Ecosystem Services of Kernza-Alfalfa Intercrops

2019 Kernza Conference, Madison, Wisconsin
Tim Crews, The Land Institute
1. Can intercropping with a legume support the nitrogen demands of an IWG crop?

2. Are there other ecosystem services captured by intercropping IWG and a legume?
Legume abundance

Low

High
Research sites and on-farm trials of IWG-legume intercrops

AUS (Down under)
1. Can intercropping with a legume support the nitrogen demands of an IWG crop?

2. Are there other benefits or drawbacks to intercropping other than N fixation?
Perennial Kernza-alfalfa biculture plots
Kernza (K) and Kernza-alfalfa (A) intercrop treatments

K-nil

K-nil + N
(75 kg ha\(^{-1}\))

K-alf

KK

KK + NP
(150 kg ha\(^{-1}\))

76 cm

38 cm
Kernza (K) and Kernza-alfalfa (A) intercrop treatments

- **K-nil**
- **K-nil + N** (75 kg ha\(^{-1}\))
- **K-alf**
- **KK**
- **KK + NP** (150 kg ha\(^{-1}\))

Dimensions:
- 76 cm
- 38 cm

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**Diagram Description**

1. **K-nil**
   - A single row of crops.

2. **K-nil + N** (75 kg ha\(^{-1}\))
   - A single row of crops with an additional nitrogen application.

3. **K-alf**
   - A single row of crops mixed with alfalfa.

4. **KK**
   - A single row of crops mixed with another crop.

5. **KK + NP** (150 kg ha\(^{-1}\))
   - A single row of crops mixed with another crop and additional nitrogen application.
Net N mineralization in field and lab soil incubations

Repeated field assays 0-22cm
4 plot reps incubation⁻¹, 2 cores rep⁻¹, 3 lab reps core⁻¹

Lab assay 0-100cm
4 plot reps, 2 cores rep⁻¹, 5 depths core⁻¹, 2 lab reps depth⁻¹
Natural abundance $^{15}$N of shoots from alfalfa (A), Kernza intercropped with alfalfa (KA) and Kernza monocropped (K) in the third year of production.
KA yield was significantly higher than K or KK in 2017.

KA was the only treatment that did not significantly decrease in yield over time.

K+N yield was significantly higher than KK yield in 2014 and 2017.

Mixed Model Type 3 Tests of Fixed Effects

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<tr>
<th>Effect</th>
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<th>Den DF</th>
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Grain yield significantly decreased over time in K+M and K treatments, but not in KA or KA-M treatments.

Grain yield in 2017 was significantly higher in KA than in K plots.

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Ecosystem Services: N$_2$O emissions reduced
Kernza (K) and Kernza-alfalfa(A) intercrop treatments

- **K-nil**
  - 76 cm

- **K-nil + N**
  - 75 kg ha\(^{-1}\)
  - 76 cm

- **K-alf**
  - 38 cm

- **KK**
  - 38 cm

- **KK + NP**
  - 150 kg ha\(^{-1}\)
  - 38 cm
$\text{N}_2\text{O Fluxes from single species Kernza plots (fertilized and unfertilized) and Kernza-alfalfa intercrops}$

\[ \text{µL N}_2\text{O m}^{-2} \text{h}^{-1} \]

- Biculture
- Fertilized Kernza Monoculture
- Unfertilized Kernza Monoculture
N2O emissions during two growing seasons in unfertilized Kernza-Kernza (KK), Kernza-alfalfa (KA), and fertilized Kernza-Kernza (KK+NP) plots.
VA Mycorrhizae responsiveness of 19 prairie and crop species in greenhouse trials
Ecosystem Services: Carbon sequestration

Photo: Jim Richardson
Net Carbon Balance of Grassland to Kernza-alfalfa Conversion in Eastern Kansas

GPP = Gross Primary Production
NEE = Net Ecosystem Exchange
Reco = Ecosystem respiration

de Oliveira, Brunsell, Crews and Kemp unpublished
Ecosystem Services: Water Resource Partitioning
Mid-day (top) and pre-dawn (bottom)
Leaf water potential in IWG (K) and IWG-alfalfa Intercrops from June 9 - July 13

IWG growing with alfalfa (KA,K) is not more Stressed than wide-spaced IWG single species (K)

As the summer progresses, alfalfa does not experience the moisture stress of IWG.

Nosshi (2019)
Percent of water uptake by intermediate wheatgrass intercropped with alfalfa from three soil depths in spring and late summer.
1. Can intercropping with a legume support the nitrogen demands of an IWG crop? Getting there.

2. Are there other ecosystem services captured by intercropping IWG with a legume?
   - Reduction in N2O emissions
   - C sequestration
   - Water resource partitioning and possible facilitation
   - Attenuate yield decline
   - Dual use forage quality
Thanks To:

**Collaborators**
Ebony Murrell
Ben Sikes
Tom McKenna
Nate Brunsell
Gabriel de Oliveira
Maged Nosshi

**Field Assistance**
Laura Kemp
James Bowden
TLI Summer Interns

**Support**
Malone Family Land
Preservation Foundation
Ecological Intensification

Vegetation

Soil microbial community

Soil development
• Letters indicate differences among treatments within a given year (shared letter=no significant difference).

• All treatments declined in ANPP over time.

• KK+NP had significantly higher yield than KK in all years except 2013.

• KA had lower ANPP than N-fertilized treatments in 2014, but otherwise had intermediate ANPP throughout the study.
• No significant treatment or treatment*year interaction effects

• ANPP in all treatments dropped significantly between 2013-2014, was stable for 3 years, then significantly dropped again in 2017.

### Mixed Model Type 3 Tests of Fixed Effects

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</table>
de Oliveira, Brunsell, Crews and Kemp unpublished
Fig. 4. The amounts of shoot N fixed as a function of aboveground net primary productivity (ANPP) in perennial forage legumes (solid diamonds, n = 83, y = 22.81x + 6.21, R² = 0.68), annual forage legumes (open triangles, n = 46, y = 26.01x + 8.37, R² = 0.78), and annual crop legumes (Xs, n = 123, y = 13.06 + 26.92, R² = 0.75). Perennial forage data from Carlsson and Huss-Danell (2003), annual forage data from Unkovich et al. (2010), and annual crop legume data from Peoples et al. (2009a).
Fig. 1. Example of a perennial grain-legume intercrop through a growing season. (a) **Spring.** The two species break winter dormancy producing similar aboveground biomass. (b) **Early summer.** The canopy of the grain crop overshadows and suppresses the legume. **Late summer.** Following grain harvest, light reaches the legume inducing a surge of growth and N$_2$ fixation. Livestock grazing or mowing may be employed to manage biomass accumulation.