Single High-Rate Compost Application in Wheat with Winter Pea Rotation: A Long-term Study

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Compost in agricultural production is used as both a source of fertility and a soil conditioner. Compost has been shown to improve crop yield and quality, stimulate soil microbial processes and nutrient cycling, improve water infiltration and retention, decrease erodibility and aid in the restoration of degraded soils. The number of composting facilities in Washington has been increasing in recent years. A development which stands to increase availability and reduce transport costs of compost materials in areas of Washington.

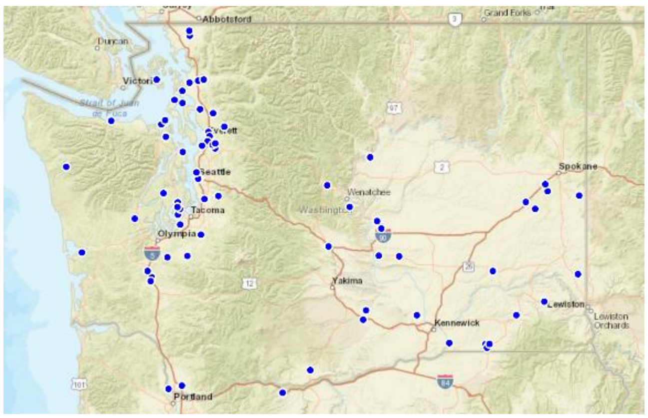

Figure 1. *Composting facilities in Washington from Data.WA.gov*

A recent study from Utah State showed that a single high-rate compost application to a dryland wheat system resulted in crop yield and soil quality benefits that were measurable 16 years after application (Reeve et al. 2012). Sustained crop and soil benefits from a single compost application may increase the practicality and economic appeal of applying compost as a soil amendment in Washington's dryland wheat-based cropping systems. A long-term compost study site was established at the Washington State University Wilke Research Farm in Davenport, Washington. The study was established in a no-till dryland wheat-based field site with silt loam soil. The site receives an average of 13.28" of annual precipitation. In Fall 2016, municipal compost from Spokane, WA, was surface-applied at one-time rates of 0, 5, 25, and 50 tons DM ac^{-1}. The compost had a pH of 7.5, and a complete nutrient analysis was performed on the compost and is outlined in Table 1. In 2017 and 2018, synthetic fertilizer (46-0-0-0 & 16-20-0-13) was applied at planting to winter wheat at a rate of 100 lb ac^{-1} Nitrogen, 20 lb ac^{-1} Sulfur, and 33 lb ac^{-1} Phosphorus applied to positive control plots.

Figure 2- *Wilke farm field site in Davenport, WA with winter wheat and winter peas growing in the spring 2019*

Table 1. *Fertilizer equivalent of nutrients added with increasing rates of compost*

Compost Rate (tons ac^{-1})	**Nutrients added with compost by treatment rate (lbs ac^{-1})***												
	Org. Matter	*Org. C*	*Tot. N*	*NH4*	*NO3*	*P2O5*	*K2O*	*Ca*	*Mg*	*S*	*B*	*Zn*	*Fe*
5	5270	2700	177	14	0.0	120	91	280	47	6	0.3	2	175
25	28985	14850	974	28	0.1	660	501	1540	259	12	0.6	4	349
50	57970	29700	1947	57	0.2	1320	1001	3080	517	23	1.3	8	698

**Converted from dry weight nutrient analysis of compost as provided by Soiltest farm consultants*

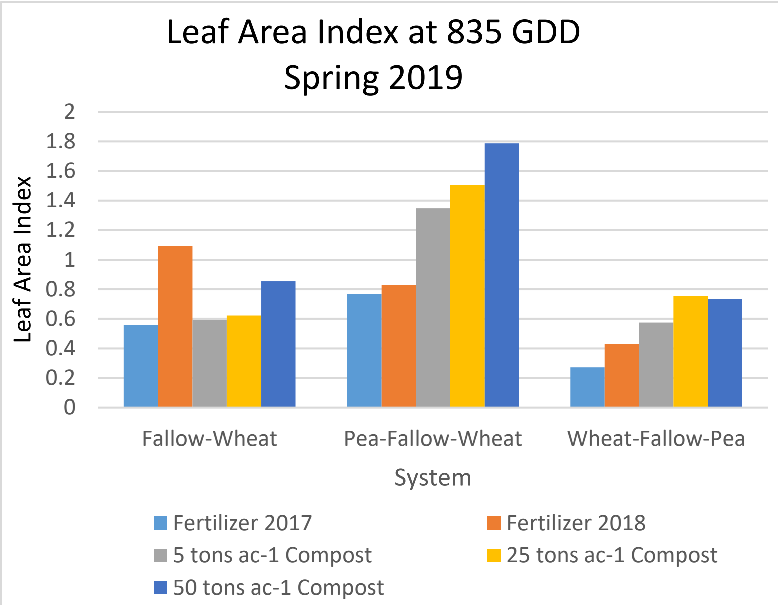

Figure 1. *Crop canopy cover in wheat and peas with compost treatment and crop rotation in Spring 2019 measured at 835 growing degree days using leaf area index*

Two cropping systems were managed within each whole treatment: a winter wheat-fallow rotation, and a winter wheat-fallow-winter pea rotation. Winter wheat grown was the soft white variety Otto. Wheat yield and quality data was collected from each year since establishment. Crop canopy was measured as light interception by leaves or leaf area index, using a ceptometer instrument. Prior to fall seeding, soil was sampled to 36” using four depth increments of 0-6”, 6-12”, 12-24”, and 24-36”. Soil measurements were analyzed for moisture, organic matter, pH, primary nutrients (N, P, K), secondary nutrients (Ca, Mg, S), and micronutrients (B, Zn, Cu, Mn, Fe). Analysis for soil enzymes dehydrogenase and phosphatase, as well as microbial biomass are pending.

Overall, wheat yield was higher with compost treatment than with no added fertility (Table 2). The greatest yield difference was seen with 50 tons ac^{-1} of applied compost, even three years after application. The 50 tons ac^{-1} compost treatment had no difference in yield compared to the positive control plots which were fertilized with synthetic fertilizer (Table 2). Addition of compost increased soil phosphorous, sulfur, and boron. Wheat yield in 2018 was increased by presence of boron and organic matter at the 6-36” depths.

Wheat quality was not affected by compost treatment in 2017 or 2018 (Table 3). Rotational effects on wheat from peas grown in 2017 were first observed in 2019 beginning early in the season with effects from both cropping system and compost treatment. Wheat following peas in rotation had greater early-season crop canopy cover than the wheat-only rotation, and the effect was increased by increasing compost rate. Early season canopy cover was also increased in peas by compost treatment (Figure 3).

Compost applied at 50 tons ac^{-1} increased soil moisture in fallow in fall of 2018 throughout the soil profile. In spring 2019, soil sampling of the top 6” in the wheat rotation had higher soil moisture for the 50 tons ac^{-1} treatment, the opposite was observed the wheat-pea rotation which resulted in lower soil moisture. In the fall of 2019, soil moisture was highest at the top three sampling depths for the 50 tons ac^{-1} compost treatment.

Moisture and many nutrient effects were most pronounced at the soil surface, which may be attributed to the surface application of the compost treatment without incorporation, creating a mulch effect. Fertility results and yield were comparable to that of synthetic fertilizer. The positive effects on soil nutrients and moisture were seen two and three years following compost application. The 50 tons ac^{-1} compost rate had the greatest impact on soil moisture, primary plant nutrients in the soil, and wheat yield.

Table 2. *Winter wheat yield by compost treatment and crop rotation at Wilke Farm from 2017-2019*

	Soft White Winter Wheat Yield (bu ac^{-1})			
	------------------Year-------------------			
	2017	*2018*	*2019*	*2019*
	Wheat-Fallow Rotation			Wheat-Pea Rotation
0 tons ac^{-1} DM compost	94	43	40	53
Synthetic Fertilizer		74	46	34
5 tons ac^{-1} DM compost	104	52	52	56
25 tons ac^{-1} DM	112	67	54	60
50 tons ac^{-1} DM	116	72	55	84
Farm average	87	72	70	70

Table 3. *Winter wheat quality for compost treatment from Wilke Farm 2017 and 2018*

Soft White Winter Wheat Quality			
	----------------*2017*-------------		
Compost rate	Falling numbers	Test Weight	Protein
0 tons ac^{-1} DM compost	374	62.2	9.9
5 tons ac^{-1} DM compost	382	62.3	9.4
50 tons ac^{-1} DM compost	378	62.1	10.1
	-----------------*2018*---------------		
0 tons ac^{-1} DM compost	348	62.2	9.5
Synthetic Fertilizer	351	62.4	9.2
5 tons ac^{-1} DM compost	361	62.7	9.2
25 tons ac^{-1} DM compost	355	62.9	9.7
50 tons ac^{-1} DM compost	370	62.5	9.9

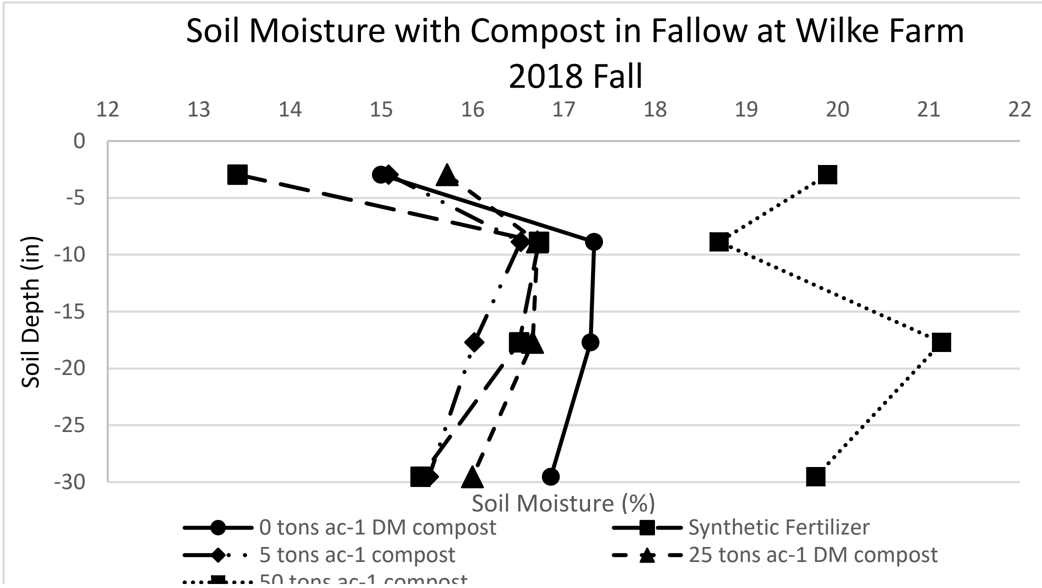

Figure 2. *Percent soil moisture with compost treatment at depths from 0-36" in Fallow at Wilke Farm in Fall 2018*

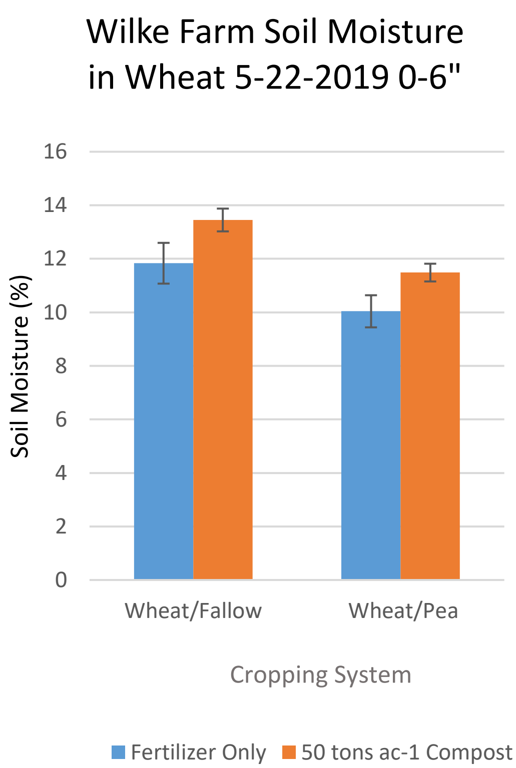

Figure 5. *Surface soil moisture with 50 tons ac^{-1} compost treatment vs. fertilizer on May 22, 2019 at Wilke farm in Winter Wheat*

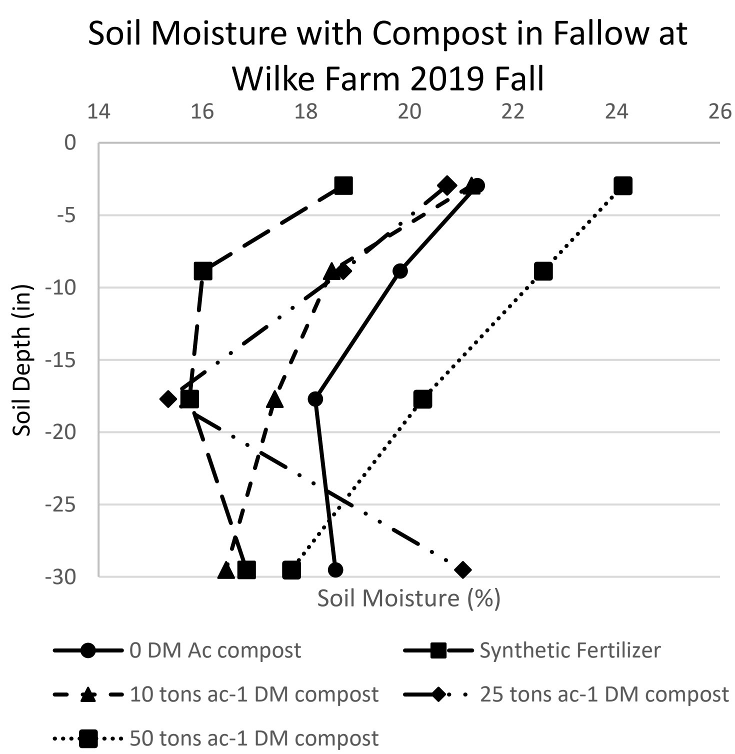

Figure 6. *Percent soil moisture with compost treatment at depths from 0-36" in fallow at Wilke Farm in Fall 2019*