Compost Carryover Effects on Soil Quality, Productivity and Cultivar Selection in Organic Dryland Wheat

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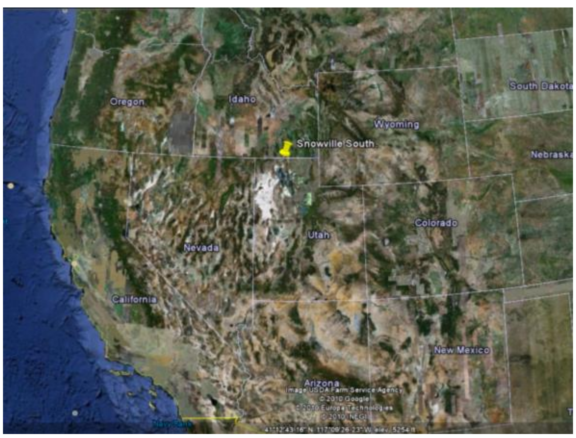
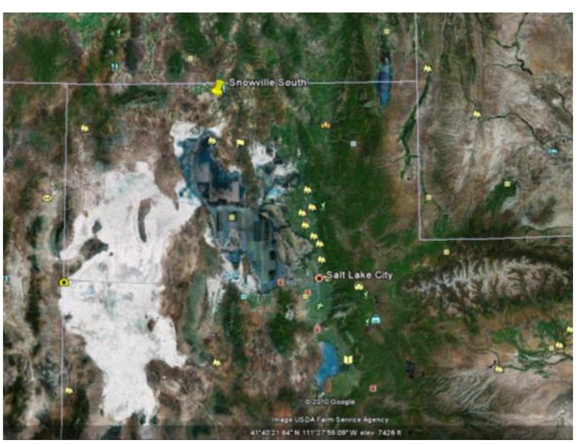
Multi-State Project

- Awarded by the USDA OREI program
  - Utah State University: Earl Creech, Jennifer Reeve, David Hole, Astrid Jacobson, Kynda Curtis
  - Washington State University
  - University of Wyoming
  - Oregon State University





Original Study

Methods

- Completely Randomized Block Design
- Three replicates
- Two treatments: compost and control
- Plot size 8 m x 15 m.
- Dairy manure + straw bedding compost applied at 22 tons per acre dry weight in 1995.

Compost Characteristics

Parameter	Analytical Result	Amount Supplied
pH	8.5	-
EC	29 dS/m	-
Moisture	55%	-
Total N	1.9%	960 kg ha^{-1}
Nitrate-N	2,415 mg kg^{-1}	120 kg ha^{-1}
C:N Ratio	20:1	-
Total P	0.57%	288 kg ha^{-1}
Total K	2.90%	1,462 kg ha^{-1}
Total S	0.36%	180 kg ha^{-1}

Winter Wheat (Weston) Yield

Yield kg ha^{-1}	Compost 1995	Control 1995	Compost 1997	Control 1997
Winter wheat	3,746†	1,480	3,410†	1,096

Yield kg ha^{-1}	Compost 2008	Control 2008	Compost 2010	Control 2010
Winter wheat	446†	213	1,560§	840

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

Soil Property 0-5cm depth (g^{-1} soil)	Compost 2008	Control 2008	Compost 2010	Control 2010
Olsen P µg	39.3‡	18.4	35.3 †	18.2
Olsen K µg	836 ‡	855	789 †	685
Dehydrogenase µg TPF	8.51	7.26	62.4 §	44.1
Acid Phosphatase µg p-nitrophenol	132§	105	43.1*	30.7
Alkaline Phosphataseµg p-nitrophenol	140	122	657 †	496
Readily Mineralizable C µg	6.97	4.84	3.51	3.58
Microbial Respiration µg	0.703	0.787	0.758	0.690
Microbial Biomass µg	104	96	218	184

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

Soil Property 0-5cm (g^{-1} soil)	Compost 2008	Control 2008
Organic Carbon µ	15,233†	6,830
Organic N µ	1,386	1,276
Nitrate µ	1.44	1.87
Ammonium µ	0.115	0.132
Manganese DPTA µ	11.0	11.0
Zinc DPTA µ	1.10*	0.74
Iron DPTA µ	4.00	3.95
Copper DPTA µ	1.79	1.62
Total Sulfur µ	277	258

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

Soil Property 5-10 cm depth (g^{-1} soil)	Compost 2008	Control 2008	Compost 2010	Control 2010
Olsen P μg	32.3‡	13.5	35.7‡	14.4
Olsen K μg	798§	602	785‡	650
Dehydrogenase μg TPF	6.10	4.90	41.0†	31.5
Acid Phosphatase μg p-nitrophenol	111	40.0	101	30.4
Alkaline Phosphataseμg p-nitrophenol	131	119	534	434
Readily Mineralizable C μg	4.32	4.02	2.55	2.50
Microbial Respiration μg	0.622	0.598	0.678	0.596
Microbial Biomass μg	74	61	137	126

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

Soil Property 5-10cm (g^{-1} soil)	Compost 2008	Control 2008
Organic Carbon μ	12,863	6,570
Organic N μ	1,742	1,228
Nitrate μ	1.03	0.928
Ammonium μ	0.198	0.079
Manganese DPTA μ	10.5	9.93
Zinc DPTA μ	1.23	0.82
Iron DPTA μ	3.90	3.68
Copper DPTA μ	1.79	1.63
Total Sulfur μ	266	244

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

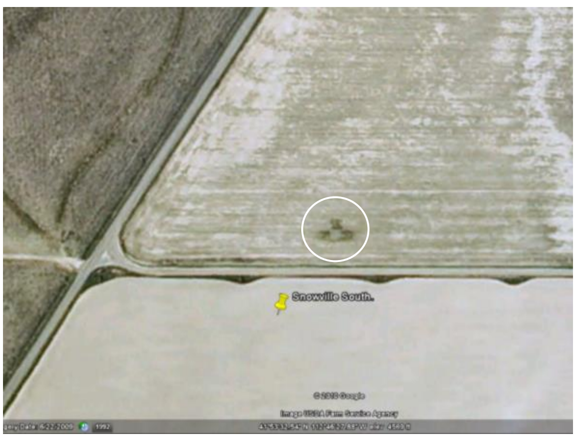
Soil Property 10-30cm depth (g^{-1} soil)	Compost 2008	Control 2008	Compost 2010	Control 2010
Olsen P μg	5.07	3.87	5.63	3.43
Olsen K μg	608	512	640	575
Dehydrogenase μg TPF	1.76	1.26	13.0	9.40
Acid Phosphatase μg p-nitrophenol	-	-	-	-
Alkaline Phosphataseμg p-nitrophenol	-	-	-	-
Readily Mineralizable C μg	1.97	1.94	1.13	1.21
Microbial Respiration μg	0.391	0.400	0.447	0.461
Microbial Biomass μg	34	34	71	65

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.

Soil Test Results

Soil Property 10-20cm (g^{-1} soil)	Compost 2008	Control 2008
Organic Carbon µ	5,870	5,657
Organic N µ	1,301	1,265
Nitrate µ	2.50	2.44
Ammonium µ	0.278	0.263
Manganese DPTA µ	4.51	4.21
Zinc DPTA µ	0.427	0.407
Iron DPTA µ	5.47	5.14
Copper DPTA µ	1.15	1.08
Total Sulfur µ	267	257

Treatment means designated *, †, ‡ and § are significant at $p < 0.05$, $p < 0.01$, $p < 0.001$ and $p < 0.0001$ respectively.



Cumulative yield gain since 1995

Year	Crop	Y_0	Y_{50} measured	Y_{50} estimate	Y_{50}-Y_0 estimate
1995	wheat	22	56	64	42
1997	wheat	16	51	43	27
1998	safflower	-	-	-	-
2000	wheat	21*	-	52	31
2002	wheat	8*	-	19	11
2004	wheat	4*	-	9	5
2006	wheat	20*	-	42	22
2008	wheat	3	7	6	3
2010	wheat	13	23	25	12

* R. Grover's average for that field in bushels / acre.
Note: missing years are fallow years i.e.. no crop grown.

Estimated Cumulative Yield Gain

- (Y_{50}-Y_0) since 1995 = 152 bu/ac = 4.56 tons/ac
- Cost of Miller's compost = $154 (ton DM compost)$^{-1}$ so 22 tones per acre = $3,394
- Average price of organic wheat in 2009 = $330 ton^{-1} and $330 x 4.56 = $1,505.
- Cost of Morgan's Dairy compost = $46 ton DM compost)$^{-1}$ so 22 tones per acre = $1,012.
- For T = infinity (assuming the average of Y_0 of 13 bu/ac), the expected cumulative yield gain for wheat-fallow is 325 bu/ac = 9.77 tons per acre.
- Total estimated yield gain worth $3,224?

Conclusions

- Compost carryover is evident on soil quality, soil fertility and yield of winter wheat 16 years after application.
- At current wheat prices this carryover is insufficient to justify application of purchased compost at the rate of 22 tons per acre.
- Further research is needed to measure long term carryover of lower application rates on yield.
- Application of cheaper compost at current hauling rates would be economical.

New Multi-State Project

- Awarded by the USDA OREI program
  - Utah State University: Earl Creech, Jennifer Reeve, David Hole, Astrid Jacobson, Kynda Curtis
  - Washington State University: Ian Burk, Randy Fortenbery
  - University of Wyoming: Jay Norton, Urzula Norton, Axel Garcia (now at University of Minnesota)
  - Oregon State University: Alexandra Stone and e-organic

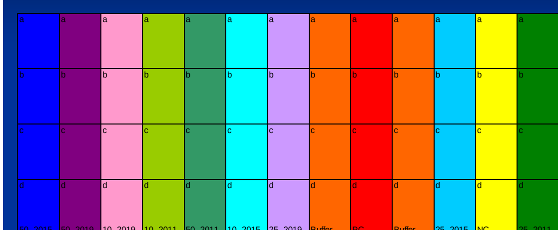
Objectives

- A) Characterize the effect of cover crops and compost carryover on soil quality, soil moisture, weed suppression, wheat yield and quality, and long-term economic return in dryland wheat-fallow production systems
- B) Select wheat varieties for optimum yield, quality and economic feasibility in organic dryland systems
- C) Increase adoption and sustainability of organic wheat production

Blue Creek Experiment Station

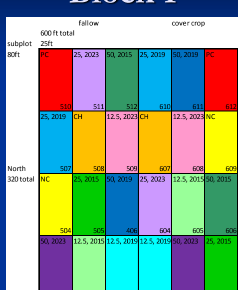
- New long-term experiments
  - RCBD four replicates and split split plot
  - Whole plot = Fertility input (compost at 0, 5, 10, 20 tons / acre + positive control)
  - Split plot = cover crop
  - New applications of compost to new ground compared to previous applications using regression analysis.

Plot layout for Blue Creek Block 1



Each whole plot = 200 x 24 ft

Plot Layout for Snowville 2 Block 1



Next steps

- Keep monitoring Richard Grover's plots
- New trials at the Blue Creek Experiment Station and Richard Grover's farm:
  compost rates = 22, 11 and 5 tons per acre
- Cover crops
- Expanded crop rotations
- Better adapted varieties
- ???

Acknowledgments

- Previous work was funded by Western SARE, the NRCS CIG program and the Utah Agricultural Experiment Station and Utah State University startup funds.
- New study funded by USDA OREI
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