Strategies for improving seed production of intermediate wheatgrass, a new perennial grain crop.

*Principle Investigator:* Craig Sheaffer.
*Project Partners:* James Anderson, Nancy Ehlke, Jacob Jungers, Don Wyse

Graduate student Charles Frahm (left) inspects intermediate wheatgrass seed heads. Project PI Dr. Craig Sheaffer (right) displays intermediate wheatgrass plants at an outreach event.

Intermediate wheatgrass stands after spring clipping and a control without clipping (left). Undergraduate students prepare harvested intermediate wheatgrass samples (right).
Abstract:
This project also reports IWG grain yields in response to variable N fertilizer rates, row spacing, and seasonal defoliation. Results from two years of data suggest that N fertilizers did not increase grain yields during year 1 at two locations in northern Minnesota, but yields increased in response to N fertilizer in year 2. Yield responses were similar between synthetic and organic nitrogen sources. During year 1, grain yields were greatest in the 6 inch row spacing, and yields declined linearly with increasing row spacing. In year 2, grain yields were similar across all row spacings and lower than in year 1. For the defoliation study, spring forage clipping did not affect summer grain yields in year 1. In year 2, grain yields were greater in plots that received both a spring and fall clipping for all row spacing treatments. Grain yields in unclipped plots decreased from year 1 to year 2 but remained stable in plots that were clipped in spring and fall. Forage yields from fall cutting were greater than forage yields from spring cutting; however, forage quality was greater in spring vs. fall cut biomass. Harvesting IWG biomass in spring and fall can provide an additional revenue stream for growers as well as increase grain yield and persistence.

Project background:
Intermediate wheatgrass (Thinopyrum intermedium, IWG) is a perennial grass that is being domesticated to serve as the world’s first widely available perennial grain crop 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 (Cox et al., 2010). Breeding activities at the University of Minnesota have successfully increased seed size and yield per acre, and food science research has shown that baking properties are suitable for a diversity of food products. Perennial plants such as IWG have extensive root systems that store carbon and effectively recycle nutrients such as nitrogen (N). Perennial plants also provide year-round ground cover and reduce soil erosion compared to annual row crops that leave the soil nearly bare during the winter (Glover et al., 2010). This project studied the effect of management strategies on grain yields of an advanced population of IWG, including effects of nitrogen fertilizer rates, row spacing, and seasonal defoliation. We conducted detailed morphological and developmental studies to understand the response of IWG to agronomic practices and to gain an understanding of stem lodging and yield changes with stand age.

Progress made towards goals:
Three experiments were successfully executed from 2015 to 2017. Results from experiment one show IWG grain yields were not affected by nitrogen fertilizer rates in the first year, and that IWG grain yields were greater when managed in 6 inch rows compared to 24 inch rows. In year 2, grain yields declined dramatically in the 6 inch rows. Year 2 grain yields were similar in the 24 inch rows compared to year 1, and peaked at a nitrogen fertilizer rate of 70 pounds per acre. Grain yields declined further in year 3 in both 6 and 24 inch rows.

In experiment two, we learned that year 1 IWG grain yields were greatest in the narrow row spacing, and that seeding rate did not affect grain yield. Grain yield declined in all row spacing treatments with stand age (Table 1).
Table 1. Intermediate wheatgrass grain yields (lbs/acre) in response to row spacing and seeding rates.

<table>
<thead>
<tr>
<th>Seedling rate (lbs/acre)</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row Spacing</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>865</td>
<td>798</td>
<td>202</td>
</tr>
<tr>
<td>12</td>
<td>586</td>
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<tr>
<td>30</td>
<td>397</td>
<td>405</td>
<td>185</td>
</tr>
</tbody>
</table>

In experiment three, we measured forage yield of IWG cut in spring and fall, and measured the effects of spring, fall, and spring + fall forage cutting on subsequent year grain yield. Forage yield was usually lower in the spring compared to the fall (spring mean forage yield = 0.6 tons per acre; fall mean forage yield = 4.0 tons per acre), but spring forage had higher relative feed value (RFV) compared to the fall (spring RFV = 153; fall RFV = 105).

Spring and fall forage clipping prevented IWG grain yield declines from year 1 to 2 (2015 to 2016) compared to the control, however, grain yields continued to decline in all treatments by year 3 (2017). Grain yields were unaffected by row spacing until year 3 (2017), when 24 inch rows produced lower yields compared to 6 and 12 inch rows.
Figure 1. Intermediate wheatgrass grain yield followed by spring, fall, or spring + fall forage biomass clipping in stands seeded in 6, 12, or 24 inch rows.
**Long-term sustainability and impact of the project:** The experimental plots developed for this project will be maintained as long as additional funds can be obtained to continue measurements. Long-term data are needed for perennial crops like IWG. The impact of this project is significant. The information garnered from this project has been presented to producers and landmanagers across Minnesota at field days, conferences, and grower meetings. It is also being incorporated into a “Kernza growers guidebook”. This agronomic data will help farmers manage profitable IWG crops and provide perennial grain for the rapidly growing market.

**Additional funds secured to continue the project:** We have received grant funding to extend the IWG research program to compliment the experiments conducted with this FGI grant. The following grants are related to the IWG research and were awarded by leveraging this FGI grant.


2016 – 2018 **USDA AFRI Postdoctoral Fellowship.** Quantifying the greenhouse gas mitigation potential of a potential perennial grain crop; intermediate wheatgrass. PI – J. Jungers ($149,807)

2015 – 2016 **The Land Institute and Malone Family Land Preservation Foundation Perennial Agriculture Research Fellowship.** Agronomic methods for increasing perennial grain yields of Kernza intermediate wheatgrass. PIs – C. Sheaffer and J. Jungers ($103,713)


2016 – 2017 **Minnesota Department of Agriculture – Forever Green Initiative.** Advanced management practices for enhancing profitability of intermediate

Undergraduate, graduate student and post-doc education and opportunities provided by the grant: This project funded a Master’s degree graduate program for Charles Frahm. The project also provided internship opportunities to 3-4 undergraduates during the summer of each year of the project. Two post-docs worked on this project with supplemental support from additional funds listed above.