Farmer Rancher Grant Program

Final Report Form

1. PROJECT IDENTIFICATION

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- Project title: **On-Farm Composting: Economics and Effects of Vegetable Produce Yield and Soil Physical and Chemical Properties**
- Project Number: **FNC07-690**
- Project Duration: March 2007 to November 2010
- Date of Report: February 22, 2011

PROJECT BACKGROUND

Our farm consists of approximately 90 acres, primarily in pasture. About thirty acres are in grazing for horses and mules, with about fifty acres mowed and baled for hay. The remaining ten acres consists of house, barns and machine shops, gardens and greenhouses.

A major portion of the gardens, as well as the greenhouses, form the basis of a small market garden business. Produce, cut flowers, fresh cut herbs and plants are grown and sold at the Columbia Farmers Market in Columbia, Missouri. The 45 foot x 55 foot garden plot used for this study was originally in pasture but was grown in sweet corn, tomatoes, and a few other vegetables for the prior six years. This garden's soil is a Moniteau silt loam with an original organic matter (OM) content of about 2.2-2.5 percent. At the time the project began, heavy use had reduced OM to about 1.2 percent.

I have been a life-long gardener and a dedicated composter for a number of years. Since beginning in 2005 to build my gardening business, I have used many techniques to increase plant diversity in my systems, to provide habitat and nectuaries for beneficial species, and to include crop rotations and cover crops to improve and maintain soil quality.

PROJECT DESCRIPTION

GOALS: With the eventual goal of improving the quality of the depleted garden plot soil, my intention was to implement a program of regular compost additions to increase the organic matter, improve the ability of the soil to hold nutrients, and generally improve soil health. I maintain a continual and permanent composting system, but was uncertain if the system was capable of producing sufficient volume to treat all of the garden area in use. The alternative would be to purchase ready-made compost. Therefore, my first objective was to compare the economy of making my own versus purchasing ready-made compost.

My second goal was to compare the impact of different soil treatments on soil properties and to look at the short-term crop response to treatments in terms of marketable yield. I selected a variety of treatments, including my own compost, an OMRI (Organic Materials Review Institute)-approved organic fertilizer, and two locally-produced composts for comparison with untreated plots used as a control.

PROCESS : On-Farm Compost Production – Compost produced prior to the first year's trials was used for initial treatment trials. During the first year's work, the time needed to prepare compost for Year 2 trials was tracked. This included the time to build, monitor, and turn the piles (by hand), and to sieve and store the compost. Two cold piles were maintained, beginning with initial layering of green and brown materials, with weekly additions of kitchen parings, equine manure, dead leaves, straw, grass clippings and other yard and garden waste, to a final volume of about one cubic yard. In the fall of 2008 finished piles were sifted through a ¼ inch mesh screen, bagged, and placed in 5-gallon buckets in a root cellar to mature over the winter.

Planting, Harvest, and Data Collection – It has been my previous experience, gleaned from years as a secondary science instructor, experience in corporate science, and graduate studies that most experiments will not go smoothly on the first try. Therefore, I planned to do one year's trials to work out the logistics of the project. Factors to consider included:

- Choice of treatments
- The best method of producing larger quantities of my own compost and time and labor needed
- Choice of crops to be grown, considering such factors as ease of measuring yield, time and effort needed for handling, and data collection
- Type of data to collect
- Methods of dealing with variability in weather, watering, weed control, etc.

For the first year's trials, I planted duplicate replicates each of a control and three treatments. The treatments were 1) farm compost, 2) Bradfield Vibrant Veggie, a 2-3-6 alfalfa-based fertilizer, and 3) Microleverage® Humified Compost. I selected four different types of vegetable crops to compare, including: 1) root crops – carrots and beets, 2) leafy greens – spinach and chard, 3) flowers – zinnia and sunflowers, and 4) solanaceous crops – tomatoes and peppers. Plots were 5 feet x 6 feet in size on slightly raised beds, with 2 foot aisles between the beds. Root, leafy and flower plots were planted at appropriate times in the spring as soil was ready, with the two varieties of each type of crop within one bed. Peppers and tomatoes were planted in individual plots, four to a plot.

The spring of 2008 was extremely cool and wet. Weather conditions interfered with soil preparation, treatment applications (crops were applied as side dressing post planting), and weed control. As a result, there was poor germination of seeded crops – root, greens and flowers. Conditions were also conducive to development of early blight in the tomatoes. Peppers were the only successful crop, although some data was also collected for the tomatoes.

For the second year's trials, I added an additional treatment – Early Bird® composted poultry litter. I selected a popular heirloom tomato – Cherokee Purple – as a summer crop.

Experimental design included four replicate 10 foot x 10 foot plots of each treatment, pre-applied prior to planting. Three tomato plants were transplanted into the north half of each plot in late June, with the remaining half planted in buckwheat for summer weed control. Soaker hose and weed mat strips were laid down for watering and weed control.

Tomato numbers and weights were measured from three consecutive weeks of harvest. After tomato harvest was complete, buckwheat on the remaining half of each plot was cut and chopped, tilled in, and a fall planting of turnips, carrots, and beets was seeded into the south half of each plot. Carrots and beets did not germinate well, but turnip plantings were successful, and two sets of harvest data were collected.

Analysis of Soil and Compost – Soil samples were taken before, during, and at the completion of the project. Soil samples, farm compost, and Microleverage® Humified Compost were analyzed by the University of Missouri Soil Testing Laboratory. Analysis of Early Bird compost was supplied the manufacturer.

Data from soil analysis, tomato data, and turnip data were analyzed using Statistical Analysis System (SAS) software.

PEOPLE

Personnel who assisted with this project:

James Quinn, Horticulture Specialist, Cole County University of Missouri Extension Center
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Contribution: assistance in planning, experimental design, data interpretation

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Contribution: Assistance in harvest and data collection

RESULTS

Economics of Compost Production vs. Purchase – A total of seventeen 5-gallon buckets of farm compost were produced during the 2008 season, weighing about 20-25 lb each for a total of 340-425 lbs. Time spent in producing the compost was approximately 13 hours at an arbitrary labor cost of $10 per hour, or about $130 total. If one uses a somewhat median weight of about 390 lbs, that figures out to roughly $10 per 30 lb of compost. (Or less, if one's labor cost is estimated at a lower rate.) When compared to a 30-lb bag of high-quality commercial compost (MicroLeverage® Humified Compost) at $35 per bag, there would seem to be considerable savings in using farm-prepared compost over purchasing. The cost for a 30-lb. bag of Early Bird compost was about $6.00, which is somewhat lower than for farm compost. However, the cost per treatment was based on the cost of the application, not the cost per bag.

Based on recommendations from soil tests, application rates were calculated based on percent nitrogen (N) in the treatment; it was necessary to supplement some treatments with bone meal and/or greensand to bring treatment applications to the recommended levels for phosphorus (P) and potassium (K). When the cost of these additional supplements was added in, the cost for some treatments was higher (**Table 1**). All things considered and not counting the cost of one's labor, farm compost, Early Bird, and Bradfield fertilizer are about equal with respect to out-of-pocket cost. Microleverage® is much more costly.

<u>Crop Yields</u> – Although 2008 data were from only duplicate plots, there were some interesting trends for both tomato and peppers in response to the different amendments.

- For tomatoes, Bradfield organic <u>fertilizer</u> treatments produced higher numbers of fruits than the controls, and than for either compost, but average weight per fruit was similar to the controls.
- For peppers, <u>purchased compost</u> (Microleverage® Humified Compost) produced higher numbers of fruits than controls, farm compost, and Bradfield fertilizer, but the <u>farm compost</u> average fruit weights were much higher.

Yields for tomatoes for 2009 (Year 2 fully replicated trials) are presented in **Table 2**. Total weight of tomatoes from the three pickings was greatest for Early Bird (140 lbs) and Microleverage® (141 lbs) composts, and weights for Bradfield organic fertilizer was very similar (135 lbs). Total weight for tomatoes amended with farm compost (125 lbs) was very similar to controls (128 lbs). Breakdown of data by grade showed the highest yield of #1 grade for Early Bird treatment (total of 105 lbs), followed by Microleverage® and Bradfield (96 lbs each), with 84 lbs and 79 lbs for controls and farm compost, respectively. Statistically, there was no significant difference between controls and any of the treatments.

Turnip data for 2009 are presented in **Table 3**. Total biomass of turnips (tops plus roots) from two consecutive pickings was highest for Bradfield fertilizer (41 lbs), followed by farm compost (35 lbs), Early Bird (31 lbs), controls (26 lbs), and Microleverage® (25 lbs). However, root weight was greatest for Early Bird (25 lbs), followed by Bradfield fertilizer (21 lbs), farm compost (19 lbs), and then Microleverage and controls (13 lbs each). Only Bradfield and farm compost treatments were statistically higher than controls with respect to total marketable weight, greens weight, and root weight.

<u>Soil Quality</u> – No apparent changes were noted in soil pH, organic matter, calcium, or cation exchange capacity over the course of this study (**Tables 4 and 5**). However, there were significant differences between treatments following the 2009 season with respect to soil concentrations of phosphorus, potassium, and magnesium.

- Microleverage® and farm compost significantly increased soil phosphorus; Bradfield and Microleverage® significantly increased soil potassium.
- Early Bird compost significantly increased soil magnesium.
- Bradfield fertilizer significantly lowered soil pH compared to controls <u>and</u> other treatments.
- There may also be treatment differences with respect to micronutrient levels (**Table 6**), but there are insufficient data to detect significance from this study.

I had no particular expectations with respect to the efficacy of any one treatment over another, but thought perhaps there might be greater treatment differences than were actually observed. I was convinced of the quality of my own compost and was gratified to see that it compared favorably with the others I tested. It was also interesting to note that, while one treatment had a possibly a greater apparent benefit for tomatoes, a different treatment was more beneficial for the turnips. If I were to repeat this kind of study, I would probably want to follow treatments over a longer time period with respect to soil changes, because I believe it takes repeated applications of any kind of treatment to give long term benefits for soil qualities.

DISCUSSION

One thing I learned (relearned!) from this project is that there is a limit to how many factors you can juggle at a time and still gain a significant insight into cause and effect relationships. I am glad I planned on a 2-year project, so that I could work out some of the initial logistical problems. The unpredictability of the seasons is a significant factor in any agricultural endeavor, and becomes particularly frustrating when you consider inputs of time and cost, but it realistically has to be factored into planning. The necessity of following through on the project, of obtaining data and reporting and sharing the results of the project, certainly are factors in considering whether to undertake additional studies such as this.

I was pleased to realize the financial benefit of making as opposed to buying compost, but I now have a greater appreciation of the relative benefits of some of the other treatments I tried. I also gained more insight into producing the respective crops, which is always useful to a producer.

Although some soil parameters appeared to be impacted by soil treatments, the impact of a single season's treatments should not be used as a measure of the value of any given treatment. Additional years of applications would probably be required to reveal the true impact of these amendments.

OUTREACH

I did a lot of talking about my project with visiting friends, curious neighbors, and fellow growers from the beginning to the end of the study. I did publicize a field day, through Extension, at the end of my second year; however, only one person attended. This was at a time when, due to adverse weather conditions, most people who would have attended were extremely busy with their own harvesting and growing efforts.

The main sharing was at the National Small Farm Trade Show & Conference in Columbia, Missouri on Nov. 6, 2010. I gave a 55-minute PowerPoint presentation at the Farmers Forum, which was attended by 45-50 people. I also prepared a photo album for the project which I have shared with attendees at the Great Plains Vegetable Growers Conference in St. Joseph, Missouri.

Table 1 - Treatment Cost Comparisons

	Cost of Amendment	Cost of Greensand	Cost of Bone Meal	Total Cost of Treatment
Bradfield Organic Fertilizer	$18.00	$0	$0	$18.00
Early Bird Compost	$6.00	$13.42	$0	$19.42
Microleverage Humified Compost	$120.00	$4.02	$13.15	$127.17
Farm Compost	$20.00 (labor)	$12.82	$6.85	$39.67

Table 2 – Tomato Yield[5]

Treatment	Plot #	Total #	Average # per plot[5]	Total Wt. (lb)	Ave. per Fruit (lb)	Treatment Ave. (lb)
Control	3	51	48	30.78	0.60	
	6	49		35.00	0.71	
	12	41		29.58	0.72	
	13	51		32.35	0.63	
Total		**192**		**127.71**		**0.67**
[1]Organic Fertilizer	4	43	47	27.31	0.64	
	10	50		39.85	0.80	
	15	48		39.45	0.82	
	17	47		28.70	0.61	
Total		**188**		**135.31**		**0.72**
[2]Early Bird Compost	1	40	49	30.53	0.76	
	8	45		32.44	0.72	
	14	50		40.66	0.75	
	19	59		36.66	0.65	
Total		**194**		**140.29**		**0.72**
[3]Micro-Leverage Compost	2	60	52	37.70	0.63	
	7	41		28.60	0.70	
	9	55		41.28	0.75	
	20	52		33.56	0.65	
Total		**208**		**141.14**		**0.69**
[4]Farm Compost	5	59	50	35.03	0.59	
	11[6]	62		34.23[6]	0.56	
	16	35		35.26	0.74	
	18	44		30.17	0.69	
Total		**200**		**125.45**		**0.63**

[1] Bradfield Vibrant Veggie 2-3-6 (www.bradfieldorganics.com)
[2] Early Bird Compost (www.earlybirdcompost.com)
[3] MicroLeverage® Humified Compost (www.humifiedcompost.com)
[4] See Table 6 for analysis data
[5] Based on three successive weekly pickings, beginning on the date that all plants showed ripe fruit. Weights and numbers are for total picking, regardless of grade.
[6] One plant of three was heavily damaged by tomato horn worn and did not recover to bear fruit. Two plants yielded 41 fruit with a total weight of 22.82 lb. Correction was made in the data for the purpose of comparing averages.

Table 3 – Turnip Yield[5]: Summary of Two Harvest Dates

Treatment	Harvest Day	Whole Plant		Greens		Roots			
		Total Wt. (lb)	Ave./Plot (lb)	Total Wt. (lb)	Ave./Plot (lb)	Wt. (lb)	Ave./Plot (lb)	Total #	Ave. Wt. (lb)
Control	1	12.97	3.24	6.08	1.52	6.89	1.72	74	0.09
	2	12.54	3.44	6.48	1.62	6.17	1.54	118	.0.05
Total		**25.51**		**12.56**		**13.06**		**192**	
[1]Organic Fertilizer	1	28.67	7.17	13.44	3.63	15.23	3.81	133	0.11
	2	11.96	2.99	6.20	1.55	5.76	1.44	[88] [6]	0.05
Total		**40.63**		**19.64**		**20.99**		**221**	
[2]Early Bird Compost	1	20.03	5.01	9.94	2.49	10.09	2.52	119	0.08
	2	10.76	2.69	5.37	1.34	5.39	1.35	[104] [6]	0.05
Total		**30.79**		**15.31**		**15.48**		**223**	
[3]MicroLeverage Compost	1	15.59	3.90	6.83	1.71	8.76	3.40	92	0.10
	2	8.92	2.23	4.42	1.10	4.50	1.37	91	0.05
Total		**24.51**		**11.25**		**13.26**		**183**	
[4]Farm Compost	1	24.75	6.19	11.16	2.79	13.59	3.40	122	0.11
	2	10.44	2.61	4.93	1.23	5.47	1.37	[84] [6]	0.06
Total		**35.19**		**16.09**		**19.06**		**206**	

[1] Bradfield Vibrant Veggie 2-3-6 (www.bradfieldorganics.com)
[2] Early Bird Compost (www.earlybirdcompost.com)
[3] MicroLeverage® Humified Compost (www.humifiedcompost.com)
[4] See Table 6 for analysis data
[5] Based on one date's yield from all turnips ≥ 1" in diameter
[6] Normalized based on 3 replicates, all other totals from 4 replicates

Table 4 – Quadrat Soil Analyses

Taken prior to planting in 2008 and 2009

Sample Date	Quad.	pH	OM (%)	Bray I P (lb/A)	K (lb/A)	Ca (lb/A)	Mg (lb/A)	CEC (meq/100 g)
April 2008	I	6.7	1.7	115	251	3533	207	10.5
	II	6.7	1.6	122	216	3762	214	11.1
	III	6.7	1.8	99	187	3341	180	9.8
	IV	6.7	1.9	104	217	3755	216	11.1
Average		**6.7**	**1.8**	**110**	**218**	**3598**	**204**	**10.6**
Jan. 2009	I	6.5	1.3	96	177	2726	178	8.3
	II	6.3	1.7	119	209	2747	168	8.8
	III	6.6	2.2	124	238	3057	184	9.2
	IV	6.6	1.5	88	179	2690	155	8.1
Average		**6.5**	**1.7**	**107**	**186**	**2805**	**171**	**8.6**

Table 5 – Final Soil Analyses by Treatment
Taken following final tomato harvest

Treatmen	Plot #	pH	OM (%)	Bray I P (lb/A)	K (lb/A)	Ca (lb/A)	Mg (lb/A)	CEC (meq/100 g)
Controls	3	6.7	1.6	109	229	3082	317	9.8
	6	6.6	1.4	108	308	3363	206	10.2
	12	6.0	1.7	116	238	2645	163	8.6
	13	6.7	1.7	191	267	2960	193	9.0
Average		**6.5**	**1.6**	**106**	**261**	**3013**	**220**	**9.4**
Bradfield	4	5.7	1.8	137	401	2865	234	10.7
	10	5.8	1.7	129	583	2907	207	10.4
	15	6.2	1.9	142	446	3126	279	10.5
	17	6.3	1.8	129	417	2086	254	9.1
Average		**6.0***	**1.8**	**134**	**462***	**2746**	**244**	**10.2**
Early Bird Compost	1	6.2	1.6	197	427	2819	271	9.7
	8	6.3	1.8	148	296	2976	344	10.3
	14	6.3	1.7	210	279	2944	300	10.0
	19	6.6	2.2	149	238	3361	406	10.9
Average		**6.4**	**1.8**	**179**	**310**	**3025**	**330***	**10.2**
Micro-Leverage Compost	2	6.8	1.4	184	328	3025	250	9.0
	7	6.7	1.6	198	304	3184	278	10.0
	9	6.6	1.6	151	386	3135	245	9.4
	20	6.9	2.6	310	377	3527	399	11.0
Average		**6.8**	**1.8**	**211***	**349***	**3219**	**293**	**9.6**
Farm Compost	5	6.8	1.4	330	256	3486	306	10.8
	11	6.8	1.5	333	250	3033	213	9.3
	16	6.5	1.9	315	293	2768	209	8.7
	18	6.7	1.9	232	236	3474	300	10.7
Average		**6.6**	**1.7**	**302***	**259**	**3190**	**257**	**9.9**

* Indicates statistical difference from controls

Table 6 – Soil Micronutrient Analyses, Post-2009 Season[1]

	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	$S0_4$-S (ppm)	B (ppm)
Controls	11.1	33.5	13.5	1.79	5.1	0.51
Bradfield Organic Fertilizer	1.5	44.4	18.4	1.68	19.1	0.40
Early Bird Compost	3.4	35.7	14.6	2.62	8.0	0.35
MicroLeverage Compost	1.9	27.8	10.0	2.25	1.56	0.32
Farm Compost	1.5	27.4	9.2	1.54	8.1	0.23

[1] Average of analysis done on soil composited from all four replicates from each treatment