Potential agronomic and soil carbon contributions from the perennial wheatgrass Kernza in California?

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Introduction

The vast majority of global grain production relies on annual crop species. However, there is growing interest in perennial grain crops. Perenniality refers to a plant's growth habit, specifically, a perennial crop regrows after grain/fruit and/or aboveground biomass has been harvested without the need to replant each year[1]. Previous research has shown that perennial crops provide ecosystems services such as soil conservation, N cycling efficiencies, and the maintenance of soil C pools[2]. Kernza is an intermediate wheatgrass (*Thinopyrum intermedium*) developed by The Land Institute and selected for its grain production potential.[2] Currently there is interest in Kernza and other perennial grain crops in the specialty foods market because of their perceived sustainability and potential to provide ecosystem services as well as food.

Because limited research has been done on Kernza's grain production and potential ecosystem services[1], and none of it in California growing conditions, a stand of Kernza was established in the fall of 2014 at Russell Ranch in Yolo County California to test its potential for grain production and ecosystems services.

Goals & Objectives

The goal of this research is to evaluate Kernza for its agronomic properties under California growing conditions and to measure its potential for soil carbon maintenance and/or contribution. Experimental objectives include:

- Measure the biomass yield and harvest index (HI) for plants grown with varying water & nitrogen (N) management/availability.
- Measure the change in soil labile carbon as a result of undisturbed, multi-year growth of Kernza as compared to fallow soil.
- Estimate the monetary value of Kernza production both as a specialty grain and as a mechanism for sequestering carbon.

Methods

A stand of Kerna was establish at Russell Ranch in the fall of 2014. During its second year of re-growth (2015-16), 2m x 4.5 m plots with irrigation treatments (+/- 0.75" applied early & late spring) and nitrogen (N) treatments (0, 60, 120 lb/acre applied late-January) were imposed with 3 replicates. In September 2016, aboveground biomass samples were taken, and the grain was hand threshed and weighed to estimate its harvest index. Soil samples were taken to 6 ft for the 0 N treatments and for the surrounding area that had been fallow during the Kernza growth. Soils were analyzed for permanganate oxidizable carbon[3] (Pox-C) from 0-12" and 12-24".

Results

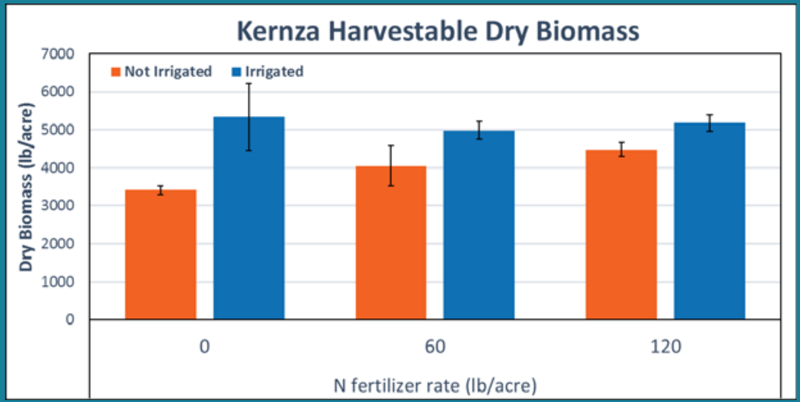

Figure 1. Total aboveground biomass for Kernza wheatgrass during the second year of growth (2015-16) in plots that either received two separate applications of 0.75" of water during the early reproductive growth phase (late-spring) or in plots that did not, across three N fertilization levels. Results from this limited irrigation treatment indicate that the rainfed crop was water-limited and that water was more limiting than N.

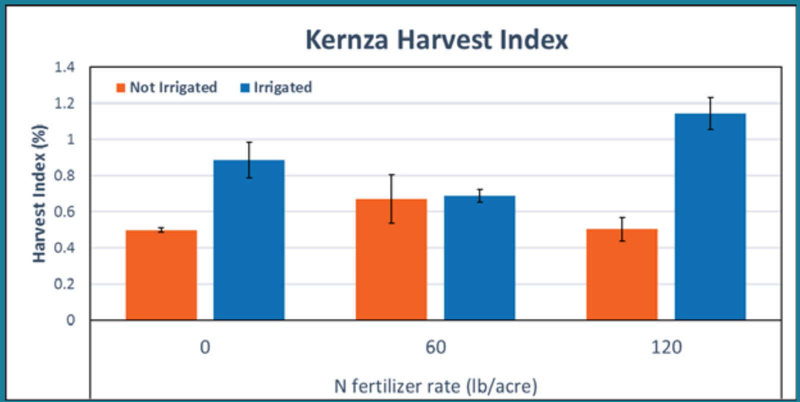

Figure 2. Harvest index (harvested grain expressed as a % of aboveground biomass) for Kernza wheatgrass during its second year of growth (2015-16) in plots that either received two separate applications of 0.75" of water during the early reproductive growth phase (late-spring) or in plots that did not across three N fertilization levels. The harvest index measured is well below those reported in other regions (10%)[2].

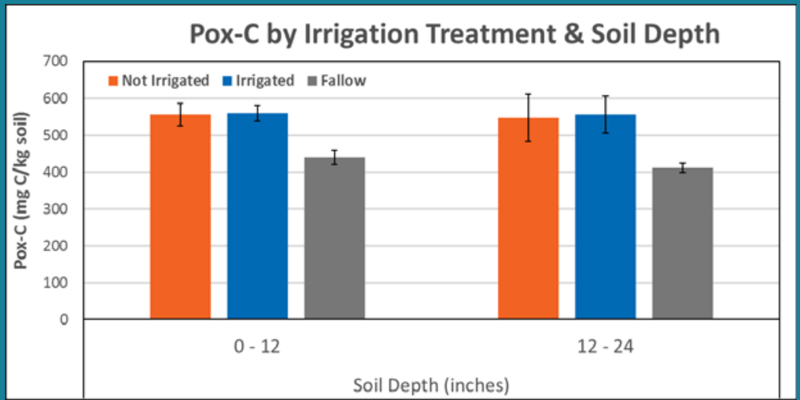

Figure 3. Permanganate oxidizable carbon[3] (Pox-C) from 0-12" and 12-24" soil depths in rainfed and irrigated plots as compared to soil surrounding the Kernza wheatgrass plots, which had been fallow for the duration of the 2014-15 and 2015-16 seasons. Results indicate a 30% increase in belowground labile organic carbon after two seasons of undisturbed growth as compared to fallow soil that was periodically tilled during the same period.

Discussion

Plant biomass increased significantly with pinpointed irrigation at a critical growth stage (early reproductive growth) when little natural rainfall occurs in California's Central Valley. Although there was a detectable trend of increasing biomass productivity with increasing N treatments under rainfed production (Fig. 1), the crop was more limited by water than N. Biomass of 3000-5000 lbs/acre in year 2 is comparable to first year biomass production reported in upper-Midwest of US[2]. Harvest index (HI) is low at about 1% for irrigated plots and 0.5% for non irrigated plots (Fig 2), compared to a HI of10% after two years and 60 lb $acre^{-1}$ N[2]. In order to gross \$250 $acre^{-1}$ with an aboveground biomass yield of 5000 lb acre and a premium specialty grain price to the farmer of \$1/lb, the HI would need to be at least 5%.

Kernza significantly increased storage of labile ("active") organic carbon as compared to the fallow. Down to 2ft, the soil in both irrigated and non irrigated plots had Pox-C measurements of about 550 mg kg^{-1} C while the fallow soil measured 400 mg kg^{-1} C (Fig. 3). If, as a simplifying assumption we relate this increase directly to increases in long-term soil organic C, there may be scope for monetizing the increases in soil C via carbon markets. This could add to the overall gross crop value and may improve its economic viability. However, soil measurements across the entire rooting depth and considering more stable carbon fractions would be necessary.

Summary

- Kernza wheatgrass was water-limited when grown under rainfed conditions in the Sacramento Valley and demonstrated a limited response to N fertilizer
- Harvest index was low and responsive to increased in water availability during reproductive growth.
- Two years of Kernza growth increased active carbon in soils down to 2ft.
- More research must be done (plant and soil effects after a 3rd season, total soil C, and analysis of soils to 6ft depth) to measure Kernza's crop potential in California.

References

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2. Culman, S.W., et al. 2013. Soil and Water Quality Rapidly Responds to the Perannial Grain Kernza Wheatgrass. Agronomy Journal 105:735-744.
3. Weil, et al. 2003. Determination of Permanganate Oxidizable Carbon. https://lter.kbs.msu.edu/protocols/133

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