Dryland crop production systems

- Highly dependent on **soil water storage**
- Fallow systems can **increase the stability of grain production**
- **Fallow moisture storage**
  - Depends on fallow management (tillage vs no-till, residue amounts, time of year, etc.)
  - Wheat-Fallow: 12-25% PSE
  - Wheat-Summer Crop-Fallow: 20-30% PSE

- **Tillage and low residue** in fallow systems has **negative effects on soil health and water storage**
Replacing fallow with cover crops

- Cover crop benefits
  - Provide residue cover to protect the soil
  - Reduced erosion
  - Improve soil organic matter & soil structure
  - Weed suppression
  - Forage for livestock

- But cover crop uses water that may affect subsequent crop yields

- Using cover crops for forage will provide economic benefits

- Developing efficient dryland cropping systems with livestock integration is crucial because of declining irrigation water levels
Research objectives

• Determining the forage production potential of cover crops in western Kansas

• Evaluating the impacts of cover crop management strategies on soil health

• Determining the effects of cover crop management strategies on weed suppression and cash crop yields

• Determine overall system profitability with grazing cover crops
Research sites across western Kansas
Cover crops in wheat-sorghum-fallow

Western Kansas (Alexander, Brownell & Hays, KS)

A: Spring-planted cover crop into sorghum stubble

B. Summer-planted cover crop after wheat harvest
Central Kansas, Rainfed

A: Fall-planted cover crops into wheat and sorghum stubble
Cover crops in continuous corn

Southwest Kansas, Irrigated

A: Fall-planted cover crops in corn stubble

B: Aerial seeding cover crops into growing corn in August
Cover crop management options at HB Ranch near Brownell

Treatments
Fallow
Standing cover crop
Hayed cover crop
Grazed cover crop

Hayed Cover Crops
- At triticale heading stage
- 15 cm cutting height

Grazed Cover Crops
- Yearling heifers
- ~One week before haying
- 1463 kg live weight ha\(^{-1}\) for from four to seven days
Spring cover crop biomass - Brownell, KS

Biomass (lb/ac)

- Oat: 2383ab
- Triticale: 2981a
- Oat/Triticale: 3020a
- Oat/Triticale/Pea: 2440ab
- Cocktail: 2225b

Cocktail: oat/triticale/pea/radish/turnip/buckwheat
Forage quality 2 or 3-way mixtures (average of four-site years)

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>CP</th>
<th>ADF</th>
<th>NDF</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat/triticale</td>
<td>12.3 b</td>
<td>37.1 a</td>
<td>63.4 a</td>
<td>72.7 b</td>
</tr>
<tr>
<td>Oat/triticale/pea</td>
<td>14.4 a</td>
<td>36.2 b</td>
<td>60.2 b</td>
<td>74.6 a</td>
</tr>
</tbody>
</table>
High variability in cover crop biomass across years at Brownell

![Graph showing biomass variation from 2015 to 2020]

- 2015: 3145a
- 2016: 2401b
- 2017: 3067a
- 2018: 2918a
- 2019: 1655c
- 2020: 1594c
Grazing cover crops at Hays, KS and Alexander, KS (2019 to 2020)

**Treatments:**
1. Non-grazed cover crop
2. Grazed cover crop

**Cover crop species:**
- Summer covers: Forage sorghum, German millet, sunflower, sunn hemp, and radish
- Spring: oat, triticale, barley, radish, sunflower, pea, rapeseed

**Cover crop grazing:**
- Cow-calf pairs at 312 kg live weight ha\(^{-1}\) from 8/24 to 10/10
- Yearlings at 514 kg live weight ha\(^{-1}\) from 8/7 to 9/18
On-farm cover crop grazing-Alexander, KS

Triticale, Oats, Barley, Peas, Sunflowers; Radish, and Rapeseed
Summer cover crop on producer field at Hays

06/28/2019

Sunn hemp, Sunflower; millet; Sudangrass, radish, rapeseed

07/25/2019
Grazing days and animal performance

<table>
<thead>
<tr>
<th>Location</th>
<th>CP %</th>
<th>Starting</th>
<th>Ending</th>
<th>Class</th>
<th>Grazing days</th>
<th>Stocking rate, lb/acre</th>
<th>ADG Ib/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexander, KS</td>
<td>26</td>
<td>5/14/19</td>
<td>6/14/19</td>
<td>calves</td>
<td>31</td>
<td>354</td>
<td>3.11</td>
</tr>
<tr>
<td>Marquette, KS</td>
<td>19</td>
<td>1/9/20</td>
<td>2/17/20</td>
<td>calves</td>
<td>39</td>
<td>552</td>
<td>1.2</td>
</tr>
<tr>
<td>Alexander, KS</td>
<td>20</td>
<td>8/05/20</td>
<td>09/18/20</td>
<td>heifers</td>
<td>41</td>
<td>576</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Residue after grazing cover crops at Marquette, KS

Cover crop biomass in the spring
Grazed winter triticale/radish/rapeseed = 1135 lb/a
Ungrazed triticale/radish/rapeseed = 2410 lb/a
Ungrazed winter triticale cover crop = 3231 lb/a
Residue after grazing summer cover crops in Hays, KS

~ 6026 lb/a produced
~ 4592 lb/a residue left after grazing
Cover crop residue retained after forage harvest at Brownell, KS

Haying and grazing retained 39% and 62% of the available forage mass (3872 kg ha⁻¹)

Forage mass retained (kg ha⁻¹)

- Standing
- Hayed
- Grazed

Error bars indicate standard error (α =0.05) and bars with the same letter are not significantly different (α =0.05) among treatments within the same year.

†Error bars indicate standard error (α =0.05) and bars with the same letter are not significantly different (α =0.05) among treatments within the same year.
Grain sorghum yields after summer cover crops

Standing and grazed treatments reduced subsequent grain yields by 11% on average or up to 44%.

†Error bars indicate standard error (α =0.05) and bars with the same letter are not significantly different (α =0.05) among treatments within the same year.
No cover crop  Standing cover
Wheat yields after summer cover crops

Grain yield (kg ha\(^{-1}\))

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2020</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow</td>
<td>a(^+)</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Standing cover crop</td>
<td>b</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Hayed cover crop</td>
<td>ab</td>
<td>ab</td>
<td>a</td>
</tr>
<tr>
<td>Grazed cover crop</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

\(^{1}\)Error bars indicate standard error (\(\alpha =0.05\)) and bars with the same letter are not significantly different (\(\alpha =0.05\)) among treatments within the same year.
Wheat yield after spring cover crops (2016-2018)

- **Fallow**: a
- **Pea**: ab
- **Trit**: abc, bc
- **Oat**: cde
- **Oat-Trit**: bc, bcd, cd
- **Oat-Pea-Trit**: cde, de
- **Cocktail**: bc, bcd

Wheat yield (bu/a)

- Cover
- Hay
- Graze
Soil Properties

- Bulk density
- Soil Organic Carbon and Organic Matter
- Water Stable Aggregates
- Dry Aggregate Stability
- Water Infiltration Rate
No increase in surface bulk density across ten farms in Colorado and Kansas

Kelly et al., 2021
Soil properties at Marquette, KS

<table>
<thead>
<tr>
<th>Depth</th>
<th>Treatment</th>
<th>BD</th>
<th>SOC</th>
<th>P</th>
<th>Fe</th>
<th>MWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5 cm</td>
<td>Ungrazed</td>
<td>1.26</td>
<td>19.4</td>
<td>50.9</td>
<td>73.2</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>Grazed</td>
<td>1.32</td>
<td>15.6</td>
<td>68.3</td>
<td>79.8</td>
<td>1.11</td>
</tr>
<tr>
<td>5 – 15 cm</td>
<td>Ungrazed</td>
<td>1.48</td>
<td>10.8</td>
<td>30.0</td>
<td>67.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grazed</td>
<td>1.51</td>
<td>11.2</td>
<td>31.5</td>
<td>69.8</td>
<td></td>
</tr>
</tbody>
</table>

No significant differences at $\alpha=0.05$.

BD, bulk density; SOC, soil organic carbon; P, phosphorus, Fe, iron

MWD, mean weight diameter of water stable aggregates.
### On-farm soil properties at Hays and Alexander, KS

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Treatment</th>
<th>BD g cm⁻³</th>
<th>SOC g kg⁻¹</th>
<th>NO₃ mg kg⁻¹</th>
<th>P mg kg⁻¹</th>
<th>MWD mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hays</td>
<td>0 – 5 cm</td>
<td>Ungrazed</td>
<td>1.25</td>
<td>20.5</td>
<td>14.4</td>
<td>48.3</td>
<td>1.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>1.32</td>
<td>18.9</td>
<td>16.4</td>
<td>45.2</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>5 – 15 cm</td>
<td>Ungrazed</td>
<td>1.38</td>
<td>15.3</td>
<td>5.2</td>
<td>24.6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>1.41</td>
<td>15.8</td>
<td>8.7</td>
<td>23.8</td>
<td>-</td>
</tr>
<tr>
<td>Alexander</td>
<td>0 – 5 cm</td>
<td>Ungrazed</td>
<td>1.32</td>
<td>12.4</td>
<td>7.0</td>
<td>33.7</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>1.40</td>
<td>14.0</td>
<td>9.7</td>
<td>42.0</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>5 – 15 cm</td>
<td>Ungrazed</td>
<td>1.39</td>
<td>9.0</td>
<td>3.5</td>
<td>15.2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>1.45</td>
<td>9.3</td>
<td>3.6</td>
<td>8.27</td>
<td>-</td>
</tr>
</tbody>
</table>

**No significant differences at α=0.05.**

BD, bulk density.

SOC, soil organic carbon.

MWD, mean weight diameter of water stable aggregates.
Cover crop increased near surface SOC at Alexander, KS

- **Grazed**
  - Initial: 0.99%
  - 2021: 1.48%

- **Ungrazed**
  - Initial: 0.96%
  - 2021: 1.27%
Cover crop effects on soil organic carbon (HB Ranch)

2019

2020

† Error bars indicate standard error (α = 0.05) and bars with the same letter are not significantly different (α = 0.05).
Cropping intensification with sorghum has significant impact on soil organic carbon.
Aggregate Stability in 2019 at Brownell

Fallow CC Standing CC Hayed CC Grazed

Mean Weight Diameter (mm)

1.65b
2.53a
2.66a
2.82a
Aggregate stability increased with cover crops across ten farms in Colorado and Kansas in

Kelly et al., 2021
Infiltration rates measured in May 2018 at Brownell

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Infiltration (cm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow</td>
<td>1.93</td>
</tr>
<tr>
<td>Oat/triticale graze</td>
<td>3.11</td>
</tr>
<tr>
<td>Oat/triticale cover</td>
<td>2.92</td>
</tr>
<tr>
<td>Cocktail</td>
<td>3.01</td>
</tr>
</tbody>
</table>
Conclusions

• Cover crops may be productive in dryland systems, but are **variable from year-to-year**
• Grazing cover crops had **no negative impact on soil bulk density**
• Soil organic carbon/organic matter **increased** with cover crops (when adequate biomass are produced)
• Cover crop **increased aggregate stability** compared to fallow
Conclusions

• **Grazed or hayed** cover crops can provide similar soil health benefits compared to standing cover crops

• **Residue management** is more critical to ensure soil health goals

• Cover crop mixtures should be simple and dominated by **productive grasses species** to maximize forage and residue retention

• Wheat and sorghum yields following cover crops **were less than that after fallow**

• Utilizing **cover crops for forage** will allow cover crop use in dryland systems to improve soil health and profitability
Funding and Contact Info

Contact information

Dr. Augustine Obour
aobour@ksu.edu
785-625-3425 ext. 215

Kansas State University
Ag Research Center-Hays