
idahowines.org
Boise, ID
iGGPRA
pasoroblieswinegrapes.com
Paso Robles, CA
J Lohr Vineyards and Winery
jlohr.com
Paso Robles, CA
JUSTIN Vineyards & Winery
justinwine.com
Paso Robles, CA
Kelsey See Canyon Vineyards
kelseywine.com
San Luis Obispo, CA
La Merika Wines
lamerika.com
Napa, CA
Laetitia Vineyard and Winery
laetitiawine.com
Arroyo Grande, CA
Le Vigné Winery
levignewinery.com
Paso Robles, CA
Ledge Vineyards
ledgevineyards.com
Paso Robles, CA
Lone Madrone
lonemadrone.com
Paso Robles, CA
Michella Vineyards & Winery
michella.com
Paso Robles, CA
Niner Wine Estates
ninerwine.com
Paso Robles, CA
Niven Family Wine Estates
nivenfamilywines.com
San Luis Obispo, CA
Paso Robles Wine Alliance
pasowine.com
Paso Robles, CA
PasoPort Wine Company
pasoportwine.com
Paso Robles, CA
Pomar Junction
pomarjunction.com
Paso Robles, CA
Record Family Wines
recordfamilywines.com
San Miguel, CA
Roxo Port Cellars
roxocellars.com
Paso Robles, CA
San Antonio Winery
sanantoniowinery.com
Paso Robles, CA
Sculptevra Winery
sculpterra.com
Paso Robles, CA
continued on next page
Main Event
@SAVORcc
SAVORCENTRALCOAST.COM 19

SUBSCRIBE NOW TO SUNSET
all you
Cooking Light
FOOD & WINE
Health
myrecipes
REAL SIMPLE
Southern Living
Sunset
Sunset
Win an
IDAHO WINERY GETAWAY FOR TWO.
Airfare included.
WIN NOW
FOOD and DRINK
GARDEN
HOME
TRAVEL
magazine
events
books
marketplace
subscribe
Enter Our Wine Competition
Sunset Wine Club
Sunset Boutique
Blog
Videos
Travel Awards Finalists Announced!
Home » Before and After » Before & After: Dramatic cosmetic update
Before & After: Dramatic cosmetic update
See how a designer updated her home with fabric and paint—no reno required
Pin it
Tweet
Like
Print
Email
1 OF 19
VIEW ALL
Surface smarts
When interior designer Jill Soderlund and her husband, Clark, bought their house in Manhattan Beach, California, it was a time capsule—and not in a good way. The home had been untouched ever since it was built in 1967. The draw? The place sat on two lots, while most spots in the town claim only one, and the floor plan included five bedrooms—meaning Sophia, 14, and twins Audrey and William, 11, could each have a private space.
GET THE MAGAZINE
CLICK HERE!
OR
GIVE THE GIFT OF SUNSET
CLICK HERE!
WHAT'S NEW
Get design ideas, travel tips and special offers
Email Address
SIGN UP
SEE MORE NEWSLETTERS | VIEW SAMPLE | PRIVACY
ADVERTISEMENT
Try New Bounty with Dawn
NEW!
Bounty
WATCH NOW!
Walmart



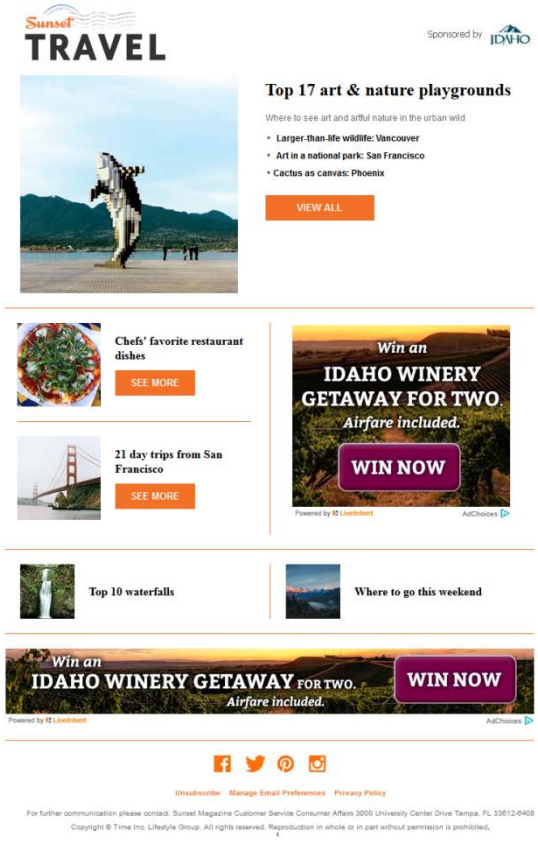
Home » 20 design tips for small bedrooms

Small-space style

Main ▼

1 of 21

SUBSCRIBE NOW TO SUNSET
Sunset
Try New Bounty with Dawn
WATCH NOW!
Walmart
FOOD and DRINK
GARDEN
HOME
TRAVEL
magazine
events
books
marketplace
subscribe
Before & After: Dramatic cosmetic update
See how a designer updated her home with fabric and paint—no reno required
GET THE MAGAZINE CLICK HERE!
GIVE THE GIFT OF SUNSET CLICK HERE!
WHAT'S NEW
Get design ideas, travel tips and special offers
SIGN UP
Surface smarts
When interior designer Jill Soderlund and her husband, Clark, bought their house in Manhattan Beach, California, it was a time capsule—and not in a good way. The home had been untouched ever since it was built in 1967. The draw? The place sat on two lots, while most spots in the town claim only one, and the floor plan included five bedrooms—meaning Sophia, 14, and twins Audrey and William, 11, could each have a private space.
Win an
IDAHO WINERY GETAWAY FOR TWO
Airfare included.
WIN NOW


Sunset
TRAVEL
Sponsored by IDAHO
Top 17 art & nature playgrounds
Where to see art and artful nature in the urban wild
Larger-than-life wildlife: Vancouver
Art in a national park: San Francisco
Cactus as canvas: Phoenix
VIEW ALL
Chefs' favorite restaurant dishes
SEE MORE
21 day trips from San Francisco
SEE MORE
Win an
IDAHO WINERY GETAWAY FOR TWO
Airfare included.
WIN NOW
Top 10 waterfalls
Where to go this weekend
Win an
IDAHO WINERY GETAWAY FOR TWO.
Airfare included.
WIN NOW
Unsubscribe
Manage Email Preferences
Privacy Policy

View in your web browser.

Sunset

Sponsored by IDAHO

How to decorate with secondhand finds

A designer shares the greenest approach to decorating: giving materials stylish new purpose

- Reupholster lounging furniture
- Refinish a table
- Rearrange art

VIEW ALL

50 dreamy dahlias

SEE MORE

25 favorite hotels

SEE MORE

11 ways with poached eggs

SEE MORE

Plant an all-container garden

SEE MORE

Another side of Alcatraz

TAKE A TOUR

Home built on a budget

TAKE A TOUR

Unsubscribe Change Email Address Privacy Policy

For further information please contact: Sunset Consumer Affairs 3000 University Center Drive Tampa, FL 33612-6405

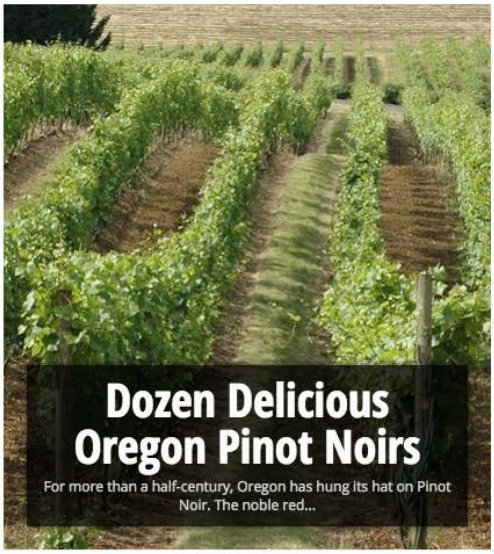
Copyright © 2016 Time Inc. Lifestyle Group. All rights reserved. Reproduction in whole or in part without permission is prohibited.

Great Northwest WINE

Contact Newsletter Wine submission guidelines

DON'T MISS Longtime wineries to pour vintage Merlot at Celebrate Walla Walla

Search site



LATEST WINE REVIEWS

Vidon Vineyard 2012 Hans Clone Pommard Pinot Noir, Chehalem Mountains, $50

The Hagges — Vicki and Don — began transforming this...

Posted 2 hours ago 0

Kramer Vineyards 2014 Celebrate! Rosé Of Pinot Noir, Yamhill-Carlton, $24

Second-generation winemaker Kimberly Kramer works with Gamay Beaujolais for this...

Posted 10 hours ago 0

Cloudlift Cellars 2012 Stratus Petit Verdot, Yakima Valley, $32

Seattle furniture craftsman Tom Stangeland didn't

WASHINGTON WINE

WINE PRESS NORTHWEST

Search WinePress NW

HOME MAGAZINE WINE INFO SUBMIT WINES WINERIES WINE SHOPS FOOD COLUMNISTS

dealsaver

TOP STORIES

- 72 hours in North Central Washington
- Match Maker: The Wright way at Semiahmoo Resort
- Red Mountain holds Vintners in the Vineyard June 6
- Kitzke Cellars 2010 Estate Cabernet Sauvignon
- Winery Fulfillment Services opens in Walla Walla
- Southern Oregon association names manager

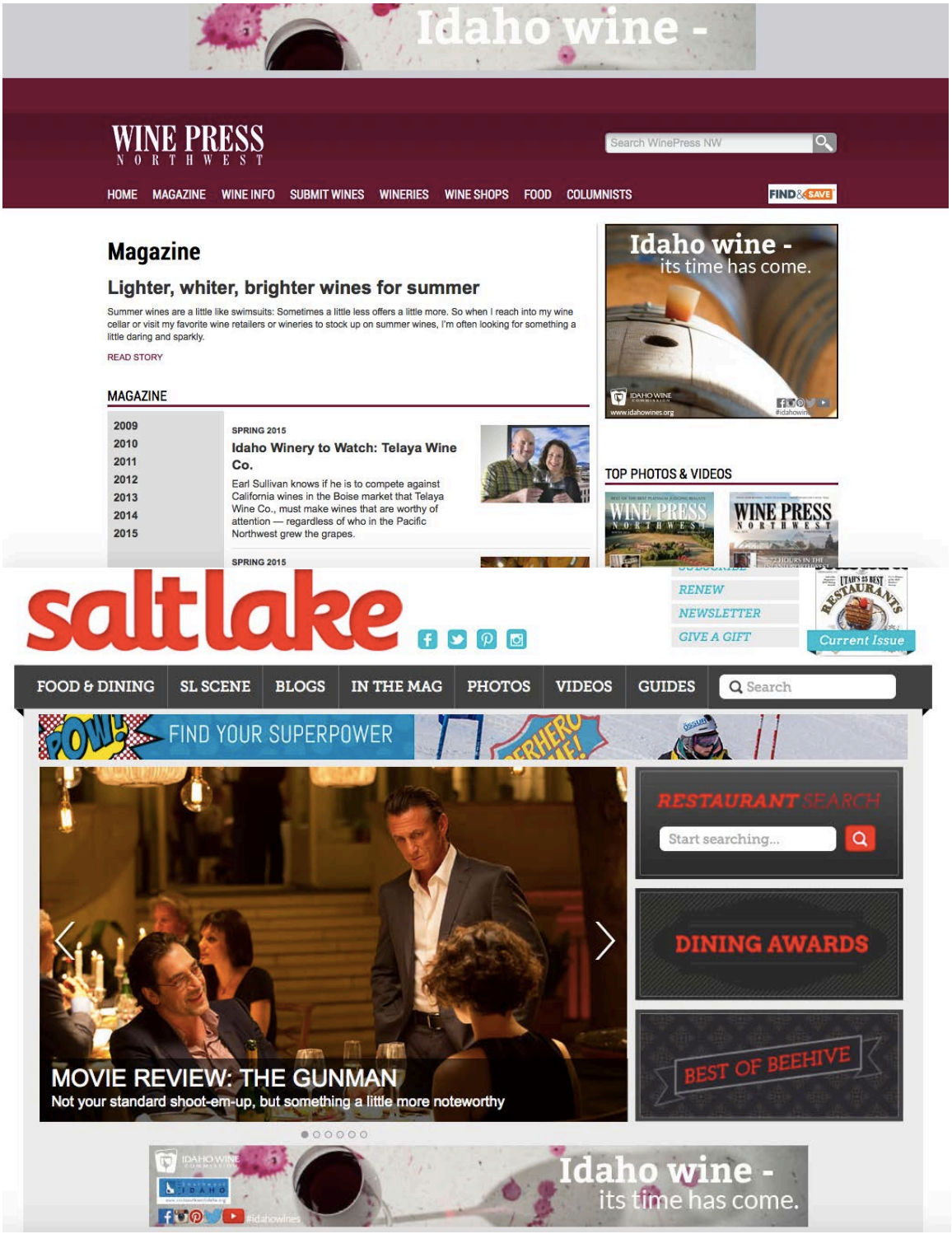
Northwest sparkling wines reviewed

The small but vibrant Pacific Northwest sparkling wine scene is rapidly changing.

RECENT HEADLINES

- Red Mountain holds Vintners in the Vineyard June 6
- Kitzke Cellars 2010 Estate Cabernet Sauvignon
- Lighter, whiter, brighter wines for summer
- Idaho's time is now
- Spice up your life with Gewürztraminer

Bolster your confidence with pricing tools and car reviews that take the guesswork out of car shopping!


Idaho wine -
WINE PRESS NORTHWEST
Search WinePress NW
HOME MAGAZINE WINE INFO SUBMIT WINES WINERIES WINE SHOPS FOOD COLUMNISTS
FIND & SAVE
Magazine
Lighter, whiter, brighter wines for summer
Summer wines are a little like swimsuits: Sometimes a little less offers a little more. So when I reach into my wine cellar or visit my favorite wine retailers or wineries to stock up on summer wines, I'm often looking for something a little daring and sparkly.
READ STORY
MAGAZINE
2009
2010
2011
2012
2013
2014
2015
SPRING 2015
Idaho Winery to Watch: Telaya Wine Co.
Earl Sullivan knows if he is to compete against California wines in the Boise market that Telaya Wine Co., must make wines that are worthy of attention — regardless of who in the Pacific Northwest grew the grapes.
SPRING 2015
Idaho wine -
its time has come.
IDAHO WINE
www.idahowines.org
TOP PHOTOS & VIDEOS
RENEW
NEWSLETTER
GIVE A GIFT
Current Issue
saltlake
FOOD & DINING SL SCENE BLOGS IN THE MAG PHOTOS VIDEOS GUIDES
Search
FIND YOUR SUPERPOWER
RESTAURANT SEARCH
Start searching...
DINING AWARDS
BEST OF BEEHIVE
MOVIE REVIEW: THE GUNMAN
Not your standard shoot-em-up, but something a little more noteworthy
Idaho wine -
its time has come.

Evaluating Experimental Hop Selections in Unique Idaho Terrior

Subrecipient
Idaho Hop Commission (IHC)

Project Summary
At one time Idaho actively took part in the hop public breeding program. The program was housed in the University of Idaho Parma extension. The last year the program was active was in the mid 1980's, over thirty years ago. Fast forward to 2014, the year this project was proposed for the first time for a Specialty Crop Block Grant. Craft beer for the first-time ever, reached double-digit volume share of the marketplace and saw and 18 percent rise in volume. The Idaho Hop Commission saw the opportunity for Idaho to once again become part of the public breeding program discussion. Over the years, several growers had separately maintained small public breeding plots, however, the harvesting and processing of these plots was inefficient and inaccurate due to the large-scale stationary harvesting machines. The main goal of this project was to establish a central test plot where new public varietal selections could be planted, harvested and evaluated in Idaho's unique terrior conditions. This would, in turn, give advantage to the Idaho growers when new varieties are released by having recorded hop brewing values, active rootstock and experience with harvest timing and production. Growers would then be enabled to make educated decisions on whether or not a variety is suitable for planting on their farm. A previous Specialty Crop Block Grant project was for a totally different activity and unrelated to evaluating new hop varieties.

Project Approach
The Idaho Hop Commission and the ISDA each had financial obligations in order for this project to come to full fruition. The goal was to establish the trellis, plant new varieties, purchase a harvester and evaluate varieties for commercial production. Cable and poles were erected as trellis in the field. Each year selections from the USDA breeding program in Corvallis were propagated and grown in the plot. Plantings varied from 6 hills to 48 hills depending on the availability of roots from the USDA. The hops were evaluated for vigor, powdery mildew resistance, downy mildew resistance, side arm growth and yield. The purchased Wolf picking machine that was purchased as match harvested varieties that showed positive responses to the unique Idaho growing conditions. They were then dried and baled. Upon completion of baling, the hops were tested to determine brewing values and the alpha and beta acid values. The selected hops were pelletized and brewed with in a variety of beers on local, regional and national sized pilot systems. Taste and smell were used to help determine if the brewer and consumer enjoyed the hops from a sensory standpoint in beer.

Goals and Outcomes Achieved
The original measureable outcomes for this project was the collection of yield data, training dates, and harvesting timing to evaluate new public varieties grown in an experimental plot. The organized collection and distribution of this information on new hop varieties will allow Idaho hop growers to make well-informed decisions regarding which varieties to put in for expansion of new acreage or replacement of old varieties in existing acreage. It is expected that this project will result in increases in production beyond the two-year project duration – these projections will be included in collected data.

Through this collection of data, the project will increase hop production in Idaho, as well as in Washington and Oregon. This data will also allow brewers to more quickly evaluate new hop varieties and identify which ones should be included in their recipes. The following goals were achieved:

- Trellis established solely for the public breeding program
- 3 varieties harvested and analyzed in 2017
- Small-plot Wolf Harvester purchased
- 26 new varieties planted over three years
- Sequential yearly plantings in alignment with Washington (#1 producing state) and Oregon (#3 producing state)

In 2016, the commission hosted the US Hop Research Council and received high amounts of praise for the plot. The variety showing the most promise is 033 (Triumph).

Beneficiaries

- Idaho hop producers
- Local FFA students
- USDA breeding program
- Craft brewers

Hop acreage has grown significantly in the past few years from 2,400 in 2012 to 5,600 in 2016. A total of 7,000 acres were strung for 2017. Idaho has 8 hop growers. The work on hops has also resulted in a new hop pelletizer moving into Idaho. Previously, all hops had to be sold out of state for pelletizing but now that process can be done in Idaho which significantly benefits Idaho producers allowing them to meet the needs of the local craft brew market.

Lessons Learned

Many lessons were learned during this process, the following are a few highlights:

- We discovered the small-scale plot is an efficient way to evaluate the hop oils, hop storage index, alpha acids and beta acids of new varieties. However, we determined in order to get accurate yield estimates, larger scale plots in the 1-3 acre range of a single variety are still needed.
- Also learned was the opportunity this plot brings to our local community. Because this plot was established we were able to reach out the Brewers Association for supplemental grants and sponsor two local FFA students from the Wilder School District.
- Finally, the commission learned how strongly this endeavor is supported by the entire industry. Many calls and donations were received from hop dealers, regional brewers and business throughout the Treasure Valley and Pacific Northwest Region.

Contact Person

Michelle Gooding
208-949-7277
michelle@goodingfarms.com

Idaho Wholesale Nursery Map and Consumer Plant Something Magazine

Subrecipient
Idaho Nursery & Landscape Association (INLA)

Project Summary
Plant Something Idaho has been of utmost importance to the industry to rebuild after the economic downturn. The timeliness is evidenced by the national wave "green" solutions and shopping locally. INLA received previous funding from a specialty crop grant which allowed us to promote the health benefits of getting outside and working in your yard. The previous grant focused on billboard ads and additions to the Planting Idaho website. This marketing campaign allowed us to take the Plant Something movement to the next level and expand our consumer accessibility.

Project Approach
The objective for this project is to increase consumer awareness of the Plant Something grassroots campaign and give them more resources to learn how to care for and where to purchase nursery and greenhouse plant material grown in their own state. Retail garden centers are where most consumers shop for plant material since the logistics to purchase online and receive the material is prohibitive. All of the material that we produced including an educational buyers' guide (magazine), banners and the website lead consumers back to the retail locations where they purchase locally. The components of this project built upon the success of the initial campaign, while working towards the central goal of increasing the competiveness and long term sustainability of specialty crops in Idaho.

Goals and Outcomes Achieved
To increase consumer awareness of "Don't Just Stand There- Plant Something" INLA opted to include several communication tools including the website, social media and printed material. One of INLA's goals was to embed YouTube videos on the website as an opportunity to learn more about gardening. INLA has included one on pruning techniques, specifics for growing specialty plants, sustainability in urban areas and a look around the state at botanical gardens and the display gardens they have that feature things you can do in your own backyard. The Boise Urban Garden school video features children talking about the enjoyment they receive out of working in the garden. Another goal with the website was to create a mobile friendly version that would appeal more to the under 40 consumer. A Facebook link to the national Plant Something site was embedded. This site has weekly garden tips. We created a Pinterest page that encourages appropriate and timely discussions and articles of interest.

In March 2015 INLA had 6,000 Plant Something magazines printed. In July 2015 INLA had 5,000 wholesale maps printed.

A survey of wholesale growers/suppliers was conducted to determine the percentage of increased sales. Results were that when comparing 2013 sales with 2014 there was an increase of 16%. The results of comparison of 2014 sales to 2015 sales were a 13% increase.

INLA did a phone survey in November of the retail nurseries/landscape contractor who received the publication. The results were inconclusive for a variety of reasons which include: businesses were

closed for the season; the person on the phone was not necessarily the buyer; yes, they did find a new supplier in Idaho but not sure if it was a result of receiving the wholesale map.
Unfortunately, the website server, Spectrum Net Designs, was hacked by an Asian company and INLA was not able to recover the information from the inlagrow.org website.

Beneficiaries

Internally the INLA members had access to material and website links so that they could include it on their website and in marketing efforts. The educational buyer's guide (magazine) encouraged the purchase of plant material from industry members. Externally some of our members produced the "how-to" videos and presented them in their stores, at home shows and state fairs. Our collaborations with industry associates such as the university of Idaho Extension Educators, Idaho Department of Lands and botanical gardens throughout Idaho also helped convey the message to consumers.

The beneficiaries of the project include the wholesale nursery growers. The economic impact of the project would be reflected in the increase of sales in both 2014 (16%) and 2015 (13%).

Lessons Learned

The lesson that I have learned more than anything is that there is more time involved in maintaining the website and Pinterest page than I had realized. To keep the website fresh requires regular visits from me and knowing what needs to be changed out. Thankfully the Facebook page is done by the national Plant Something administrator and she is very good at keeping up to date information. With the help of volunteers our Pinterest page stays fresh. I was amazed when I received the report that in 2014 668 people saw pins from Planting Idaho on Pinterest.

Contact Person

Ann Bates, Executive Director,
Idaho Nursery & Landscape Association
Phone: 208-681-4769
Email: abates@inlagrow.org

Media Plant Something Marketing Campaign

Subrecipient
Idaho Nursery & Landscape Association (INLA)

Project Summary
The Idaho Nursery and Landscape Association (INLA) Plant Something media campaign marketing support grant was a continuation of grants awarded in previous cycles. It has been established that the most effective form of advertising is repetitive "hits" of the same message.

Through previous specialty crop block grant funds, INLA has used the slogan Plant Something in promotional campaigns to encourage consumers to Plant Something and to Buy Local, Plant Local. INLA first introduced the campaign to retail nurseries and garden centers with promotion marketing materials they used in their businesses. The next step INLA took was to use Gardening for Health slogans on billboards and smaller banners of the same message were displayed in businesses. Last year INLA included updates to our plantingidaho.org website, launched Facebook and Pinterest pages to encourage younger people to Don't Just Stand There – Plant Something.

The INLA has prioritized the Plant Something campaign and has consistently determined it is in the nursery industry's best interest to continue building upon this successful campaign. The funding from this marketing grant made it possible to reach thousands of consumers with the Plant Something message.

Project Approach
The project approach was to continue exposing consumers in Idaho to the successful Plant Something promotion with a goal of increasing the sale and use of Idaho grown nursery crops. Promoting original green products, Idaho grown plants, increased consumption of nursery crops as well as the public's understanding of their many benefits. The exposure worked towards the central goal of increasing the competitiveness of the Idaho nursery industry. It also expanded the scope of work accomplished by the other grants and continued to build the promotion's momentum.

The campaign targeted consumers through paid media and public events throughout Idaho to continue increasing awareness of the Plant Something campaign, driving consumers to the website which in turn directs them to their local retail nursery. Marketing was done throughout Idaho on radio and television stations spreading the Plant Something message.

The success of this marketing campaign was tremendously increased by the partnership that INLA had with the Idaho State Broadcasters Association. The line item in the grant for advertising was $15,000. The return on investment for the media campaign was $87,445.50.

Plant Something's goal is to encourage Idaho-appropriate landscapes and educate the public about their benefits: lower utility bills, improved air quality and property values, stress reduction, increased outdoor activity and a legacy of healthy landscapes for future generations. The broad nature of the marketing campaign allowed this promotion to be utilized by nursery retailers, landscape installation and maintenance, and growers at all levels within the industry.

Goals and Outcomes Achieved

The media plan was designed to promote and stimulate positive behavioral change with females 25-64, increase awareness of the importance of planting specialty crops and create new attitudes that impact gardening habits.

The goal was to develop maximum awareness by using the highest rated local news and radio programs reaching females 25-64. Based on a 4 diary average of 2013 Nielsen ratings survey INLA learned that local news sources reach our target demographic with the most efficiency and impact during times when the community is most open to influence.

In the spring, there were two radio spots and two different television ads that had statewide coverage. The radio ads carried the message of Don't Just Stand There- Plant Something. The television ads had two messages. One was Imagine a World without Trees and Other Plants, and the second one was "Plant a Tree for Arbor Day". With money not spent in the first year, in May of year two INLA did another television message for Father's Day in the Treasure Valley.

The Idaho State Broadcasters Associations has a program (NCSA) which works with non-profit agencies to distribute their material. In return, the agency receives advertising time donated by the Idaho broadcasters. They took our $15,000 grant funds and turned it in to:
3813 radio spots for an advertising worth of $65,783; 853 television spots for an advertising worth of $21,662.

The Plant Something message was sent in banners and marketing materials to retail nurseries and garden centers and shared with cities throughout Idaho who promote planting through Arbor Day activities.

In April 2015, retail members received banners that they hung in their businesses that were designed to match the theme of the "Imagine a World Without Trees" and "Don't Just Stand There – Plant Something" television ads. In the spring of 2016 INLA sent out additional banners so the retailers would have a fresh new look, and had several comments on how much they liked receiving the banners.

Because there had been a hack to the website server INLA were unable to track the visitors to our Planting Idaho website until June, 2015. From June to December 2015 we had just over 6,900 visits to plantingidaho.org. Throughout the spring of 2016, the website continued to have monthly visits on average of 1,200. The Father's Day promotion was done the first of June and in the month of June and July 2016, the website had 2,625 visits.

The goal was to increase consumer sales between 5 and 20%. INLA conducted a survey of the Retail/Service companies and asked them to compare their sales during the two-year grant cycle. The first year the average sales increase was 12% and the second year the sales increase was also 10%. Both years we were above the lowest goal figure.

An announcement was made in January 2015 during the Idaho Horticulture Expo to outline the Media Plan for the Plant Something Campaign. The INLA had a booth during the event and had information explaining campaign where there were over 1,100 attendees.

In February 2015 INLA had a booth at the Turf, Tree and Landscape Conference to outline the Media Plan for the Plant Something Campaign. There were over 100 attendees.

In the spring of 2015 Ann Bates represented the INLA during Arbor Day celebrations, introducing the Media Plan to over 20 cities.

Beneficiaries

To date, twelve state partners, Long Island and British Columbia are currently participating in the Plant Something campaign with their own funds and are utilizing and sharing the Plant Something message with their consumers. While this marketing campaign was specifically focused only on Idaho consumers, INLA believes there is strength in numbers and that Plant Something is making a difference on the state and national level. This marketing effort is assisting the nursery industry in getting out their message of the monetary, health and environmental benefits of planting trees and plants, therefore encouraging sales of nursery crops.

This project benefited the entire Idaho nursery crop industry, thereby INLA believes that educating consumers on the environmental benefits of planting results in cities and neighborhoods with sustainable, mature landscapes with higher carbon sequestration, energy savings and pollution reduction. The more exposure an Idaho specialty crop grower, retailer and installer has for his business the better chance to increase their market share.

The increase in sales of nursery products due to the higher demand of product and services by the consumer benefited each industry segment. Growers sold more product to retail/landscape companies, retail garden centers sold more to the consumer, landscape contractors purchased and installed more plant material and landscape maintenance firms secured more work with the additional installations.

The beneficiaries of this project were retail garden centers, landscape contractors and maintenance firms. We conducted a survey of these businesses and found that comparing 2014 sales to 2013, there was an average sales increase of 12%. When comparing 2015 sales to 2014 there was an average sales increase of 10%.

Lessons Learned

The greatest lessoned learned was that by reaching out and partnering with other associations, marketing efforts were made stronger.

Contact Person

Ann Bates, Executive Director,
Idaho Nursery & Landscape Association
Phone: 208-681-4769
Email: abates@inlagrow.org

Identification of potato genes conferring resistance to NTN and N-Wilga recombinants of Potato Virus Y

Subrecipient
Idaho Potato Commission (IPC)

Project Summary

A shift in the PVY strain population circulating in the U.S. has been documented recently, with recombinant isolates from NTN and N-Wi strains now representing over 90% of field isolates. Tuber necrosis, or PTNRD, has been primarily associated with recombinant, NTN strains of PVY. However, other types of PVY recombinants had been reported to induce PTNRD as well, albeit at a lower frequency than PVY^{NTN}. Resistance genes to these recombinant strains of PVY have not been identified yet, and molecular markers associated with such genes are not known at the moment. Hence, the problem addressed in this project was to identify these new sources of resistance to recombinant strains of PVY available in commercial potato cultivars and develop molecular markers helpful in potato breeding. It is important to have simple, laboratory tools to track the desirable PVY resistance traits to speed up the release of new potato cultivars resistant to the most prevalent recombinant strains of the virus. The project built partially on the previous ISDA-SCBG project that determined the strain composition of PVY circulating in Idaho potato. Specifically, we looked at resistance to those strains that were found most prevalent in the field. Here, we characterized a group of new genes in potato cultivars conferring hypersensitive resistance (HR) to recombinant strains of PVY. Several new genes conferring resistance to different PVY strains were identified, and molecular markers associated with these genes have been developed. These new genes represent valuable new tools for management of PVY in potato production.

Project Approach
The following activities were conducted:

1. Generate segregating populations from Yukon Gem and Russet Norkotah crosses
During 2014 several crosses were made between Yukon Gem and Russet Norkotah parents, and seed was harvested. In spring of 2015, 92 potato seedlings were transferred to tissue culture to allow screening with multiple strains of PVY. Hayam Alruwaili, a master student, and Mohamad Chikh_Ali, research associate, tested parental cultivars for HR induction and systemic susceptibility to PVY infection using three different strains, NTN, N-Wi, and NE-11 (Table 1).

Table 1. Local reaction observed visually and confirmed by ELISA. The ratio is the number of plants with observed symptoms out of the total number of plants.

Isolate (Strain)	No. of plants	Local reaction		Systemic infection	
		Yukon Gem (Ratio)	Russet Norkotah (Ratio)	Yukon Gem (+/-)	Russet Norkotah (+/-)
N1 (PVY^{N-Wi})	5	HR (5/5)	No local	(1/4)	(5/0)

			symptoms (5/5)		
HR1 (PVY^{NTN})	5	HR (5/5)	No local symptoms (5/5)	(5/0)	(5/0)
ID20 (PVY-NE11)	3	HR (2/3)	Local HR (3/3)	(0/3)	(3/0)

2. Screen PVY recombinants on these progenies, identifying plants susceptible and resistant to PTNRD-inducing recombinants

In 2015 and in 2016, 89 plants in total were separately inoculated and analyzed for the development of HR and systemic infection, using three strains of PVY, such as NTN, N-Wi, and NE-11 (Figs 2 and 3). Different segregation ratios were observed for the HR reaction on one hand (Table 2) and for the development of systemic infection on the other (Table 3). Individual potato lines that exhibited resistance to the NE-11 infection, four lines in total (Table 3), were separated and continued to be tested with other strains of PVY.

Table 2. Segregation of the progeny of crosses between cvs Yukon Gem and Russet Norkotah according to their hypersensitive resistance (HR) to PVY strains.

Isolate (Strain)	# of plants	# of displaying local HR	# of not displaying local HR	Ratio (+/-)
1. N1 ($PVY^{N\text{-}Wi}$)	32	17	15	1:1
2. HR1 (PVY^{NTN})	31	4	27	1:7
3. ID20 (PVY-NE11)	26	2	24	1:12

Table 3. Segregation of the progeny of crosses between cvs Yukon Gem and Russet Norkotah according to systemic infection with PVY strains. The plants were tested for systemic infection by ELISA and PCR.

Isolate (Strain)	#. of plants	#. of infected plants	#. of negative plants	Ratio (+/-)
1. N1 ($PVY^{N\text{-}Wi}$)	32	32	0	1:0
2. HR1 (PVY^{NTN})	31	31	0	1:0
3. ID20 (PVY-NE11)	26	22	4	5.5:1

3. Apply PCR-based molecular marker sets and screen for linkage with resistance genes, and develop specific molecular markers closely linked to genes conferring resistance to PTNRD-inducing PVY recombinants

Thirty-seven progeny from a Yukon Gem by Russet Norkotah crosses and the two parents were analyzed with the SolCAP SNP chip version 2, which includes ~12,000 single nucleotide polymorphisms (SNPs). All thirty-seven progeny and both parents passed with a minimum call rate of 95.7 percent, and averaged 96.5 percent. Single nucleotides polymorphisms segregated in expected tetraploid ratios. Genomic DNA has been extracted and will be sent for SNP chip analysis from ~140 additional Yukon Gem by Russet Norkotah progeny. Once analyzed this data can be used to develop additional molecular

markers. Additional backcrosses have been made between two YGRN progeny (YGRN 147 and YGRN 154) and the susceptible parent Russet Norkotah. Seed from these crosses will be used to establish segregation of the HR phenotype.

Goals and Outcomes Achieved

- A segregating population of progeny of the Yukon Gem x Russet Norkotah crosses was established in tissue culture, to be screened with various strains of PVY. The number of lines, 72, is sufficient to conduct genetic and molecular tests of resistance genes
- Screening of the segregating population against three different strains of the virus indicated that i) the HR reaction and the inability of the virus to systemically spread in potato are two separate traits segregating independently; and ii) three different alleles confer resistance to three different strains of PVY, with only one (specific to N-Wi) being a dominant allele, with two others appearing recessive.
- All outcomes of the project were communicated to the interested stakeholders in two different forms: a) through presentations at the annual Idaho Potato Conference (Jan-2015, Jan-2016, and Jan-2017), and at the annual Potato EXPO meeting (Jan-2015 and Jan-2016); and b) through a series of peer-reviewed publications in leading national and international journals (see the list of publications at the end of the report).
- This project lays foundation for the development of new tools conferring strain-specific resistance to PVY.

Beneficiaries

Beneficiaries are expected to be Idaho potato seed growers, as well as all potato growers, and entire potato industry in the state. Every single percentage point reduction in PVY infection level in potato saves approximately $5M in the state of Idaho alone. The number of potato growers benefiting from this work can be estimated based on the attendance of the annual Idaho Potato Conference, which is around 1,200 people in each of the three years we communicated our research outcomes. Ultimately, consumers in the entire country will benefit through more affordable prices and better quality of fresh market potato. Understanding of the mechanisms driving PVY resistance in potato will help in development of resistant varieties and guide growers in choices of grown cultivars.

Lessons Learned

- Resistance to PVY in potato is often strain-specific.
- Now we realize that HR and the block of the systemic spread of the virus are two distinct traits.
- There are many more PVY resistance sources to be used for the development of new cultivars of potato.

Contact Person

Alexander V. Karasev
208-885-2350 (office)
akarasev@uidaho.edu

Additional Information

Peer-reviewed scientific publications:

Funke, C.N., Nikolaeva, O.V., Green, K.J., Tran, L.T., Chikh-Ali, M., Quintero-Ferrer, A., Cating, R., Frost, K.E., Hamm, P.B., Olsen, N., Pavek, M.J., Gray, S.M., Crosslin, J.M., and Karasev, A.V. (2017) Strain-

specific resistance to Potato virus Y (PVY) in potato and its effect on the relative abundance of PVY strains in commercial potato fields. Plant Disease 101: 20-28. – This paper was featured as Plant Disease Editor's pick in January 2017, with free on-line access during the month of January 2017.

Benedict , C., McMoran, D., Inglis, D., and Karasev, A.V. (2015) Tuber symptoms associated with recombinant strains of Potato virus Y in specialty potatoes under northwestern Washington growing conditions. American Journal of Potato Research 92: 593-602. Fig. 1 of this paper has been selected for the cover of the October 2015 issue of American Journal of Potato Research.

Rowley, J.S., Gray, S.M., and Karasev, A.V. (2015) Screening potato cultivars for new sources of resistance to Potato virus Y. American Journal of Potato Research 92: 38-48. – Fig. 8 of this paper has been selected for the cover of the February 2015 issue of American Journal of Potato Research.

Chikh-Ali, M., Rowley, J.S., Kuhl, J.C., Gray, S.M., and Karasev, A.V. (2014) Evidence of a monogenic nature of the Nz gene conferring resistance against Potato virus Y strain Z (PVY^Z) in potato. American Journal of Potato Research 91: 649-654.

International Development for Idaho Potatoes

Subrecipient
Idaho Potato Commission (IPC)

Project Summary
The grant funds from the 2014 Specialty Crop Block Grant allowed the Idaho Potato Commission (IPC) to organize and implement events such as trade shows, trade missions, cooking competitions and in-store promotional activities in current regions. These monies also enabled the IPC to support the launch of Idaho® potatoes in two new markets as well as regain sales in two lost markets. The sum of all these activities supported the goal of this project in creating a heightened awareness for Idaho® potatoes in all of their forms and led to increased sales in almost all targeted markets.

In the realm of both the Trans-Atlantic Trade Agreement and the Trans-Pacific Partnership negotiations underway, the world is becoming a global market place with regions such as the EU and China ready to compete for large pieces of the agricultural trade. These SCBG grants are extremely important to the IPC in order to help gain and maintain the Idaho potato industry's relevance in this global playing field.

As with previous grants, these funds were utilized in the IPC's continuing support of the Idaho potato industry in developing new markets and creating a broader awareness for the premium Idaho® potato and its potato products. Training and education was a focus with this grant. The IPC working, together with our regional representatives, conducted chef training for fresh and dehy potato products in Latin America, sponsored Chef cooking competitions in Asia, trained produce buyers and managers in Central America and conducted a very successful and educational all region Reverse Trade Mission (RTM) during the harvest season this past fall.

Project Approach
In all of our regions: Southeast Asia, Greater Asia and Latin America, face-to-face conversations are key to building and maintaining loyal business relationships. The IPC's approach in all our projects is to repeatedly bring the buyers and distributors in direct contact with the Idaho potato shippers and processors.

Travel is a large cost in budgeting for events in international markets. In order to create and maintain awareness for the Idaho® potato, travel costs are unavoidable. However, the last 18 months we have worked to organize trade missions or market visits that coincide with trade shows in the various regions. This has taken participants (shippers and processors) away from their homes and families for extended periods, but in the long run has helped us to keep travel costs within reason, while at the same time giving the IPC and our shippers and processors access to their buyers and distributors in faraway markets, as well as lending awareness and importance to the Idaho® potato and the Grown in Idaho brand.

Putting these grant funds to use, the IPC followed up the 2014 WUSATA Trade Mission to Vietnam by participating in the Vietnam Food and Hotel Tradeshow in 2015. This showed consistency within the market and was used to build upon business relationships started in the previous year and introduce shippers to new perspective buyers. We continued in Southeast Asia on a trade mission to the Philippines, Singapore and Malaysia to introduce new shippers to these markets and connect them with possible buyers.

Puerto Rico was our next trade mission where we met with 2 current long-time buyers/distributors of Idaho® potatoes, 2 new buyers and introduced shippers to several prospective retail buyers.
Back in Asia we participated in the Taipei Food show in June following a WUSATA trade mission to Taiwan the previous year. At the show we were able to combine efforts with other Idaho products and sample potatoes with a side of steak in the booth, as well as sponsor a variety of Idaho grown potatoes for a Jr. Chef cooking competition at the Headquarters of the largest Foodservice distribution company in Taiwan.

To support our Idaho® potato processed industry in Hong Kong, we purchased a booth at the Restaurant and Bar Show in September and invited the first and newly installed distributor of Idaho dehy to sample products and find new customers. We also sponsored a fresh shipper to come to the show, meet with buyers and establish new relationships in Hong Kong and Macau.

The culmination of the past two years was an all-region Reverse Trade Mission in which mostly prospective buyers, with whom the IPC and our shippers/processers had been cultivating relationships, were invited to be our guests for a five-day harvest/processing tour in Idaho.

Between trade mission, market visits and trade shows, the IPC representatives had planned, organized and implemented several successful training events and in-store promotional activities for fresh and dehy products within their regions.
The logistics (air, hotel and ground transportation), meeting scheduling and in-country organization (booth set-up, dinners, entertainment, etc.) for all international events in SE Asia, Greater Asia and Latin America were planned and implemented by the regional representative. Their market knowledge and relationships with buyers and distributors in the regions are key to the Idaho® potato success in those markets.

Goals and Outcomes

The continuous face-to-face meetings and the building of trust in relationships between the IPC, our representatives, key buyers/distributors and the Idaho shippers and processors has proven very effective. We were able to achieve all of our goals and more:

- Launched Idaho potatoes in two new markets. Both Taiwan and the Philippines have ordered fresh Idaho® potatoes from this season's (2015) new crop. The IPC was able to support both new markets with in-store promotional materials.

Taiwan Fresh Supermarkets

Cebu, Philippines

- Idaho potatoes are now back in both the Hong Kong and Singapore markets. In fact, we were just informed by the Idaho shipper that his 6th container of the season was on its way to Singapore. And through our representatives work in Hong Kong we were able to not only bring together an Idaho shipper with a larger retail grocery chain, but also find a distributor for fresh table-stock to service the smaller retail outlets as well as the western Foodservice industry through Hong Kong and Macau.
- We added Wellcome grocery stores to dehy distribution as well as Yata and Aeon Supermarkets in Hong Kong.
- While implementing an in-store promotion with the 2nd largest chain in El Salvador, Walmart contacted the IPC representatives in Latin America asking for Idaho® potatoes and our marketing support. Idaho shippers were sent the lead and we now have Walmart in both Guatemala and El Salvador.
- Puerto Rico, Guatemala and El Salvador: in-store product training of 50 produce managers, chef training for 25 regional chefs and promotional events in a combined 75 stores in El Salvador and Guatemala.

El Savador

Guatemala

Puerto Rico

- Malaysia: large in-store promotion with two of the largest retail chains – promoting both fresh table-stock potatoes and dehydrated mashed potatoes. The promotion took place in 100+ stores throughout Malaysia with chef sampling in 8 of the larger stores in Kuala Lumpur

- The overreaching goal for this project was to increase sales for Idaho® potatoes and potato products. The baseline was the 2013 crop and was to span over three years. We have exhausted the funds in this grant after 15 months, but as the table below will show, we are on track to increase sales again for the 2015 crop season. When looking at this graph there are a couple things to be aware of: 1)Mexico is a standout for 2014 as the border opened briefly in May of last year, but closed again after 5 weeks. The forecast for Idaho® potatoes in this crop year is +/- 50 container loads. 2) International shipments are heaviest from January – May of each season.

In sum, and not including Mexico numbers at all, IPC were able to increase the sales of Idaho® potatoes by close to 130%. We hope to build upon this increase by continuing activities in these markets and opening new markets as the international trade agreements allow.

Idaho Export Countries Volumes
Containers per market

Regions/Countries	2013 Crop	2014 Crop	% increase	2015 Crop 1st quarter (Sept-Dec)
Latin America	**81**	**425**		**11**
Mexico (border region)	35	366	945.71%	
Central America				
- El Salvador	10	18	80.00%	
- Guatemala	3	6	100.00%	1
- Panama	7	2	-71.43%	
- Caribbean (incl. Puerto Rico)	24	33	37.50%	10
- Colombia	2		-100.00%	
Middle East	**3**	**14**		**2**
- UAE	3	6	100.00%	2
- Kuwait	0	2		
- Qatar	0			
- Saudi Arabia	0	6		
-other	0			
Southeast Asia	**32**	**25**		**9**
- Malaysia	30	25	-16.67%	1
- Singapore				6
- Vietnam	2			
- Philippines				2
Greater Asia	**0**	**3**		**3**
- Hong Kong	0	3		2
- Taiwan	0	0		1
- Macau	0	0		
Totals	116	467	1075.12%	25
total without Mexico			129.40%	

Beneficiaries

The trade shows, trade missions and promotional activities and training that this grant helped to fund benefited not only the Idaho shippers and processors present at these events, but the many Idaho® potato growers, who fill the ever increasing orders coming from international markets.

Idaho was able to increase its international exports by 125% over the previous year. In value that is an increase of approximately $1,030,000. Through trade missions, market visits and continuous follow-up from regional representatives, our dehydrated processors were able to find new retail distributors in Central America, Taiwan and Hong Kong that increased their total sales in these targeted markets by approximately 80%.

Lessons Learned

Through market visits and trade missions, IPC has definitely learned to look for and ask about appropriate cold storage facilities. Vietnam as an example is still grappling with the idea of a cold chain from port to warehouse and warehouse to store. IPC had to deal with product issues due to inappropriate handling and storage.

IPC has found that although a distributor is very excited about our potatoes, they may run into issues finding enough buyers to enable them to bring in full containers. It has now become a priority for the IPC and our representatives to help the distributor find retail and foodservice customers to keep orders of Idaho® potatoes coming.

A wonderful, but unexpected outcome of the all-region Reverse Trade Mission was not only that the individuals learned about and from other markets, but they concluded that they each had a better understanding of the culture and people from the other regions. And on top of that, several started talking about importing each other's products, ie, bananas from El Salvador for mangoes from the Philippines. It was quite an unexpected and very positive outcome to witness these stirring events.

Contact Person

Traci Hiebert
208 514 4228
Traci.hiebert@potato.idaho.gov

Promoting Specialty Crops through Advertising and Retail Promotions

Subrecipient
Idaho Preferred

Project Summary
Idaho Preferred® is a program managed by the Market Development Division of the Idaho State Department of Agriculture (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.

As a result of successful promotions conducted on behalf of specialty crop growers, the Idaho Preferred® program had attained brand awareness of 50% of consumers statewide, according to research conducted by the University of Idaho in October, 2012. Awareness among young consumers 18-34 was even higher at 60% and 51% of consumers report seeing specialty crops, including fruits and vegetables, wine, and nursery products, in advertising and promotion materials. Additionally, the number of consumers reporting having seen Idaho Preferred® signage at a retail location had more than doubled from 19% in 2008 to 40% in 2012. This level of awareness was due to the combination of an effective advertising campaign and a successful retail promotion strategy funded by previous Specialty crop grants. The 2014 grant built on the success of these previous programs by continuing effective television and retail campaigns promoting Idaho specialty crops.

In 2013, the Idaho State Department of Agriculture conducted a specialty crop industry survey to identify needs and set priorities. The top priority identified by 62% of specialty crop industry respondents 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 in 2012 to 50% statewide and over 60% in the Treasure Valley thru effective advertising, retail and foodservice programs and educational efforts.

In order to be effective in the Idaho television market, Drake Cooper (a Boise based advertising and public relations agency) estimates that a campaign should reach approximately 85% of consumers an average of 14 times in order to reach consumer awareness of 50%. This campaign strategy had proven successful, as research showed that consumer awareness of the ads had increased from 32% in 2007 to 50% in 2012. Television advertising at that level would not be possible with state funds, and only through Specialty Crop Grants could the television campaign continue.

"Local foods" continued to be a hot trend in both retail and foodservice channels throughout the duration of this project. The National Restaurant Association's survey of 1,600 chefs found that locally grown produce was in top five trends from 2014-2016. Environmental sustainability was also a top trend and locally sourced produce fit well within this trend.

Previous retail campaigns had been very successful, with 40% of consumers reporting they had seen the Idaho Preferred® logo identifying local products at retail – double the number who saw it in 2008. Consumer market research conducted on behalf of the ISDA Idaho Preferred® program in 2012 found that 27% of consumers were buying more local products – up from 19% in 2008, and 60% reported

supporting local farmers and economy as their primary reason for doing so. It was critical that the specialty crop industry take advantage of these consumer trends by increasing the availability and awareness of Idaho fruits, vegetables, wines and nursery products at retail through promotions, events and point of sale materials.

To take advantage of consumer demand for local products and specialty crop producer request for increased marketing and promotion (as detailed above) this grant included television advertising and retail promotions which are 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 for two years. These projects helped in "conducting consumer education programs" and "enhancing local food systems" – identified as the second and third highest priorities in the Specialty Crop Industry Survey.

Project Approach

The purpose of this project was to increase consumer awareness and demand for Idaho fruits, vegetables, wine, herbs and nursery products through statewide advertising and retail marketing. Per the plan and budget, activities planned for summer-fall 2015 and 2016 were completed. In addition, additional promotion occurred in 2017 as detailed below.

Per the work plan, three weeks of television advertising ~~that~~ aired September 1-14, 2015 ~~was~~ funded by this grant and achieved average statewide reach of 91.3% and 13.6 frequency. These ads aired again across the state in August 2016 during Summer Olympic programming and regular September schedule. Funds from this grant paid for 3 weeks of a nine-week schedule. Reach and frequency for the combined Summer Olympic and September schedule reach was 88% and frequency was at 12.3. Television and digital advertising resulted in just over 6.56 million impressions in 2016. Ads used included images of summer squash, sweet corn, tomatoes, apples, peaches and melons.

As this grant period approached final deadline, some funds were unused or returned to the Idaho State Department of Agriculture from other subrecipients. These funds were redirected to Idaho Preferred and approximately 3 weeks of television ads were purchased in August 2017.

In addition to television, six weeks of Facebook ads and nine weeks of Google Adwords promoted apples, peaches, watermelon, tomatoes, squash and sweet corn. This online campaign ran in August and September 2015, the height of harvest season in Idaho, and strengthened the fall television campaign detailed above. Three weeks of nursery Facebook and Google Adwords ads were placed in April-May 2016 per the marketing plan. This digital ad schedule resulted in 318,147 impressions and 7,572 clicks to the website. This is a very high click rate at 2.4% with industry standard at less than 1% and cost of only 36 cents per click.

In 2015 the combination of television and on-line advertising resulted in 5.52 million impressions, 32,560 clicks to the Idaho Preferred website where consumers could find specialty crop grower information, product details and recipes. The 2016 schedule resulted in 6.66 million impressions and 21,872 clicks to the website.

Retail promotions included providing produce bins to 55 stores across Idaho including Walmart, Albertsons, Paul's Markets, Broulim's Markets, and several other small grocery stores and stands. In

addition, point of sale materials were produced and distributed to retailers upon request. In-store tastings of apples and peaches were conducted in selected Albertsons stores in September 2015. In 2016, peach demos were conducted in September in all Idaho Walmart and Albertsons stores as well as Broulim's and Swenson's stores.

In 2017, Idaho State Department of Agriculture awarded to Idaho Preferred additional grant funds that were unused and returned by another grant subrecipient. These funds were used to enhance the retail portion of this project by engaging a merchandising company to install, monitor and increase use of grant-funded point of sale materials and bins. The program included weekly visits to 55 stores throughout Idaho from June through September 2017.

In addition to advertising and retail programs, the grant funded personnel who conducted the following projects per the plan:

- Three consumer events will be conducted each year to increase consumer awareness and provide opportunities to sample and/or purchase specialty crop items from growers and processors
    - Consumer events conducted since January 2016 include Foodfort (March 2016 and 2017), Savor Idaho (June 2016 and 2017), Weekly booth at Boise Farmers market (April-October 2016), Savor North Idaho (August 2016 and 2017), and Schweitzer Fall Festival (September 2016)
- The number of schools serving Idaho specialty crop products in their cafeterias will increase by 20% by 2016 and 23% in 2017.
    - The USDA National Farm to School Census reported in 2014 that 80% of Idaho schools were serving local fruits and 72% were serving local vegetables. This Census in 2016 reported 88% of Idaho schools were serving local fruits and 82% were serving local vegetables, an increase of 10% for local fruits and 14% for vegetables. 2017 data is not available.
- At least 10 seasonal blogs and Facebook postings relative to Idaho specialty crops will occur in 2016 and 2017.
    - From January 2016- September 2017, 299 Facebook posts, 201 Instagram posts, 120 Newsletter articles/Recipes, and 44 Blog Posts
- Ten new specialty crop producers will be recruited to take part in demand-building programs.
    - Since January 1, 2016, 21 new specialty crop producers have become marketing partners with Idaho Preferred.
- Two new retailers will begin identifying local specialty crop items in their stores.
    - Since January 1, 2016, 4 new retailers have begun identifying specialty crops in their store
- Five new restaurants will begin identifying local specialty crop items on their menus.
    - Since January 1, 2016, 5 new restaurants have begun identifying specialty crop items on their menus and/or other promotional materials.

Goals and Outcomes

Consumer market research was conducted in September 2014 and October 2016.
The following are baseline and goals per the plan and actual outcomes:

Measurable	Baseline 2012	2014 Goal	2014 Actual	2016 Goal	2016 Actual
Awareness	50%	60%	52%	65%	42%
Buying More Local	27%	40%	30%	45%	18%
Seeing Message at retail	40%	50%	37.2%	60%	31.6%*
Buying more Fruits/veggies	79%	80%	94%	80%	77%

Buying more Nursery items	3.8%	12%	12.1%	15%	19.6%
Buying more ID Wine	5.5%	12%	6.5%	15%	15.5%

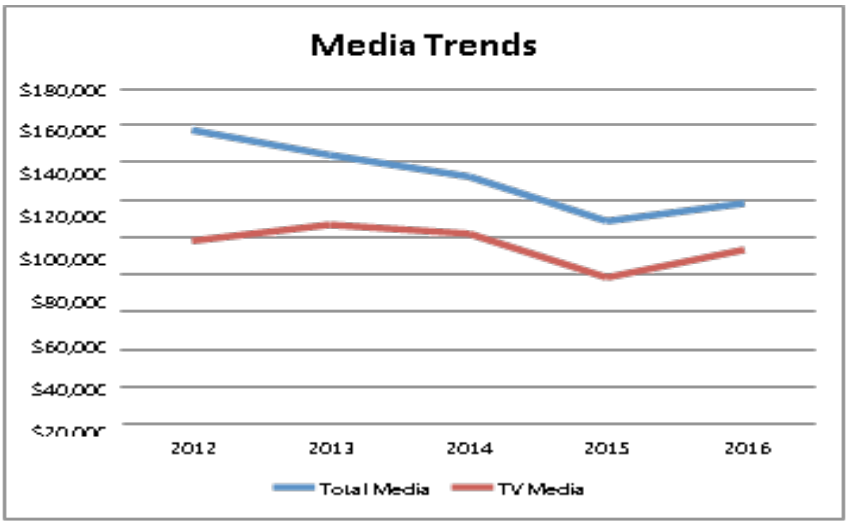
*Question on seeing message at retail separated "grocery store" and "on a food product label." Results for "on a food label" increased from 14% in 2014 to 23.3% in 2016 which may account for some the decrease in 'grocery store" response.

Beneficiaries

According to the 2012 USDA Agricultural Census for Idaho, 3629 farms report growing or producing fruits, vegetables, nursery stock and other specialty crops. Since reporting to the Ag Census is voluntary, there are likely additional specialty crop producers in Idaho that are not represented by the census. All of these farms can potentially benefit from the promotion of specialty crops in Idaho.

Lessons Learned

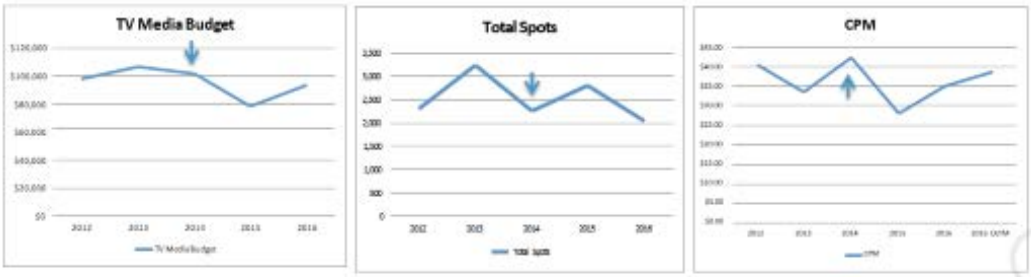
From the Outcome chart above, it is obvious we did not meet our goals of increasing awareness. In reviewing our media spending, we found direct correlation between spending, reach, frequency and awareness as seen on the graphs below. It becomes obvious that to make significant increases in awareness and intent to purchase, additional resources would need to be allocated to advertising and retail promotion programs. Additionally, the local food trend has now been occurring for nearly 10 years. Consumers who choose to increase their consumption of local foods have likely done so, so the number of people who say they are buying more local foods may be leveling or declining as they have already made this move. Also, if this question were to be asked again, there should be a qualifier in the question re: "…are you buying more local foods that you did last year…" or "…X number of years ago…"



Media Budget Declining

MEDIA OVERVIEW

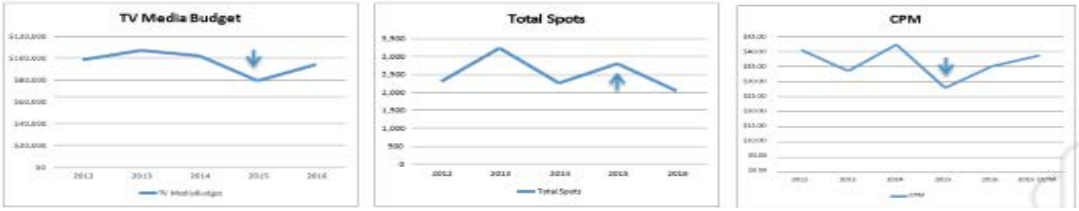
> **2014:** TV budget declined slightly and we had less matching (political year), resulting in a decrease in spots and a higher cost per thousand impression (CPM).



2014

MEDIA OVERVIEW

> **2015:** TV budget declined significantly but we mitigated by switching from :30s to :15s, resulting in an increase in spots and a decrease in CPM.



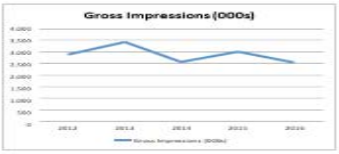
2016

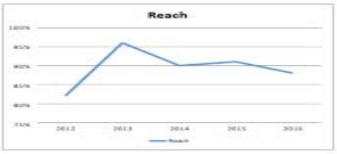
MEDIA OVERVIEW

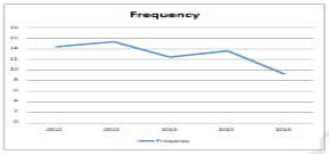
2015 **16:** Budget increased but total spots decreased because of lower matching. We allocated 30% of 2016's budget to Olympics (hardly any matching), plus it was a political year. CPM was higher for 2016 TV overall and 2016 Olympics.

MEDIA OVERVIEW

> This resulted in a decrease in our gross impressions, reach & frequency levels.

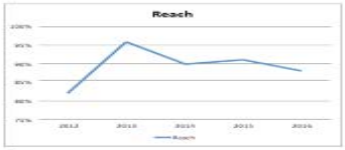


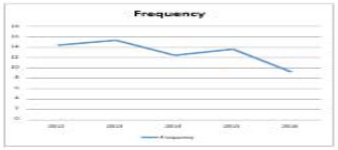


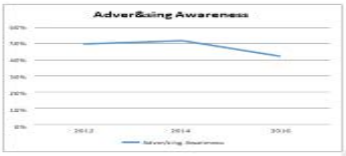


AWARENESS

> And, our awareness level declined to 42%.

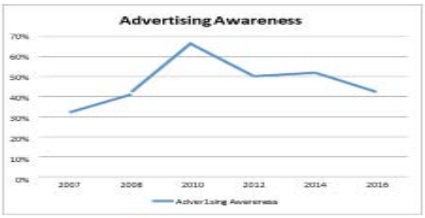






AWARENESS

> Awareness trend since 2007.



Contact Person
Leah M. Clark
Idaho Preferred Program Manager
Idaho State Department of Agriculture
Leah.clark@isda.idaho.gov
208.332.8684

Developing Awareness of Idaho-E. Oregon Onions and Building International Markets in Mexico and Central America through In-store Promotions and Trade Missions

Subrecipient
Idaho-Eastern Oregon Onion Committee

Project Summary
The project "Developing Awareness of Idaho-E. Oregon Onions, and Building International Markets in Mexico and Central America through In-store Promotions and Trade Missions" is a project that was conducted by the Idaho-Eastern Oregon Onion Export Committee (IEOOC). Idaho and Eastern Oregon's crop is 90% yellow onions and it is important to stay in front of the Mexico retailers and consumers and let them know of the versatility, the availability, and the benefits of yellow onions, and this project allowed the Export Committee to offer promotions in the Mexico market. This was intended as a two year project, but the Committee asked for an extension and change in scope to include International Trade Shows as well.

It is important to continue to look for ways to expand export markets. The potential impact of this grant would be that Mexico and Central America retailers, buyers, and consumers would understand the versatility, availability, and attributes of Idaho-E. Oregon Onions, and give them knowledge as to why Idaho-E. Oregon onions would be of benefit in their category management program. A greater understanding of the onion industry would lead to increased business and market share for the area shippers which would be of great benefit to the entire Idaho-E. Oregon Onion industry--shippers and producers.

Trade missions and Trade Shows are an effective way to learn new markets; they provide opportunities to meet new buyer's one on-one. Trade Missions provide in depth information about the country visited giving the shippers and business owners an insight to the demographics of the country and other useful information when making a decision to sell to a certain countries. Participating in Trade Shows also allows the Committee to meet interested and potential buyers which is a great benefit to the Idaho-E. Oregon Onion industry.

Project Approach
The activities for the first six months of the Idaho-Eastern Oregon Onion Committee's grant project, "Developing Awareness of Idaho-E. Oregon Onions and Building International Markets in Mexico and Central America through In-store Promotions and Trade Missions" included the 2014 Yellow Onion Promotion from September through December 2014, the WUSATA Trade Mission to Brazil, November 3 to 11, 2014, and the WUSATA Trade Mission to Columbia, February 22-28, 2015. All three events were well organized and gave the Committee great opportunity to showcase onions from Idaho-E. Oregon, and to build awareness of the onions from the Idaho-E. Oregon growing region. The Committee contracted with Imalinx in Mexico to conduct the Yellow Onion Promotion. The Committee sent representatives on the two trade missions giving the Committee the opportunity to learn first-hand the potential opportunities in Brazil and Columbia.

Continuing with the activities for the project, the activities included participation in Idaho Governor Otter's Trade Mission to Mexico and Peru. The Trade Mission ram from May 9 through May 16, 2015.

This trade mission proved to be effective for the Idaho-E. Oregon Onion Committee. Joe Farmer, Export Chairman, met with many companies and brought back market information and contact names for the companies. In September one buyer that Mr. Farmer met in Mexico purchased onions from our area.

With the change of scope and the extension for the project the Export Committee was able to participate in the ANTAD show in Guadalajara Mexico. The 2016 ANTAD Show was held at Expo Guadalajara, Guadalajara, Mexico, March 16 - 18, 2016. Ann Jacops and Candi Fitch represented the Committee at the show. The Export Committee's booth was located in the WUSATA Pavilion. Marco Albarran, IMALINX, was the contractor for the show and he and his staff helped make the show very successful for the Committee. We were provided with a translator who had worked at ANTAD before, and was inter-active with Ann and Candi and the people who stopped by the booth. She had studied about Idaho-E. Oregon Onions and was well informed when the show opened. Skylar Jett, ISDA, was also at the convention. She helped at the WUSATA booth and also helped at the onion booth if we needed another set of hands.

Also with the change of scope to include Trade Shows, airfare for one Committee member to the 2017 Canadian Produce Marketing Association was included with the projects.

Goals and Outcomes Achieved

The goals of the project were to build awareness and reinforce the benefits of Idaho-E. Oregon Onions with Mexico retailers and consumers through the Yellow Onion Promotion, and to build awareness and make new buyer contacts through trade missions and trade shows in Mexico and Central America.

The goals outlined in this project were achieved. The Yellow onion promotion reported an increase in onion sales in the stores where the demos were held, building continued awareness that the Export Committee was seeking. The Trade Mission and the Trade Shows gave the additional exposure for Idaho-E. Oregon Onions.

Imalinx contacted the most important retailers and wholesalers in Mexico setting up programs in 4 different retailers: Soriana (National), Chedraui (National), Casas Ley (Regional), and AlSuper (regional). The programs included merchandising and sampling activities as well as Cooking Shows in different stores. It is important to mention that because of the large size of the retailers contacted the reach of the program had to be extended to 10 different cities reducing the number of weeks to 4 in each retailer.

A total of 56 stores received promotional support. In total there were 126 demo days, 229 merchandising days and 4 cooking shows with an estimated 12,600 consumers reached, based on a reach of 100 customers per demo per demo day. Additional efforts were done through newsletter publications released for both consumers and industry contacts. These publications were meant to inform the industry about the availability of the yellow onions as well as the seasonality as well as to reach consumers sharing recipes, health information and tips to handle the product. Another great way to let the market segments in Mexico understand Idaho and Eastern Oregon onions.

The IEOOC was also able to participate in three trade missions and one International Trade Show with this grant funding. With these four events, there were numerous opportunities for one-on-one meetings during trade missions as well as the trade show, and over 42 contacts with prospective buyers were made. This was great exposure for the IEOOC. During the 2014-2015 seasons there were 172

loads of onions shipped to Mexico and Central American countries. At an average price of $7 a bag the total dollar amount for those shipments came to $825,600.

As the Idaho-E. Oregon Export Committee works with limited funding the Specialty Crop Grant allowed them to have further International representation and let consumers and buyers know of the quality and availability of Idaho-E. Oregon Onions.

Beneficiaries

The beneficiaries of this project include the 26 Idaho-E. Oregon Onion Shippers and approximately 190 growers in the Idaho and Eastern Oregon onion growing region. It is important to stay competitive in this global economy, and having the grant money gave the Export Committee that opportunity.

Lessons Learned

It is important to constantly look for opportunities to promote Idaho-E. Oregon Onions in other countries to stay competitive. As a whole this project was very worthwhile. The Yellow Onion Promotion provided a great avenue to educate the Mexican consumer and build awareness with them of yellow onions. Sometimes with timing and different regulations it is difficult to ship Idaho-E. Oregon onions into some countries. However, most of the countries visited were very interested in the onions

Contact Person

Candi Fitch, Executive Director
Idaho-E. Oregon Onion Committee
(208) 722-5111
candif@cableone.net

Expanding the Application of the Crop Monitoring and Assessment Platform

Subrecipient
Northwest Nazarene University (NNU)

Project Summary
Through a previous grant received in 2012, we developed a Crop Monitoring and Assessment Platform (C-MAP) and tested it on apples. The Crop Monitoring and Assessment Platform (C-MAP), which is an off-the-shelf small Unmanned Aerial System (sUAS) equipped with a multispectral camera, was successful in demonstrating that the enhanced Normalized Difference Vegetation Index (NDVI) images correlated with the water deficiency in an experimental apple orchard. This grant was designed to expanded on the previous success by testing the application on other specialty crops found in Idaho, specifically peaches and onion. The main goal for the peaches was to use C-MAP to detect blossoms from an aerial perspective, while the goal for the onions was to extend the utility of C-MAP to ground specialty crops. With the introduction of sUAS to agriculture, this project is important and very timely in demonstrating the potential of this tool in conducting precision agriculture for specialty crops. We acquired images from peach orchards and onion fields using C-MAP and we developed special image processing programs to analyze the images. For the peach study, we were able to develop an image processing algorithm to calculate blossom density for each tree. It has been found that blossom density correlates well with the fruiting capacity of the tree. For the onion study, we used the enhanced Normalized Difference Vegetation Index to analyze a commercial onion field and was able to demonstrate its utility for ground crops. These results demonstrated the added capabilities of C-MAP. In the previous project, we were able to demonstrate that C-MAP was able to detect water deficiency in an orchard. The results of this project verified the extended potentials of C-MAP in the detection of blossom for peaches and in the surveillance of ground specialty crops such as onions.

Project Approach
The C-MAP is composed of an unmanned aerial vehicle (UAV) and a multispectral sensor, which is a color and near-infrared camera. For the peach study, an experimental peach orchard in the Parma Research and Extension Center of the University of Idaho and commercial orchards of Symms Fruit Ranch and Williamson Orchard were used as test fields. The experimental orchard has different varieties of peaches and nectarines, while the commercial orchards had different varieties of peaches. For the Symms Fruit Ranch orchards, a field of newly planted trees and a field of mature trees were used. The sUAV was flown over these orchards and multispectral images were acquired during the growing season of 2015 and 2016, which started before appearance of blossom, during blossom, and during the growing period. Image processing algorithms were developed to process, analyze the images, and count the blossoms (Figure 1). For the onion study, commercial onion fields of JC Watson Company were used. Images of the onion fields were acquired using the sUAV during the summers of 2015 and 2016. Different paths for image acquisition were tested to determing the optimal path to acquire images. The multispectral images were analyzed using the enhanced Normalized Difference Vegetation Index (NDVI) as shown in Figure 2 .

Goals and Outcomes Achieved
The following are the goals and outcomes achieved:

1. Goal 1: To acquire multispectral images of fruit orchards starting from pre-blossom, during blossom, before thinning, after thinning, before harvest, and after harvest.

   Outcome 1: We acquired multispectral images of peach orchards during the growing season in both year 1 and year 2. Two sets of images were acquired; color and multispectral.

2. Goal 2: To process/register the acquired images and create a time-based development of fruit orchards from pre-blossom to harvest.

   Outcome 2: We developed a customized computer program to process and mosaic the images. However, we ended up using the DroneDeploy software which combines both image acquisition and post-processing of images.
   In the development of the computer program, we conducted a study to compare different off-the-shelf drones and we used the program in the evaluation. This study was published in the Journal of Imaging (see publication list). The result of this study will help farmers decide which off-the-shelf drone to acquire for crop monitoring.

3. Goal 3: To calculate the VIs including NDVI, NIR/Green, NIR/Blue, canopy cover/structure, bloom density and evaluate the orchard variation.

   Outcome 3: Although we used DroneDeploy to acquire and mosaic the images, we developed a customized image processing program to calculate the vegetation indices and bloom density. Results have shown that bloom density correlates positively with fruit yield. A bloom density map could be a good tool for orchard management. Part of the work was published in the Journal of Imaging (see publication list).

4. Goal 4: To acquire multispectral images of an onion plantation starting from pre-planting, growth development, and before harvesting.

   Outcome 4: We acquired multispectral images of commercial onion fields during the growing season in both year 1 and year 2. Two sets of images were acquired; color and multispectral.

5. Goal 5: To process/register the acquired images and create a time-based development of the onion plantation.

   Outcome 5: Similar to the peach study, we ended up using the DroneDeploy software which combines both image acquisition and post-processing of images.

6. Goal 6: To develop and evaluate an image processing algorithm to correlate the VIs with soil nutrient condition (based on manual soil testing).

   Outcome 6: We developed an image processing program to calculate the enhanced Normalized Difference Vegetation index and produce an NDVI false color image that correlated with the water input.
   We published our study on the comparison of NDVI falsc color image using a commercial multispectral camera and our modified multispectral point-and-shoot camera in the Journal of Unmanned Vehicle System (see publication list).

7. Goal 7: To conduct a workshop that will enhance the knowledge of Precision Agriculture to specialty crop growers and enable them to transfer the technology developed from this research to their own farm.

   Outcome 7: We conducted a workshop to demonstrate the application of C-MAP for specialty crops and how to operate them using the DroneDeploy app in August 9, 2016 in conjunction with the Nitrogen Use Efficiency. During the workshop, we also conducted a survey about the use of UAVs in agriculture. Table 1 shows the result of the survey.

   Table 1 Survey for the Use of UAV in Agriculture

Rate the following from low to high.	Low				High
	1	2	3	4	5
1. Usefulness of UAV for crop scouting	0%	0%	17%	26%	57%
2. Danger of using UAV in the farm	26%	52%	13%	4%	4%
3. Interest in using UAV for crop scouting	0%	4%	0%	35%	61%
4. Rate the importance of cost in acquiring UAV	0%	9%	22%	35%	35%
5. Rate the importance of ease-of-use in using UAV	0%	9%	17%	26%	48%
Total Number of Respondents	23				

   We conducted a demonstration of the application of C-MAP, specifically with the use of Drone Deploy, during the Annual Fruit field Day of the University of Idaho in the fall of 2015 and 2016 in Parma, ID.
   We also demonstrated C-MAP during the Fruit Day events of the University of Idaho in the Parma extension center during 2015 and 2016.
   We also presented in the 2016 Leadership Conference of the Boise Chamber of Commerce with the theme, 'From the Field to the Table – Growing the Food and Beverage Industry in the Boise Valley' in Sun Valley, Idaho.
   The agricultural research of NNU (Idabot, C-MAMP(drones), Fruit Counting App) that is funded by the Idaho State Department of Agriculture was featured in the Science and Innovation section of Voice of America. The feature can be accessed here:

http://www.voanews.com/a/idabot-robot-tackles-mundane-farm-tasks/3571812.html

Beneficiaries

The following are the beneficiaries of the project:

1) Specialty crop farmers (over 100 farmers)

   During our demonstration in the Fruit Field Day in Parma (2015 and 2016), there were over 100 farmers who attended and saw the demonstration. Several farmers have expressed their interest in using drone technology. With the decreasing cost of drone hardware and the availability of easy-to-use apps, crop monitoring using drones could become a common tool for the farmers in the near future. This project provided a demonstration of the potential of drone technology.

2) Environment and economic impact (about 100 farmers)

The main application of C-MAP is crop monitoring and the use of multispectral imaging widens the domain of the things that can be monitored. These would include water input, blossom density, canopy size, and others. By monitoring these parameters, the farmer can use these information to control the input to his field and these include water, herbicides, and other chemicals. This would then _lessen the environmental impact and conserve our natural resources. In addition, by conserving water, the farmer has the potential of reducing the production cost while maintaining high quality fruits.

3) Local community (about 200 high school students/100 college students)

As part of NNU's concurrent engineering program in the local high schools, NNU conducts seminar to local schools (middle school and high school) about the project. About 200 high school students and over 100 college students have attended the seminars conducted about this project. This will provide advanced scientific knowledge to students and help in the STEM (Science, Technology, Engineering, and Mathematics) program of Idaho.

Lessons Learned

1) It is a challenge to fly-over and conduct image acquisition on ground crops such as onions. The UAV should be flown at a lower altitude (< 75 ft), which could pose several problems. One of these problems is battery life; flying at a lower height means higher resolution but lesser field-of-view, which requires more passes and longer battery life. The other problem is safety; flying at lower altitude means there is a higher probability of obstacle.

2) For the onion study, we did two different fields for years 1 and 2, because the field we used for year 1 changed crops (crop rotation practice). It would have been better to use the same field. In addition, the commercial onion field had uniform application of nutrients, and so there was less variability in our images.

Contact Person

Duke M. Bulanon
Physics and Engineering Department
Northwest Nazarene University
Tel no. (208)-467-8047
Email: dbulanon@nnu.edu

Additional Information

1) Peer-reviewed Publication:
    a. Barrows, C. and Bulanon, D.M. Development of a low-cost multispectral camera for aerial crop monitoring. Journal of Unmanned Vehicle Systems, Published on the web 28 August 2017, https://doi.org/10.1139/juvs-2017-0008

    b. Cano, E.; Horton, R.; Liljegren, C.; Bulanon, D.M. Comparison of Small Unmanned Aerial Vehicles Performance Using Image Processing. J. Imaging 2017, 3, 4.

    c. Horton, R.; Cano, E.; Bulanon, D.; Fallahi, E. Peach Flower Monitoring Using Aerial Multispectral Imaging. J. Imaging 2017, 3, 2.

d. Bulanon, D.M.; Lonai, J.; Skovgard, H.; Fallahi, E. Evaluation of Different Irrigation Methods for an Apple Orchard Using an Aerial Imaging System. ISPRS Int. J. Geo-Inf. 2016, 5, 79.

2) Conference Papers and Presentations

a. Bulanon, D.M. and Fallahi, E. A Smart Vision System for Monitoring Specialty Crops. Future Technologies Conference (FTC) 2017, 29-30 November 2017, Vancouver, Canada

b. Bulanon, D.M., Cano, E., Horton, R., Fallahi, E. Peach Flower Monitoring Using Aerial Multispectral Imaging. ASABE Paper No. 162461520 St.Joseph, MI: ASABE

c. Bulanon, D.M. Using Drones and Other Technology for Agriculture. Presented at the 2016 Leadership Conference, From the Field to the Table – Growing the Food and Beverage Industry in the Boise Valley, on April 24-26, 2016 in Sun Valley, ID

d. Bulanon, D.M., Cano, E. Comparison of Off-the-Shelf UAVs for Agricultural Application. 24th Annual Murdock College Science Research Conference, November 5, 2015, Vancouver, WA

e. Lonai, J., Bulanon, D.M., Skovgard, H., Cano, E., Liljegren, C., Fallahi, E. (2015) Automatic Detection of Individual Trees in an Apple Orchard Using Modified Watershed Algorithm. UAS Mapping 2015 Reno. ASPRS UAS Technical Demonstration and Symposium, September 29-30, 2015, Reno, NV

f. Liljegren, C., Cano, E., Skovgard, H., Fallahi, E., Bulanon, D M.(2015) Flight Pattern Generation for Automated Aerial Imaging of Crops. Idaho Conference on Undergraduate Research (ICUR), July 29-30, Boise State University

g. Lonai, J., Skovgard, H., Cano, E., Bulanon, D.M. 2015. Image processing and analysis of an apple orchard's aerial images. Presented at the 57th Annual Meeting and Symposium of the Idaho Academy of Sciences and Engineering, March 19, 2015, Boise, ID

h. Skovgard, H., Lonai, J. Cano, E., Bulanon D.M. 2015. Analyzing crop efficiency through UAV imaging. Presented at the 57th Annual Meeting and Symposium of the Idaho Academy of Sciences and Engineering, March 19, 2015, Boise, ID

Identification and exploitation of resistance to Zebra chip disease in potato

Subrecipient
University of Idaho (U of I)

Project Summary
This project proposes to identify and explore resistance to Zebra chip disease (ZC) in potato. Using a combination of molecular biology, biochemistry and molecular genetics, we seek to identify and characterize defense response pathway(s) in potato to Candidatus Liberibacter solanacearum (Lso), the causal agent of Zebra chip potato disease, and explore new approaches to generate resistant potato lines. In particular, potato plants will be explored to identify putative resistance genes that recognize Lso virulence effectors and activate resistance pathways to Lso bacterium. Once specific Lso effectors and related potato resistance genes are identified, strategies will be explored to develop resistant potato lines by manipulation of these putative resistance genes in potato. Ultimately, the development of resistance to ZC in potato will contribute to sustainable potato production in Idaho. This proposal takes the first step towards resistant lines by identifying activated defense pathways. This will lead to strategies to produce potato lines resistant to Lso.

No research has reported on the elucidation of defense response to Lso infection or identification of activated potato resistance-related genes. It is important to keep in mind that a defense response can be triggered in a host plant that does not necessarily result in resistance. In fact, it is generally believed that during co-evolution between Lso bacteria and host potato plants, Lso may have evolved mechanisms to inhibit the potato defense responses, which originally evolved in plants as an innate immune defense system. Thus, it is important and necessary to explore potato in an effort to identify activation of relevant defense pathways triggered by Lso, especially putative resistance genes related to bacterial proteins (virulence effectors) that trigger a defense reaction. To this end, we will first clone Lso virulence genes that might trigger a defense response in potato and/or Nicotiana benthamiana. N. benthamiana, a close relative of potato, has been widely used by researchers for studying defense pathways. Virulence effectors triggering a defense response (hypersensitive response or callose deposition) will be used to identify potato genes that recognize these effectors for defense signaling, which will be accomplished through the molecular technique called yeast two-hybrid screening using the virulence effectors as bait. Eventually, these putative potato resistance genes will be used to develop strategies that may result in resistant potato plants.

Idaho potato growers utilize many different potato cultivars for a wide range of end products, from French fries to fresh market potatoes. The focus of this work is on Idaho russet potatoes. Numerous different russet cultivars are produced in Idaho, including GemStar and Alturas, both of which are susceptible to Lso. However, as stated above, the defense response pathway exists in these cultivars but is inhibited by Lso bacterium. If the defense signaling is elucidated and putative resistance genes are consequently identified, it opens up the possibility to manipulation of these putative resistance genes to confer Zebra chip resistance in potatoes.

Project Approach

Initial strategy was to identify potato defense gene by Y2H screening using Lso effectors triggering HR cell death on plants. Research has demonstrated inability of Lso effectors NAC1 contribute such activity after tested more than forty cloned effectors, which is a new discovery for Lso effectors. In the meantime, U of I found four Lso effectors that interfere with defense signaling in plants, suggesting these Lso effectors may target resistance proteins for their virulence function. Based on these findings, U of I generated Y2H bait construct of one particular effector Lso1894. We further carried out the Y2H screening using Lso1894 as bait against a newly generated potato cDNA leaf library. The screening resulted in identification of two defense-related genes from potato, which have been further cloned and characterized in planta.

Drs. Kuhl and Xiao have equally contributed to the above activities.

Goals and Outcomes Achieved

Timeline: September - December 2014; Clone and characterize virulence genes from the Lso bacterium
Activity: Current literature was searched for putative effector genes in closely related Candidatus Liberibacter species, specifically Candidatus Liberibacter asiaticus and Candidatus Liberibacter americanus, 37 and 3 genes were identified respectively. Primers were designed on these genes with the goal of amplifying full-length genes (ATG to stop codon) from Lso. DNA was extracted from aphis infected with Lso and was used as template for Polymerase chain reaction (PCR), which resulted in most genes (37 out of 40) being amplified and were cloned in pENTR Gateway cloning vector. All cloned genes were sequenced and compared to online sequence data.

Timeline: January - August 2015; Identify bacterial virulence effectors that trigger defense responses.
Activity: Isolated Lso effector genes have been transferred to a pEarleyGate vector and confirmed with restriction enzyme analysis. Significantly progress has been made to optimize a transient expression on N. leaves and all 37 effector genes have been transiently expressed in leaves. Among these 37 effectors, one was found to trigger defense response in host plant as manifested by its ability to cause weak cell death on N. benthamiana leaves.

Timeline: September 2015 - March 2016; Identify potato proteins that interact with these virulence effectors using yeast two-hybrid (Y2H) screening.
Activity: Further characterization identified another four Lso effectors that interfere with defense signaling in plants, suggesting these Lso effectors may target resistance proteins for their virulence function. One particular effector, termed Lso1894, has been cloned into the yeast expression vector pEG202. In the meantime, a potato cDNA library has been generated into the yeast express vector pJG4-5; and this library was used to identify potato proteins interacting with Lso1894.

Timeline: April - August 2016; Clone and characterize putative potato resistance genes encoding proteins that interact with and recognize these Lso virulence effectors. We have conducted Y2H screening using Lso1894 as bait against the potato cDNA library. Two putative defense-related genes were identified. These genes are BEL30 and Serine carboxypeptidase, both of which have been further cloned and characterized in plant cells.

Drs. Xiao and Kuhl have equally contributed to the above activities, no other partners have contributed.

Due to personal reason, U of I was not able to attend the American Phytopathology Meeting. Instead, we attended the annual INBRE (IDeA Networks of Biomedical Research Excellence) conference and presented research results.

One manuscript describing research results of this project is in preparation for publication on a peer-reviewed journal.

With results obtained from this research, we have developed a research project focusing on effector biology and were recently funded by USDA-NIFA. In addition, we submitted another proposal to Northwest Potato Research Consortium. Unfortunately this proposal was not funded.

Beneficiaries

Potatoes are the most valuable crop in Idaho ($3.5 billion in sales) and Idaho is ranked first in the United States for potato production. Unfortunately, Zebra chip disease is a present threat to Idaho potato growers and is a source of expense to control. Currently control of Zebra chip mainly relies on use of insecticide to control the psyllid vector, which is costly and potentially harmful to human health as well as the environment. Identification of defense pathways in potato and manipulation of resistance genes provide additional management strategies to protect potato crops from Zebra chip and eventually will contribute to sustainable potato production in the state of Idaho. Thousands of growers and stakeholders will benefit from these efforts. Beneficiaries of this project will be all growers, as well as the Idaho potato industry as a whole.

Lessons Learned

Project funding became available on November 6, 2014, approximately 9 weeks after the expected start date of September 1, 2014. This caused a bit of a delay for research progress.

Contact Person

Fangming Xiao
208-885-0120
fxioa@uidaho.edu

Studying Adaptation, Introduction, and Quality of Alternative Fruits to Enhance Profitability of Small Businesses and Public Health in Idaho

Subrecipient
University of Idaho (U of I)

Project Summary
During the past 25 years, the University of Idaho Pomology Program has experimented with several new fruit crops and as a result, a new alternative fruit industry, such as table grape, is emerging in Idaho. However, there are additional alternative fruit that need to be studied in Idaho. Alternative fruit have become extremely popular, mainly because of the health benefits that exist in these fruits. Our main objectives in this study were:

1) study performance and adaptation of several new fruit and nut species and cultivars in Idaho;
2) Improve fruit quality and yield by studying fruit thinning, maturity date, and cold tolerance of different cultivars of quince, persimmons, and Asian pears in an existing mature orchard;
3) Promote commercialization of successful alternative fruits such as Jujubi, Fuyu and Matsumo persimmons, Asian pears, quince, and haskaps;
4) develop an educational program to teach the public about the use and consumption of these alternative fruits.

We gained significant information to what we knew about alternative fruits before. To achieve our first objective, we studied performance of white apricots, new yellow and purple plums, pomegranates, blue berries, strawberries, black berries, Saskatoon berry, gooseberries, pecans, and hickory nuts. White apricot called 'Shekarpareh' was found to have higher cold tolerant and had superior quality with lower acids than traditional apricots. 'Apache' black berry had the best performance, with largest berries. 'Hatfield' walnut was very cold tolerant and had high yield. Our soil pH is high and we needed major acidification for a successful production of blue berries. Newly introduced pear cultivars, including 'Domkaj Damavand' had large size and pleasant flavor.

To pursue our second objective, we studied quality attributes, maturity dates, and cold tolerance of persimmons, Asian pears, and quinces that we had already planted and were bearing fruit. Rich quince, Smyrna Quince, and Isfahan Quince showed excellent performance with high yield and excellent fruit quality. 'Kikusol' and '21st Century' Asian pears showed great quality and good yield. Thinning fruit at a 15-cm spacing significantly improved fruit quality in Asian pears. In 2015 and 2016, 'Fuyu' and 'Matsomoto' persimmons had high yield and excellent quality but these cultivars were not tolerant to the -21 F temperatures that accrued in early winter of 2017.

For our third and fourth original objectives, we establish "pilot plantings" of alternative fruits that have shown promising results in our earlier study with growers and home gardeners. The pilot plans included Asian pears, quinces, and unique plums, and strawberries in Eagle, Idaho and quince and persimmons in Sunny Slope and Payette, Idaho. We also had a total of 7 classes, 6 educational tours, three TV interviews and three newspaper articles during this study.

Project Approach

Methodology, Data Collection and General Orchard Cultural Practices:

The experimental orchards (both existing and new alternative fruits) were located at the University of Idaho Parma Research and Extension Center, Parma Idaho. 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. Trees and shrubs were irrigated through a drip system twice a week at 100% of daily ETc. from mid-May through mid-October of every year.

Collection of new materials. Materials were gathered from unique but reliable (clean) nurseries in the USA by the project leader. Plants were planted at different spacing in spring of 2015 and 2016 by part-time workers, research technicians, students, and farm assistant. Data were gathered in 2015 and 2016 on the early-maturing materials. Tree or vine growth and performance were monitored every year. Fruits were harvested and evaluated for quality attributes every year. The new fruit species included, but not limited to: pecans, blueberries, gooseberries, currants, goji berries, Saskatoon berries, cold-tolerant pomegranates, unique apples and pears, new quinces, persimmon, filberts, and exotic plums.

Research on existing alternative fruit: Data was taken between 3/1/2015 and 4/30/2017. Several alternative fruits, including persimmons, quince, Asian pears, jujube and haskap were planted in 2005 and these plants were fully mature during the period of data collection. We collected data on tree and shrub performance, yield and fruit quality attributes, bloom and harvest dates, and cold and disease tolerance on these plants during the period of this project. Asian pears were hand-thinned and studied for yield, fruit size and quality. Quince cultivars were compared for their yield and quality over two seasons.

Goals and Outcomes Achieved

Goals and propose: Suitable land and water for fruit production is decreasing as world population is increasing, and this trend mandates a more efficient use of orchard lands and growing unique fruit with a greater margin for profitability.

In September and October of every year, we harvested Asian pear and quince fruits from different cultivars and analyzed for quality attributes, including soluble solids concentration (SSC), color, internal quality, firmness, and bitter pit at harvest time. Fruits were then stored at 32 ^{0}F and analyzed again for the same quality attributes as well as percentage of spoilage after storage in late February every year.

'Niitaka' Asian pear had the largest and firmest fruit with the lowest soluble solids concentration (SSC) among all tested Asian pears (Table 1). 'Semi Dwarf Shinko' Asian pear had larger fruit than 'Kikusui' and '20th Century' but smaller than 'Niitaka'. However, 'Kikusui' and '20th Century' had excellent fruit flavor and quality. Thus, 'Kikusui', '20th Century' and 'Niitaka' Asian pears can be chosen for planting under condition of this study.

Fruits in Asian pears were thinned at two levels: 1) no thinning 2) thinned to only one fruit per spur at 4 to 6 inches apart. Fruit from the Asian pear thinning study were harvested and evaluated for size, yield, color, firmness and sugar at harvest in October each year. Results showed that thinning fruit down to one fruit per spur significantly increased fruit size, color, sugar, and marketability in all cultivars of Asian pears. Thinning at 4 to 6 inches apart, as was the case in 2016, showed larger fruit size than thinning at

2 or more fruit per spurs like we did in 2015. Hand thinning slightly promoted retuned bloom of 2017 season.

'Aromantnaya' and 'Rich' quinces matured earlier and had lower fruit firmness than other cultivars (Table 2). These cultivars can be planted for early market. Based on this study, 'Van Deman' can be chosen for fresh consumption if sweet cultivars are in demand by the market. However, 'Rich' and 'Smyrna' quinces can be chosen if fruit with large size and bright yellow color is preferred. Fruit of Aromntyana had short shelf life and could not be kept in the storage for a long time.

'Isfahan' and 'Gourtan' quinces were harvested for the first time and analyzed for quality attributes at harvest and after storage. Fruit of these cultivars were crisp and had sweet taste and could be consumed as fresh fruit. 'Gourtan' was slightly juicier than 'Isfahan' quince. This suggests that 'Isfahan' cultivar may need more irrigation than other cultivars.

'Damavand Domkaj' and 'Karaj Domkaj' pears had excellent crop. Fruit size of 'Damavand Domkaj' was larger and fruits matured later than those in 'Karaj Domkaj'.

Goji berries and Saskatoon berries, and gooseberries bushes had excellent growth and were harvested in late June 2016 and 2017. 'Apache' black berry had the best performance, with largest berries. 'Black Magic' black berries were smaller and more roundish than 'Apache' but had excellent flavor and high yield. We strongly recommend 'Apache and 'Black Magic' for planting in southern Idaho. 'Arapaho' black berries did not produce sufficient fruit. 'Hatfield' walnut was very cold tolerant and had high yield.

We extensively tested four cultivars of strawberries ('Laramie', 'Jewel', 'Earliglo', and 'Ozark Beauty') for two years. 'Earliglo' was not acceptable and is not recommended for planting in southwest Idaho as this cultivar had very low production and small fruit. 'Laramie' matured relatively early with sufficient crop and good flavor. However, fruit of 'Laramie' did not have acceptable storage life. 'Jewel' and 'Ozark Beauty' had berries with great flavor and good storage life and both can be recommended for Idaho. 'Ozark' had two heavy crops in 2016 and a light crop in 2017. Light crop in 2017 could be because spring season was very short and summer was extremely hot.

We provided several shrubs and trees to our cooperators. Those materials were planted in Sunny Slope, Parma and Payette, Idaho by our cooperators. We monitored their progress and their results are similar to ours.

Measurable Outcomes:

We clearly achieved our original objectives, as observed in the outcomes related to fruit yield/cost and other projected outcomes in this project and these achievements are assessed as follows. We have observed a significant movement towards production of alternative fruits in Idaho, Utah, Colorado, and Washington as a direct result of our project. Idaho growers are finding a niche market in which they can make a higher income than their traditional crops. We monitored the number of specialty crop producers who participate in our workshops and tours, and interviewed them in person or by e-mails and follow to see how many of them are using these alternative crops. We concluded that at least 110 small businesses, home gardeners, commercial growers, families, and numerous workers in various sectors of fruit production and packinghouses are affected by this project in different ways:

1. We believe that the production of alternative fruit production in Idaho has increased at least by two folds because of this project. In general, many of alternative fruits or their bi-products are

appearing in farmer's markets in different cities in Idaho. Examples for the increase in alternative fruit because of our project is as follows:

i. These is a 4-acre planting of haskap in Emmett, using our varieties.
ii. A comprehensive production of blue berry in 20 acres was started in 2016 in Wilder, Idaho.
iii. A 4-acre orchard of quince was established in Sunny slope, Idaho.
iv. Several small-scale businesses have been starting to propagate white-flesh apricots, Asian pears, and unique plums that we started in our alternative fruit research project.
v. Small-scale straw berry production, using 'Laramie' and 'Ozark Beauty' (introduced from this project) have started by many home gardeners in Idaho.

2. Recipes are developed and/or improved for making jellies and jams from the berries that we have experimented in Idaho. These include strawberry and haskap jams from our tested cultivars at the University of Idaho. Asian pears, and quinces are being established in Idaho and some are producing fruit now.
3. There is much less market competition and thus, more demand and potential profit for alternative fruit than traditional fruit. For example, some growers in Riggins area have started producing raisins from some selected cultivars of grapes. These raisins with different flavors (cinnamon, sugar powder, etc.) have entered in the market now.
4. Based on our findings, large quinces ('Smyrna' and 'Rich') and Asian pears are produced in Idaho and sold at over $1/piece.
5. We expect to significantly increase the consumption of healthy alternative fruit and nuts through tours, media interviews and programs, and educational and demonstration classes that we have offered during the period of this project.

5. We offered at least 4 educational classes, 5 tours, and 3 practical workshops to the citizens of Idaho each year. In each class, we taught basics physiology on the growth and climate requirements, limitations and potential that exist for production of each alternative crop. Each of the five tours was offered at the critical growth cycle of these alterative fruits. For example, one was offered at training and pruning time and another one at bloom time, thinning and harvest tine etc. In each of the three practical workshops, we showed the flowing and fruiting habits, diseases and deficiencies, training and pruning, and harvesting to participants. We asked each participant to prune or thin these alternative fruits by himself/herself to have a personal experience and develop self-confidence to work with alternative fruits.

Work with cooperators:

We worked with our cooperators, including some commercial and home gardeners. They have used some of the promising alternative fruit in their operations with great results. These cooperators have been following the progress in every step of our experiment and we have closely cooperated with their pilot studies. We expect a larger scale of application of these materials within the next few years.

Lessons Learned

Results of this project have been extremely informative. Based on our results:

1. Some quinces, Asian pears, unique plums, and various berries, particularly blackberries can successfully be grown in Idaho and they can have a great chance for success at a commercial scale. Among the tested black berries, 'Apache' had outstanding performance.
2. Thinning Asian pear is extremely beneficial and can increase fruit size and marketability.
3. Haskap berries can survive and produce successfully under the high pH soil and cold desert conditions of southwest Idaho.

4. Certain strawberries, including 'Laramie', 'Ozark Beauty' and 'Jewels' can be grown in southern Idaho for fresh consumption, jams and jellies.

Beneficiaries

Based on monitoring the number of specialty crop producers who participate in our workshops and tours, and interviewed them in person or by e-mails concluded that at least 110 small businesses, home gardeners, commercial growers, families, and numerous workers in various sectors of fruit production and packinghouses are affected by this project in different ways. We also estimate that total of 450 people were educated in classes and tours about benefits and possibilities of growing alternative fruits during the course of this project.

Contact Person

Dr. Esmaeil "Essie" Fallahi
Professor and Director of Pomology Program
University of Idaho, Parma Research and Extension Center
29603 U of I lane, Parma, Idaho 83660
Tel: 208-722-6701 Ext 225 OR 208-880-8088
efallahi@uidaho.edu

Enhancing domestic trade of dry peas, lentils and chickpeas by educating the food/foodservices industry about the benefits of utilizing pulses as ingredients

Subrecipient
USA Dry Pea & Lentil Council (USADPLC)

Project Summary
The objective of this proposal is to increase the use of the regions peas, lentils and chickpeas in the United States as an ingredient in food products and food-service menus. The USADPLC is requesting funds to host an educational, informative and hands-on product development course that will target and educate a specific audience in the food industry including product development specialists, nutritionists, and food marketing professionals.

The Pulse industry has been very successful in marketing pulse crops throughout the world and now there is a need to expand value added markets domestically for whole dry peas, lentils and chickpeas and processed products. With the International Year of the Pulse (IYP) declared by the U.N. in 2016, it was incredibly important to increase awareness and consumption in the U.S. before the declaration so that consumers were aware of pulses and their benefits. Timeliness with this grant was critical in maximizing our overall efforts.

Project Approach
The USADPLC will design a two-day course introducing new applications for pulses along with technical demonstrations at the Culinary Institute of America in Hyde Park, New York and follow up activities to increase buyer interest in the region's pulse industry. In addition, the course will provide information on utilizing dry peas, lentils and chickpeas and their respective flours and isolates as ingredients to enhance the nutritional value of foods. Key technical information such as product formulations, process flows, research findings, and marketing considerations for new and traditional high value foods that utilize pulses as raw materials will be presented.

The CIA Course was hosted September 11th- 13th, 2015, with experts on:

- Pulse fractions and functionalities
- Applications in baked goods, beverages, extruded snacks, and pastas
- Sensory properties of pulse fractions
- Nutritional properties of pulses and pulse fractions
- Marketing trends for pulse ingredients in value-added food applications.

The course was split into three segments; Day one included a welcome, session overview, basic pulse nutrition and trends in foodservice. Day two focused on technical applications and hands on kitchen sessions. Day three focused on US protein regulations, pulse texturization and extrusion. Throughout the three-day course there were chef demonstrations strategically placed each day to help break up the day and to showcase the versatilities of pulses.

Sixty-one applications were received for the course and 32 companies were accepted to attend and participate in the hands on training during the event. There were 50 total people in attendance including companies, speakers, staff and pulse industry representatives.

Remaining funds were directed at an additional workshop conducted at Washington State University focusing on the extrusion process with pulses. Extrusion is a very common processing technology used in the food industry to produce direct expanded snack foods, cereals, and pet foods, among other products. This introductory course provided information about the extrusion processing systems, extruder parts, basic heat and mass transfer, extruder screws and dies, food ingredient functionality (with a focus on pulse ingredients) and food product development with extrusion. The course provided practical examples of product development with extrusion using pulse ingredients.

This specific project builds off of the momentum created with our ISCBG from 2013. With that grant, we increased the usage of dry peas, lentils and chickpeas as ingredients in a variety of value-added food products through online education of food industry members. Thus, we increased awareness of pulses and their many benefits domestically. Once people understood the versatility of pulses it was much easier to help increase the demand with our 2014 grant efforts.

Goals and Outcomes Achieved

Overall the CIA course was a huge success and the USADPLC achieved the goals and objectives that were determined for the project. Food processing and foodservice companies are very excited about the new opportunities that exist when using pulses and pulse ingredients in their product lines. The main goal of the project was to educate companies about the benefits of using pulse ingredients in new products, current value-added project lines, as an ingredient offering, or a new foodservice menu and this was accomplished during the event. The survey that was done after the course shows that a hands-on course is an extremely effective way to introduce and educate people about the functionality of pulse ingredients. This course will help companies accelerate the R&D process, which will lead to new pulse product lines in the food industry. Goals and outcomes are listed below that will help analyze the success of the project.

Goal	Benchmark / Target	Performance Measures	Progress in meeting goals
Increased Awareness	A 50% in awareness among participants of how to use DPLC in value-added products	Participants will complete a survey before and after the course to assess their knowledge of using DPLC in value-added products	Survey results Pre test- 8 % reported being extremely knowledgeable about pulse ingredients with 16% reporting so after the course.
Industry Promotion	Increase the number of new domestic value-added processor members to Commission	Signed new value-added membership contracts	58% of participants reported interest in becoming a USADPLC member.
Increased value-added products using DPLC ingredients	At least 50% of participants working on a pulse ingredient project post course	To be determined through a follow up survey	52% of participants reported they are likely to incorporate pulse ingredients into new products. Survey Question 3
Increased	A 50% increase in	A list of all request will be	Future assessment of

request for DPLC ingredient suppliers list	requests for DPLC flour, flakes, starches, fibers, etc.	complied along with the company represented	product requests
Increased interaction between industry members and pulse ingredient experts	Open dialogue between food industry members and pulse experts.	Overall course interaction between experts and food industry professionals (TBD with tape recording review)	See "lessons learned" notes

Dr. Girish Ganjyal and his students conducted the extrusion short course focusing on pulse ingredients November 30- December 1, 2016. Factsheets on the short course were developed by Dr. Ganjyal for industry outreach and education.

Beneficiaries

In addition to the attendees of the course who experienced hands-on training in use of pulse ingredients in gluten-free baking applications, materials and prototypes for this workshop were incorporated outreach on the website www.cookingwithpulses.org.

The primary beneficiaries of this project were the region's 1,100 Pacific Northwest (PNW) pulse farmers. PNW growers harvested 374,000 acres of dry peas, lentils, and chickpeas in 2013 according to USDA-NASS. The 1,100 growers ship product to 20-22 processors that include over 5,000 jobs in WA/ID. Production of dry peas, lentils, and chickpeas has more than doubled in the past 5 years and there is tremendous opportunity for market growth both internationally and domestically.

Improving nutrition in a variety of food channels reduces costs to Idaho State and the US. Developing additional markets improve demand, leading to more regional jobs and overall prosperity. For example, hummus in the U.S. has grown from $100 million in 2003 to an estimated $700-$800 million market in 2013, and that is only penetrating 15-20% of U.S. households. In the same decade, Idaho State production has grown from 15,000 acres to over 80,000 acres with gross revenue of $600/acre. The increase in acres has brought over $39 million annually to Washington growers. Pulses serve as an excellent rotational crop due to their ability to fix nitrogen in the soil and help breakdown grain disease cycles by increasing the yield of wheat and other major cereals. Pulse acres have also expanded into Colorado, Nebraska, and Kansas as producers realize the rotational benefits and value of including these crops in their farming operations.

Lessons Learned

With limited information available in the pre-competitive space on use of pulse flours and pulse ingredients in gluten-free and extrusion applications there is an on-going interest in these topics both in R&D for bakery and snack applications.

Contact Person

Jessie Hunter, Director of Domestic Marketing
USA Dry Pea and Lentil Council
2780 West Pullman Road
Moscow, ID 83843
208-882-3023
Jhunter@usapulses.org

Deciphering the effects of grapevine virus on Idaho grape/wine quality

Subrecipient

USDA, Agricultural Research Service (USDA-ARS) and University of Idaho (UI)

Project Summary

Grapevine virus management has been a top research priority for the major winegrape growing regions of the US (CA, OR, WA, and NY). There are few mechanisms to address negative virus consequences beyond removal of infected vines, replant, and more attempting rigorous control of insect vectors. Some grapevine viruses are thought to reduce sugar, color, and yield. These are all important grape quality parameters that are directly linked to vine health, crop value, and wine quality. The first steps in controlling these viral diseases are their identification in Idaho vineyards and determining if they negatively affect quality. The results from this work will be the first to report on Idaho grapevine virus status and quality. This work was conducted in collaboration with Idaho winegrape growers, and we particularly acknowledge their aid in allowing us to sample from their vineyards. 'Merlot', 'Cabernet Sauvignon', 'Tempranillo', 'Syrah', and 'Cabernet franc' leaves and clusters were sampled for growing seasons 2014, 2015, and 2016 (n > 300). Virus testing was completed on the leaves collected from growing seasons 2014 and 2015 by UI graduate student B. Thompson. Though these samples, in addition to the 2016 collected samples, are currently undergoing secondary testing with recently developed primers by newly joined graduate student (G. Orellana). From this work, we confirmed that Grapevine leafroll associated viruses (GLRaV)-1 and -3, Grapevine viruses A and B, Grapevine fleck virus infections, and Grapevine red leaf blotch (GRBaV) are present in Idaho vineyards. It is too early to tell exactly how fruit qualities from this region's virus positive vines will differ when compared to those of healthy vines. One commercial vineyard was found 100% positive for GLRaV, which likely explains this vineyard's grape ripening and yield problems. Both of those production issues are known possible consequences of GLRaV-3 infections. Samples (leaf blades and grape clusters) continue to be stored frozen until all tests are complete and verified. Identified vines, positive-infected versus healthy, make up the vine-pairs will be used for the chemical component analyses. This remains an ongoing project. Research steps have also been begun that will examine the effects of GRBaV upon a variety of grape cultivars.

Project Approach

During growing seasons 2014, 2015, and 2016, leaf and cluster samples were collected from the collaborating commercial vineyards. UI graduate students (B. Thompson and G. Orellana) have conducted total nucleic acids extraction from leaf petioles along with RT-PCR (Reverse Transcription-Polymerase Chain Reaction) tests using virus specific primers from the leafroll complex, and direct PCR for the GRBaV (Grapevine red-blotch associated virus). To ensure data quality, we have re-examined the vine virus status results of the initial results and have a clear picture of the infectious status of the vines. Chemical component analyses on all grape cluster quality constituents based on the vine virus status is currently on-going.

Goals and Outcomes Achieved

Grapevine leafroll-associated virus (GLRaV)-3 was identified in 41 samples, while Grapevine red-blotch associated virus (GRBaV) was found in only 3 samples of 'Syrah' from a single vineyard. . A new strain of GLRaV-3 was discovered which may evade the regular laboratory testing tools, and new detection methods were developed.

Dr. Karasev's research group cloned and sequenced the GRBaV genome from a positive sample collected at Skyline Vineyard in September 2014. Based on the restriction map generated, graduate student (B. Thomson) created a series of more than 1.0-genome GRBaV constructs in a pCambia-1300 binary vector for infectivity testing in a model plant, Nicotiana benthamiana. All constructs were transformed into Agrobacterium tumefaciens and agro-infiltrated into N. benthamiana. We are working to create an infectious clone of GRBaV, which will be used to produce virus-specific antibodies, and study effects of the virus on various cultivars of grapevine.

UI graduate student- B. Thompson is currently re-working through data analysis and interpretation of his findings, in preparation of Masters' thesis (student able to resume after leave of absence). We anticipate he will graduate in Winter 2018. After thesis completion, the experimental chapter will be re-formatted for submission to a peer-reviewed journal publication. Submission, review, revision, and final paper acceptance for peer-review journals may take up to 1.5 years (journal dependent). Interpretive summary and technical abstract of the manuscript will appear on Dr. Lee's webpage after the paper is accepted.

The progress of the research and outcomes of the project were presented to the stakeholders at the annual Idaho Grape Growers and Wine Producers meetings (Feb 2015 and Feb 2016) and multiple informal meetings with growers.

Lee, J., and **Karasev, A.V.** "Impact of grapevine viruses on grape quality", Idaho Gape Growers and Wine Producers Annual Meeting, Garden City, ID, February 2016. [invited] (~60 attendees)

Thompson, B.D., Nikolaeva, O.V., **Lee, J.**, and **Karasev, A.V**. "Grapevine viruses in Idaho", Idaho Grape Growers and Wine Producers Annual Meeting, Garden City, ID, February 2016. [invited] (~60 attendees)

Virus results from samples taken from the commercial vineyards were discussed with vineyard owners and managers individually (~12 individuals; including the one vineyard that produces the majority of the state's winegrapes).

Anticipated publication:

Thompson, B.D. 2018. Idaho vineyards virus status. University of Idaho, Moscow, ID. M.S. thesis. In preparation. - Graduate student (B. Thompson) is working on data analysis and interpretation of his findings in preparation of Masters' thesis. We anticipate he will graduate in Winter 2018. Once thesis is complete, the experimental chapter will be re-formatted for submission to a peer-reviewed publication. Submission, review, revision, and final paper acceptance for peer-review journals may take ~1.5 years (journal dependent). After the paper is accepted, an interpretive summary will appear on Dr. Lee's webpage.

Beneficiaries

Idaho grape growers and winemakers (~50 Idaho farmers and ~50 Idaho wineries; but this work can be used in established regions like CA, OR, WA, and NY) will benefit from vine virus status information. Identification of the virus in Idaho grape vineyards is the first step in lessening the economic losses caused by grapevine viruses.

Virology researchers will benefit from molecular diagnostic techniques developed from this work. This work as also uncovered a rare GLRaV clone.

Currently, GLRaV can only be eliminated by vine roguing, which could cost a vineyard owner $5,000-$16,000 per acre. Also, there will be a loss of income during reestablishment (need to wait >3yrs for vines to be commercial production level). Monitoring the GLRaV-3 status of the grapevine using the novel detection methods, the growers in Idaho can reduce the cost for vine replacement on their ca. 1,200 acres of winegrapes grown in Idaho.

Lesson Learned

Interagency administrative procedures delayed receiving and obtaining access to grant funds. This caused a postponement of initially spending and project start date. This administrative issue remains unresolved.

Growing winegrapes are weather dependent and we were not expecting 2016-2017 winter's extreme low temperatures, which killed off many of the commercial vineyard vines we identified for multi-year sampling.

Due to the high percentage of vines with positive virus status within some target vineyards, supplementary vine samples (leaves and clusters) had to be collected from additional cooperating commercial vineyards. For example, one vineyard tested 100% positive for leaf roll virus, so there were no healthy and infected pairs for chemical analyses.

Contact Person

Jungmin Lee, Ph.D.
Research Food Technologist / Food Chemist USDA-ARS-HCRU worksite
29603 U of I Ln
Parma, ID, 83660, USA
Jungmin.Lee@ars.usda.gov
541-745-8377

Alexander V. Karasev, Ph.D.
University of Idaho (UI)
Department of Plant, Soils, and Entomological Sciences
Moscow, ID 83843
akarasev@uidaho.edu
208-885-2350

Method Development for Automated, Real-time Monitoring of Wine Grape Vine Water Stress for Use in Wireless Sensor-based Irrigation Networks

Subrecipient

USDA, Agricultural Research Service

Project Summary

All wine grape acreage in Idaho requires irrigation. A vineyard manager's decision about how much and when to irrigate is a major factor affecting wine grape yield, berry composition and water use efficiency. Idaho vineyard managers currently do not have a guide that they can use to easily determine grapevine water stress severity to guide their irrigation management decisions. Their irrigation decisions are often based upon past experiences and current weather conditions, without any actual measurement of grapevine water status. The goal of this research project was to develop a plant-based, remote method to measure the water status of grapevines in real-time throughout the growing season to use as a guide for irrigation decision-making. A support tool for irrigation decision-making will enhance irrigation efficiency and conserve Idaho water resources by increasing the productivity of irrigation water use. Optimizing the productivity of water used for irrigated agriculture is critical in arid regions, such as Idaho, where urban water demands are often in direct competition with agriculture. The increase in global water demand with rising average ambient temperatures predicted by climate change models highlights an urgent need for global water conservation. Grape acreage in Idaho is second only to apple in percent of total fruit acreage; and, according to the U.S. Dept. of Agriculture, grape production acreage increased 86% from 1999 to 2007. The estimated economic impact of the Idaho wine grape industry to the state of Idaho was $73 million in 2008. Measurement of leaf temperature has been used as an indicator of water stress in other crops, but leaf temperature-based indices of water stress have not been widely used in wine grape production because index calculation requires knowing, in real-time, the corresponding leaf temperatures of a well-watered and extremely water stressed (non-transpiring) grapevine. In this project we designed and validated a neural network model used to predict the canopy temperature of a well-watered grapevine and a method to estimate the leaf temperature of a non-transpiring grapevine. The predicted and estimated canopy temperatures were used to calculate a daily water stress index (WSI) for grapevine. Values of the calculated WSI were related to plant-based indicators of water status and vine yield components during the 2015 and 2016 growing seasons.

Project Approach

The field research was conducted in the USDA-ARS experimental vineyard located at the University of Idaho Research and Extension Center in Parma, ID. The vineyard was planted in 2007 with one acre each of the wine grape cultivars Malbec and Syrah. Field equipment to measure and record meteorological data and grapevine canopy temperatures was installed in 2015 and 2016 by the USDA-ARS scientist from Kimberly, ID. The experimental vineyard was managed each year according to local commercial practices by the University of Idaho Vineyard Manager. Replicated plots of 18 vines (three vines rows with 6 vines per row) were supplied via above ground drip with 35, 70 or 100% of estimated water demand either as a single weekly event or apportioned into thirds and delivered as three irrigation events per week. The weekly irrigation amount and water application was calculated and managed by the USDA-ARS Biological Science Technician. Stationary infrared radiometers (SI-121 Infrared Radiometer; Apogee Instruments, Logan, UT) were used each year to measure the temperature of sunlit leaves on well-watered and differentially irrigated vines. The infrared sensors were positioned

~ 30 cm above the grapevine canopy. Sensors were installed in the vineyard each year to measure and record wind speed, air temperature, relative humidity, and solar radiation. Sensor measurements were made at 1-min intervals and recorded on a data logger as 15-min average values.

The canopy temperatures of well-watered grapevines and vineyard meteorological conditions measured between 13:00 and 15:00 MDT were used to train, test and validate an Artificial Neural Network (NeuroIntellligence, Alyuda Research Inc., Cupertino, CA) model for predicting the canopy temperature of a well-watered grapevine. Model accuracy was evaluated by the USDA-ARS Scientist from Kimberly, ID by comparing the canopy temperature of well-watered grapevines predicted by the Neural Network (NN) model to actual field-measured values. The data set collected in year 1 and year 2 was divided into three data subsets. One data subset was used to identify and select the neural network (NN) model architecture that had the strongest correlation with and least amount of standard error between measured and NN predicted well-watered canopy temperature. The other data subsets were used to validate and test the selected NN model to verify that it consistently minimized the amount of standard error between measured and NN predicted well-watered canopy temperature (first performance measure).

A daily WSI was calculated each growing season by the USDA-ARS Scientist from Kimberly, ID using data downloaded and sent electronically by the USDA-ARS biological science technician in Parma. The WSI (value of 0 to 1 where 0 represents well-watered conditions and 1 represents severe water deficit) was calculated as follows:

$$\mathrm{WSI} = \frac{(\mathrm{T_{canopy}} - \mathrm{T_{ww}})}{(\mathrm{T_{dry}} - \mathrm{T_{ww}})} \qquad (1)$$

where T_{canopy} is measured leaf temperature, T_{ww} is the NN predicted well-watered leaf temperature, and T_{dry} is a constant calculated from ambient temperature (second performance measure).

The WSI was related to midday leaf water potential, vine yield components, and berry composition in both years by the USDA-ARS Scientist at the Parma worksite. Data were analyzed by year using a mixed model Analysis of Variance (irrigation amount and frequency as fixed and replication as random effects) with a factorial split plot treatment structure. Mean separation was determined using Tukey-Kramer adjusted T-test (third performance measure).

The principal investigator for this project, Dr. Krista Shellie, Research Horticulturist, USDA-ARS in Parma, ID coordinated the execution of activities with the U of I vineyard manager, the USDA-ARS biological technician at Parma, and the USDA-ARS Research Scientist at Kimberly, ID throughout the two year grant period. The co-leader of this project, Dr. Bradley King, Agricultural Engineer at the USDA-ARS Irrigation and Soils Research Unit in Kimberly, ID was directly involved in accomplishing the first two project performance measures.

Goals and Outcomes Achieved

The three performance measures for this project were achieved. The performance measures were to: 1) design and validate a neural network (NN) model for predicting the leaf temperature of well-watered grapevines, 2) use predicted and estimated canopy temperature values to calculate a water stress index (WSI), and 3) relate WSI values to plant-based indicators of water status, water productivity, yield and berry composition.

Design and validation of NN models. Cultivar differences in plant water response required development of separate NN models for Syrah and Malbec. The predicted canopy temperature of a well-watered grapevine was more accurate from the NN model than from traditional linear regression. The relationship between measured (15-min average values) and predicted leaf temperature values are presented in Fig. 1 and 2 for the cultivar Syrah and Fig. 3 and 4 for the cultivar Malbec. The correlation coefficient between predicted and measured temperatures was stronger when well-watered grapevine leaf temperature was predicted by the NN (Fig. 1 and Fig. 3) than when predicted by traditional linear regression (Fig. 2 and Fig. 4). The correlation coefficients for values predicted using the NN model and linear regression were 0.937 and 0.914 for Syrah, and 0.907 and 0.881 for Malbec, respectively.
Calculation of WSI using NN model. A daily WSI was calculated using the average of the 15-min average values for predicted and measured leaf temperatures from 13:00 to 15:00 MDT. The daily WSI for Malbec and Syrah corresponded with irrigation amount (Fig. 5). Index values increased between irrigation events and decreased after an irrigation event. For both cultivars, vines supplied with 70% of estimated demand had a lower WSI than vines supplied with 35% of estimated demand.
WSI values in relation to leaf water potential and yield. The daily values of the WSI were compared to weekly measurements of midday leaf water potential, which is a plant-based indicator of vine water status widely used in research. Each year, midday leaf water potential was measured on the day preceding a weekly irrigation event; when, in the absence of precipitation, vine water stress was expected to be at its most severe weekly value. A more negative leaf water potential and higher WSI value is indicates more severe water stress. Midday leaf water potential values of -1.0, -1.2, and more negative than -1.4 MPa are usually categorized as mild, moderate and severe levels of water stress, respectively. In both study years and for both cultivars, grapevines irrigated at 35% ET_c had more negative leaf water potential values and higher WSI values than vines irrigated at 70% ET_c (Fig. 7 and Fig. 8). There was a weak correlation between weekly values of midday leaf water potential and daily WSI; however, average seasonal leaf water potential values corresponded with average seasonal maximum WSI values. The average weekly leaf water potential of vines irrigated at 35% of ET_c was -1.3 and -1.4 in 2015 and 2016, respectively, indicating a moderate and severe level of water stress. The corresponding seasonal average maximum WSI value for vines irrigated at 35% ET_c in 2015 and 2016 was 0.2 and 0.4, respectively. The average weekly leaf water potential of vines irrigated at 70% ET_c was -1.1 MPa in 2015 and differed by cultivar in 2016. In 2015, the corresponding seasonal average maximum WSI value for vines irrigated at 70% ET_c was -0.1. In 2016, vines irrigated at 70% ET_c had an average weekly leaf water potential and average maximum WSI value of -1.3 MPa and 0.2 for Malbec and -1.2 MPa and 0.1 for Syrah (Fig. 8). Vines irrigated at 35% ET_c had lower yield and fewer of clusters per vine than vines irrigated at 70% ET_c (Table 1). Yield and cluster number per vine was lower in 2015 than 2016 due to a November 2014 cold event that caused injury to the vines.

Beneficiaries

Results of this project were presented to Idaho vineyard managers, research scientists, software engineers, manufacturers of integrated precision irrigation networks, and other grape growers through posters, abstracts and oral presentations at seven conferences with local (3), national (3) and international (1) audiences. The number of attendees at each of the local conferences (Idaho Wine Commission Annual Meeting and Grower Seminar) was approximately 50 to 100 members of the Idaho wine grape industry. At each of the national conferences (American Society of Enology and Viticulture annual meeting, BC Wine Grape Council Conference, Irrigation Association Conference) the number of attendees ranged from approximately 200 to 1000 people and included growers, researchers and other affiliated industry professionals. Approximately 200 international viticulture and enology researchers attended the international conference (GIESCO). Results from this project were also published in an

open-access, peer-reviewed scientific journal (Agricultural Water Management). While total readership of the published article is unknown, the 5-yr impact factor for the journal (average number of times a published article in this journal is cited in another publication) is 3.37. The date, name and venue of the conferences and complete citation for the publication are listed below.

Presented Abstracts/Posters at National and International Conferences:
June 2016. American Society of Enology and Viticulture annual meeting. Monterey, CA.
July 2015. BC Wine Grape Council Conference, Penticton, BC Canada
June 2015. Les 19émes Journées GIESCO, Guisson, France
Nov. 2014. Irrigation Association Conference. Phoenix, AZ.

Invited oral presentations:
August 2016. Idaho Wine Commission Grower Seminar. Sawtooth Winery, Nampa ID.
June 2016. American Society of Enology and Viticulture annual meeting. Monterey, CA.
February 2016. Idaho Wine Commission Annual Meeting. Boise, ID.
February 2015. Idaho Wine Commission Annual Meeting. Boise, ID.

Publications in peer-reviewed scientific journals:
King, B.A. and K.C. Shellie. 2016. Evaluation of neural network modeling to predict non-water stressed leaf temperature in wine grape for calculation of crop water stress index. Agricultural Water Management 167:38-52.

Lessons Learned

The neural network model developed in this project predicted the canopy temperature of well-watered grapevines more accurately than could be achieved using traditional linear regression. Cultivar differences in plant water relations necessitated the development of cultivar-specific neural network models. Estimating the leaf temperature of non-transpiring grapevines using a constant value and measured ambient temperature provided a sufficiently consistent lower threshold to use for calculation of the water stress index (WSI). Using measured and predicted values from 13:00 to 15:00 MDT to calculate a daily WSI corresponded well with applied irrigation amounts and changes in soil moisture between irrigation events.

Contact Person

Dr. Krista Shellie, Research Horticulturist USDA-ARS
208 722-6701, ext. 219
Krista.Shellie@ars.usda.gov

Additional Information

Abstracts/Posters:
June 2016. American Society of Enology and Viticulture annual meeting. Monterey, CA.
July 2015. BC Wine Grape Council Conference, Penticton, BC Canada
June 2015. Les 19émes Journées GIESCO, Guisson, France
Nov. 2014. Irrigation Association Conference. Phoenix, AZ.

Invited oral presentations:
August 2016. Idaho Wine Commission Grower Seminar. Sawtooth Winery, Nampa ID.
June 2016. American Society of Enology and Viticulture annual meeting. Monterey, CA.
February 2016. Idaho Wine Commission Annual Meeting. Boise, ID.

February 2015. Idaho Wine Commission Annual Meeting. Boise, ID.

Publications in peer-reviewed scientific journals:
King, B.A. and K.C. Shellie. 2016. Evaluation of neural network modeling to predict non-water stressed leaf temperature in wine grape for calculation of crop water stress index. Agricultural Water Management 167:38-52.