**February 2003**

## FY2004 Oat Research Priorities

The National Oat Improvement Committee (NOIC) and North American Millers Association (NAMA) represent the oat milling industry, oat producers and oat research scientists. NAMA and the NOIC request the support and assistance of your office in ensuring that funding is available for crucial programs in oat research. **Oat research priorities for FY2004 are described in the following pages.** Funding for these areas is essential to the continued competitive position of U.S. oats in the marketplace and on the landscape.

Oats are an essential grain, both for human consumption and animal feed. Oat products are heart-healthy, safe, whole-grain and beneficial in dietary and nutritional function. Oats are also a valuable addition to crop rotation systems, helping to ensure sound cropping and conservation methods. In addition, oats and oat-based products hold great potential for growth in domestic and export markets.

In 2002, the 119 million bushels of oats produced in the U.S. contributed to the production of more than $2.5 billion in food, feed, cosmetics, pharmaceuticals, sweeteners and industrial products generating hundreds of millions of dollars in tax income. Despite the steady decline in oat production in this country, the food use of oats has been growing at about 5% per year due to the unique nutritional benefits provided by oat products for human food

Continued investment by the Federal Government in strong oat research programs is required to keep the U.S. at the forefront in the development and implementation of new technologies to improve oat productivity and quality**.** No private commercial oat breeding programs exist in the U.S., so oat research is conducted only at state land-grant universities and U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) facilities. Current federal investment in oat research is $4,183,900 per year, so the returns from this modest federal investment in oat research more than exceed the current expenditure. Continued federal investment is essential and justified.

Basic genetic research, including new molecular techniques, plant breeding, research on disease resistance, germplasm enhancement, and research on new and value-added uses will enhance the value of oats and provide benefit to the producer, processor, end-user and consumer. In addition, oats play an important role in sustainable grain production in the U.S. and provide producers with another crop option. To remain a viable crop, progress in oat improvement must be sustained. Federal support for oat research is essential to this progress.

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## Reinstatements:

Congress has been very responsive to the needs of constituents and the national agricultural economy, supporting and initiating critical USDA research projects. Several research programs of critical importance to oat (and other small grains) were removed from the Administration budget proposal for FY2004. NAMA and the NOIC ask Congress to restore funding to existing programs of critical importance to small grains, including the following with oat research components:

**1. National Small Grains Germplasm Research Facility, Aberdeen, Idaho $100,000**

Enhancement of the germplasm of important field crops is a national responsibility of ARS. The Germplasm Evaluation and Enhancement Project provides valuable information and breeding materials to breeding programs for numerous economically important oat plant traits (FY2002). (See page 5)

**2. Oat Virus Research, USDA-ARS, West Lafayette, IN and Urbana, IL $260,000**

This program addresses one of the most economically important diseases of oats in North America – Barley Yellow Dwarf Virus (BYDV). The focus is on research to improve resistance to BYDV in the next generation of cultivars (FY2002). (See page 6)

**3. USDA-ARS Cereal Disease Lab, St. Paul, MN $250,000**

The USDA-ARS Cereal Disease Laboratory (CDL) is a Federal research facility with the national mandate of providing improved methods for controlling diseases of wheat, barley, and oat that are effective, safe, and environmentally friendly. The CDL plays a crucial role in resistance to crown and stem rusts in oats (FY2003). (See page 7)

**4. USDA-ARS Northern Crops Research Laboratory, Fargo, ND $1,767,700**

The NOIC and NAMA support the reinstatement of support for research on oat, wheat, barley, and sunflower including research on improvement of oats for food, feed, and value-added applications (FY2001 and FY2002). (See page 8)

**5. USDA-ARS Cereal Crops Research Unit, Madison, WI $569,500**

The CCRU is in a unique position to address grain quality attributes of oats and barley. Development of new small grain cultivars with enhanced grain quality traits will benefit farmers, the grain processing industry, and consumers who want more healthful foods in their diets (FY2001 and FY2002). (see page 9)

**6. USDA-ARS Regional Small Grains Molecular Genotyping Laboratories $1,099,450**

| | |
|---|---|
| Manhattan, Kansas | $ 249,450 |
| Raleigh, North Carolina | $ 250,000 |
| Fargo, NC | $ 600,000 |

A gap exists between the discovery of molecular information and the use of that information in wheat, barley, and oat improvement programs. These laboratories fill that gap. The model is based on the highly successful USDA-ARS Regional Wheat Quality Laboratories, Germplasm Centers, and Cereal Disease Lab. (FY2002). (See pages 13-16)

**7. USDA-ARS Aquaculture Research – Hagerman and Aberdeen, Idaho $830,000**

This unique coordinated research program focuses on concurrently developing genetically enhanced oats and barley as feed sources for aquaculture, and developing genetically enhanced fish to efficiently use these feed sources (FY2002 and FY2003). (See page 10)

FY 2004 Oat Research Priorities

**New Research Funding:**

The National Oat Improvement Committee (NOIC) and North American Millers Association (NAMA) seek your assistance and support to help meet the following program objectives in the areas of germplasm enhancement, disease resistance research, and molecular genetics.

## I. Oat Germplasm Enhancement, USDA-ARS, Aberdeen, ID

**Request: Additional funding of $400,000**

Oat germplasm enhancement is fundamental to genetic improvement of oats if oats are to attain their full potential to provide improved health benefits for human consumers, serve as an important source of animal nutrition, and continue to be a component of a cropping systems approach. Germplasm enhancement is also needed to protect oats from disease and to provide maximum economic returns to farmers. The program has a national focus.
(See page 5)

## II. Disease Resistance Research

### A. Resistance to oat barley yellow dwarf virus, USDA-ARS, W. Lafayette, IN and the University of Illinois, Urbana, IL.

**Request: Additional funding of $100,000**

We request support of the total $360,000 per year for the establishment of a research scientist position at the USDA-ARS Crop Production and Pest Control Research at Purdue University, West Lafayette, IN, and for support of oat virus research at the University of Illinois, Urbana, IL. This program addresses one of the most economically important diseases of oats in North America – Barley Yellow Dwarf Virus (BYDV) and focuses on resistance to BYDV in oats and control of this significant virus pathogen of oats. Additional funding is required to support a USDA scientist and to support evaluation of germplasm conducted by the University of Illinois for numerous oat breeding programs at other locations.
The program has a national focus. (See page 6)

### B. USDA-ARS Cereal Disease Lab, St. Paul, MN

**Request: Additional funding of $50,000**

The CDL plays a crucial role in resistance to small grain diseases including crown rust in oats. A strong national effort directed toward cereal diseases is essential for the security of our small grain crops. (See page 7)

**New Research Funding continued:**

## III. Molecular Genetics Research

### A. Increase in Funding for GrainGenes (USDA-ARS Plant Genome Database for Grain Crops)

**Request: Additional funding of $300,000/ year for the next 5 years**

GrainGenes is a support platform resulting from the growth of molecular research technologies over the past decade. It is of great value to crop improvement and basic research on cereal crops in the U.S and is widely used by scientists around the world. (See page 11)

### B. Comparative Oat Genomics Research, USDA-Aberdeen, ID and Cornell University, Ithaca, NY.

**Request: New Funding of $410,000 per year for 5 years**

Genomics research can lead to improvements in efficiency in breeding new crop cultivars. With funding of oat genomics research scientists working on oat can utilize and leverage the large amount of data already discovered for other species such as rice, wheat, maize and barley. (See page 12)

### C. Additional funding for Regional USDA-ARS Small Grains Molecular Genotyping Laboratories at: Raleigh, NC; Manhattan, KS; Fargo, ND; Pullman, WA

| | **FY2004 Request** |
|---|---|
| **Fargo, ND (north central)** | **$150,000** |
| **Manhattan, KS (central/south central)** | **$500,000** |
| **Raleigh, NC (east/southeast)** | **$500,000** |
| **Pullman, WA (west)** | **$750,000** |

The National Barley, Oat and Wheat Improvement Committees recommend increased funding to enhance regional molecular genotyping laboratories that have been established at Fargo, ND (partially funded at $600,000 in FY2002); Manhattan, KS (partially funded at $250,000 in FY2001); Raleigh, NC (partially funded at $300,000 in FY2003) and to establish a laboratory at Pullman, WA. Funding of $750,000 per laboratory is needed, which would require the funding shown above in FY2004 to make each lab fully operational. (See pages 13-16)

Please see the following pages for rationale and justification for these programs.

**Oat Germplasm Enhancement**
**USDA-ARS, Aberdeen, Idaho**

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association request reinstatement of $100,000 previously appropriated for oat germplasm enhancement and recommend establishment of a research geneticist position at the USDA Aberdeen facility with additional support of $400,000 per year. This new funding will allow hiring a research geneticist with responsibilities on oat germplasm enhancement and support germplasm enhancement and cooperative germplasm evaluation performed by university researchers under terms of Specific Cooperative Agreements and by USDA-ARS researchers.

**Justification:** Oat germplasm enhancement is fundamental to genetic improvement of this crop if it is to attain its full potential to provide improved health benefits for human consumers, serve as an important source of animal nutrition, and to become a component of a cropping systems approach to maintaining healthy grain and soybean production. Germplasm enhancement is also needed to protect oat from disease and to provide maximum economic returns to farmers.

Enhancement of the germplasm pools of important field crops is a national responsibility of the ARS. Oat is a major cereal grain and requires germplasm enhancement for future improvement of its yield and value as food and feed. It is unique among cereal grains in several respects, especially for nutritional properties and for its diverse utilization. The protein content of oats is the highest among the cereal grains and the quality of the protein is also superior. Soluble dietary fiber found in oats reduces serum cholesterol levels and provides other health benefits.

The acreage of oats in the U.S. has declined significantly during the past decade, due in part to pressures from diseases. Improvements in productivity and disease resistance in oat are needed to maintain crop diversity in this country and to assure significant domestic supplies of this important grain. The development of value-added traits will also contribute to improved profitability of oat. The Oat Crop Germplasm Committee (CGC) has identified specific enhancement objectives: 1) development of germplasm with improved yield potential through the introgression of genes from wild species and through recurrent selection programs that accumulate genes from cultivated species; 2) enhancement of disease resistance using genes from both *Avena sativa* and wild relatives; 3) incorporation of genes for increased protein content in desirable cultivated germplasm; 4) determination of the diversity for dietary fiber components in cultivated and wild germplasm; 5) incorporation of genes for high groat oil content or modified fatty acid composition from cultivated and wild species for development of special purpose oat cultivars; and 6) development of germplasm with improved lodging resistance

Special attention will be given to value-added or other unique traits, looking toward new or innovative crop uses, and more effective utilization of germplasm resources in the development of a sustainable agriculture system and increased global competitiveness. The project will continue to maintain contacts with a diversity of small grains researchers, nationally and internationally, to optimize limited resources and to speed efficient development, distribution, and use of improved germplasm.

## Oat Virus Research
## USDA-ARS, West Lafayette, Indiana and the University of Illinois

**Recommendation**: The National Oat Improvement Committee and the North American Millers Association recommend funding of $360,000 per year for a research scientist position at the USDA-ARS Crop Production and Pest Control Research at Purdue University, West Lafayette, IN, and for support of oat virus research at the University of Illinois, Urbana, IL. We request reinstatement of $260,000 previously appropriated and $100,000 additional funding which is required to support a USDA scientist and cooperative evaluation of germplasm conducted by the University of Illinois for numerous oat breeding programs at other locations.

**Justification:** Barley Yellow Dwarf Virus (BYDV) causes one of the most economically important diseases of oats in North America. Chronic BYDV problems have contributed substantially to the decline in U.S. oat acreage, yet there is no full-time position, either in USDA-ARS or state agricultural experiment stations, devoted exclusively to this problem.

Plant breeders, using conventional phenotypic selection methods, along with controlled inoculation with the virus, have made substantial progress in reducing susceptibility to this disease; however, for further progress research is needed on the mechanisms involved in resistance. The situation is complicated by the existence of several strains of the virus. Two of the strains have recently been elevated to the status of a separate viral species, *Cereal Yellow Dwarf Virus* (CYDV). If an oat plant is infected by two or more strains, which often happens, damage may be greater than would occur from infection by one strain. Research is required on how plants resist infection with several virus strains. Additional research to identify molecular markers associated with genes for resistance to BYDV would be very beneficial, and would allow oat breeders to more efficiently select for BYDV resistance.

There are many practical questions that a scientist in this position should address:
What are the mechanisms that make some plants resistant to the virus? What accounts for the much higher titer of virus in oat compared to wheat? Does host plant resistance in oat interfere with infection, or subsequent movement of virus within the plant? What are the differences in the virus found in different regions of the U.S.? Is it possible to transfer highly effective genes for resistance from wheat grasses to oat and will they then be expressed? Can novel forms of resistance in oat be developed through bioengineering, e.g. transcription factor modification? What is the source of virus inoculum for oat and wheat: local perennial grasses or viruliferous aphids carried on wind from remote sources? What are the consequences to oat of mixed infections of more than one strain of the virus or a mixture of BYDV and CYDV? Is there competition between strains following mixed infection? What is the annual extent of infection of oat by BYDV and CYDV and what losses do these infections cause?

It is our expectation that an ARS scientist would collaborate with oat breeders at Purdue, the University of Illinois, and other locations to enhance the understanding of this important disease and accelerate the capability to develop BYDV resistance oat varieties.

## USDA-ARS Cereal Disease Laboratory (CDL)

## St. Paul, Minnesota

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association request that Congress appropriate $50,000 in additional program support for the USDA-ARS Cereal Disease Laboratory in St. Paul, Minnesota ($250,000 was appropriated in FY2003 but was omitted in the Administration's budget proposal). A strong national effort directed toward cereal diseases is essential for the security of our small grain crops.

**Justification:** The USDA-ARS Cereal Disease Laboratory (CDL) is a Federal research facility with the national mandate of providing improved methods for controlling diseases of wheat, barley, and oat that are effective, safe, and environmentally friendly, mainly through the deployment of resistant cultivars. Rusts are fungal diseases that are capable of destroying our nation's cereal crops. Through the deployment of resistant cultivars and continued monitoring of pathogen races in the field, stem rust has been held in check and significant losses have not occurred for at least 35 years; however, other rust diseases still threaten our cereal crops. Although stem rust has been effectively controlled for many years, crown rust of oat, and leaf rusts of wheat and barley continue to cause serious losses. Stripe rust, traditionally a problem in the western US has been a local problem in the south-central US, and its potential to become a greater problem in the Great Plains and eastern US is uncertain. To combat these rust diseases, a sustained research effort is needed.

In the early 1990s, another fungus disease called *Fusarium* head blight or scab re-emerged in many areas of the United States. So far, scab has not been a serious problem on oat, but the NOIC fully supports the expansion of the CDL's mission to include scab. Basic research projects are being conducted on host plant resistance, infection mechanisms of the pathogen, and identification of novel control measures by means of advanced genomic and molecular technologies.

Because there has been increased cereal disease pressure in the Upper Midwest in the last decade, scab in wheat and barley and crown rust in oats, research activity at the CDL has increased considerably to respond to the needs. To effectively deal with these diverse rust diseases, as well as scab, the CDL must maintain its core group of research scientists and support staff. This requires funding at levels sufficient to provide operating funds to the CDL scientists.

**USDA-ARS Oat Quality Research**
**Northern Crop Science Laboratory, Fargo, ND**

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association support the reinstatement of $1,767,700 for USDA-ARS research programs on oat, wheat, barley, and sunflower at the Northern Crops Research Laboratory in Fargo, ND, including research on improvement of oats for food, feed and value-added applications (FY2001 and FY2002).

**Justification:** Research at the USDA-ARS Northern Crop Science Laboratory includes research projects on oat, wheat, barley, and sunflower. The following paragraphs will focus on the oat grain quality components of the research conducted at the Northern Crop Science Laboratory.

Oat research conducted at the Northern Crop Science Laboratory (NCSL) provides a better understanding of oat quality characteristics that confer increased value to oats for milling and animal feed markets. In cooperation with oat breeders, this research enhances development of oat cultivars with improved grain value. Information provided by the NCSL program is critical to the development of cultivars that will improve the competitive position of U. S.-produced oats in the world market. The funding level proposed by the administration would severely curtail the research on oat, wheat, barley, and sunflower. We request reinstatement of funding previously appropriated to allow operation of these research projects at a level sufficient to continue progress on oat, wheat, barley and sunflower including increasing the value of U. S. oats in the milling oat market, thus increasing the proportion of U. S.-grown oats in the domestic milling oat market.

The economic value of oats may be improved by increasing the milling yield to obtain more processed oat products from each bushel of oats produced. The NCSL oat grain quality research project is evaluating many physical and chemical oat kernel characteristics to identify those that contribute to improved milling yield. The NCSL project developed a technique for rapid determination of soluble fiber content that facilitates development of cultivars with improved beta-glucan levels. Selection for beta-glucan content was previously an expensive, labor-intensive process. Methods of determining kernel uniformity are being evaluated along with their relationship with milling yield. A model developed in this program helped to explain the effect of environment on oat yield and quality and is providing information that is helpful in developing cultivars that produce consistent grain quality over a range of environments. Other NCSL oat research areas include lipid stability, potential value-added products derived from oat oil, and the effect of crown rust on oat milling characteristics.

**USDA-ARS Cereal Crops Research Unit**
**Madison, Wisconsin**

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association request the reinstatement of $569,500 for the USDA-ARS Cereal Crops Research Unit located at Madison, Wisconsin. (FY2001 and FY2002). Funding to complete a new building housing the CCRU was appropriated in FY 2003; reinstatement of funding for effective operation of the research programs is essential for the effective use of the new facility.

**Justification:** The USDA-ARS Cereal Crops Research Unit (CCRU) Barley & Malt Laboratory scientists conduct basic and applied research on improving the quality of barley and oat. The CCRU is in a unique position to address grain quality attributes of oats and barley. Development of new small grain cultivars with enhanced grain quality traits will benefit farmers, the grain processing industry, and consumers who want more healthful foods in their diets. In addition, scientists at the CCRU collaborate with barley and oat researchers by analyzing the quality of breeding selections and other experimental samples.

Research at the CCRU emphasizes quality of malting barley and the nutritional quality of barley and oat for food. The unit has a broad mission: 1) identify and characterize the biological and biochemical mechanisms of cereal plants that affect the properties of their grain products; 2) develop knowledge about the basic growth, development and metabolic processes of cereal plants; 3) apply these findings to improving cereal quality through the development of enhanced germplasm and altering production practices; and 4) provide support for applied oat and barley research and breeding programs at various ARS locations and state agricultural experiment stations. Protein, oil and beta glucan concentrations of the barley and oat accessions in the National Small Grains Collection are assessed. The data obtained are added to the GRIN database so that plant breeders can obtain information about these traits and use the germplasm in their breeding programs. The information provided by the lab is of value to other researchers, plant breeders, oat and barley processors, the malting and brewing industries, and consumers.

There is a great need to develop new small grain cultivars that can be used to produce high-value products. This will benefit farmers, the grain processing industry, which needs grains with specific characteristics to develop new and improved products, and consumers who want more healthful foods in their diets. A Research Chemist was recently hired to identify and characterize constituents of oat and barley that have health promoting and/or disease preventing properties, establish the biochemical pathways by which they are synthesized and degraded, and determine how the activities of these pathways are regulated. This knowledge will be applied to develop new food and industrial uses for these cereals.

Research is in progress on the nutritional components of oat and barley, with an emphasis on the phenolic antioxidants of the grain. Antioxidants in the diet are believed to have health benefits because of their abilities to scavenge free radicals, which are naturally produced substances that are damaging to cells. The avenanthramides, a group of compounds that are unique to oat, are now being studied. Preliminary experiments have been conducted to measure their effects on cancer cell cultures and on indicators of acute stress in laboratory rats. The information gained from this work will allow plant breeders to develop oat cultivars that have superior characteristics for use as human food.

**Development of Genetically Enhanced Fish and Feeds**
**For Aquaculture Utilizing Specialized Grains**
**Hagerman and Aberdeen, ID**

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association recommend reinstatement of $830,000 for the Development of Genetically Enhanced Fish and Feeds for Aquaculture Utilizing Specialized Grains at Hagerman and Aberdeen, ID (FY 2001, FY 2002 and FY 2003).

**Justification:** Discovery of new uses and value-added uses for small grains enhance the value of small grains and benefit the industry as well as producers. New uses for oats and barley provide new markets and increase the demand for these small grains, which in turn increases the return to the producer. This program is a unique coordinated research program focused on concurrently developing genetically enhanced oats and barley as feed sources for aquaculture, and developing genetically enhanced fish (trout and other species) to efficiently use these feed sources.

This is a unique program involving the disciplines of plant and animal breeding at the USDA-ARS National Small Grains Germplasm Research Facility and the University of Idaho Hagerman Fish Culture Experiment Station. On the plant side, the focus is development of cultivars with unique traits such as low phytic acid content, enhanced protein and/or oil content, and modified amino acid composition to improve the nutritional value of oats and barley for aquaculture feed. On the fish side, selection is for enzymes involved in carbohydrate digestion in trout and evaluation of the genetic diversity for trout in their ability to utilize small grains in their diet.

## GrainGenes: A Database for the Grains Community

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association request increased funding for GrainGenes (USDA-ARS database) of $300,000 / year.

**Justification:** GrainGenes, a USDA-ARS database provides readily accessible, valuable information, especially molecular genetics information for oat, wheat and barley for many scientists. GrainGenes is a system of data acquisition, curation, maintenance, display, analysis, and distribution. The direct users of GrainGenes are grains researchers; however, stakeholders such as crop producers, distributors, consumers, and taxpayers are the ultimate users and benefactors as their needs are served by the direct users who depend on the ARS GrainGenes effort. Much of the research that results in crop improvement is collaborative, and GrainGenes both fosters collaboration and depends on it. The unique feature of GrainGenes lies in the broad spectrum of data it handles and the connections it makes among that data, connections not available anywhere else.

The members of a recently established GrainGenes Liaison Committee, which is broadly representative of users of GrainGenes, research groups and individuals who contribute data to GrainGenes, strongly attest to the importance of GrainGenes to crop improvement and basic research for cereals crop in the U.S. GrainGenes is a valuable genetic data resource, a source of tools for genetic data analysis, a source of information on biology, taxonomy, and pathogen issues relevant to the crops, a communications center linking national and international researchers, and a clearinghouse for links to other organizations and research efforts. It has been a model for other crop and research organism databases. GrainGenes is a highly visible and significant resource for the entire community of researchers working on cereal crops and represents a significant contribution and investment of ARS resources. It is essential for it to continue.

Current GrainGenes staff are dedicated and excellent; however, projected flat funding over the next five years threatens the ability of the GrainGenes staff to address rapidly changing priorities and increasing responsibilities. The five-year plan for GrainGenes now mandates inclusion of three major tasks not originally part of the project. The first of these tasks is the system administration activities necessary to host GrainGenes databases and websites. Second, staff time is required to address new security issues required for dataservers involved in web activities. Expenses are associated with both of these activities, and staff who normally work on curation and programming have had to be diverted to these tasks, thus reducing their efforts on data curation and management. Third, the five-year plan for GrainGenes also calls for transition from its current database format to a relational database system.

This transition is driven by the increasing number of display and analysis tools available for relations database systems. Several other genetics information database projects have made the transition or are in the process of making it with additional funds. This transition process requires careful analysis and prioritization, as well as, additional financial support to accomplish these goals. Thus, additional funding for GrainGenes is essential to maintain this valuable and highly visible program.

## Comparative Oat Genomics Research
## USDA-Aberdeen, ID and Cornell University
## Benefits to Crop Improvement and Consumer Health

**Recommendation:** The National Oat Improvement Committee and the North American Millers Association recommend funding a comparative oat genomics research project as a collaborative effort between the USDA facility at Aberdeen, Idaho and Cornell University for a period of 5 years, with support of $410,000/year. Several other laboratories will collaborate with the two primary locations through Specific Cooperative Agreements.

**Justification:** Genomics research can lead to great improvements in breeding improved cultivars of crops. How can we utilize the new technologies, information, and materials that are generated by research with model species and other crops for improvement of oat, forage grasses and other under-funded crops? Genomics research on model species is identifying many genes involved in disease and insect resistance, stress tolerance, and quality traits. Oat researchers can exploit the large amount of data for rice, wheat, maize, and barley if genomics research on oat is funded. Data from other species can be used to study expression of similar genes in oat that control key traits such as disease resistance, drought and heat stress, and grain quality traits. The application of marker assisted selection, comparative mapping, and improved knowledge of genes and gene interactions will contribute to the improvement of oat and benefit both producers and consumers. Funding is required so that the enormous volume of information and many techniques that have been generated for other crops can be applied to oat improvement.

The primary goals of oat genomics research are: 1) implementation of molecular marker-assisted selection for key traits; 2) transfer and use of information from other species and simpler organisms to benefit oat; 3) integration of information on gene location and gene expression across species and scientific disciplines; and 4) use of genetic information gained in other species for improvement of oat. The ability to identify specific oat genes that are turned on or off during infection by a pathogen or during adverse growing conditions will improve our ability to breed oat cultivars with better disease resistance and stress tolerance. For quality traits that are specifically important in oat (e.g., β-glucan or endosperm oil content), identifying genes that differ in expression between good and poor quality cultivars will improve breeders ability to manipulate these traits. Microarray technologies for quantifying differences in gene expression have been developed using sequence information from other species and require characterized oat sequences to be useful to oat improvement.

Several Land-Grant universities have established initiatives in genomics research. The USDA also recognizes the need for emphasis in this area with the plant genome databases. The plant genome database system provides a vital service to the research community including the development of databases and user interfaces for comparative maps, DNA homologies, phenotypic and metabolic relationships and specialized queries. Research support for oat and other under-funded crops will enhance the diversity and strength of our agricultural economy and consumer health.

## USDA-ARS Regional Small Grains Molecular Genotyping Laboratories

**Recommendation:** The National Barley, Oat, and Wheat Improvement Committees recommend increased funding to enhance regional molecular genotyping laboratories that have been established at Fargo, ND (partially funded at $600,000 in FY2002); Manhattan, KS (partially funded at $250,000 in FY2001); Raleigh, NC (partially funded at $300,000 in FY2003) and to establish a laboratory at Pullman, WA. Funding of $750,000 per laboratory is needed, which would require the following funding in FY2004 to make each lab fully operational.

| | **FY2004 Request** |
|---|---|
| **Fargo, ND (north central)** | **$150,000** |
| **Manhattan, KS (central/south central)** | **$500,000** |
| **Raleigh, NC (east/southeast)** | **$500,000** |
| **Pullman, WA (west)** | **$750,000** |

The laboratories will facilitate application of DNA molecular marker information to plant improvement in wheat, barley and oat breeding programs.

**Precedent:** The USDA-Agriculture Research Service has provided leadership and services when local resources have not been available to meet national needs in crop improvement. Current regional ARS laboratories characterize germplasm, improve end-use quality, and improve resistance to rusts, smuts, blights, and insect pests of wheat, barley, and oats.

**Justification:** Molecular information for small grains is being compiled daily through the International *Triticeae* expressed sequence tag (EST) consortium (ITEC), the USDA-ARS Wheat Endosperm sequencing project, the NSF Wheat Genome project, the North American Barley Genome Project and the USDA-NRI-CGP funded barley EST project.

A gap exists between the discovery of molecular information and the use of that information in practical wheat, barley, and oat improvement programs. As markets move away from a commodity basis toward a value-defined, end product basis, plant breeders must equip themselves with gene-specific markers that give them rapid access to traits of value.

Regional genotyping centers will overcome the barriers to practical use through automated DNA extraction, and high-throughput marker screening procedures. They will provide a bio-informatics interface between molecular genetic data and practical public and private breeding programs.

Regional laboratories are proposed to enhance close alignment between breeders and mappers for traits of value to particular geographical production areas, anticipated high genotyping demand, the regional nature of market classes and production systems, and the critical mass of breeding programs in each of the regions.

**Objectives:** Proposed objectives for the laboratories:

- Identify new DNA markers associated with resistance to important production risks like rust, scab, wheat streak mosaic virus, Karnal bunt, and cold injury. Identify new DNA markers associated with end use quality.
- Create marker profiles of cultivars and breeding lines and provide this information to plant breeders. Marker profiles will be cross-linked to other genetic information currently available in the Regional Cooperative nurseries, the USDA-ARS National Small Grains Germplasm Center, and through the USDA-NAL crop databases.
- Develop and deploy breeder friendly markers for widely used genes derived from cereal wild relatives and other germplasm resources.
- Develop and deploy microarray technology for basic gene detection research and selection in breeding programs.

**Impact:** By providing the biotechnology tools to enhance end use quality and resistance to production risks, these regional laboratories will benefit all components of the wheat, barley, and oat industries, from producers to consumers in the public and private sectors. For example, in barley, molecular markers are being used to convert traditional high quality malting barley to modern high yielding and disease resistant cultivars that maintain their traditional malting quality.

Other examples of genotyping needs waiting for the personnel, equipment and facilities in the proposed labs are:

- Markers to select for *Triticum diccocoides*-derived high protein in wheat.
- Markers to select for resistance to *Fusarium* head blight (scab) in wheat and barley.
- Markers to select for durable resistance to stripe and leaf rust in barley and wheat.
- Markers to select for improved winter survival in winter wheat and barley.
- Markers for slow rusting to develop durable crown rust resistance in oats.

**Budget justification:**

- Each laboratory will include a **lead scientist**. As a molecular breeder, that scientist will develop new methods to improve molecular marker systems and genotyping in cereal crops.
- **A bioinformatics specialist** is needed to interpret and automate data analysis.
- **Two support technicians** will assist the scientists.
- **Indirect research costs** include utilities, printing, and data dissemination.
- **Materials and supplies** costs are significant for a facility of this type and are estimated to be $1.00 per sample processed.
- **Equipment costs** are significant at startup and reduce over time.

| Item Description | Cost |
|---|---|
| **1 Scientist** | $ 100,000 |
| **1 Bioinformatics Specialist** | $ 75,000 |
| **2 Support Technicians** | $ 100,000 |
| **Indirect Research Costs** | $ 35,000 |
| **Materials and Supplies** | $ 250,000 |
| **Equipment** | $ 115,000 |
| **ARS HQ Administrive Costs** | $ 75,000 |
| **Total** | $ 750,000 |

*Note that because of the very large operating costs, it is necessary that a total of $275,000 of funds should be used for personnel (including one Category I scientist and one Category 4 bio-informatics specialist). It is expected that some operating costs for the collaborative research conducted in the laboratory will exceed these requested funds. Those costs will be covered through collaborative research grants between the lead scientist and other scientists in the region.*

**Location Justifications:**

**EAST: RALEIGH, NC**
(The laboratory at Raleigh was partially funded at $300,000 starting in FY2003)
The laboratory is part of the USDA-ARS Plant Science Research Unit. The unit includes two lead scientists in small grains plant pathology. The Department of Crop Science at North Carolina State University has lead scientists in small grain breeding and in molecular genetic analysis. The genetics and statistics departments at North Carolina State University include persons with expertise in molecular marker development and bioinformatics.

Collaboration can be established with breeding programs in MI, OH, NY, PA, MD, VA, KY, NC, SC, GA, FL, LA. Private breeding companies active in the region include Syngenta, Pioneer Hi-Bred, Agripro, and Western Plant Breeders.
The crops covered by the Raleigh lab include soft red and white winter wheat, six-row winter barley, and winter and spring oats.
The main traits for molecular genotyping in the East Region are:
Quality traits: Protein functionality, sprouting resistance, milling and baking quality in wheat; groat protein and oil content in oats.
Resistance to Production Risks: Resistance to powdery mildew, Hessian fly, *Septoria tritici* and *Stagonospora nodorum* in wheat; resistance to leaf rust in wheat and barley; resistance to crown rust in oats; resistance to cereal leaf beetle and barley yellow dwarf virus in wheat and oats.

**NORTH CENTRAL: FARGO, ND**
(The laboratory at Fargo was partially funded at $600,000 starting in FY2002). Searches for a lead scientist and molecular geneticist to run the laboratory are currently underway. The laboratory is part of the USDA-ARS Cereal Crops Research Unit of the Northern Crop Science Laboratory with lead scientists in wheat and barley genetics and plant pathology. The Department of Plant Sciences and Dept. of Plant Pathology at NDSU have lead scientists in wheat and barley breeding, genetics, and plant pathology and grain quality.
Collaboration can be established with breeding programs in ND, SD, MN, and WI. There are currently 18 small grain breeding and genetics programs in those four states.
Private breeding companies active in the region include Agripro, and Western Plant Breeders.
The crops covered by the Fargo genotyping center are six-and two-row barley, spring oat, Durum, hard red, and hard white spring wheat.
The main traits for molecular genotyping in the North Central Region are:
Quality traits: Protein quantity, gluten strength, kernel color and sprouting resistance in wheat; percentage of deoynivalenol in wheat and barley; protein, malt and nutritional quality traits in barley; milling and nutritional quality (including protein, antioxidants, lipids and nutritional fiber) in oat.
Resistance to Production Risks: Resistance to *Fusarium* head blight in wheat and barley; resistance to sawfly, tan spot, leaf rust, and stem rust in wheat; resistance to leaf and stem rust, barley stripe, net and spot blotch, and scald in barley; resistance to crown rust, and stem rust in oats.

**CENTRAL: MANHATTAN KANSAS**

(The laboratory at Manhattan was partially funded at $250,000 starting in FY2001). A Lead Scientist has recently been appointed. Since its inception in 2001, the laboratory has collaborated with at least 12 breeding programs in the region.

The laboratory is part of the Plant Science and Entomology Research Unit of the Grain Marketing Production Research Center in Manhattan, KS, which has lead scientists with expertise in germplasm development, mapping, and molecular biology. The unit has established the wheat genomics facility in partnership with the Wheat Genetics Resource Center of Kansas State University. At Kansas State University, expertise exists in wheat breeding, molecular genetics, grain quality and virtually all areas of wheat research.

Collaboration has been established with public breeding programs in IL, IN, KY, OH, MN, ND, and VA. Additional collaborative arrangements are possible with programs in AR, KS, IA, MO, NE, OK, and TX. Some of the current collaborative arrangements will shift to other labs once they are established. Private breeding companies active in the region include Agripro, Cargill, Pioneer, and Syngenta.

The crops covered by the Manhattan genotyping center include hard winter wheat, soft winter wheat, spring and winter oat and winter barley.

The main traits for molecular genotyping in the Central Region are:

Quality traits: Improved gluten functionality, noodle quality, and bread baking quality for hard wheat; forage and grain feed/food quality for oat and winter barley.

Resistance to Production Risks: Resistance to Russian wheat aphid, leaf rust, stem rust, scald, wheat streak mosaic virus, *Fusarium* head blight and Hessian fly in wheat and barley and resistance to crown rust in oat.

**WEST: PULLMAN, WA**

The laboratory will be part of the Wheat Genetics, Quality, Physiology and Disease Resistance Unit at Pullman WA. The unit includes lead scientists in germplasm development, molecular genetics, breeding, disease resistance, and grain quality in the Western Wheat Quality Laboratory. The Departments of Crop and Soil Sciences and Plant Pathology at WSU have lead scientists with expertise in barley and wheat germplasm improvement, molecular genetic analysis, cropping systems research, and diseases of wheat and barley.

Collaboration will be established with more than 15 public small grain breeding programs in CA, CO, ID, MT, OR, UT, and WA. Private companies active in the region include Agripro, Busch Ag. Res. Inc., Coors, and Western Plant Breeders. Other states including AK, AZ, NM, and WY grow cultivars developed from those breeding programs.

The crops covered by the Pullman genotyping center include hard and soft winter wheat, hard and soft spring wheat, club wheat, spring barley and winter malting barley.

The main traits for molecular genotyping in the Western Region are:

Quality Traits: Starch composition and properties, gluten strength, flour color, noodle color and texture, milling quality, club wheat flour functionality, and sprouting resistance in wheat; improvement of food, feed and malting quality in barley.

Resistance to Production Risks: Resistance to cold injury, stripe rust, eyespot, *Cephalosporium* stripe, *Fusarium* crown rot, and Hessian fly in wheat; resistance to winter injury, stripe rust, soil borne diseases, and Hessian fly in barley.