# Cover Crop Biomass Production and Water Use in the Central Great Plains Under Varying Water Availability

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## Introduction

Cover crop use in cropping systems is promoted based on a number of beneficial consequences that follow their use, including reduced erosion, increased soil organic matter, increased infiltration rates and precipitation storage, increased nutrient availability, reduced nutrient loss, and weed suppression. The historical, conventional definition of cover crops stated that the crop is not taken for a profitable purpose. However, more recent definitions of cover cropping allow for the use of the cover crop for animal feed so that there can be some direct profitability from growing the cover crop.

For such profitability to occur there must be enough biomass produced by the cover crop such that a portion can be grazed or taken for forage while maintaining enough residual mass and surface cover to prevent soil erosion. Under the water-limited conditions of the semi-arid Central Great Plains, producing enough biomass from cover crops to sufficiently meet both of these needs (i.e., wind erosion control and profitable forage production) may be a challenge.

Some reports of cover crop biomass production from the Northern Great Plains would suggest that cover crop production is sufficient to produce both profitable forage production and wind erosion protection. Additionally there are reports that mixtures of species can produce more biomass than monocultures.

## Objectives

Determine whether a 10-species cover crop mixture produced more biomass than single-species plantings

Determine whether a 10-species cover crop mixture exhibited greater water use efficiency of dry matter production than single-species plantings

Quantify residue cover differences on the soil surface between a 10-species cover crop mixture and single-species plantings at cover crop termination and subsequent winter wheat planting

## Materials and Methods

**Locations:** Akron, CO (Weld silt loam) and Sidney, NE (Keith silt loam); **Years**: 2012, 2013

**Main plot treatments**: 1) Dryland (rainfed); 2) Irrigated: At Akron, irrigated to simulate average rainfall in south-central Nebraska (Bladen), and at Sidney, irrigated to simulate slightly above-average precipitation

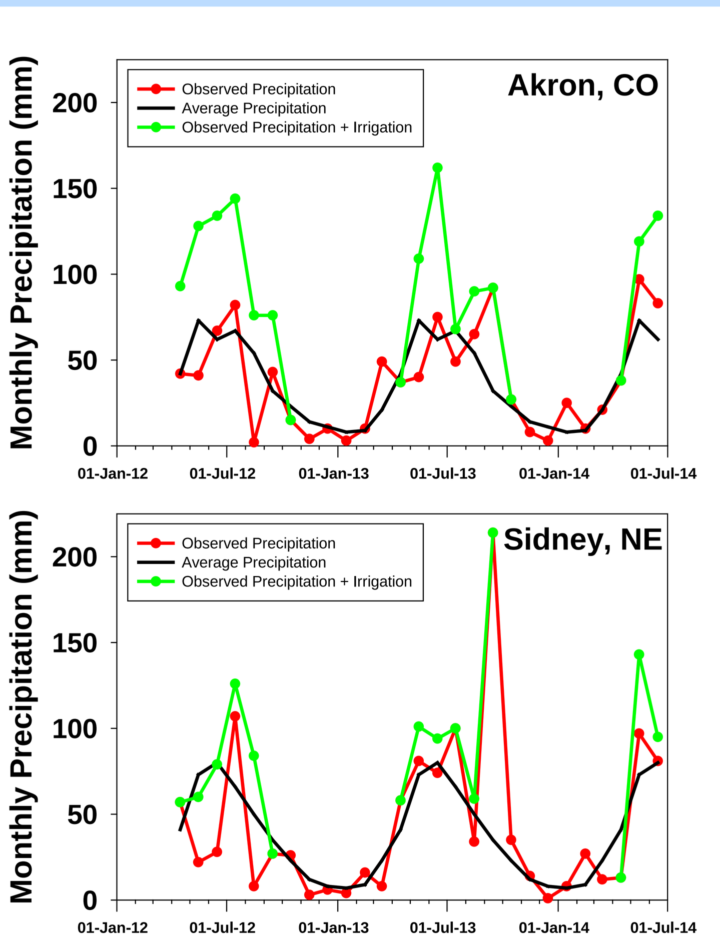
**Split plot treatments**: 1) Single-species plantings of flax, oat, pea, rapeseed; 2)10-species mixture comprised of flax, oat, pea, lentil, rapeseed, common vetch, berseem clover, barley, phacelia, safflower; 3) no-till fallow with proso millet residue

**Cover crops planted** 27 Mar 2012 and 4 Apr 2013 (Akron) and 4 Apr 2012 and 30 Apr 2013 (Sidney); **Cover crops terminated** (spraying) 16 Jun 2012 and 27 June 2013 (Akron) and 15 Jun 2012 and 18 Jul 2013 (Sidney)

**Soil water measured** with neutron probe: 0-180 cm at Akron; 0-150 cm at Sidney in 2012; 0-120 cm at Sidney in 2013; Soil water in the 0-30 cm layer measured by TDR at Akron; **Water use calculated by water balance** from soil water content changes plus precipitation and irrigation; **Residue cover measured** at Akron following cover crop planting and termination and at wheat planting

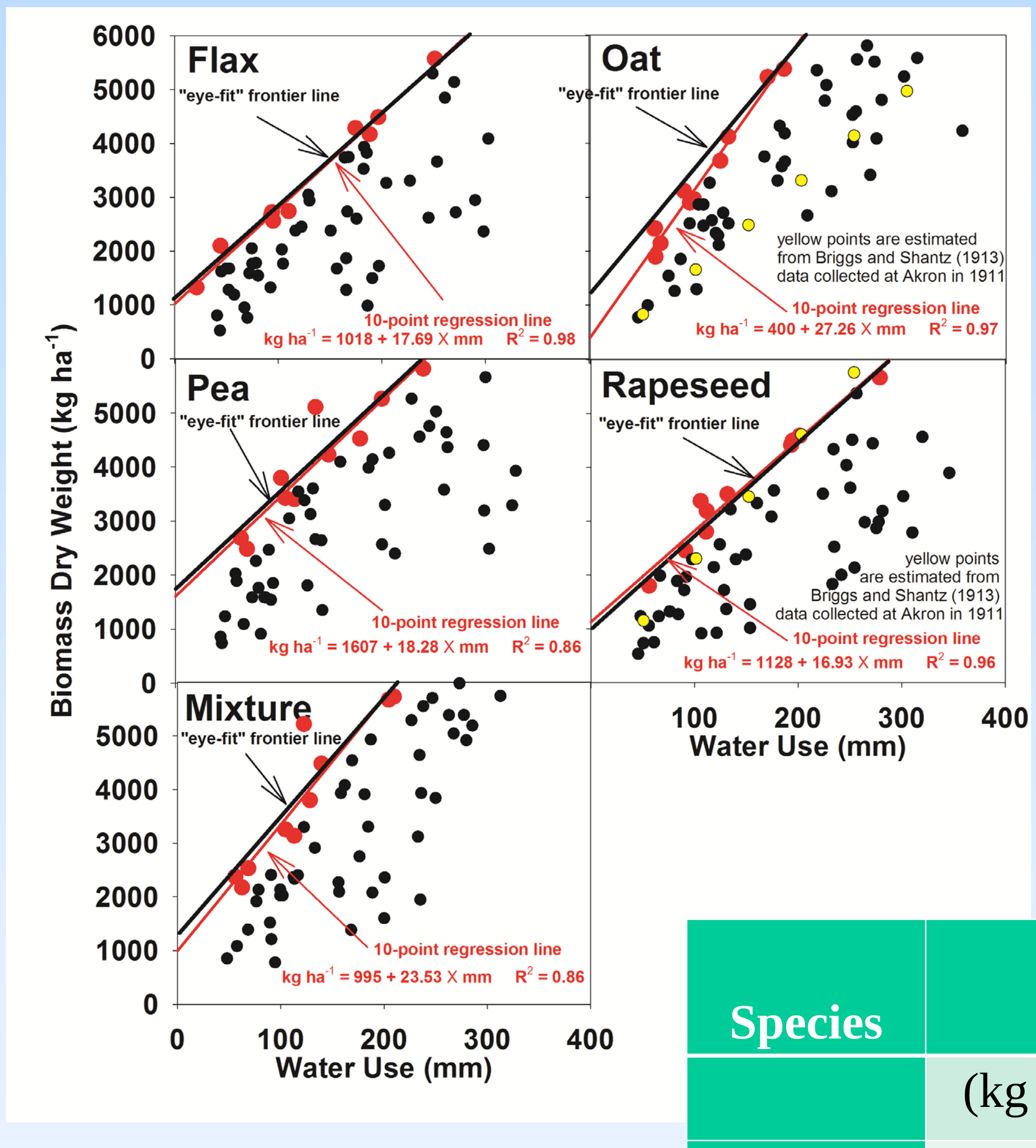
## Results

**Monthly average and observed precipitation and applied irrigation at Akron CO and Sidney NE during the experimental period**




Averages are from 1908-2013 at Akron and 1946-2013 at Sidney.

**Water use and biomass dry weight of flax, oat, pea, rapeseed, and a 10-species mixture of cover crops grown at Akron, CO and Sidney, NE in 2012 and 2013.**




Using the water-limited yield "frontier line" approach proposed by French and Schultz (1984, Aust. J. Agric. Res.) we can see that water use efficiency (slope of line) is greatest for oat, followed by the mixture, pea, flax, and rapeseed.

The order of these slopes is the same as would be expected from the biomass productivity calculated by Tanner and Sinclair (1983, Limitations to Efficient Water Use in Crop Production) based on the energy requirements to produce different plant compositions (e.g., starch, protein, oil). The mixture does not exhibit greater water use efficiency than the single-species cover crops. The slope of the mixture line is intermediate to the slopes for oat and pea. The fractional composition of the mixture (by dry weight at termination) was 80% grasses, 6% legumes, and 7% oilseeds.

| Species | Slope | Intercept | $R^2$ | Biomass Productivity |
|---|---|---|---|---|
| | (kg ha$^{-1}$ mm$^{-1}$) | (kg ha$^{-1}$) | | (g g$^{-1}$) |
| Rapeseed | **16.93** | 1128 | 0.96 | **0.43** |
| Flax | **17.69** | 1018 | 0.98 | **0.46** |
| Pea | **18.28** | 1607 | 0.86 | **0.65** |
| Mixture | **23.53** | 995 | 0.93 | --- |
| Oat | **27.26** | 400 | 0.96 | **0.70** |

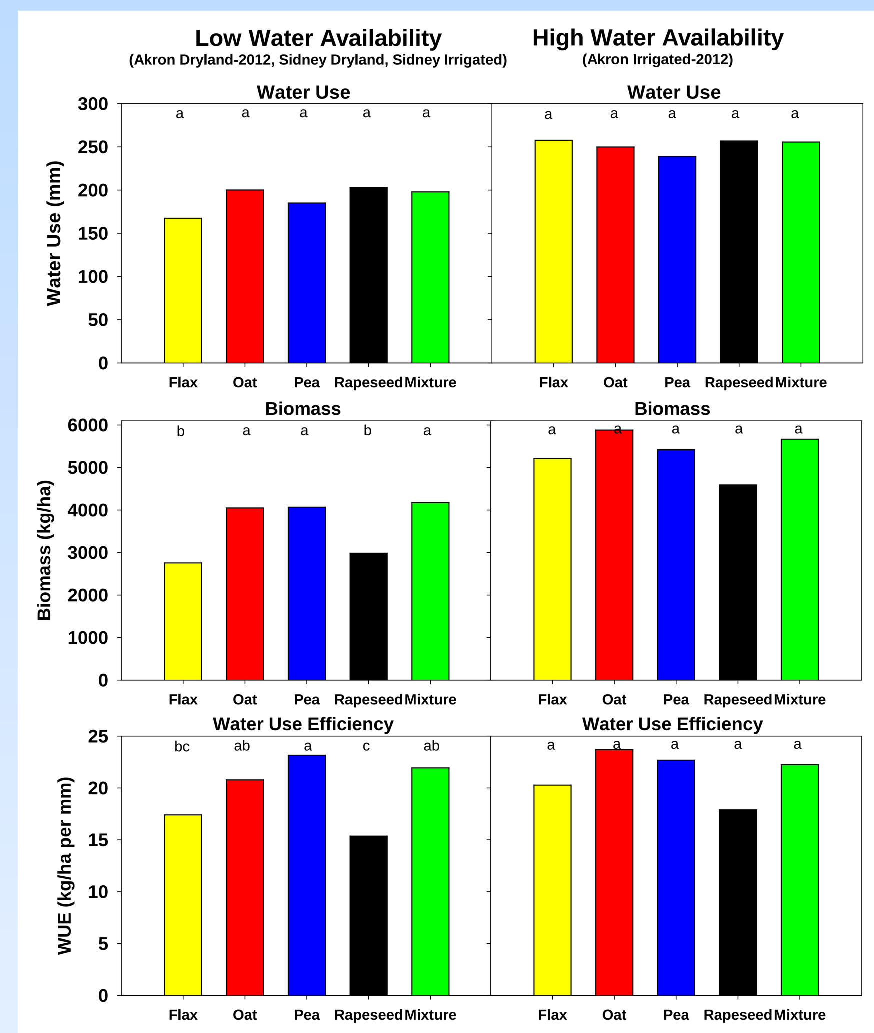
**Same order**

Growing season water use by the cover crop mixture was not consistently different from water use by single-species plantings of cover crops under either water availability condition

Biomass was greater for oat, pea, and the mixture compared with flax and rapeseed under the low water availability condition, and the same for all species under the high water availability condition.

Water use efficiency was greatest for oat, pea, and the mixture and lowest for flax and rapeseed under the low water availability condition and the same for all species under the high water availability condition.

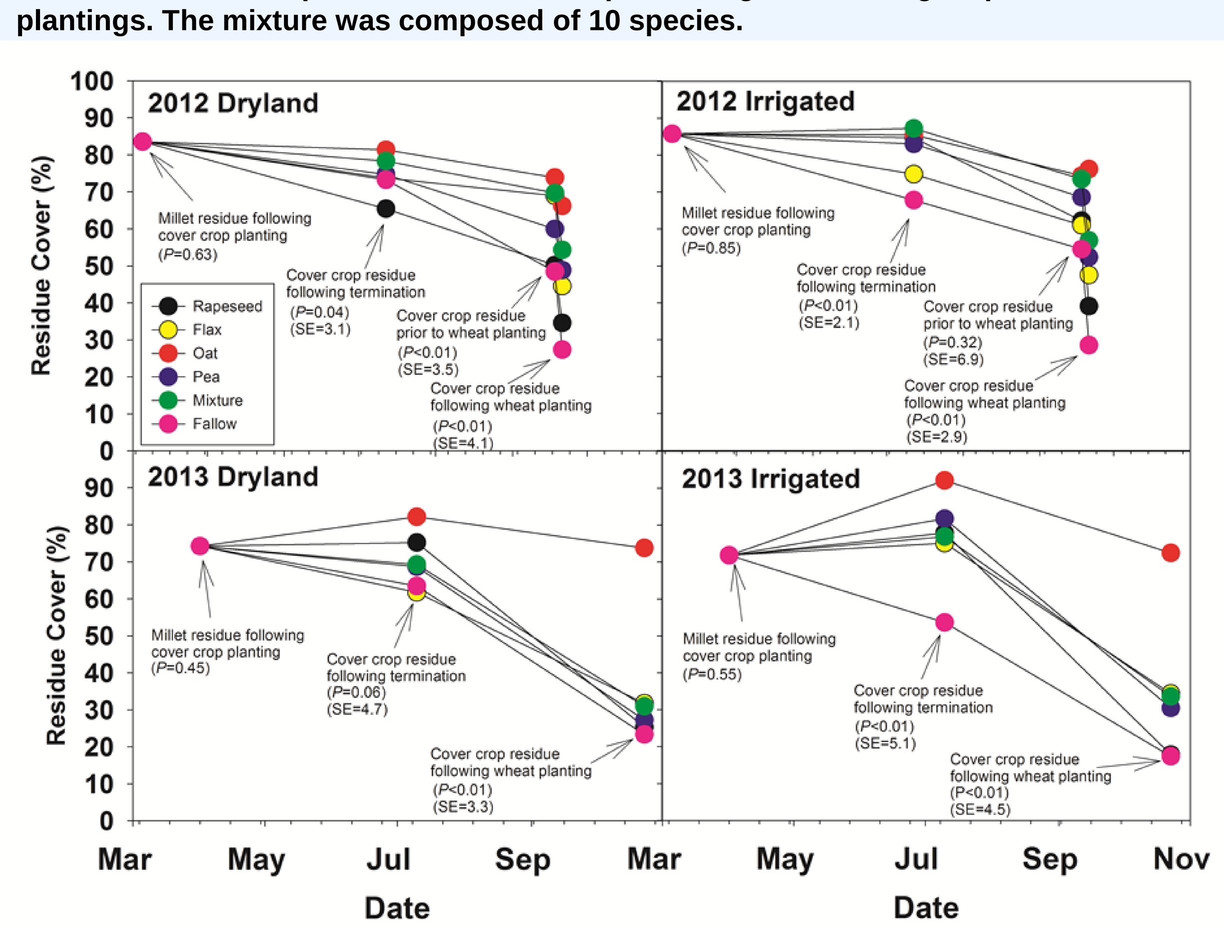
**Water use, biomass dry weight, and water use efficiency of flax, oat, pea, rapeseed, and a 10-species mixture of cover crops grown at Akron, CO and Sidney, NE in 2012 and 2013.**




### Cover Crop Seed Costs

| Species | Single Species: Seed Cost $/kg ($/lb) | Target Rate kg/ha (lb/a) | Total $/ha ($/a) | Mixture | Mixture: $/ha ($/a) |
|---|---|---|---|---|---|
| | | | | Planted at 58.3 kg/ha (52 lb/a) [Mixing cost of $0.11/kg ($0.05/lb)] | |
| Pea | $0.88 ($0.40) | 112 (100) | $98.77 ($40.00) | Seed | $84.70 ($34.29) |
| Lentil | $1.43 ($0.65) | 56 (50) | $80.25 ($32.50) | Mixing | $6.42 ($2.60) |
| Vetch | $1.76 ($0.80) | 56 (50) | $98.77 ($40.00) | Total | $91.12 ($36.89) |
| Clover | $4.74 ($2.15) | 17 (15) | $79.63 ($32.25) | | |
| Oat | $0.64 ($0.29) | 101 (90) | $64.44 ($26.10) | | |
| Barley | $0.68 (0.31) | 101 (90) | $68.80 ($27.90) | | |
| Rapeseed | $2.20 ($1.00) | 7 (6) | $14.81 ($6.00) | | |
| Flax | $1.43 ($0.65) | 39 (35) | $56.17 ($22.75) | | |
| Safflower | $1.54 ($0.70) | 34 (30) | $51.85 ($21.00) | | |
| Phacelia | $9.81 ($4.45) | 6 (5) | $54.94 ($22.25) | | |

**Residue cover of fallow and cover crops following proso millet fallow at Akron, CO in 2012 and 2013. Rapeseed, flax, oat, and pea were grown as single-species plantings. The mixture was composed of 10 species.**

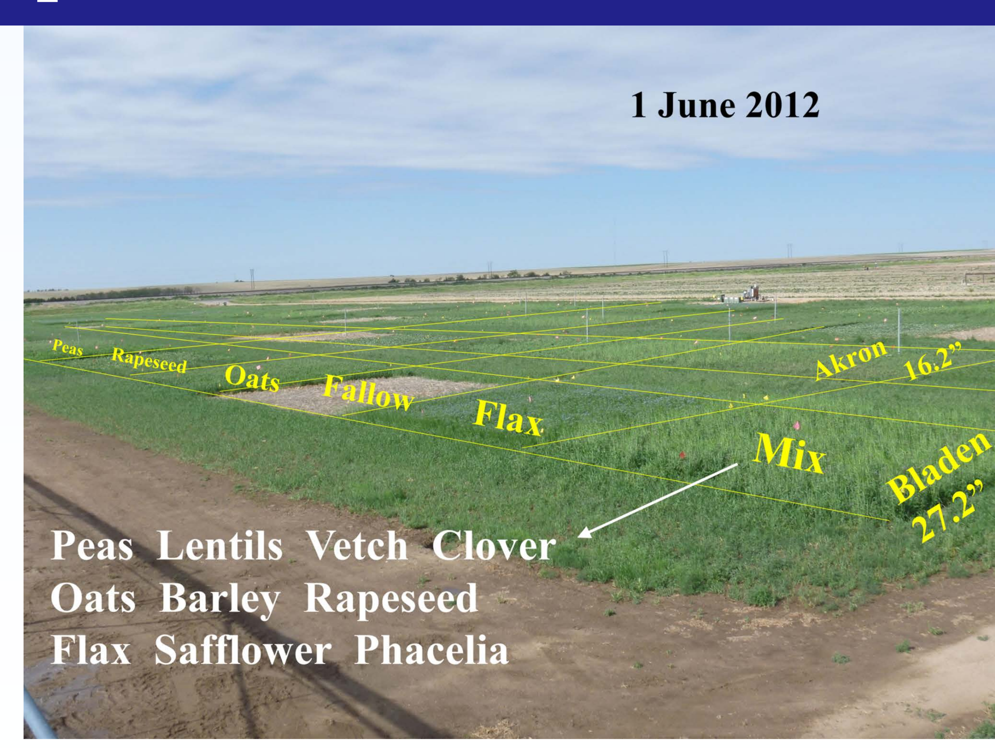



Proso millet residue cover following cover crop planting was 73-85%. The proso millet residue aged and degraded and lost ground coverage over the five months until wheat planting. Ground coverage was maintained at higher levels with the cover crop in 2012, but not in 2013 which had poorer stand establishment due to persistent cool weather following planting, except for oat which was not as much affected by the cool weather at planting.

## Conclusions

- Cover crop biomass production under dryland conditions in the semi-arid Central Great Plains is limited by available water.
- Under these water-limited conditions cover crops may not produce enough biomass to allow for profitable grazing while maintaining erosion protection and soil organic matter levels.
- Growing cover crops in mixtures does not improve the water use efficiency of biomass production and is not likely to produce greater biomass than a single-species planting.
- The added expense of cover crop mixtures compared with single-species plantings is difficult to justify unless a certain forage quality is desired.

## Experimental Area at Akron, CO

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