**Project Title:** Potential for Use of Perennial Grasses as Organic Dual-Purpose Forage-Grain Crops in Michigan

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## Project Summary

This project is an investigation to determine the effect of forage harvest on growth, regrowth, and grain production of two novel perennial genotypes. Perennials offer many environmental benefits, such as erosion control (Ewel, 1999; Glover et al., 2010; Jackson, 2002; Bell et al., 2010), decreased nitrate leaching (Culman and Snapp, Unpublished data), and improved soil quality (Franzluebbers et al., 2000; Dalal and Chan, 2001), as compared with annual species. In addition, perennial forages such as these may extend the grazing season, which is extremely desirable for organic farmers in Michigan.

We conducted a field experiment testing five treatments: fall-planted, uncut perennial wheat; fall-planted, cut perennial wheat; fall-planted, uncut intermediate wheatgrass; fall-planted, cut intermediate wheatgrass; and spring-planted, cut perennial wheat. Cut plots were harvested for forage each spring just before stem elongation and all plots were harvested for grain and stover in late summer each year. Spring-planted plots were only harvested in 2012.

In order to track growth, we made weekly plant height, growth stage, and leaf area index (LAI) measurements, biweekly tiller and leaf counts, and periodic (three times per year) biomass measurements. We evaluated post-sexual cycle regrowth each year by determining the percentage of plants that died each fall. We also measured the amount of spring forage, grain, and stover harvested each year, as well as quantifying the quality of spring forage and stover through neutral detergent fiber (NDF), acid detergent fiber (ADF), and in-vitro dry matter digestibility (IVDMD) analyses.

Overall, we found that perennial wheat produced more than two-fold higher grain yields than intermediate wheatgrass. Forage production was primarily made up of stover at grain harvest, and substantially higher amounts were produced by intermediate wheatgrass. In year one, perennial wheat produced equivalent forage to intermediate wheatgrass, but this was not the case in year two. A major challenge with perennial wheat was that it was less able than intermediate wheatgrass to initiate late-season regrowth, and thus maintain perenniality. Cutting regime did not initially affect plant growth, indicating the potential to use both crops for dual purposes (forage and grain). In the second year of cutting, during which the weather was very dry, there was an apparent reduction in regrowth among plants that were cut for spring forage. Overall, intermediate wheatgrass shows potential to be a robust perennial grass that produces forage under Michigan weather conditions, although selection for higher grain yield is clearly required if this new crop is to be a dual-purpose producer of grain and forage.

**Problem Addressed**

Despite the fact that grains provide more than 70% of calories consumed worldwide, none of the major commercial grain crops are perennials (Cox et al., 2004). Perennial grains would offer many environmental benefits, which were discussed in the previous section, as well as providing farmers with some exciting new cropping options. Perennial grains may be particularly useful for organic farmers, as they can thrive with decreased fossil fuel and agrochemical inputs (Jackson, 2002), and because some species offer excellent weed control for much of the year, after initial stand establishment (personal observations, 2012).

Midwestern organic farmers whom we interviewed described a diversity of creative uses for which they may find perennial grains desirable (Schmitt-Olabisi et al., unpublished data, 2012). For example, one organic farmer in Ohio talked about how he would be interested in the potential to plant perennial grains as buffer strips between his organic fields and neighboring conventional fields. Other farmers,

particularly those who already raise livestock as well as plant crops, were interested in the possibility of using perennial grains as dual-purpose forage-grain crops, since this system would enable them to harvest two products from a single field (Schmitt-Olabisi et al., unpublished data, 2012). In addition, dual-purpose crops are flexible in a way that may become very important under changing climate scenarios, as these crops allow farmers to cut their losses and harvest a forage crop in midsummer if drought or other unfavorable weather causes the grain crop to fail.

The overall goal of this project was to gain an understanding of the growth, regrowth, and production potential of two novel perennial grains in order to evaluate their potential to be grown as dual-purpose forage-grain crops by organic farmers in the Midwest.

**Project Objectives**

*Objective 1: To investigate effect of genotype (perennial wheat versus intermediate wheatgrass), planting date (spring versus fall planting), and cutting regime (spring cut versus uncut).*

It was important for us to compare the growth, regrowth, and production potential of each species under multiple management regimes in order to gain a better understanding of the comparative strengths and weaknesses of these two novel crops, as well as how they should each be managed for optimal production. The two cutting regimes were used to evaluate the effect of spring forage harvest on later growth, regrowth, grain production, and stover production. The spring-planted treatment was only implemented for cut perennial wheat, as its purpose was to determine whether increased rates of perenniality could be induced by allowing the plants to establish themselves for an entire year before allowing them to vernalize and complete their reproductive cycle.

*Objective 2: To evaluate initial stand establishment, early growth, regrowth after cutting, forage and grain harvest, and post-sexual cycle regrowth.*

As these plants are novel varieties, little is currently known about their growth, particularly in the northern Midwest region. By closely monitoring plant growth, regrowth, and production potential, we were about to gain a better understanding of how these plants may be used most effectively in this region.

*Objective 3: To determine robustness of perenniality based on post-sexual cycle regrowth.*

Perenniality is key to the usefulness of these plants. If vigorous regrowth does not occur for a substantial percentage of plants, many benefits of perennials, such as erosion control, weed control, and infrequent planting expenses, are not conferred and these crops would effectively be poorly yielding annuals. Therefore, it is critical to monitor perenniality for both species under all management regimes in order to discover strategies for optimizing this important characteristic.

## Methodology

*Field Experiment:* We established a field experiment in a randomized complete block design with four replications at W.K. Kellogg Biological Station. This experiment was designed to provide information regarding the growth, regrowth, and production potential of perennial wheat and intermediate wheatgrass under two cutting regimes (spring cut and uncut), as well as two planting times (fall-planted and spring-planted) for the cut perennial wheat.

Fall-planted plots were sown on October 13, 2010 and spring-planted plots were sown on May 3, 2011. Cut plots were harvested for forage each spring just before stem elongation and all plots were harvested for grain and stover in late summer each year. Spring-planted plots were only harvested in 2012. In addition, growth was evaluated based on weekly measurements of height, growth stage, and LAI, biweekly counts of leaves and tillers per plants, and periodic (three times per year) measurements of biomass dry weight. We also measured the amount of spring forage, stover, and grain produced each year, as well as the percentage of plants that showed new growth after grain harvest (i.e., post-sexual cycle regrowth).

*Laboratory Analyses:* We conducted NDF, ADF, and IVDMD laboratory analyses to determine the quality of spring forage and stover produced by each species. We also analyzed biomass samples collected after spring forage harvest, but before grain and stover harvest. These samples were intended to simulate a green chop that could be harvested under a scenario where weather conditions rendered grain harvest unprofitable or impracticable.

*Farmer Interviews:* Beginning in early 2012, we visited a number of farming and grazing conferences, as well as wheat growers' meetings, in order to identify farmers with an interest in being interviewed about their opinions and perceptions regarding perennial wheat and intermediate wheatgrass. During the spring and summer of 2012, we interviewed 11 farmers from Michigan, Ohio, and Indiana. Interviews were each about an hour long, with two to four researchers and one to three farmers present at each interview. When multiple farmers were present at a given interview, they were generally members of one family who worked one farm together. The interviews were transcribed and coded in the summer and fall of 2012 and these data are currently in the process of being analyzed.

## Results

*Growth:* In both the first and second years of growth, perennial wheat started out taller than intermediate wheatgrass. However, by harvest time each year, intermediate wheatgrass had surpassed perennial wheat in height (Figures 1 and 2). Similarly, perennial wheat had a higher LAI than intermediate wheatgrass early in the first year, but by the time grain was harvested intermediate wheatgrass had surpassed perennial wheat in LAI (Figure 3). In contrast, during the second year of growth, intermediate wheatgrass had an LAI that was consistently higher than that of perennial wheat (Figure 4). LAI is an important measurement because it

indicates the amount of light that penetrates the canopy, and thus it serves as a proxy for plant thickness and ability to compete with weeds.

*Regrowth:* At the end of the first year, fall-planted, cut perennial wheat regrew more poorly than the other treatments (Table 1). At the end of the second year, intermediate wheatgrass regrew better than any of the perennial wheat treatments. Fall-planted perennial wheat regrew better than spring-planted perennial wheat. Cumulatively over two years of growth, intermediate wheatgrass had the highest rate of regrowth, followed by fall-planted, uncut perennial wheat. Fall-planted, cut perennial wheat had the lowest percentage of regrowth after two years. Spring-planted perennial wheat had a two-year regrowth rate that overlapped with those of both the fall-planted perennial wheat treatments (Table 1).

*Grain Harvest:* Overall after two years, fall-planted perennial wheat treatments produced over twice as much grain as intermediate wheatgrass (Figure 5). Spring-planted perennial wheat produced as much grain in one year of production as fall-planted intermediate wheatgrass produced in two (Figure 5).

*Spring Forage and Summer Stover:* After two years, the two intermediate wheatgrass treatments had each produced the most spring forage and stover, while spring perennial wheat had produced the least (Figure 6). Among just the fall-planted treatments, cut intermediate wheatgrass yielded more spring forage and stover than cut perennial wheat and uncut intermediate wheatgrass yielded more than uncut perennial wheat. This indicates that, in general, intermediate wheatgrass produces more forage and stover than perennial wheat. In addition, it is important to note that the amount of stover produced by any given treatment was much larger than the amount of spring forage (Figure 6).

In the first two years of growth, the intermediate wheatgrass treatments generally produced higher quality (i.e., lower ADF and NDF and higher IVDMD) forage and stover than the fall-planted perennial wheat treatments. However, the reverse was seen in the first year when perennial wheat forage was of higher quality than intermediate wheatgrass (Tables 2 and 3). Early in the second year, spring-planted perennial wheat produced one of the highest quality forages measured. However, by the end of the growing season, it was one of the lowest quality forages. In general, forages from both species and all treatments tended to produce large amounts of forage, but they were of modest quality compared to other forages used in Michigan, and the forage reduced in quality throughout the year (Tables 2 and 3).
It is clear that more plant breeding improvements are needed but there is some potential for these novel crops to provide organic farmers with new product options.

**Conclusion**

The funding we received from the Ceres Trust was essential to the successful completion of this project. This funding helped offset the expense of travelling back and forth between the Michigan State University main campus in East Lansing, MI and W.K. Kellogg Biological Station in Hickory Corners, MI, where the field plots for

this research were located. Funding from the Ceres Trust also provided a graduate student and a field assistant with pay for their summer fieldwork. In addition, the Ceres Trust's funding enabled us to purchase supplies, such as filter bags, laboratory chemicals, field stakes, and wire, without which none of this research would have been possible.

**Outreach**

*Workshops and Presentations*

As part of this project, we presented versions of the poster "Potential for Perennial Grasses as an Organic Dual Forage-Grain Crop in Michigan" at the following meetings and conferences:

-ASA, CSSA, and SSSA International Annual Meetings, Cincinnati, OH. 21-24 Oct. 2012.

-Plant Science Graduate Student Research Symposium, Michigan State University (MSU), East Lansing, MI. 3 Apr. 2012.

-Organic Reporting Session, MSU, East Lansing, MI. 2 Mar. 2012.

-Annual Perennial Grain Meeting, Kellogg Biological Station (KBS), Hickory Corners, MI. 11-13 Jul. 2011.

-Organic Reporting Session, MSU, East Lansing, MI. 4 Mar. 2011.

We also made oral presentations with the title "Potential of Perennial Grasses for Use as Organic Dual-Purpose Forage/Grain Crops" at the following times and locations:

-M.S. Defense Presentation, KBS, Hickory Corners, MI. 12 Dec. 2012.

- Perennial Wheat and Grains Field Day and Farmer Assessment, KBS, Hickory Corners, MI. 27 Jun. 2012.

-Annual Perennial Wheat Project Meeting, MSU, East Lansing, MI. 23 Feb. 2012.

-Kellogg Biological Station Brown Bag Seminar, KBS, Hickory Corners, MI. 11 Nov. 2011.

*Printed Materials*

As part of this project, an M.S. thesis, entitled "An Evaluation of Perennial Wheat and Intermediate Wheatgrass as Dual-Purpose, Forage-Grain Crops, under Organic Management" was recently completed. At least one peer-reviewed journal article related to the fieldwork will be written in the near future. At least one peer-reviewed journal article based on data from the farmer interviews is also planned. Finally, an article for a grazing newsletter is also planned.

**Addenda**

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