Perennial wheatgrass- alfalfa bicultures enhance soil health and plant productivity

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BACKGROUND

- Modern agricultural practices have eroded soil health across large swathes of Midwestern United States. [3]
- In response, there has been renewed interest in exploring alternatives to monoculture agriculture as well as the development of new crops that are inherently more sustainable.
- One promising alternative is Kernza, a deep-rooted perennial wheat grass developed at The Land Institute (Figure 1). Although Kernza has the potential to improve soil health, the available data are limited.
- Here, we explored the effects of growing Kernza as mono- or in bi-culture (with alfalfa, a perennial legume) on two key components of soil health, nutrient availability and mycorrhizal function.

OBJECTIVE

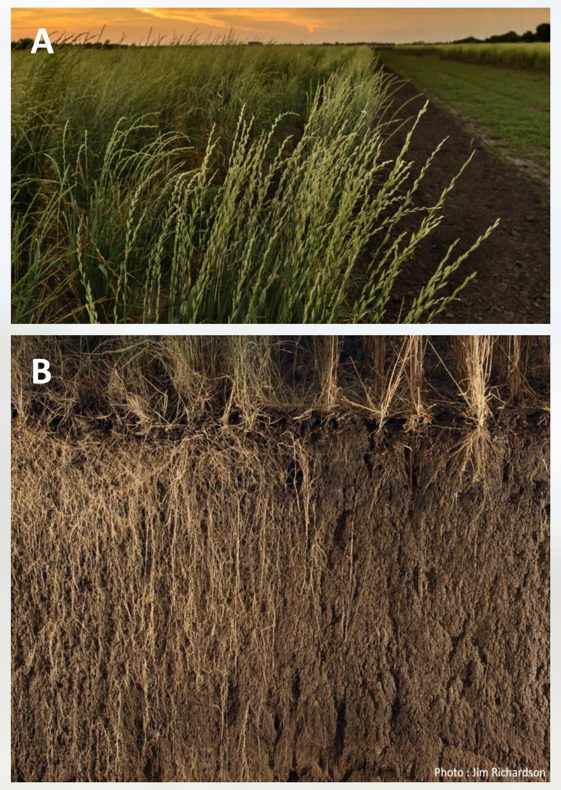

Figure 1. A) Kernza crop aboveground; B) Deep roots of Kernza in a soil profile. Images sourced from The Land Institute

Our objective was to document variations in soil nutrient levels and mycorrhizal function generated by Kernza mono- or bi-culture and a tallgrass prairie restoration.

We used these data to test the hypothesis that planting Kernza in degraded soils produces increases in soil health factors that are comparable to a perennial tallgrass prairie restoration.

METHODS

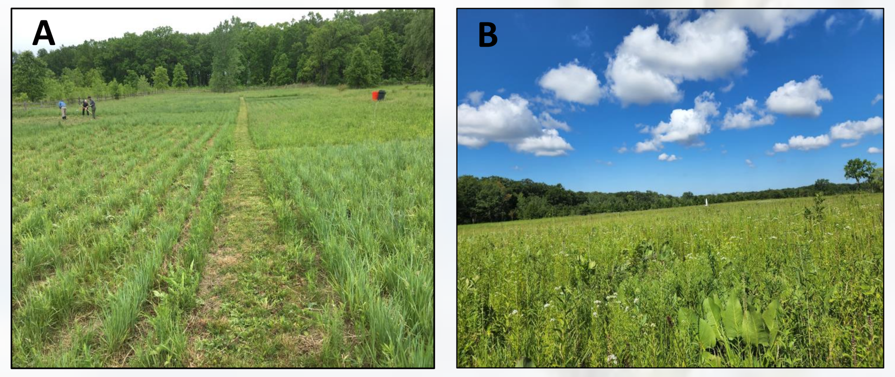

Figure 2. A) Experimental plots of Kernza mono- and bi-cultures at Mettawa, IL; B) Restored tallgrass prairie site, Mettawa, IL.

Soil Sampling

Soil samples (15 cm deep) were collected from an experimental plot established on a degraded farm field in 2018, and planted with Kernza monoculture and bicultures with alfalfa (Figure 2A). Additional samples were collected from an adjacent tallgrass prairie restoration (Figure 2B).

Soil nutrient levels

Soils from each site were analyzed for gravimetric moisture; plant-available N (NH_4, NO_3) and PO_4, and reactive carbon by colorimetry- spectrophotometry; and pH (pH probe).

Mycorrhizal function (bioassay)

Pots containing a soil mix were inoculated with intact or autoclaved (i.e., sterilized) soil cores from each site. Peas (*Pisum sativum*) were grown for five weeks, harvested and dried, and plant biomass and arbuscular mycorrhizal fungal (AMF) root colonization documented.

RESULTS

Table 1. Levels of plant- available nutrients that differed between mono- and bi-culture plots and prairie restoration. Data given as means with standard deviation in parentheses. Means within rows with the same letter do not differ significantly at p< 0.05 (ANOVA).

	Monoculture	Biculture	Prairie
Ammonium (NH_4)	4.3 (0.9) [b]	5.7 (0.7) [a]	3.9 (0.4) [b]
Nitrate (NO3)	7.6 (4.7) [a]	6.7 (3.9) [a]	2.1 (2.1) [b]
Reactive C (POXC)	605 (43) [b]	647 (44) [a]	596 (37) [b]

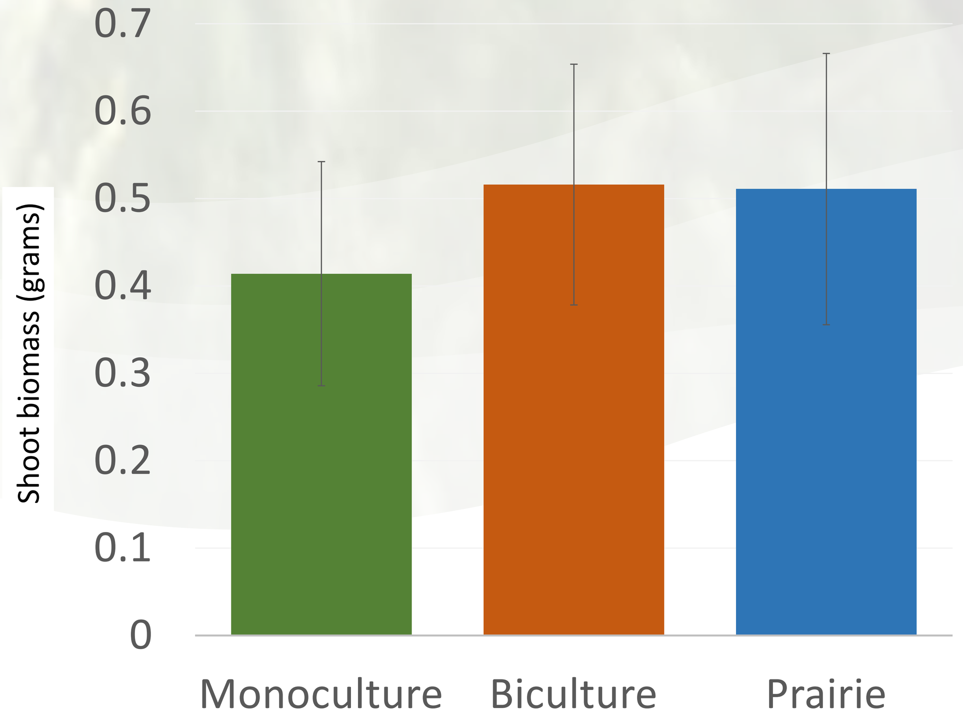

Figure 3. Shoot biomass in pea bioassay plants grown with soil inoculum from mono- and bi-culture Kernza plots, and a prairie restoration.

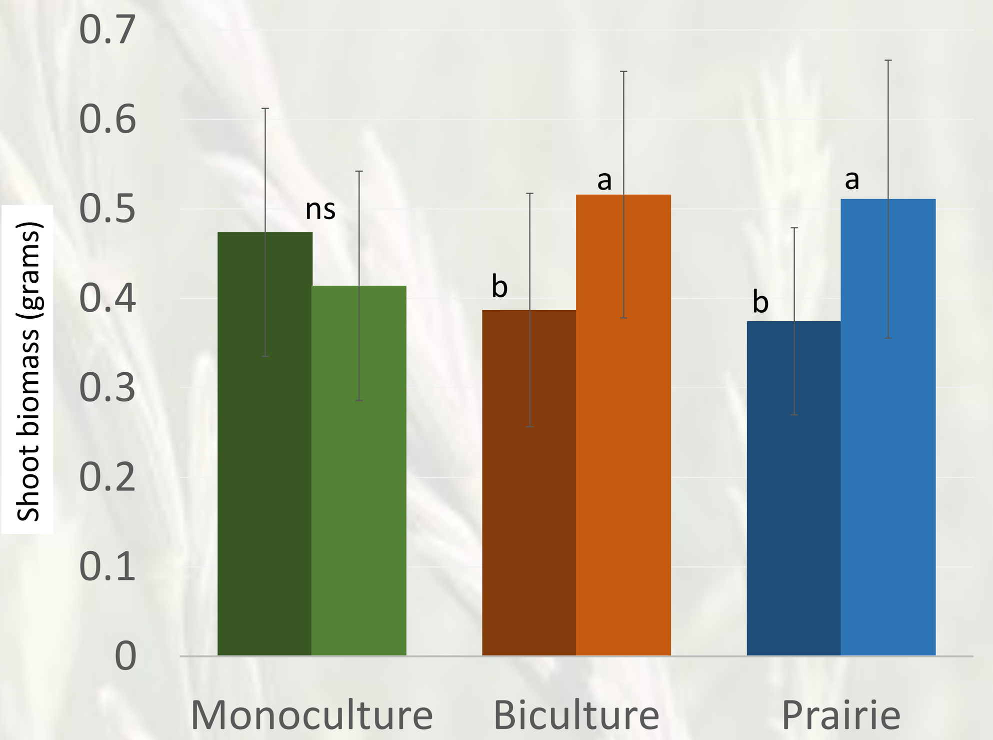

Figure 4. Shoot biomass in pea bioassay plants grown with live or sterilized (control) inoculum from mono- and bi-culture Kernza plots, and a prairie restoration.

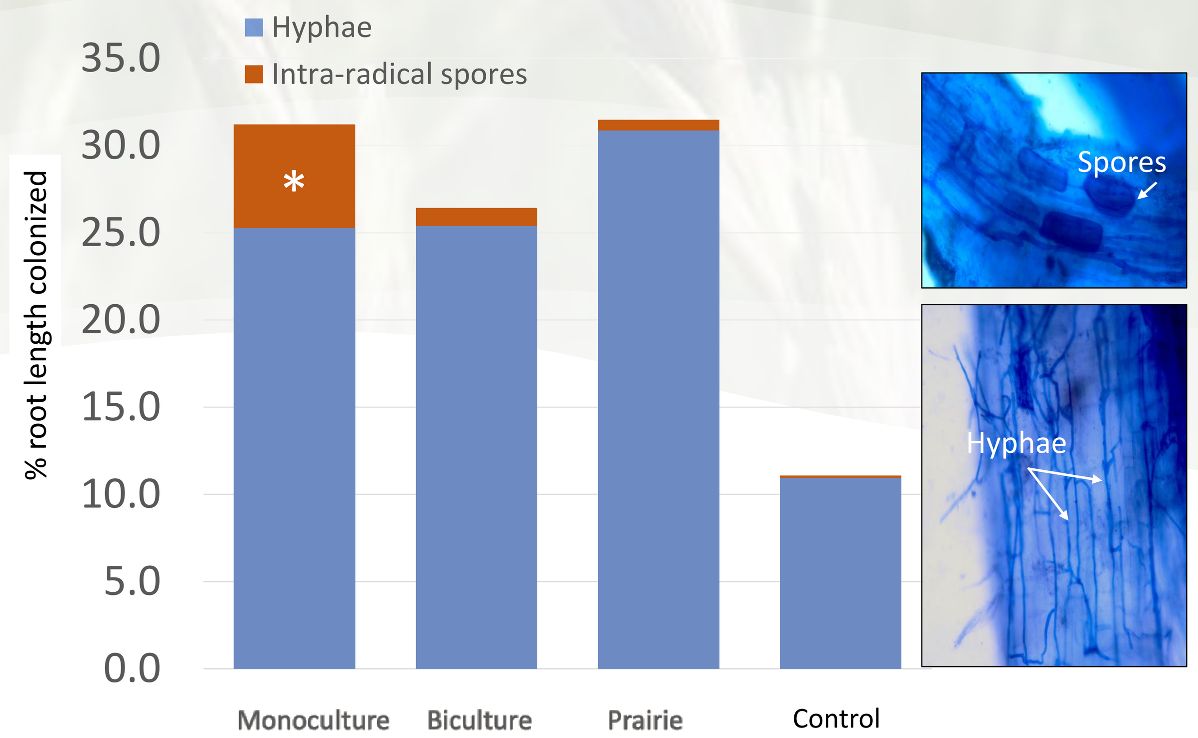

Figure 5. Arbuscular mycorrhizal root colonization of bioassay plants. Inset: microscope images of hyphal colonization on roots, and intra-radical spores and vesicles.

RESULTS

- *Soil nutrients*: Levels of NH4 and NO3 were significantly higher under mono- and bicultures than the prairie restoration (Table 1). Reactive C, an indicator of soil health, was significantly higher in biculture soils than monoculture or prairie soils. Soil moisture, pH and P did not differ between sites.
- *Bioassay*: Shoot biomass was significantly higher in plants inoculated with biculture or prairie soils than monoculture soil (Figure 3). Plants receiving fresh inoculum showed a significant growth response over controls (sterilized) for biculture or prairie soils (Figure 4). Plants receiving fresh or control inoculum from monoculture plots showed similar biomass (see McKenna et al. 2020).
- *AMF root colonization*: Levels of AMF root colonization were similar across treatments (~30% vs 10% control; Figure 5). Roots of plants inoculated with monoculture soil were also well colonized by large intra-radical spores that, morphologically, were consistent with the less mutualistic AMF species, *Rhizophagus intradices.*

CONCLUSIONS

- Planting Kernza biculture- but not monocultures- produced increases in soil health factors comparable to a tallgrass prairie restoration, indicating some abiotic-biotic context dependencies in Kernza.
- The synergy between Kernza and alfalfa improved soil health (reactive C) and also promoted the development of microbial communities, e.g. AMF, that enhanced plant biomass accumulation.

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