Can cover crops replace summer fallow?

Moisture removal rates in cover crops vs. fallow on five low to high rainfall farms

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WATER USE BY COVER CROP VS. FALLOW

FIVE 2014 LOCATIONS: ASOTIN, GARFIELD, COLUMBIA, AND WALLA WALLA COUNTIES
OVERVIEW

• Initial Goals

• Instrumentation

• Summary of 2014 Observations
  – Daily Weather
  – GDD Accumulation
  – Changes in soil profile moisture
  – Soil Profile Water

• Biomass produced per unit water consumed
Goal ONE

• Determine amount of water consumed per unit of cover crop biomass produced
  – Daikon oilseed radish (large, deep taproot, C3 spp.)
  – sorghum sudangrass (high biomass warm-season forage grass, C4 spp.)
  – sun hemp (tropical legume, C3 spp)
  – winter forage pea (Site 2, cool season legume, C3 spp.)
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  – Bare soil
  – Wheat straw
  – Full shade
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• Instrumentation
  – air temperature, relative humidity, solar radiation, soil moisture, leaf wetness, wind speed and direction, precipitation
Soil Moisture Sensors. FOUR inch depth under both fallow and cover crop.
COVER CROP

FULL SHADE

BARE SOIL

STRAW COVER

Buried soil temperature probes
Goal TWO

- Combined effects of cover type and soil temperature on evaporative water loss.
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  – Three temperature data loggers buried at three depths (0-6, 6-12, 12-18 in) under four cover conditions:
    • cover crop seeded into straw residue
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    • wheat straw residue
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  – Data summaries for GOAL 2 are not included in this presentation
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**DAILY TEMPERATURE (°F)**

**DAYS (04/18 - 07/14)**

**MAX T °F**

**MIN T °F**

**PRECIPITATION (100th in)**

**DAILY COVER CROP %VWC**

**DAILY STRAW FALLOW %VWC**

**OPTIMAL TIME TO TERMINATE, *90 days prior to planting***
Growing Degree Day Accumulation

- **GDD** = \( \frac{T_{\text{MAX}} + T_{\text{MIN}}}{2} - T_{\text{BASE}} \)

![Diagram showing Growing Degree Day Accumulation with lines for Cool Season, Brassicas, and Sorghum across months from April to September.](image-url)
Growing Degree Day Accumulation

- **GDD** = \( \left( T_{\text{MAX}} + T_{\text{MIN}} \right) \div 2 - T_{\text{BASE}} \)
- **Growing Degree Day (°C)** assume 0-10 cm soil temperature drives germination through emergence (e.g., 200 GDDₜ).
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- **Growing Degree Day (°C)** assume 0-10 cm soil temperature drives germination through emergence (e.g., 200 GDD\(_C\)).

- Delayed germination/emergence and exceptionally slow GDD accumulation rates provide evidence that warm season species are not suitable for PNW dryland cover cropping systems.
E + T = ET

- E = Evaporative Water Loss
  - water lost as vapor, varies with:
    - amount of stored water,
    - frequency of precipitation
    - air and soil temperatures,
    - intensity and duration of solar radiation,
    - relative humidity
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Soil Profile Moisture
(inches)

Fallow System vs. Mature Cover Crop

Bare Soil

- at planting
- upon removal

Time of sampling

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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Soil Depth
(ft)

water
(in)
Soil Profile Moisture (inches)
Fallow System vs. Mature Cover Crop

Time of sampling
- Green: at planting
- Red: upon removal

SITE 2

Bare Soil

Soil Depth (ft)

Water (in)

0 1 2 3 4 5
Soil Profile Moisture (inches)
Fallow System vs. Mature Cover Crop

SITE 2

Bare Soil

<table>
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<tr>
<th>Soil Depth (ft)</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>1</td>
<td>1.5</td>
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Storage Efficiency = Percentage of stored water retained
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Soil Profile Moisture (inches)
Mature Cover Crop vs. Spring Cereal Crop

SITE 4

Soil Depth (ft)
Soil Profile Moisture (inches)
Mature Cover Crop vs. Spring Cereal Crop

**Cover Crop**

- **SITE 4**
  - Soil Depth (ft)
  - Water (in)
  - Soil Depth (ft)
  - Water (in)
  - Storage Efficiency = Percentage of stored water retained

- **SITE 5**
  - Soil Depth (ft)
  - Water (in)
  - Soil Depth (ft)
  - Water (in)
  - 57% at planting
  - 55% at planting
  - 53% upon removal
  - 54% upon removal

**Spring Cereal**

- **SITE 4**
  - Soil Depth (ft)
  - Water (in)
  - Soil Depth (ft)
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  - Storage Efficiency = Percentage of stored water retained

- **SITE 5**
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### Average Effects of Cover Type on Soil Water Storage

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- Inches = inches of water, E or ET from 5-ft profile
- **Storage Efficiency %** = average 5-ft soil water content before ÷ average 5-ft soil water content after x 100
- Cover Crop and Spring Cereal storage efficiencies are for sites 4 & 5
Preliminary analysis of 2014 biomass yields versus cumulative evapotranspiration

Biomass Yield = 0.20 x ET, $R^2 = 0.93$
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10" of water needed to produce 2.0 ton Biomass per acre
Confounding Factors

Nutrient Stratification

Soil Acidification

Soil Organic Matter (%) vs. Soil Depth (in)

0 1 2 3 4 5 6
0 1 2 3 4 5 6 7 8 9 10 11 12
Confounding Factors

Nutrient Stratification

Soil Acidification

Mineral Nitrogen (ppm)

Soil Phosphorus (ppm)

Soil Depth (in)
Confounding Factors

**Nutrient Stratification**
- Mineral Nitrogen (ppm)
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**Soil Acidification**
- Soil pH

Soil Depth (in)
Confounding Factors

**Nutrient Stratification**

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**Soil Acidification**

- Soil pH
- Buffer pH

Graphs showing nutrient stratification and soil acidification with depth.
Confounding Factors

**Nutrient Stratification**

- Mineral Nitrogen (ppm)
- Soil Phosphorus (ppm)

**Soil Acidification**

- Aluminum (ppm)
- Manganese (ppm)
Observations

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• Is it practical to grow a cool season species as winter cover/forage crop option assuming access to grazing livestock?
2014 Collaborators

• **Growers**
  - Walla Walla: Seth and Mark Small, Don Anderson
  - Columbia: Eric Thorn
  - Garfield: Mary and Roger Dye
  - Asotin: Mark Greene

• **USDA ARS and NRCS Personnel by Office**
  - Pendleton: Dan Long, Research Agronomist, Center Director and Research Leader
  - Pomeroy: Rick Stauty, Soil Conservationist
  - Clarkston: Jim Schroeder, Soil Conservationist
  - Walla Walla: Jessica Taylor, Soil Conservationist
  - Pasco: Keith Harrington, Soil Scientist
  - WSU Campus: John Morse, Ian Guest, and Jack Niedbala - USDA-ARS Research Technicians
  - WSU Campus: Dave Huggins, USDA-ARS Research Soil Scientist/Affiliate Professor

• **WSU Faculty**
  - Columbia County: Paul Carter, Extension Agronomist