

**V(A). Planned Program (Summary)**

**Program # 5**

**1. Name of the Planned Program**

Global Food Security and Hunger -- Plant Breeding, Genetics and Genomics

**V(B). Program Knowledge Area(s)**

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			15%	
202	Plant Genetic Resources			35%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			30%	
205	Plant Management Systems			10%	
	<b>Total</b>			100%	

**V(C). Planned Program (Inputs)**

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	30.0	0.0
Actual	0.0	0.0	41.0	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	267774	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1605765	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1871927	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

- Communication of information on plant breeding and genomics advances through classroom activities, field days, variety trials, news releases, presentations at county and state meetings and conventions

- Release germplasm, new varieties and new genomics tools and techniques
- Strategic planning with state agricultural groups
- Technical and non-technical publications

**2. Brief description of the target audience**

- Domestic and foreign buyers of quality wheat
- Farmers, colleagues, and stakeholders
- Grain associations, Montana Department of Agriculture, Montana Wheat and Barley Committee, grain elevators and state commodity groups
  - Seed companies

**V(E). Planned Program (Outputs)**

**1. Standard output measures**

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
<b>Plan</b>	2000	500	0	0
<b>Actual</b>	2400	800	0	0

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

**Patent Applications Submitted**

Year: 2010  
 Plan: 0  
 Actual: 0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

2010	Extension	Research	Total
<b>Plan</b>	0	5	
<b>Actual</b>	14	29	43

**V(F). State Defined Outputs**

## **Output Target**

### **Output #1**

#### **Output Measure**

- Number of foreign trade teams in Montana

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2010	15	10

### **Output #2**

#### **Output Measure**

- Number of foreign trade teams at MSU

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2010	4	5

### **Output #3**

#### **Output Measure**

- Number of research citations

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2010	16	16

**V(G). State Defined Outcomes**

**V. State Defined Outcomes Table of Content**

O. No.	OUTCOME NAME
1	Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets.
2	The number of new molecular techniques used to enhance breeding results.
3	Average per bushel yield increase of Montana grains while maintaining product quality.
4	Number of elite lines of wheat and barley screened for agronomic and quality characteristics.
5	Number of improved variety recommendations by districts across Montana.
6	Planted acreage percentage increase per year of new MSU-released small grains in Montana.

## **Outcome #1**

### **1. Outcome Measures**

Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets.

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Condition Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2010	100	100

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Grain producers in Montana rely on research at MSU for the development of new genetics and cultivars adapted to Montana's climate. New disease and insect resistant wheat and barley cultivars, new cultivars with value-added traits, and new crops weigh heavily in the priorities of Montana stakeholders.

#### **What has been done**

We recently released four feed, forage, and malt barley cultivars that fit Montana's production environments and that provide added value to Montana barley growers and to growers throughout the Northern Plains. MSU is developing multiple pest-resistant dryland alfalfa cultivars with good agronomic traits for Montana. In addition to alfalfa projects, efforts have been made to develop new grass cultivars suitable for Montana. Barley research continues to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. Successful genetic research is increasing the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and desirable end-use qualities.

#### **Results**

Continued productivity of our breeding program will improve our understanding of the genetics of key traits and allow the development of new selection tools. The broader impacts of the work are a larger food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat. Research results will increase the competitiveness of Montana wheat producers through improved winter wheat varieties with enhanced yield potential, pest resistance, and end-use qualities.

### **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
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)

## **Outcome #2**

### **1. Outcome Measures**

The number of new molecular techniques used to enhance breeding results.

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Condition Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2010	1	1

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Reliable high quality wheat yield is essential for the long-term marketing of Montana products. The broader impacts of MSU research are a larger and higher quality food supply for the world, and an improved ability of Montana farmers to compete in a global marketplace. The goals of cultivar selection are to ensure that we select for high grain protein and gluten strength, high flour extraction and low ash content, good dough mixing and bread baking quality, and superior noodle color and textural characteristics.

#### **What has been done**

MSU researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs. We are examining the degree to which puroindoline proteins control wheat grain hardness and cereal quality and their effect on end-product quality. Further research will address the effects that modifying the starch biosynthetic pathway has upon grain hardness, milling quality, yield, and end-product utilization. Our research provides methods to analyze all lines of wheat to detect novel gene expression related to post-harvest resistance, which could lead to new strategies for post-harvest protection.

## **Results**

Continued productivity of our breeding program will improve our understanding of the genetics of key traits and allow the development of new selection tools and plant varieties. Our research demonstrates that manipulation of puroindoline levels can create defined wheat grain hardness levels. Alterations in puroindoline content can generate desired milling and end product quality. Projects are underway to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. Preliminary results have demonstrated that we can modify plant viruses and other protein cage architectures to impart novel functions with applications in drug delivery and in Magnetic Resonance Imaging (MRI). These discoveries significantly contribute to our long-term goal of producing new therapeutic treatments using plant virus nanoparticles with direct benefits for human and plant health.

#### 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)

#### Outcome #3

##### 1. Outcome Measures

Average per bushel yield increase of Montana grains while maintaining product quality.

##### 2. Associated Institution Types

- 1862 Research

##### 3a. Outcome Type:

Change in Condition Outcome Measure

##### 3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	1

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

MSU seeks to maintain its role as a leading university in small grains genetics research. The agricultural community and allied industries depend on new cultivars of important crops to remain competitive in the world marketplace. Researchers evaluate germplasm and identify traits that produce wheat and barley cultivars that meet increasing world demands for quality, while maintaining yields for producers.

###### **What has been done**

The development and distribution of high quality, drought tolerant barley cultivars that provide the highest production potential is a priority of barley breeding programs. We have increased our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance. Our multi-state barley research focuses the disciplines of plant breeding, genetics, plant pathology, cereal science, molecular biology, and genomics for barley improvement in Idaho, Montana, and North Dakota.

### Results

Based on average planted acreage and prices, development of an improved winter wheat cultivar which produces an additional one bushel per acre either by enhanced yield or reduced yield loss to disease, insects, or environmental stresses, potentially impacts the Montana economy by \$5-\$6 million, annually. Efforts have been made to develop new grass cultivars suitable for Montana. We have consistently maintained a positive annual statewide yield increase of 0.5 bushels per acre for spring wheat and winter wheat over the last 10 years.

## 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

## Outcome #4

### 1. Outcome Measures

Number of elite lines of wheat and barley screened for agronomic and quality characteristics.

### 2. Associated Institution Types

- 1862 Research

### 3a. Outcome Type:

Change in Condition Outcome Measure

### 3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	100	100

### 3c. Qualitative Outcome or Impact Statement

#### Issue (Who cares and Why)

MSU is a recognized international leader in the development of new cultivars of small grains sought by global buyers. Global traders want high quality wheat with characteristics that enhance their production of food products. Bread making characteristics, especially dough strength and

extensibility, are considered when evaluating spring wheat cultivars. Montana stakeholders rely on MSU new cultivar development to ensure that they can remain competitive in the global market. Small grains grown for ethanol production influences the cultivar selected by the grower whose goal is higher production and less attention to protein content.

#### **What has been done**

MSU has a high throughput of potential lines of winter and spring wheat through our breeding programs. Successful genetic research will increase the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and desirable end-use qualities. The Asian noodle market is an important business opportunity for Montana growers. The quality of noodles made from different wheat samples is evaluated on entries from the MSU and intrastate nurseries. The use of small grains for ethanol production is a potential market providing a new source of sustainable energy fuels. Researchers work to improve animal and human nutrition, add value to raw products, improve safety of products, and increase product development of biobased chemicals, fuels, lubricants, pharmaceuticals, and nutraceuticals.

#### **Results**

We have been able to evaluate wheat varieties and conduct quality testing across different Montana environments with new varieties entering the market every four to five years. Our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance has been developed and extended through genetic diversity experiments. The broader impacts of the work are a larger food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat. Cultivar selection for small grain ethanol yield focuses primarily upon grain yield at the expense of protein content. Projects are underway to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. Results have demonstrated that we can modify plant viruses and other protein cage architectures to impart novel functions with applications in drug delivery and in Magnetic Resonance Imaging (MRI). These discoveries significantly contribute to our long-term goal of producing new therapeutic treatments using plant virus nanoparticles with direct benefits for human and plant health.

#### **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
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**

Number of improved variety recommendations by districts across Montana.

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Condition Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2010	5	2

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Montana crop producers want improved hard red and hard white winter wheat cultivars that are adapted to Montana conditions and suitable for both domestic and export markets. Producers want the highest yielding and most pest resistant barley varieties as well. Montana is recognized for production of high quality bread wheat which is essential in maintaining domestic and foreign markets. The export trade in recent years has accounted for about 3/4 of our wheat market.

#### **What has been done**

One or two new small grain cultivars are released (or changed through a collaborative process) to growers every other year and the lower yielding or less desirable cultivars may be removed from the recommended lists based upon agronomic and pest responses. This keeps only those cultivars that will be the most beneficial for Montana growers. These decisions are made from a group of MSU faculty, seed growers, seed trade members, and state agencies. Variety recommendations are established each year for wheat (spring, winter, and durum) and barley for the six Montana growing districts and published in the Performance Evaluation and Recommendations guides by MSU-MAES.

#### **Results**

As wheat and barley cultivars are developed, information is reviewed by MSU researchers and the larger constituent groups for inclusion in the year's recommendations. These recommendations are made available to growers and seed distributors each year. New small grain varieties developed at MSU and other institutions are annually reviewed by MSU and other industry and state partners before releasing to the public. Additionally, new alternative crops are tested to determine suitability for Montana growing conditions. Several new varieties of Camelina sativa have been developed and two new selections/cultivars of high protein oats have been developed. Sawfly resistant wheat cultivars will prevent crop losses of 15-90% on 379,000 acres, and reduce harvest machine repair costs. Resistant cultivars are the highest producer-generated

priorities.

#### 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
205	Plant Management Systems

#### Outcome #6

##### 1. Outcome Measures

Planted acreage percentage increase per year of new MSU-released small grains in Montana.

##### 2. Associated Institution Types

- 1862 Research

##### 3a. Outcome Type:

Change in Condition Outcome Measure

##### 3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	3	5

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Montana crop producers want improved hard red and hard white winter wheat and barley cultivars that are adapted to Montana conditions, resist pests, and generate higher yields. Producers anxiously await new MSU cultivars when released.

###### **What has been done**

One or two new cultivars may be introduced each year to Montana growers. As new cultivars are introduced and accepted, the acreage planted of older cultivars (including those developed at MSU) goes down. New varieties are developed on-going at MSU and are annually reviewed by MSU and the Montana Wheat and Barley Committee before being released to the public and allied seed partners.

###### **Results**

As wheat and barley varieties are developed, information is reviewed by MSU researchers and recommendations made for the year. The top four varieties of winter wheat planted in 2010 account for nearly 55% of the total winter wheat planted in Montana. The top four varieties of

spring wheat planted in 2010 account for 61% of the total seeded. Three of the four were developed in MSU laboratories. The top four varieties of malting barley represent about 47% of the total planted. Hockett is the third leading malting barley variety seeded and was developed by MSU in 2008. It generates excellent yield and malt quality under dryland conditions. Haxby is the top feed barley variety for the fourth year. It was developed by MSU and performs well in low moisture conditions.

#### 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

#### V(H). Planned Program (External Factors)

##### External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Other (Funding)

##### Brief Explanation

A variety of weather patterns influence Montana agriculture each year including extreme cold, early frosts, and hail storms. Severe hail across much of southwestern Montana in June caused widespread crop and property damage.

#### V(I). Planned Program (Evaluation Studies and Data Collection)

##### 1. Evaluation Studies Planned

- Retrospective (post program)
- During (during program)

#### Evaluation Results

On-going development in plant genetics ensures that growers will have access to the most adapted and highest yielding varieties of small grains. Growers readily accept new varieties as indicated by purchase and planting records.

#### Key Items of Evaluation

The rapid adoption and growth of new varieties demonstrate the successful plant breeding programs established at MSU.