Cover crops can affect subsequent wheat yield in the Central Great Plains

This research documented water use, grain yield, and water use efficiency of wheat following a 10-species cover crop mixture and single-species plantings (planted no-till into proso millet residue) compared with winter wheat following a no-till fallow period. The study was conducted under varying water availability conditions in western Nebraska and northeastern Colorado. Earn 0.5 CEUs in Soil & Water Management by reading this article and taking the quiz at www.certifiedcropadviser.org/certifications/self-study/775.

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In recent years, the USDA-NRCS has widely promoted the use of cover crops in cropping systems to improve soil health throughout the USA. There are indisputable reasons for implementing cover crops, such as providing protection from wind and water erosion and building soil organic matter levels. But in semi-arid regions (10 to 20 inches of annual precipitation), which are chronically short of water for stable dryland crop production, there may be significant costs associated with cover crop water use and reductions in subsequent cash crop yields that will make successful implementation of cover crops difficult to achieve.

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Previous studies documenting the effects of cover crops on subsequent crop yields from many different regions have shown both positive and negative effects on yield. In the studies that have been done in the semi-arid environments of the Central and Southern Great Plains (Colorado, Kansas, Oklahoma, and Texas) most have shown that growing cover crops reduced subsequent crop yields. Unger et al. (2006) cautioned that cover crop use in semi-arid dryland regions could be detrimental to yields of subsequent crops because of the water that the cover crop used that was not replenished by precipitation between the time of cover crop termination and planting the next crop. But even in some studies conducted in more humid conditions, negative effects on yield have been reported although the yield

Table 1. Winter wheat yield and water use efficiency following fallow or following cover crops at Akron, CO and Sidney, NE in 2013 and 2014.

	Dry year (2013)					Wet year (2014)				
	Akron dryland	Akron irrigated	Sidney dryland	Sidney irrigated	Avg	Akron dryland	Akron irrigated	Sidney dryland	Sidney irrigated	Avg
Wheat yield	bu/ac									
Following fallow	27.5	102.0	49.3	62.2	60.2	66.4	83.7	58.0	64.5	68.1
Following cover crop	16.5	92.4	40.3	51.9	50.3	63.1	80.9	55.5	61.1	65.1
Difference	10.9	9.6	8.9	10.3	9.9	3.3	2.8	2.5	3.4	3.0
Wheat water use efficiency	bu/ac/inch									
Following fallow	2.12	3.71	2.86	2.73	2.85	3.14	3.45	3.46	3.59	3.41
Following cover crop	1.40	3.72	2.58	2.47	2.54	3.20	3.52	3.52	3.66	3.47

reduction was attributed to effects other than cover crop water use (however, soil water was not always measured). In those cases, yield depressions were sometimes associated with emergence and stand establishment problems or nitrogen unavailability. In results from the U.S. Northern Great Plains states and Canadian Prairie provinces, yields were not as frequently reduced by a prior cover crop, and this is likely a result of the lower demand for water seen at those locations.

Some recent statements by NRCS personnel and others have suggested that cover crops grown in mixtures use far less water than single-species plantings due to enhanced microbiological activity (soil fungal and bacterial associations) that improves drought tolerance through access to greater soil volume. Consequently, detrimental effects on subsequent crop yields would be minimal following a cover crop. However, recently published work from northeast Colorado reported that cover crop mixtures do not use less water than single-species plantings of cover crops (Nielsen et al., 2015), and microbiological populations for cover crop mixtures were not different from those observed with single-species plantings of cover crops (Calderón et al., 2016).

A recent study published in the January–February 2016 issue of *Agronomy Journal* (http://bit.ly/1RI1iXO) documented water use, grain yield, and water use efficiency of wheat following a 10-species cover crop mixture and single-species plantings (planted no-till into proso millet residue) compared with winter wheat following a no-till fallow period. The study was conducted under varying water availability conditions in western Nebraska and northeastern Colorado. Water availability ranged from dryland conditions with below-average precipitation to irrigated management that simulated south-central Nebraska average precipitation. The 10-species mixture was comprised of rapeseed, flax, oat, pea, lentil, common vetch, berseem clover, barley, phacelia, and safflower. The single-species cover crop plantings were flax, oat, pea, and rapeseed.

Of the eight individual data sets acquired during the study, the four collected in 2013 (dry year) showed significant reductions in wheat yield where the cover crop had been grown ahead of the wheat compared with wheat on fallow (average yield of 60.2 bu/ac on fallow vs. 50.3 bu/ac following cover crop, Table 1). The other four data sets came from 2014 with generally greater May and June precipitation and greater available soil water at planting than in 2013. The average yields observed in these four wetter-condition data sets were 68.1 bu/ac for wheat on fallow and 65.1 bu/ac for wheat following cover crop (difference not statistically significant). An additional reason found for no yield difference following fallow vs. following a cover crop in these four data sets (2014) was that the proso millet residue on the fallow treatment was in very poor condition by the time the cover crop was terminated (about nine months after millet harvest) compared with the new cover crop residues. This resulted in very low precipitation storage efficiencies during the fallow period for the fallow treatment compared with the cover crop treatments with their greater residue covers.

These data demonstrate that under some conditions (greater water availability and poor condition of existing residue) cover crops may be grown without causing significant reductions to the next wheat crop. However, even though in some years there may be no (or only minor) wheat yield depressions following cover crops, in those years, there will be lowered economic returns due to the costs associated with cover crop seed and planting and termination operations that a farmer must consider and account for. These may be offset if the cover crop can provide some economic benefit through forage harvest or grazing, as seems to fit the current definition of cover cropping.

Table 2. Winter wheat yield and water use efficiency following a 10-species cover crop mixture or following single-species plantings of cover crops at Akron, CO and Sidney, NE in 2013 and 2014.

	Dry year (2013)					Wet year (2014)				
	Akron dryland	Akron irrigated	Sidney dryland	Sidney irrigated	Avg	Akron dryland	Akron irrigated	Sidney dryland	Sidney irrigated	Avg
Wheat yield	bu/ac									
Following mixture	19.6	91.2	42.3	52.8	51.5	67.1	82.5	54.5	60.0	66.0
Following single species	15.8	92.6	39.9	51.8	50.0	62.1	80.5	55.8	61.4	64.9
Difference	3.8	-1.4	2.5	1.0	1.5	5.1	2.0	-1.3	-1.4	1.1
Wheat water use efficiency	bu/ac/inch									
Following mixture	1.59	3.58	2.67	2.51	2.59	3.31	3.45	3.44	3.72	3.48
Following single species	1.35	3.75	2.56	2.46	2.53	3.18	3.53	3.53	3.64	3.47

The study also found that wheat following cover crops grown in a 10-species mixture did not yield significantly more than wheat that followed single-species plantings of cover crops (Table 2). Wheat water use efficiency (yield divided by water use) was generally greater for wheat following fallow than for wheat following a cover crop in the dry year, but not in the wet year. There were no differences in wheat water use or water use efficiency between wheat following a cover crop mixture and wheat following single-species cover crops in either the wet or the dry year.

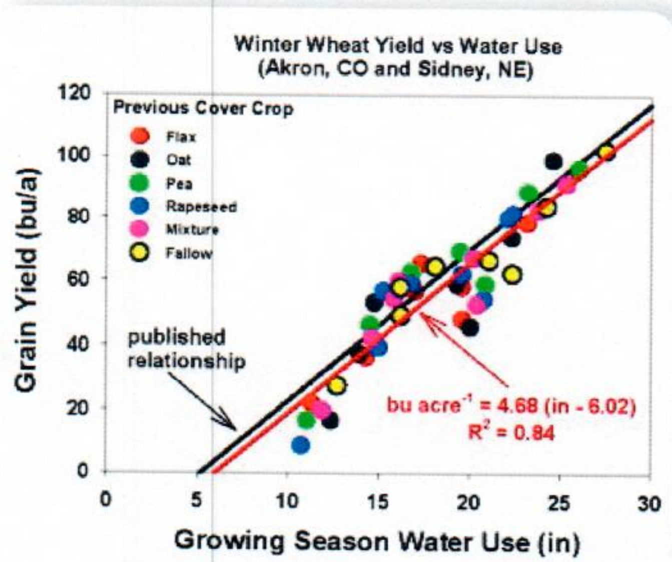

Fig. 1. Winter wheat water use and yield following fallow, flax, oat, pea, rapeseed, and a 10-species mixture of cover crops grown at Akron, CO, and Sidney, NE, in 2013 and 2014. The published relationship is from Nielsen et al. (2011).

An additional analysis of water use efficiency was done by regressing wheat yield against growing season water use and comparing the slopes of the regressions (Fig. 1 and Table 3). The water use-yield relationship found using all of the data collected in the study was found to be

$$\text{Yield (bu/ac)} = 4.68 \times [\text{water use (inches)} - 6.02]$$

This relationship was nearly identical to a previously published relationship. There were no statistically significant differences in the slopes of the regressions found for wheat following specific single-species plantings of cover crops or the cover crop mixture.

Since wheat water use efficiency appears to not be improved following a cover crop mixture when compared with following single-species cover crops, there appears to be no reason to recommend a cover crop mixture over a single-species cover crop. Additionally, the large amount

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Table 3. Winter wheat water use efficiency following a 10-species cover crop mixture, single-species plantings of cover crops, or fallow at Akron, CO and Sidney, NE in 2013 and 2014. Values are the slopes of the water use-yield regression relationship with form Yield (bu/acl) = a × [water use (in) – b]. Slopes are not significantly different from one another.

Previous crop	Slope (a)
	bu/ac/inch
	4.46
Flax	4.66
Oat	4.96
Pea	4.79
Rapeseed	5.13
Fallow	4.28

Chuck Bolte named

2016 Wisconsin CCA of the Year

By Bryan Jensen, University of Wisconsin IPM Program and Wisconsin CCA Board

Please join the WI CCA Board in welcoming Chuck Bolte as the 2016 Wisconsin CCA of the Year! Chuck is currently working for AgSource Laboratories in Bonduel, WI and has more than 20 years of agricultural work experience, including 15 years of CCA status from Minnesota and Wisconsin. He also holds the 4R NPM specialty certification.

Chuck's background includes internships with Pest Pro's and Jefferson County Land Conservation, a degree from the University of Wisconsin–Stevens Point, and full-time employment at the Richland County Land Conservation Office. A one-year tour of duty in Iraq ended with a job switch to the Frito Lay Research Station at Rhinelander, WI where he was involved with several areas of research including potato breeding and field trials for chipping potential. Chuck has worked for AgSource since 1996 and is currently the manager for the precision agriculture and nutrient management division.

In addition to his normal workload, which includes nutrient management, cover crops, and the use of aerial imagery to plan management zones and to write VRT recs for lime and potash, he has been actively involved with writing grants and working with farmer-led watershed projects. Chuck's volunteer service includes the Langlade County Breakfast on the Farm, Women in the Outdoors, mentoring youth hunts, high school career day speaker, membership and committee service with the Wisconsin Association of Professional Agricultural Consultants, and membership in the Farm Bureau.

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Cover crops and wheat yield

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of previous research detailing the generally detrimental effects on yield due to previous crop water use in dryland semi-arid environments in the Central and Southern Great Plains should be used to guide decisions about cover crop use in these regions. If cover crops are needed to augment existing crop residues to provide erosion protection or for supplemental livestock feed, the added expense generally seen for cover crop mixtures compared with single-species plantings (Nielsen et al., 2015) is not likely to be justified. If the cover crops are being grown primarily to provide soil surface protection against erosion, the recommendation of Unger and Vigil (1998) should be followed in semi-arid production regions: cover crops should be terminated as early as possible after acquiring sufficient biomass and ground cover to provide erosion protection, thereby minimizing detrimental effects on subsequent crop yields due to cover crop water use.

References

Calderón, F.J., D.C. Nielsen, V. Acosta-Martinez, M.F. Vigil, and D.J. Lyon. 2016. Cover crop effects on soil microbial communities and enzymes in semiarid agroecosystems of the central Great Plains of North America. Pedosphere 26:192–205.

Nielsen, D.C., D.J. Lyon, G.W. Hergert, R.K. Higgins, F.J. Calderon, and M.F. Vigil. 2015. Cover crop mixtures do not use water differently than single-species plantings. Agron. J. 107:1025–1038. doi:10.2134/agronj14.0504

Nielsen, D.C., M.F. Vigil, and J.G. Benjamin. 2011. Evaluating decision rules for dryland rotation crop selection. Field Crops Res. 120:254–261. doi:10.1016/j.fcr.2010.10.011

Unger, P.W., D.W. Fryrear, and M.J. Lindstrom. 2006. Soil conservation. In: G.A. Peterson et al., editors, Dryland agriculture. Agron. Monogr. 23. ASA, CSSA, and SSSA, Madison, WI. p. 87–112.

Unger, P.W., and M.F. Vigil. 1998. Cover crop effects on soil water relationships. J. Soil Water Conserv. 53:200–207.

Adapted from Nielsen, D.C., D.J. Lyon, R.K. Higgins, G.W. Hergert, J.D. Holman, and M.F. Vigil. 2016. Cover crop effect on subsequent wheat yield in the Central Great Plains. Agron. J. 108:243–256. View the full article online at http://bit.ly/1Uw4uMo