# *Minnesota Legislative Funding for the Forever Green Agricultural Initiative - update*

CFANS Dean Brian Buhr requested the establishment of an advisory committee for this legislative funding, with the goal of determining how to allocate the Forever Green Agricultural Initiative funds and establish a system for reporting and accountability.

A committee composed of three ex-officio members (CFANS Associate Dean for Research, Forever Green Initiative PI, and CFANS Grants Manager) and ten voting faculty members from the CFANS departments of: Agronomy and Plant Genetics; Applied Economics; Food Science and Nutrition; Horticultural Sciences; and Soil, Water and Climate, were invited and agreed to serve. An internal request for proposals was drafted and posted 7/29/14 with a proposal deadline of 9/15/14. Proposal review criteria, in alignment with the legislative language, were as follows:

- Proposed project advances the goal of incorporating perennial or winter annual crops into existing agricultural practices;
- Proposed project focuses on research that will advance the protection of natural resources while increasing efficiency, profitability and productivity of Minnesota farmers;
- Objectives are measureable, specific, and clearly stated;
- The plan for carrying out the proposed activities is well-reasoned, well-organized, and based on a sound rationale. Proposed project explores creative, original, or potentially transformative concepts and can reasonably be accomplished with in the planned budget and timeline;
- Project team is sufficiently comprised of members who have the necessary skills and expertise to accomplish the proposed research;
- Proposed research fits within the investigator's larger area-of-interest research enterprise and is necessary at this time in order to move forward.

A total of 21 proposals were received. Each proposal was reviewed by multiple committee members and scored according to the posted review criteria and then discussed by the whole committee. The committee made a recommendation to Dean Buhr to fund the following seven proposals (one-third of the projects). Most proposals were budgeted at ~$150K for three years; one proposal was budgeted at ~$100K for three years.

1. High-density Genetic Mapping of Intermediate Wheatgrass QTLs Associated with Disease and Agronomic Traits *PI: James Anderson, Professor, Department of Agronomy and Plant Genetics*
2. Propagation of Hybrid Hazelnut for Minnesota *PI: Jerry Cohen, Professor, Department of Horticultural Sciences*
3. Assessing Nitrogen Contribution and Soil Biological Effects of Promising Winter Annual Legume Cover Crops for Minnesota *PI: Julie Grossman, Assistant Professor, Department of Horticultural Sciences*
4. Functional Characteristics and Quality of Intermediate Wheatgrass for Food Applications *PI: Baraem (Pam) Ismail, Associate Professor, Department of Food Science and Nutrition*
5. Strategies for Improving Seed Production of Intermediate Wheatgrass, a new Perennial Grain Crop *PI: Craig Sheaffer, Professor, Department of Agronomy and Plant Genetics*
6. Development of Perennial Sunflower for Food Production and Wildlife Services *PI: Robert Stupar, Associate Professor, Department of Agronomy and Plant Genetics*
7. Integration of Field Pennycress and Camelina in a Field Corn Production System *PI: Scott Wells, Assistant Professor, Department of Agronomy and Plant Genetics*

# *Project Summaries*

## High-density Genetic Mapping of Intermediate Wheatgrass QTLs Associated with Disease and Agronomic Traits

*Principal Investigator:*
James Anderson, Professor, Department of Agronomy and Plant Genetics
*Co-Investigators:*
Donald Wyse, Professor, Department of Agronomy & Plant Genetics
Carol Ishimaru, Professor, Department of Plant Pathology
Ruth Dill-Macky, Professor, Department of Plant Pathology
*Collaborators:*
Lee DeHaan, The Land Institute
Steve Larson, USDA-ARS, Logan, UT

*Project Summary:* Intermediate wheatgrass is a perennial plant that produces large biomass and has traditionally been used as a forage crop, but it shows great potential to be developed as a grain crop. The environmental benefits of perennials include reduced soil and water erosion, soil nitrate leaching, increased carbon sequestration, and reduced inputs of energy and pesticides. The success of intermediate wheatgrass as a perennial grain crop will depend on improvement of traits such as seed yield, seed size, shattering, height, and disease resistance. The genes for some of these traits in related annual cereal species such as wheat are known. This information can be exploited to increase the efficiency and speed of developing superior germplasm. In this project, the main goal is to develop a high-density genetic map and identify major genes/loci for agronomic traits. Three full-sib (bi-parental) populations will be investigated using next-generation sequencing technology to discover genome-wide genetic markers. The three populations will be characterized for seed size, height, threshing ability, shattering, and resistance to *Fusarium* head blight and bacterial leaf streak in the field or greenhouse. By statistically analyzing the data of genetic markers and agronomic traits, the genes controlling the agronomic traits will be identified. Then, we will be able to make crosses using parents possessing superior genetic loci, and select germplasm combining the best genes for disease resistance and agronomic traits. The identification and application of major genetic loci will greatly accelerate the breeding process of intermediate wheatgrass and help to improve commercial intermediate wheatgrass cultivars.

**Propagation of Hybrid Hazelnut for Minnesota**

*Principal Investigator:*
Jerry Cohen, Professor, Department of Department of Horticultural Sciences
*Co-Investigator*:
Donald Wyse, Professor, Department of Agronomy and Plant Genetics

*Project Summary:* As woody perennials, hazelnuts are an important piece of the Forever Green initiative, providing continuous living cover to protect soil quality and reduce agricultural runoff. Because of a highly variable genetic background of hazelnut, seed propagation is not an effective method for increasing plant numbers. Thus, adventitious root formation is the preferred method for propagation from elite plants selection, but this process is also a critical and limiting step in all methods of vegetative propagation used in hybrid and American hazelnuts. Because of the shortcomings of current propagation methods, widespread adoption of hazelnuts in the Midwest is limited by a lack of quality plants.

Our goal is to identify the hormonal roadblocks to adventitious root formation in hazelnuts using stable isotope methods of analysis of plant hormone changes. Identifying these limitations will provide knowledge that can be used to make more informed decisions on how to optimize the rooting phase and also to identify which genotypes are most likely to form adventitious roots.

The major anticipated outcomes include 1) creation of a screen to identify genotypes likely to have poor rooting ability to exclude from breeding programs; and 2) determination of changes in primary metabolism, peroxisome function and the potential for metabolic manipulation to effect rooting ability in response to rooting hormone treatments. These results could greatly accelerate the process of propagating many genetically uniform plants that can then be strategically placed on the Minnesota landscape.

**Assessing Nitrogen Contribution and Soil Biological Effects of Promising Winter Annual Legume Cover Crops for Minnesota**

*Principal Investigator:*
Julie Grossman, Assistant Professor, Department of Horticultural Sciences
*Co-Investigators:*
Craig Sheaffer, Professor, Department of Agronomy and Plant Genetics
Nancy Ehlke, Professor, Department of Agronomy and Plant Genetics
Scott Wells, Assistant Professor, Department of Agronomy and Plant Genetics

*Project Summary:* Cover crops are non-food crops that provide important benefits including erosion control, landscape diversification, nutrient addition and soil quality improvement. *The purpose of this project is to provide legume cover crop options to growers in the upper Midwest to help increase soil quality and nutrient availability to cash crops.* We will do this by examining key soil microbial processes that regulate nitrogen (N) cycling in select winter-hardy legumes, with an emphasis on hairy vetch (*Vicia villosa)*. This project will address the lack of winter hardy legume cover crop species options that can contribute to soil quality, fertility and active microbial functioning in northern climates. Specifically, we will identify promising species of winter annual legumes that contribute to soil carbon and nitrogen in cold and variable Minnesota climates. Objectives include 1) Quantification of amount of the critical plant nutrient nitrogen that is contributed to soils following the growth and incorporation of legume cover crops, and 2) assess the impact of legume cover crops on biological soil quality parameters that are related to decomposition and nutrient release of the legume residue in the spring. We will develop two replicated field trials on Minnesota Research and Outreach Centers (Lamberton and Grand Rapids, MN) and evaluate three hairy vetch ecotypes, as well as two additional legumes or legume mixes of interest to growers. To disseminate the information generated from this project, we will prepare and present workshops to two separate audiences, including one organic-focused conference (MOSES) and one regional MN-based conference.

**Functional Characteristics and Quality of Intermediate Wheatgrass for Food Applications**

*Principal Investigator:*
Baraem (Pam) Ismail, Associate Professor, Department of Food Science and Nutrition
*Co-Investigators:*
Tonya Schoenfuss, Associate Professor, Department of Food Science and Nutrition
Devin Peterson, Professor, Department of Food Science and Nutrition
*Collaborators:*
Donald Wyse, Professor, Department of Agronomy and Plant Genetics
James Anderson, Professor, Department of Agronomy and Plant Genetics
Lee DeHaan, The Land Institute
Laura Hansen, General Mills

*Project Summary:* Intermediate wheatgrass (IWG) is a perennial crop that produces a large biomass that can be used for hay or forage, shows great potential to be developed as a grain crop, and provides sustainable environmental benefits. The environmental benefits of perennial crops in comparison to annual grain crops include reduced soil and water erosion, reduced soil nitrate leaching, increased carbon sequestration, and reduced inputs of energy and pesticide. From a consumer perspective, the engagement in purchasing habits that can improve the environment is gaining prominence. The use of perennial crops in food products will allow consumers to feel good about their purchase, and their role in supporting a sustainable agricultural system. The overall objective of this project is to characterize advanced breeding lines of IWG for grain/flour functional attributes, flavor quality and storage stability, and identify new technologies to incorporate selected lines in a variety of food products that can serve as a new food supply. Understanding nutritional and flavor attributes as well as the functionality of perennial grains for food applications is vital if the dual use of these crops is to be realized. Farmers will be reluctant to plant the crop if there is not a strong market for these crops, and this market pull cannot be established unless the crop is characterized and developed for food use. Data gathered will provide necessary information to the breeding program for the continued screening and breeding efforts to ultimately develop IWG with good yield, size and quality traits for food applications.

**Strategies for Improving Seed Production of Intermediate Wheatgrass, a new Perennial Grain Crop**

*Principal Investigator:*
Craig Sheaffer, Professor, Department of Agronomy and Plant Genetics
*Co-Investigators:*
Nancy Ehlke, Professor, Department of Agronomy and Plant Genetics
James Anderson, Professor, Department of Agronomy and Plant Genetics
Donald Wyse, Professor, Department of Agronomy and Plant Genetics
Jacob Jungers, Research Associate, Department of Agronomy and Plant Genetics

*Project Summary:* Intermediate wheatgrass is a long-lived, large-seeded grass that is being domesticated for grain as part of the Forever Green Initiative at the University of Minnesota. It is the first significant new grain crop developed in the US in over 50 years. The uniqueness of this grain has led to partnerships with major food marketers whose surveys have shown consumer demand for sustainably-produced whole-grain products from wheatgrass. While producers have long sought alternative crops to diversify cropping systems, often markets – and therefore economic returns – have been limited. Intermediate wheatgrass provides economic opportunities for producers to diversify their operation. Use of intermediate wheatgrass on agricultural landscapes will provide unique environmental benefits. Intermediate wheat grass production will provide year-round soil cover, thereby reducing soil erosion, while its extensive root system will sequester carbon and recycle soil nutrients such as nitrogen.

Intermediate wheatgrass is a new crop, and to capture economic and environmental benefits, farmers will need to know the best practices for producing high-quality intermediate wheatgrass grain. We will study the effect of field management strategies on grain yields of intermediate wheatgrass. We will study how plant populations, row spacing, and fertilizer affect grain yield and grain quality, and determine how grain yield changes as these long-lived plants age from year to year. To understand environmental effects on grain production, field research will be conducted at Roseau and St. Paul. Our short-term outcome will be the development of best management practices for economical grain production. Farmers will integrate intermediate wheatgrass production into their crop rotations. In the long-term, we will facilitate development of a new seed production and processing industry, improve environmental quality and wildlife habitat, and provide a new food to consumers.

**Development of Perennial Sunflower for Food Production and Wildlife Services**

*Principal Investigator:*
Robert Stupar, Associate Professor, Department of Agronomy and Plant Genetics
*Co-Investigators*:
Michael Kantar, Research Associate, Department of Agronomy and Plant Genetics
Donald Wyse, Professor, Department of Agronomy and Plant Genetics
Yaniv Brandvain, Assistant Professor, Department of Plant Biology

*Project Summary:* Perennial crops provide living ground cover for longer periods during the year than annual crops and do a better job of protecting against soil erosion and improving water quality. Commercial sunflower is an annual species which produces a valuable vegetable oil, making it the 2nd most widely grown hybrid crop in the world. A perennial sunflower would allow farmers to diversify their operations, improve profits, improve environmental quality, and reduce inputs of labor and supplies. The long-term goal of this project is to develop a perennial sunflower that is equally productive to current commercial varieties, but offers superior ecosystem services. The wild sunflower relative Helianthus divaricatus will be used as a source for breeding the perenniality trait into the commercial sunflower. This wild relative, commonly known as the woodland sunflower, has been used as a donor for disease resistance in the past and has great potential as donor for perenniality in northern climates. We are creating populations that use the woodland sunflower and cultivated sunflower as parents to create perennial sunflower populations with superior characteristics. In this project we are going to use modern genetic and genomic techniques (DNA sequencing, RNA sequencing, genetic mapping, and gene expression analysis), to create new resources for rapid improvement of breeding populations. We also hope to identify the genes responsible for perennial organ formation (tuber, rhizomes) and cold tolerance, which then can be used to screen populations and improve selection efficiency.

**Integration of Field Pennycress and Camelina in a Field Corn Production System**

*Principal Investigator:*
Scott Wells, Assistant Professor, Department of Agronomy and Plant Genetics
*Co-Investigators:*
Gregg Johnson, Associate Professor, Department of Agronomy and Plant Genetics
Donald Wyse, Professor, Department of Agronomy and Plant Genetics
Russell Gesch, USDA-ARS, Adjunct Assistant Professor, Department of Agronomy and Plant Genetics
Frank Forcella, USDA-ARS, Adjunct Associate Professor, Department of Agronomy and Plant Genetics
Julie Grossman, Assistant Professor, Department of Horticultural Sciences
Axel Garcia y Garcia, Assistant Professor, Department of Agronomy and Plant Genetics

*Project Summary:* The goals outlined in this proposal support the land-grant mission by providing research-based information and management recommendations to winter oilseeds, field pennycress and camelina. The objectives are to i) determine optimal corn stover removal rates and subsequent impacts to soil carbon and oilseed productivity, ii) assess the role planting date and seed dormancy plays in establishment and yield for both the oilseeds and subsequent soybean yield along with providing critical information to the breeding/genetics researchers for future directions. Both objectives were designed with the express goal of increasing oilseed production in a double-cropped soybean system. Beyond determining the agronomic practices that increase the profitability and sustainability of Minnesota farmers, this project was designed to strengthen linkages between breeding/genetics and crop production faculty by providing a field orientated context to test and exchange ideas, along with offering interdisciplinary training to our graduate students. To successfully test objective one, corn stover gradients were achieved by removing a portion of the stover. Oilseed growth characteristics will be assessed throughout the season along with measuring soil organic C which provides an indirect assessment of soil health. Winter oilseed production is expected to be hampered by increasing corn stover rates, whereas, the soil organic C pool is expected to increase or at least be greater in the higher stover rates. The role of planted date and seed dormancy will be determined via field studies utilizing oilseed lines of varying dormancy coupled with gibberellin (i.e. removes dormancy) all interseeded into standing corn.