Biosolids and Conservation Tillage: Long-Term Effects on Grain and Straw Yield of Dryland Wheat

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The Experiment: Biosolids produced from municipal wastewater treatment plants are applied to many agricultural fields around the world as a source of nitrogen, phosphorus, and other plant nutrients. Biosolids also provide stable soil organic matter (SOM) and, therefore, can replenish some of the SOM lost to oxidation and wind erosion during the past 135 years of dryland farming in the wheat-fallow region of the Pacific Northwest. An 8-year biosolids field experiment was initiated at Lind, WA in April 2011. We used a split-block experimental design with tillage method (either traditional tandem disk or conservation undercutter) for main-plot treatments and sub-plot treatments were fertilizer type (either synthetic fertilizer or biosolids). There are two sets of plots to allow for data collection every year in the 2-year wheat-fallow rotation. Biosolids were applied with a manure spreader at a rate of 2.8 dry tons/acre to meet the nutrient requirements for two winter wheat crop over four years (2012-2015). Biosolids were reapplied to both sets of plots at the same rate for the 2016-2019 crop years. The synthetic fertilizer treatment receives 50 lbs. N and 10 lbs. S/acre as aqua + thiosol for every wheat crop.

Results: The first six years showed equal winter wheat grain yield between tillage method and fertilizer method combinations (Table 1). More spikes were produced with biosolids, but this was offset by greater kernel weight in the synthetic fertilizer treatment (Table 2). These yield component differences primarily occurred during the first crop after biosolids application when relatively more nitrogen is released compared to the second crop cycle. Importantly, biosolids-amended soils produced 22% more wheat straw ($p = 0.007$) compared to synthetic fertilizer (Table 2). Undercutter primary tillage retained significantly ($p<0.001$) more surface residue through the fallow cycle compared with the tandem disk. Table 3 shows that adequate plant nutrients remain in biosolids-amended soils in east-side plots even after producing two wheat crops in 2013 and 2105. This study has documented that use of biosolids combined with low-soil-disturbance conservation tillage is an agronomically sound practice for dryland wheat production.

Table 1. Winter wheat grain yield (bushels/acre) in Lind biosolids experiment for the first six years.

	2012	2013	2014	2015	2016	2017	6-yr avg.
Application							
Synthetic Fertilizer	50	42	32	21	21	72	45
Biosolids	54	44	31	23	23	69	45
Significance ($p \leq 0.05$)	ns	ns	ns	ns	ns	ns	ns
Tillage							
Undercutter	52	43	33	22	22	73	46
Tandem disk	52	43	30	23	23	69	45
Significance ($p \leq 0.05$)	ns	ns	ns	ns	ns	ns	ns
Crop-year precipitation	11.09	10.87	7.69	7.61	12.66	14.78	10.78

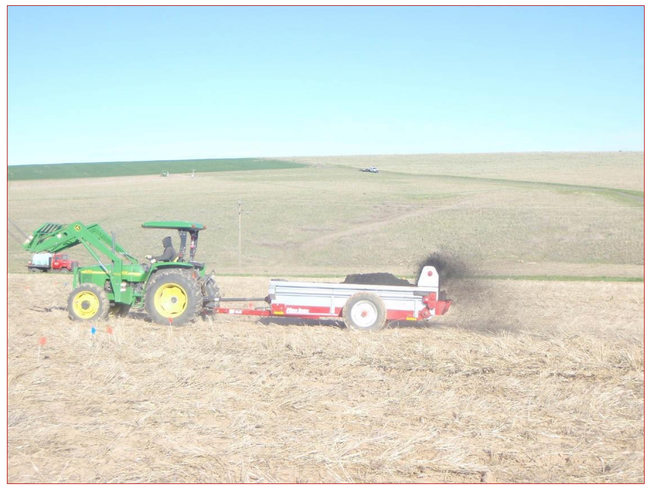
Table 2. Winter wheat grain yield components, straw production, and surface residue after planting averaged over years at Lind.

		Yield Components				
	Surface residue (%)*	Spikes (m^2)	Kernels / Spike	1000 Grain wt. (g)	Grain yield (bu/A)	Straw wt. (lbs/A)
Application						
Synthetic fertilizer	24	220	35	39	40	3220
Biosolids	24	262	35	35	41	3910
Significance ($p \leq 0.05$)	ns	0.02	ns	0.002	ns	0.007
Tillage implement						
Undercutter	29	238	35	37	40	3500
Tandem disk	19	244	35	37	40	3630
Significance ($p \leq 0.05$)	< 0.001	ns	ns	ns	ns	0.03

*Percent surface residue cover remaining after planting into summer fallow with deep-furrow drills.

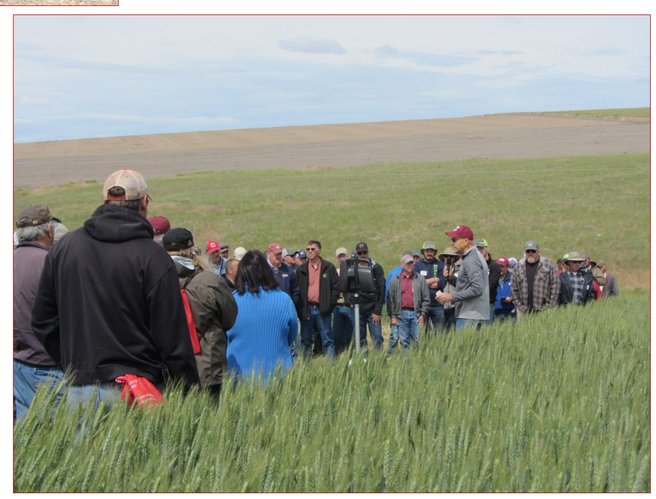
Table 3. Soil test data from east-side biosolids plots in April 2016 prior to application of synthetic fertilizer and the second application of biosolids. Biosolids from the first application fertilized the 2013 and 2015 wheat crops. More nitrate-N was present than expected in this sampling, likely due to limited N uptake by the low-yielding wheat in 2015 (see yield data above).

	Nitrate (lbs/ac/4 ft)	Phosphorus (ppm)	Sulfate (lbs/ac/4 ft)	Water (in./4 ft)	SOM (%)
Application					
Synthetic Fertilizer	42	15	45	5.8	1.04
Biosolids	96	26	45	5.9	1.06
Significance ($p \leq 0.05$)	0.04	0.009	ns	ns	ns
Tillage					
Undercutter	67	22	51	5.9	1.04
Tandem disk	67	19	38	5.8	1.06
Significance ($p \leq 0.05$)	ns	ns	ns	ns	ns



Biosolids are applied with a manure spreader once every four years at a rate of 2.8 dry tons/acre, which is adequate to produce two crops of winter wheat. Biosolids applied at this rate contain 55 pounds of available phosphorus, an expensive nutrient for farmers to buy as synthetic fertilizer.

The east-side biosolids plots were shown and discussed in June 2017 at the annual WSU Lind Dryland Research Station field day with 259 farmers and others attending.



Grain harvest of the west-side biosolids plots in July 2012. The town of Lind is in the background.

Further Reading:
Schlatter, D.C., W.F. Schillinger, A.I. Bary, B. Sharratt, and T.C. Paulitz. 2017. Biosolids and conservation tillage: Impacts on soil fungal communities in dryland wheat-fallow cropping systems. Soil Biology & Biochemistry 115: 556-567.