V(A). Planned Program (Summary)

Program # 9

1. Name of the Planned Program

Breeding Crops For Adaptation to Changing Environments: Addressing Food Security and Global Hunger

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships			5%	
111	Conservation and Efficient Use of Water			5%	
112	Watershed Protection and Management			5%	
131	Alternative Uses of Land			5%	
132	Weather and Climate			10%	
201	Plant Genome, Genetics, and Genetic Mechanisms			10%	
202	Plant Genetic Resources			10%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			5%	
205	Plant Management Systems			5%	
211	Insects, Mites, and Other Arthropods Affecting Plants			10%	
212	Pathogens and Nematodes Affecting Plants			10%	
215	Biological Control of Pests Affecting Plants			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Actual Paid Professional	0.0	0.0	11.6	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
0	0	46992	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	654672	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	320536	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Global food security will provide adequate access to food for the world's population. Worldwide, millions of people live with inadequate nutrition due to poverty or lack of access to food security. As the global population grows, there is a need to increase productivity per hectare, enhance water use efficiency and improve the nutritional value of crops in order to provide enhanced food quality. Increasing production must coincide with improving land use and reducing negative environmental impacts of intense agriculture. Finally, these accomplishments must take place in response to a changing climate and the resulting abiotic stresses that can influence production. This project provides a coordination of research in plant breeding and genetics to make fundamental and applied contributions to plant science that will lead to economic development and an equitable, sustainable and nutritious food supply. Objectives include a) accelerated programs to create desirable traits in crop cultivars; b) identification of novel genes and molecular breeding techniques for adapted germplasm; c) identification of growth and development pathways; and d) a better understanding of the mechanisms and resistance to abiotic and biotic stresses.

2. Brief description of the target audience

Agricultural producers
Pant breeders
Extension agents
Researchers
Policy makers
Decision makers
Food processors
Consumers
Water managers
Climate adaptation specialists

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	1000	40	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	36	36

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Use molecular breeding tools to develop resistance to abiotic and biotic stressors and to improve traits related to human health and nutrition in cultivars of importance in agriculture systems.

Year	Actual
2013	0

Output #2

Output Measure

- Use a systems biology approach to better understand mechanisms affecting target traits in cultivars of importance in agriculture systems.

Year	Actual
2013	0

Output #3

Output Measure

- Evaluate new germ plasm, cultivars or varieties for commercial viability.

Year	Actual
2013	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	1. Use molecular breeding tools to develop resistance to abiotic and biotic stressors and to improve traits related to human health and nutrition in cultivars of importance in agriculture systems. a) Conduct a systematic evaluation of germplasm resources to identify sources of genetic variation i. Develop new high throughput markers anchored in genome sequences ii. Map genes/QTLs determining target traits iii. Characterize gene/QTL networks and interactions iv. Measure gene/QTL x environment interaction v. Validate and fine map putative genes/QTLs vi. Transfer identified genes/QTLs into economically useful backgrounds, using accelerated generation advance strategies
2	Improve the nutritional value of important food grains; 2) reduce the impact of wheat storage proteins on human health; and 3) target nutrient development with ripening control. Examples at OSU include barley (Hayes and Ross), wheat (Zemetra, Flowers, and Ross), and grape (Deluc).
3	The mission of the Ornamental Plant Breeding Program is to develop new cultivars that are ecologically sound for producers and consumers as well as economically viable for producers. We seek to develop sterile forms of non-native species, insect and disease resistant cultivars, and low input cultivars that can be grown in nurseries and landscapes with less water or nutrient inputs.
4	Fundamental Research Supporting Multiple Breeding Programs. Two research groups are engaged in fundamental research relevant to multiple breeding programs. These include seed dormancy and germination (Nonogaki) and a systems biology approach to stress tolerance (Jaiswal).
5	Validation of cultivar performance and stripe rust resistance for wheat.

Outcome #1

1. Outcome Measures

1. Use molecular breeding tools to develop resistance to abiotic and biotic stressors and to improve traits related to human health and nutrition in cultivars of importance in agriculture systems. a) Conduct a systematic evaluation of germplasm resources to identify sources of genetic variation i. Develop new high throughput markers anchored in genome sequences ii. Map genes/QTLs determining target traits iii. Characterize gene/QTL networks and interactions iv. Measure gene/QTL x environment interaction v. Validate and fine map putative genes/QTLs vi. Transfer identified genes/QTLs into economically useful backgrounds, using accelerated generation advance strategies

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In Oregon there are over 38,000 farms producing crops on over 16 million acres. Because 25% of Oregon?s economy is based on agriculture; successful breeding programs directly influence and affect the success of a good portion of that value. Fruits, nuts, berries, vegetables, seed and specialty crops are produced on over 320,000 acres, and production has been increasing by 12% per year, generating $30-50 million per year. Cereal grains, potatoes and row crops account for over 10% of agricultural farm gate value in a typical year. The Oregon greenhouse and nursery industry typically accounts for approximately 15% of farm gate value annually.

Oregon? crops are hosts to a wide variety of pathogens, pests, and stresses for which durable resistance genes are actively sought. At the same time, allelic variation in genes and gene networks associated with plant growth and development are targets for optimization in order to ensure maximum plasticity, productivity, and efficiency.

What has been done
Pests, such as diseases, nematodes and weeds, continue to extract an economic, environmental, and social cost and are exacerbated by variable weather conditions. Efforts are needed to improve crop production efficiency by integrating genetic resistance and/or tolerance. Examples at OSU include wheat stripe rust (Mundt and Flowers), eastern filbert blight (Mehlenbacher), white mold (Myers), and multiple diseases of potato (Sathuvalli). The fundamental work involving the

Pto gene in tomato (Chang) provides a foundational example for the more applied projects.

Results
Faculty participating in this project published 22 peer reviewed articles on breeding efforts and new developments in genomics of disease resistance.

Pests, such as diseases, nematodes and weeds, continue to extract an economic, environmental, and social cost and are exacerbated by variable weather conditions. Efforts are needed to improve crop production efficiency by integrating genetic resistance and/or tolerance. Examples at OSU include wheat stripe rust (Mundt and Flowers), eastern filbert blight (Mehlenbacher), white mold (Myers), and multiple diseases of potato (Sathuvalli). The fundamental work involving the Pto gene in tomato (Chang) provides a foundational example for the more applied projects.

White mold (caused by Sclerotinia sclerotiorum) is the most economically significant disease of snap beans (Phaseolus vulgaris), currently grown on 13,400 acres for processing in Oregon. While some variation for resistance is found within common bean, the best source of resistance is found in scarlet runner bean (P. coccineus) (Gilmore, 2007). Resistance QTL were identified and mapped in three runner bean x common bean backcross-inbred (BCIB) populations (Haggard, 2007; Zimmerman, 2010). Additional sources of resistance in common bean have been identified. In order to ensure the continued viability of beans as a crop in Oregon, and to contribute to global solutions to this disease, research is needed to identify, introgress, and characterize new sources of resistance (Miklas et al., 2013).

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #2

1. Outcome Measures

Improve the nutritional value of important food grains; 2) reduce the impact of wheat storage proteins on human health; and 3) target nutrient development with ripening control. Examples at OSU include barley (Hayes and Ross), wheat (Zemetra, Flowers, and Ross), and grape (Deluc).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Population growth and climate change will continue to stress available resources and limit our ability to meet the nutritional needs of the world population. Advances in genetic enhancements of food crops have improved yields and resistance to biotic and abiotic stresses. The same approaches can be used to further improve production agriculture by seeking genetic enhancements that: 1) improve the nutritional value of important food grains; 2) reduce the impact of wheat storage proteins on human health; and 3) target nutrient development with ripening control.

What has been done
we are developing healthy foods that will assist the nation in addressing the challenges of serious health issues aggravated by diets high in processed foods, sugars, and fats (Park et al., 2011). Americans are increasingly becoming overweight and even obese; more healthy foods are needed. Part of the solution is the development, promotion, and adoption of whole foods, including fruits and grains. We have used, and are currently using these molecular breeding tools for a range of traits in barley and improvement (Fisk et al., 2012; Von Zitzewitz et al., 2011). Foremost among the quality traits of interest are dietary fiber, antioxidants and phenolics, which are recognized as having potential health benefits in human nutrition (Chutimanitsakun, 2013).

There is evidence that the incidence of celiac disease has increased in recent decades and not simply as a result of increased diagnosis (Rubio-Tapia and Murray 2010). The increase in celiac disease has generated interest about the impact of wheat storage proteins on human health and the potential role of wheat breeding through selection for improved end-use bread quality. We are determining if selection away from dough strength such as practiced in development of soft white wheat cultivars results in a decrease in the level of the offending gliadin proteins.

Using an asynchronous grape berry cluster, we identified a natural regulatory mechanism, named ?ripening synchronization?, aimed to reduce the inherent variability between developmentally different berries towards maturity. The nature of this mechanism must be elucidated before proposing a mechanistic model of the ripening control in grape. Moreover, understanding this biological process will enhance our understanding of the overall ripening in grape and will provide insights into other fruits and cereal crop models that suffer from biological variability.

Results
Because this project was initiated in late 2013, we expect to have preliminary results in 2014.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
212	Pathogens and Nematodes Affecting Plants

Outcome #3

1. Outcome Measures

The mission of the Ornamental Plant Breeding Program is to develop new cultivars that are ecologically sound for producers and consumers as well as economically viable for producers. We seek to develop sterile forms of non-native species, insect and disease resistant cultivars, and low input cultivars that can be grown in nurseries and landscapes with less water or nutrient inputs.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Nursery and greenhouse represents the largest sector of Oregon?s agricultural production and was valued at nearly $742.5 million in 2011. Historically, most new cultivars of woody nursery crops arose as chance seedlings or vegetative sports from plants being grown on nurseries or in landscapes. Climate change, changing consumer attitudes, access to new tools, and growers? desire to market ecologically sound cultivars has led to increased targeted breeding of woody nursery crops for traits such as drought tolerance, insect and disease resistance, and sterility (Harding et al., 1991; Li et al., 1996; Vining et al., 2012).

What has been done
We are developing sterile forms of non-native species, insect and disease resistant cultivars, and low input cultivars that can be grown in nurseries and landscapes with less water or nutrient inputs. A major focus of our program is with Cotoneaster, which is a genus of landscape plants that has lost favor in the industry due to losses from fire blight (Erwinia amylovora) and concerns about invasive potential of the genus. However, most species in the genus are extremely hardy landscape plants that can be grown in harsh conditions with little water, thus would fit well into sustainable landscape situations.

Results

Team members are conducting experiments to evaluate if progeny of Cotoneaster resulting from susceptible X resistant crosses exhibit fire blight resistance. These same progeny are triploids and will be evaluated for fertility. To date, we have germ plasm from which we will select im[roved forms based on fertility, disease resistance, fruit size, and growth characteristics.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
132	Weather and Climate
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #4

1. Outcome Measures

Fundamental Research Supporting Multiple Breeding Programs. Two research groups are engaged in fundamental research relevant to multiple breeding programs. These include seed dormancy and germination (Nonogaki) and a systems biology approach to stress tolerance (Jaiswal).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

PHS is a serious problem in wheat production, since precocious germination dramatically reduces the quality of final products, which causes substantial financial losses for wheat growers and affects food supply in our society. Understanding the mechanisms of seed dormancy and germination will provide solutions to these agricultural problems.

Systems biology approaches to understanding stress response. There is a compelling need to understand pathogens, light, moisture, salt and temperature. This can be addressed using a reference species approach to build tools and models to profile the transcriptome of important crops, such as wheat. Assembly of de novo transcriptomes and alignment of expressed gene sequences identify (1) genetic markers and (2) stress responsive differentially expressed genes. Our strategy is to further knowledge in the de-novo transcriptome assembly of large plant genomes and to create a reference for the annotation and enrichment of wheat and related crops.

What has been done

The plant hormone abscisic acid (ABA) plays an important role in imposing seed dormancy (Martinez-Andujar, Ordiz, et al., 2011). To establish strategies to prevent PHS, expression of ABA metabolism and signaling genes will be characterized and enhanced. The promoter and coding regions of ABA metabolism and signaling genes will be isolated from wheat and sorghum and analyzed for their potential for technology development. Gene function will be tested in model plants such as Arabidopsis and Brachypodium, while transformation to crop species will also be tested. Transcriptional profiling on the CGRB?s Illumina HiSeq2000 platform will be used to examine the consequence of modifying target genes that are associated with seed dormancy and germination.

The project will attempt to identify a reference set of SNP markers and transcriptomes from the founder A, B and D genome diploid wheats in phase-I. These references will be used for performing a large-scale genotype and transcriptome sequencing-based GWAS analysis. A similar approach will be attempted on hexaploid (cultivated) wheat. It is expected that during phase-II of this project the hexaploid wheat genome will be published and its availability will further strengthen the investigation on GWAS. The wheat survey sequences from the heaxploid genome (Brenchlet et al 2012), A-genome (Ling et al 2013) and D-genome (Jia et al (2013) reference transcriptomes from T. monococcum (Fox et al. 2013) are already available. The process will include growing wheat A, B and D genome donors in controlled and growth chambers and separate experiments involving cold and hot temperature regimes, drought and salt stresses.

Results

This project was approved in late 2013. Necessary greenhouse experiments are currently beginning and we expect to begin reporting preliminary results in 2014.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #5

1. Outcome Measures

Validation of cultivar performance and stripe rust resistance for wheat.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The OSU Department of Crop and Soil Science hosts breeding programs for five crops? barley, hops, meadowfoam, potatoes, and wheat ? which account for over 10% of agricultural farm gate value in a typical year. Hence, roughly 2% of Oregon?s economy can be directly influenced and affected by the success of these breeding programs. The OSU Department of Crop and Soil Science hosts breeding programs for five crops? barley, hops, meadowfoam, potatoes, and wheat ? which account for over 10% of agricultural farm gate value in a typical year. Hence, roughly 2% of Oregon?s economy can be directly influenced and affected by the success of these breeding programs. Via integration of fundamental and applied research, CSS researchers work hand-in-hand with their producer clientele to improve the sustainability of growing these crops in Oregon. Researchers strive to develop crop varieties with the best disease and pest tolerance possible and with quality attributes that allow growers to expand and enter new markets. At the same time, the plant breeders make significant contributions to a fundamental understanding of plant genetics, biology and chemistry.

What has been done
Systems biology approaches to understanding stress response. There is a compelling need to understand pathogens, light, moisture, salt and temperature. This can be addressed using a reference species approach to build tools and models to profile the transcriptome of important crops, such as wheat. Assembly of de novo transcriptomes and alignment of expressed gene sequences identify (1) genetic markers and (2) stress responsive differentially expressed genes. Subsets of stress responsive genes and the association of gene expression and polymorphic genetic marker site associations are functionally annotated and computationally analyzed for identifying expression QTLs (quantitative trait loci) and compared to the known/novel QTL from the genomes of closely related species. This computational approach has been successfully adopted by the NSF funded Gramene database (www.gramene.org) where researchers can query the database for a set of genes and their association to trait phenotypes, regulatory and

metabolic networks, and gene function at the molecular level (Ni et al 2009). Our strategy is to further knowledge in the de-novo transcriptome assembly of large plant genomes and to create a reference for the annotation and enrichment of wheat and related crops.

Results

This research involves field screening of wheat cultivars and elite germplasm for resistance to common wheat disease in Oregon (stripe rust, and septoria are examples). Trials will be conducted at a maximum of 15 and a minimum of 9 locations in Oregon, northern California, and southwestern Idaho. 25 ? 40 entries will be tested per experiment. Trial sites are chosen to represent a diverse array of production conditions; from very low rainfall to full irrigation, shallow to deep soils, and low residue to high residue management practices. Exact location of the trials may vary each year. Data from each experiment will be collected, analyzed and made available to growers soon after harvest. Data will be summarized and distributed via web, email, newsletters, print media, and various extension outlets as well as delivered to clientele through presentations at grower meetings, crop tours, and field days. The trials also provide grain samples to evaluate stability and consistency of end-use quality traits by the OSU Wheat Quality Improvement Program and ARS Western Wheat Quality Lab.

This project was initiated in late 2013. We expect to begin disseminating results in 2014 as field trials have just begun during the 2014 growing season.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

This project was initiated in late 2013 and we expect initial results in 2014. Researchers involved in this project published 36 peer reviewed articles on various aspects

of the project that will provide the basis for continued investigations over the 5 year life span of the project.

The continued prevalence of drought, water stress, and emerging resistance of plants to various pathogens demonstrates the importance of this project for a variety of producers (grapes, barley, hazelnuts, beans, potatoes, wheat, tomato, and berry crops). The Center for Genome Research and Biocomputing (CGRB) at OSU will provide the necessary technical backdrop to allow this project to move forward.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Researchers need to address gaps in our existing knowledge if we are to create efficient ways to ensure food security for the broader population. The goals of this project are to develop comprehensive approaches to (i) improving productivity and (ii) controlling or mitigating losses. Better diagnosis of plant diseases as well as prevention and treatment measures are crucial for the productivity and sustainability of food systems as well as the establishment of safe food sources. This project provides important insights into the coordination of fundamental and applied research to achieve demonstrable advances in plant breeding to alleviate the impacts of biotic and abiotic stresses associated with climate change and an expanding human population.

Key Items of Evaluation

Plant genetics, breeding, physiology and entomology are disciplines that directly impact every Oregonian, have stakeholders in multiple sectors of the state's economy, and have significant economic, environmental, and political impacts. Internationally and nationally, population growth and climate change make providing nutritious, diverse, and abundant food an imperative. There is also a shortage of highly trained college graduates to address these challenges. Herein lies an opportunity for OSU to contribute to the PNW economy, to train the next generation of agriculture and food system scientists and producers, and to meet global challenges for food, fiber, and a healthy environment. Meeting the needs of our students and PNW growers will provide new information on how crops can be bred to deal with abiotic and biotic stressors. Many of the crops now grown in the Oregon and region were originally from elsewhere, and what we learn from improving the quality and quantity in the new growing region, i.e., the PNW, will provide the basis for advancing our basic understanding of plant biology and related issues. New genetic technologies will be instrumental in developing, and building on, our knowledge.

This project has two major priorities: 1) integrate basic and applied science to yield on-the-ground deliverables with high impacts in the state and the region; and 2) develop gene validation and expression genetics in economically important crop plants. This project will allow integration of these two priorities. Leadership in this integration aspect will be provided by the OSU Center for Genome Research and Biocomputing (CGRB), which provides services in the areas of Genomics, Functional Genomics, Biocomputing and BioInformatics, and Imaging and Image Analysis. The plant breeding and genetics faculty at OSU are members of the CGRB and reside in two academic units: Crop and Soil Science (CSS) and Horticulture (HORT). Research and teaching functions are integrated in an emerging Plant Breeding and Genetics Program.