Cover Crop Water Use and Subsequent Effects on Wheat Yield

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Introduction

The past few years have seen a greatly renewed interest in adding cover crops to agricultural production systems. Much of the literature documenting these benefits associated with cover crop use come from studies done in regions with less evaporative demand and/or more precipitation than the semi-arid region of the central Great Plains of the United States.

Recently, the results from a single-year, unreplicated demonstration plot in south-central Nebraska have been widely disseminated indicating that cover crops grown in mixtures of 9 to 14 species and seeded in mid-July did not show declines in soil water content during the August through November period while single-species plantings of cover crops planted at the same time and location did use significant amounts of soil water.

Other statements have been made that growing cover crops in mixtures will result in no adverse effects on subsequent crop yields in semi-arid environments.

Objectives

Compare soil water extraction by a 10-species cover crop mixture with water extraction by four single-species plantings

Compare evaporative water loss from a no-till fallow treatment with cover crop water use (from planting to crop termination) for the four single-species plantings and the 10-species mixture.

Determine the effect of cover crop water use on subsequent winter wheat yield.

Materials and Methods

Locations: Akron, CO (Weld silt loam) and Sidney, NE (Keith silt loam); **Years**: 2012-2014

Main plot treatments: 1) Dryland (rainfed); 2) Irrigated: At Akron, irrigated to simulate average rainfall in south-central Nebraska, 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 on proso millet residue

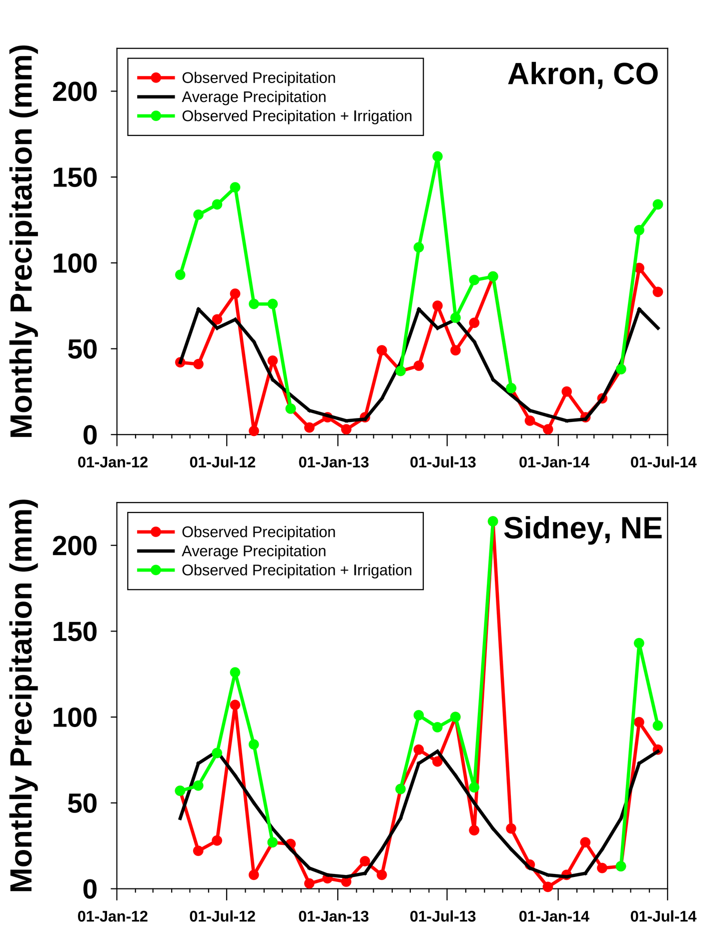
Cover crops planted 27 Mar 2012 and 4 Apr 2013 (Akron) and 4 Apr 2012 and 30 Apr 2013 (Sidney); **Cover crops terminated** (spraying) 16 Jun 2012 and 27 June 2013 (Akron) and 15 Jun 2012 and 18 Jul 2013 (Sidney)

Winter wheat planted at Akron on 19 Sep 2012 and 4 Oct 2013 and at Sidney on 20 Sept 2012 and 21 Sep 2013

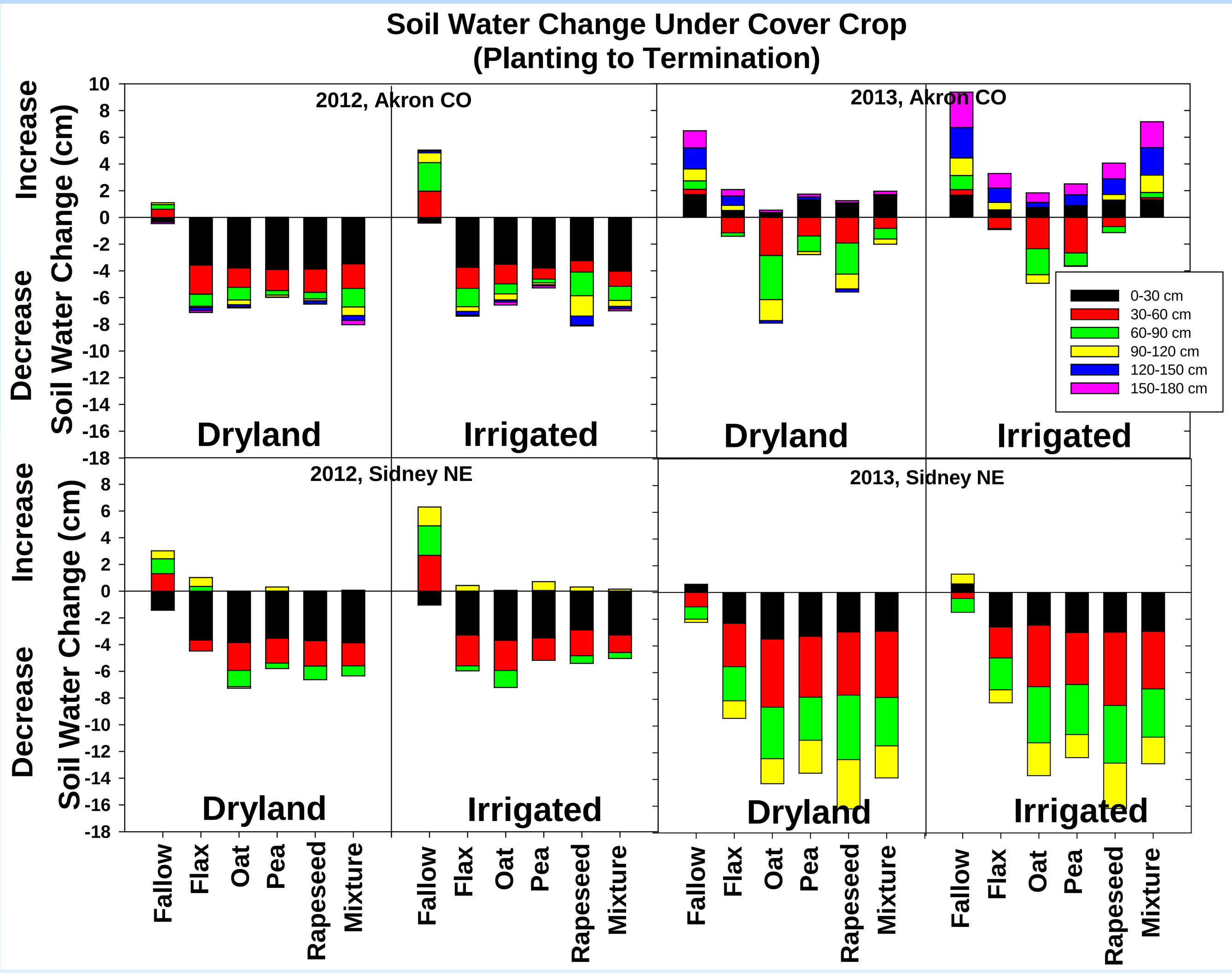
Soil water measured with neutron probe: 0-180 cm at Akron; 0-150 cm at Sidney in 2012; 0-120 cm at Sidney in 2013; Soil water in the 0-30 cm layer measured by TDR at Akron; **Water use calculated by water balance** from soil water content changes plus precipitation and irrigation

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.

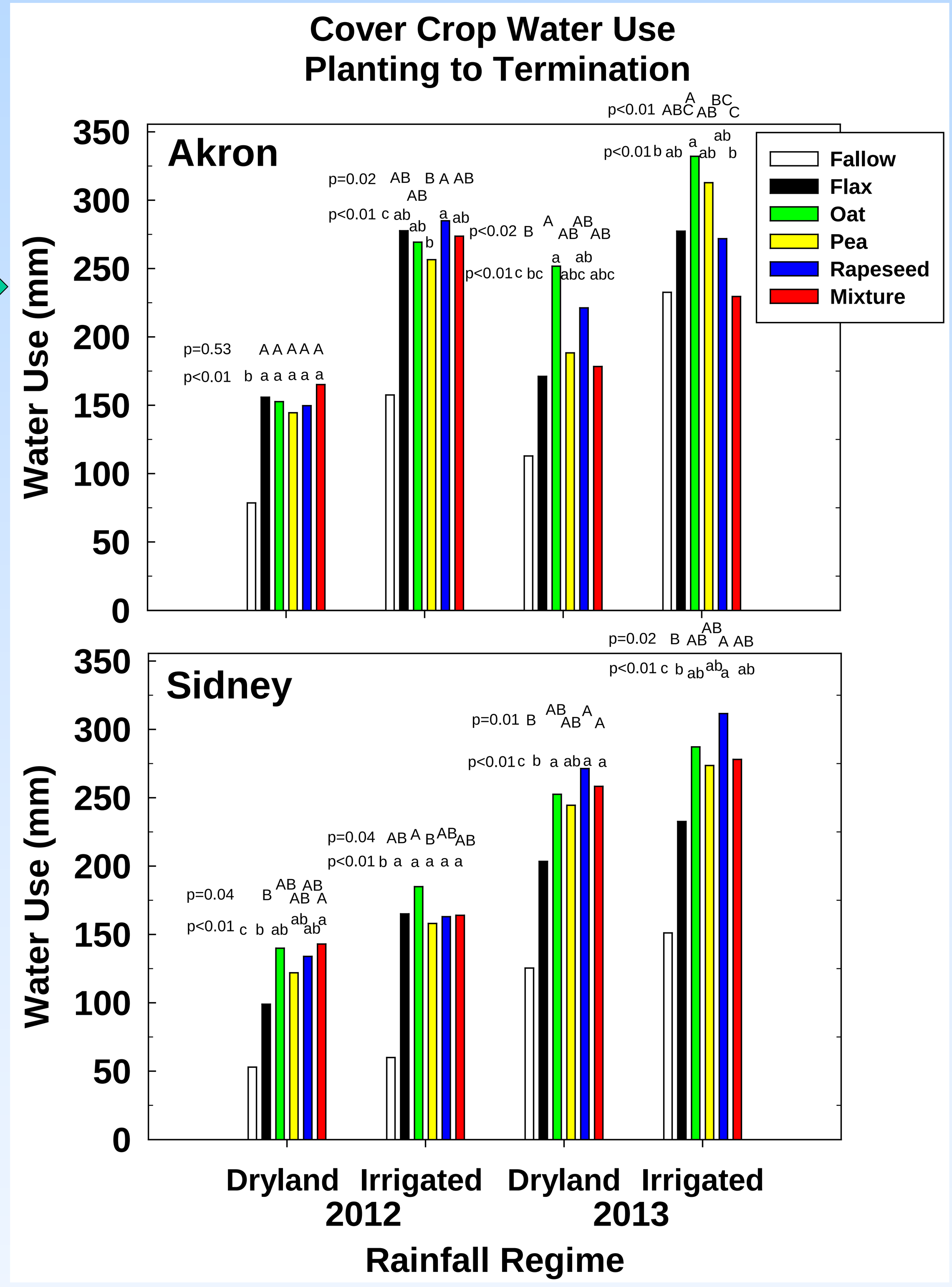


Soil water change during the cover crop growing season was similar at both locations under both water treatments in 2012. Greater water extraction was seen at Sidney in 2013. For those six data sets the mixture did not extract water differently than the single-species plantings.

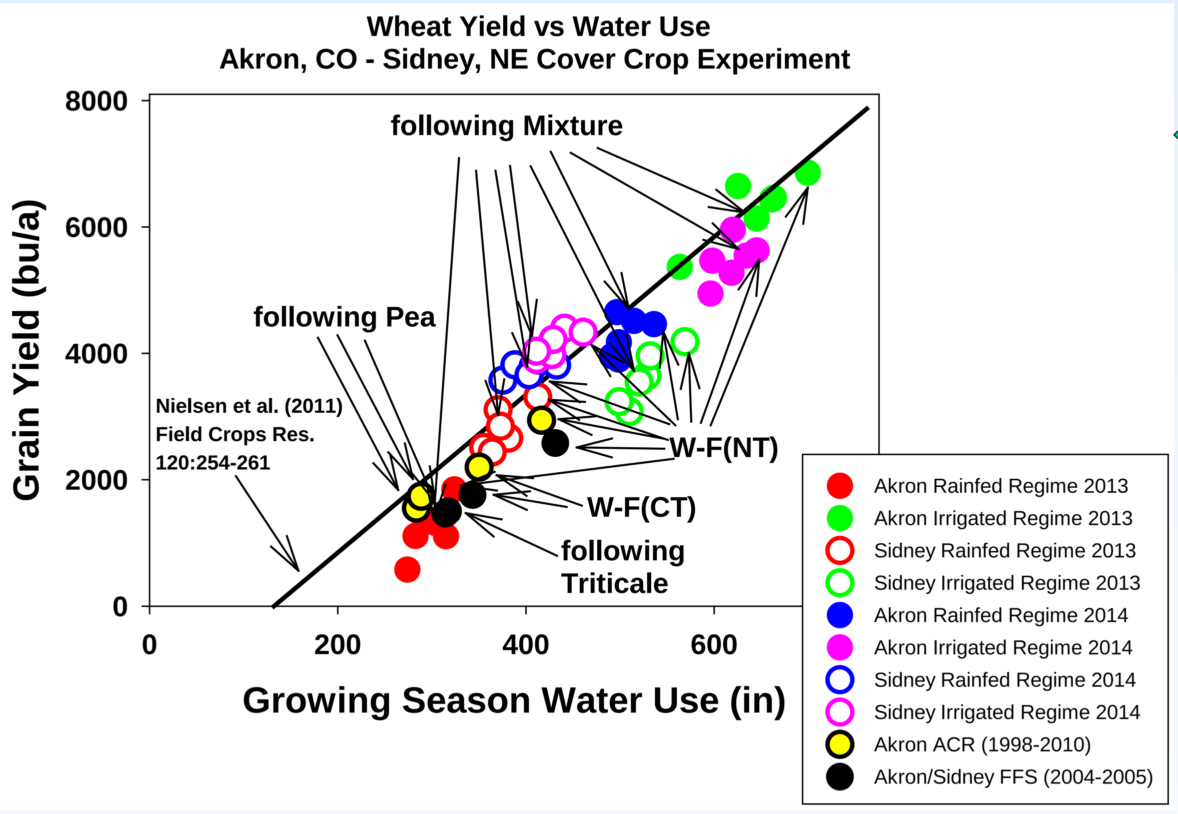
In 2013 at Akron (two upper right panels) the mixture under the dryland treatment showed a similar water change pattern as flax and pea, which was less water extraction than seen with oat and rapeseed. Under the irrigated condition the mixture gained water at all depths during the growing season, similar to the fallow plot but to a lesser amount. Flax and rapeseed also gained water in four of six depths. Irrigated oat and pea showed much greater water use from the 30-90 cm layer than the other crops.

Growing season water use by the cover crop mixture was not consistently different from water use by single-species plantings of cover crops. Under the irrigated conditions at Akron in 2013 the mixture showed water use similar to the amount of water lost by evaporation from fallow.

The somewhat anomalous water extraction and water use results from Akron in 2013 compared with the other data sets should be viewed with some caution due to the poor plant stands that resulted in much lower plant populations and biomass production in 2013 compared with 2012, except for oat. These poor plant stands were likely the result of much below normal April temperatures (5.5ºC vs 8.1ºC) that slowed emergence (beginning emergence occurred 21 days after planting) resulting in seed depredation.



Plant Population at Akron						
	Dryland			Irrigated		
Species	2012	2013		2012	2013	
	-------plants/ha------		% of 2012	-------plants/ha------		% of 2012
Pea	885,400	381,200	43.1	922,300	418,100	45.3
Rapeseed	1,315,900	897,700	68.2	1,106,800	676,400	61.1
Flax	3,295,800	1,254,400	38.1	3,308,100	983,800	29.7
Oats	2,582,600	2,201,300	85.2	2,840,800	1,992,300	70.1
Mixture	2,791,600	402,800	14.4	3,468,000	322,800	9.3
Biomass at Termination at Akron						
	---------kg/ha--------		% of 2012	---------kg/ha--------		% of 2012
Pea	3298	2691	81.6	5420	3612	66.6
Rapeseed	2916	2149	73.7	4591	3109	67.7
Flax	3042	1829	60.1	5215	3464	66.4
Oats	3461	3967	114.6	5880	6306	107.2
Mixture	4189	2265	54.1	5667	2943	51.9



Wheat water use and grain yield for the current cover crop study and from two other studies (Akron ACR and Akron/Sidney FFS).

All of the data presented demonstrate that the water use by cover crops grown previous to winter wheat production will result in lower wheat water use and lower wheat grain yield. The current water use and yield data follow a previously published relationship.

For all of the data from the current cover crop study (red, green, blue, purple points) the greatest water use and yield in each color grouping is seen for the wheat following fallow. There appears to be no enhanced water use efficiency of wheat following a cover crop mixture as the points associated with the mixtures are not above or to the left of the other points with similar color.

Cover Crop Seed Costs

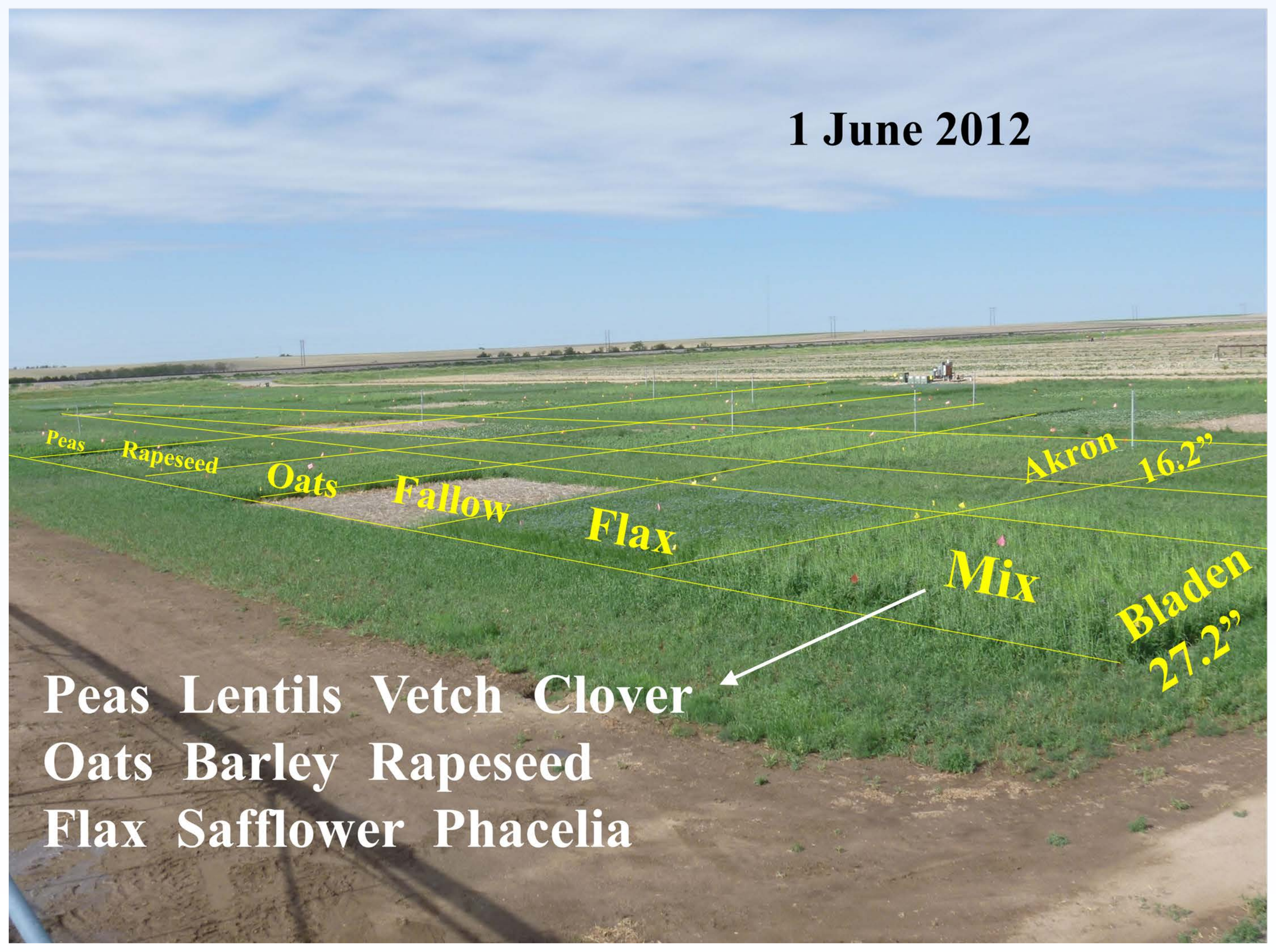
Single Species				Mixture Planted at 58.3 kg/ha (52 lb/a)	
				[Mixing cost of $0.11/kg ($0.05/lb)]	
	Seed Cost	Target Rate	Total		
Species	$/kg ($/lb)	kg/ha (lb/a)	$/ha ($/a)		$/ha ($/a)
Pea	$0.88 ($0.40)	112 (100)	$98.77 ($40.00)	Seed	$84.70 ($34.29)
Lentil	$1.43 ($0.65)	56 (50)	$80.25 ($32.50)	Mixing	$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)		

Cover crop seed costs range from $14.81/ha (rapeseed) to $98.77/ha (pea, vetch) The mixture cost $91.12/ha. Additional costs include the seeding operation (~$36/ha) and the chemical spray operation to terminate cover crop growth (~$30/ha).

Conclusions

Cover crops grown in mixtures generally do not use less water than cover crops grown in single-species plantings and generally will use more water than is lost by evaporation from fallow. The cover crop water use will generally result in lower water availability at planting of the subsequent wheat crop which will depress yield. The consistency in the wheat water use/yield response should inspire confidence in the conclusions derived from many previous rotation studies conducted in this region, i.e., that cropping intensification (elimination of fallow) will generally reduce subsequent crop yields. Replacing fallow with a crop that has some economic value is highly desirable in dryland cropping systems, but evidence of enhanced system productivity with the use of **cover crop mixtures** is currently not evident for this region. Farmers will have to determine whether the costs of cover crop production are justified for their individual farming operations, but the use of more costly cover crop mixtures in place of less costly single-species plantings does not appear to be justified for dryland systems in this semi-arid region. These conclusions may be different under more humid conditions.

Experimental Area at Akron, CO



Acknowledgements

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