What's Cropping Up?

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Perennial Grain Crop Production in New York State

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What are perennial grain crops?

Grain crops constitute the majority of human caloric intake and have been bred for high yields and consistent production. Although these crops are incredibly productive and feed billions of people every year, intensive cultivation of grain crops can contribute to soil and water degradation because of annual operations that often include planting into tilled soil. Perennial grain crops are one solution to some of the problems associated with annual grain crops. Perennial grain crops have lower annual production costs than annual grain crops because farmers do not need to purchase seed or use labor and fuel for planting each year. Because of year-round ground cover and deeper root systems than annual crops, perennial grains can also be produced more sustainably on sloped land that is prone to soil erosion.

Fig. 1. Kernza, a perennial grain, prior to grain harvest at the Cornell Musgrave Research Farm in Aurora, NY, on August 11, 2016.

Dr. Wes Jackson, founder of the Land Institute in Kansas, has been promoting perennial grains for the last 40 years. At first perennial grain crops were just an idea, but now they are becoming a reality and attracting the attention of farmers, bakers, brewers, and consumers. One particular perennial grain crop, intermediate wheatgrass (*Thinopyrum intermedium*) is especially advanced and well poised for adoption. However, grain yields of intermediate wheatgrass are substantially lower than from comparable annual grain crops, such as wheat.

Intermediate wheatgrass is a long-lived, rhizomatous perennial grass native to central Asia. In the early 1980's, researchers at the Rodale Institute evaluated nearly 100 perennial grass species for potential domestication, and selected intermediate wheatgrass due to its favorable yield potential, nutritional profile, and suitable agronomic traits. Work with intermediate wheatgrass was later carried out at the NRCS Big Flats Plant Materials Center in Big Flats, New York. Now,

Fig. 2. De-hulled Kernza grain (left), harvested from plots in Aurora, NY and a can of the first commercially available product made from Kernza grain (right).

Dr. Lee DeHaan at the Land Institute in Kansas is leading breeding efforts with this perennial grain crop, which is marketed as Kernza®.

Kernza is gaining in popularity and some food enthusiasts are speculating that consumers will gladly pay a higher price to compensate farmers for lower grain yields. The Perennial, a restaurant in San Francisco, serves bread made from Kernza (www.theperennialsf.com). An offshoot of the sustainable outdoor clothing company, Patagonia Provisions, in partnership with Hopworks Urban Brewery, recently launched a beer made with Kernza, "Long Root Ale" (Figure 2, www.longrootale.com). Although the first commercial production of Kernza has just begun, there appears to be consumer interest and demand for perennial grain products.

The Cornell Sustainable Cropping Systems Lab has been working on perennial grains for the past two years. Here we summarize some of our recent projects related to perennial grains.

Multi-site forage experiment

In August of 2014, we initiated a long-term experiment (Figure 3) at the Cornell Musgrave Research Farm in Aurora, NY in collaboration with Dr. Steve Culman (a Cornell Soil and Crop Sciences alumnus, now Assistant Professor of Soil Fertility at The Ohio State University) and five other researchers across the US. The objectives of this experiment are to: 1) determine the effects of harvesting forage on Kernza grain yields and profitability, and 2) evaluate Kernza grain and forage yields over time across multiple environments.

We planted Kernza at 15 lb seed/acre at 7.5-inch row spacing using a grain drill. Although this experiment compared several treatments, here we focus on two. One treatment, 'Grain', was harvested for grain and then straw in the summer. The other treatment, 'Forage & Grain', included a spring forage harvest prior to stem elongation (Figure 4) in addition to the summer grain and straw harvest. We measured forage yield, grain yield, and plant height at grain harvest.

In 2015, grain yield was lower in the 'Forage & Grain'

Fig. 3. Farmer advisors and Cornell University researchers evaluate a plot of Kernza at the Musgrave Research Farm, July 19, 2016.

Fig. 4. Kernza harvested for forage prior to stem elongation by cutting the early vegetative growth to a height of 4-inches on May 9 2016.

treatment compared to the 'Grain' treatment (Figure 5), showing that harvesting forage in the spring can reduce grain yields slightly. In 2016, there was no difference between these treatments. Straw production was greater in the 'Grain' treatment than in the 'Forage & Grain' treatment in both years (Figure 5). Spring forage yields in the 'Forage & Grain' treatment averaged 1,390 lb/ac (standard error ±340 lb/ac) across both years. Noteworthy is that the spring biomass had better forage quality than the straw at grain harvest (Table 1). Although it appears that Kernza can produce high quality forage, which might offset the relatively low grain yields and increase profitability, more research is needed to determine how harvesting forage in the spring prior to stem elongation affects crop performance.

Table 1. Forage quality metrics for Kernza forage harvested in spring at elongation and in summer at grain maturity in 2015. Prime forage standards from "What is Forage Quality", Ashley Pierce, Rensselaer County Cornell Cooperative Extension. Spring forage harvest dates were May 22, 2015 and May 9, 2016. Summer straw forage harvest dates were September 11, 2015 and August 31, 2016.

Forage quality metric	Spring Vegetative Forage	Summer Straw Forage	Prime forage standards
Crude Protein %	19 (1.2)	30 (1.7)	> 19
Total Digestible Nutrients %	77 (0.2)	68 (0.3)	--
Relative Feed Value	214 (2.9)	144 (2.6)	> 151
Acid Detergent Fiber %	16 (0.3)	29 (0.5)	< 31
Neutral Detergent Fiber %	33 (0.4)	43 (0.6)	< 40
Net Energy Mcal/100 lb.	83 (0.3)	67 (0.7)	--

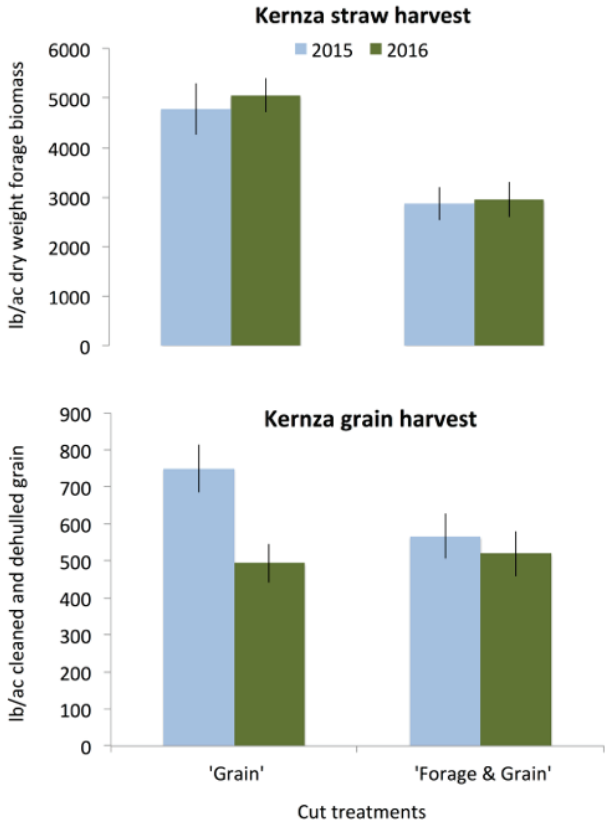

Fig. 5. Kernza straw (above) and grain (below) yield for treatments 'Grain' and 'Forage & Grain' in 2015 and 2016. Error bars indicate standard error within each treatment within a year. Harvest occurred on September 11, 2015 and August 23, 2016. Kernza grain yields are based on a subsample of hulled grain that was hand threshed and a conversion factor was then used to estimate yield expressed as cleaned and de-hulled grain.

Perennial grains survey

Given that perennial grains are a novel development and farmers have not grown these crops before, we conducted an online survey with Dr. Christophe David from ISARA-Lyon in France, to assess farmers' potential interest in perennial grains. A link to the survey was e-mailed to farmers in the US and France, and posted on pertinent farming websites. A total of 88 and 319 farmers, in the US and France respectively, responded to the survey between June 23 and July 25, 2016.

Farmers were asked about: 1) their previous knowledge of perennial grains, 2) their interest in growing them, and 3) factors motivating their interest. Fifty-eight percent of respondents said they were "interested" or "very interested" in growing perennial grains, and 39% said they "needed more information". Seventy-three of farmers who had already heard about perennial grains before the survey said they were "interested" or "very interested", whereas 47% of farmers who did not know about these crops said they were "interested" or "very interested". The top three reasons selected by farmers for growing perennial grains were: "*to increase or maintain farm profitability*" (56%, n=188), "t*o reduce labor requirements*" (44%, n=145), and "*to improve soil health*" (44%, n=145)."

New perennial grain field experiment

In September 2016, we started a 3-year field experiment at Cornell Musgrave Research Farm in addition to planting three on-farm strip trials with collaborating farmers. The goal of this work is to measure the effect of perennial grains on soil health and to work with farmers to develop management guidelines. The grain from our field experiments will be tested by local bakers, brewers, and distillers, which will help guide future research.

At the Cornell Musgrave Research Farm we are comparing perennial rye (*Secale cereale* x *S. montanum*) and Kernza side-by-side with an annual malting barley cv. 'Endeavor' and a hard red winter wheat cv. 'Warthog'. These plots will have a split-plot treatment of interseeded red clover, which is a short-lived perennial legume forage crop. Frost-seeding red clover into winter wheat is common for farmers in New York, as it can improve soil health and also be harvested for forage. We selected these treatments to compare the two most promising perennial grain crops to two annual grain crops that farmers are currently growing in the region. Grains were drill seeded at 7.5-in row spacing using the standard seeding rate for each species on September 19, 2016. We aim to test two hypotheses over the next three years: 1) Transitioning fields used for annual grain crop production to perennial grain crop production increases soil health, and 2) Intercropping legume forage crops with perennial grain crops reduces need for nitrogen inputs compared to perennial grain monocultures. In addition to evaluating soil health parameters, we will also be monitoring crop and weed biomass, disease incidence, yield, and grain quality to further inform future development of best management practices for perennial grain cropping systems.

Kernza Conference

The Land Institute hosted a meeting in July 2016 to bring together researchers from around the world who are interested in Kernza. Attendees included plant breeders, geneticists, agroecologists, and producers of grain-based products. Sandra Wayman represented the Cornell Sustainable Cropping Systems Lab and presented on our research. The take-home message from this meeting was that there is strong interest in developing products made from Kernza and more research is needed for management practices. For example, Zachary Golper, baker and owner of *Bien Cuit* in Brooklyn, spoke about the need to scale up production to support his interest in incorporating Kernza into his products.

Conclusions

Perennial grains are becoming a plausible option for farmers. Although grain yields are still much lower than annual grain crops, harvesting perennial grain for both forage and grain could increase profitability. Additionally, growing perennial crops on land unsuitable for annual crops that require yearly tillage (e.g. sloped land) could make them more attractive to farmers. As with any new crop, we have experienced some challenges in our research including difficulty harvesting grain and weed suppression during the establishment year. However, we remain optimistic about perennial grain crop production in New York and look forward to working with our farmer collaborators to improve production.

Reference Cited

Jackson, W., 1980. New Roots for Agriculture. U of Nebraska Press.

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