DAIRY COMPOST UTILIZATION IN CROPPING SYSTEMS

Christi L. Falen[1], Dale T. Westermann[2], Jeff C. Stark[3], and Terry A. Tindall[4]

[1]University of Idaho, Lincoln County Extension Educator

[2]USDA-ARS, Kimberly, Idaho

[3]University of Idaho, Aberdeen R&E Center

[4]JR Simplot Company

ABSTRACT

Composted dairy manure applications were evaluated for four years in crop production at Kimberly, Idaho. Optimum dairy compost rates considering economic, agronomic and environmental factors for sustainable crop production were determined. Sweet corn for seed had adequate nutrients available for production, with compost not significantly increasing yield over the control. The optimum compost rate for potato production was 2.5 tons/acre (T/A) compost plus 150 lbs nitrogen (N)/acre (A) of commercial fertilizer. In organic potato production an application rate of 5-10 T/A of compost and then holding it in the "soil bank" for several years would be advantageous, as long as the fields are level with little chance for soil erosion and loss of nutrients into water sources. Malt barley production was good with 2.5 T/A of compost, but maximum profits were obtained with no compost and 60 lbs N/A of fertilizer. Sugarbeet production was optimized with 2.5 T/A of compost and 100 lbs N/acre of fertilizer.

INTRODUCTION

Manure can be a valuable resource material in crop production systems without a negative environmental impact if properly managed. One impediment to its use is high hauling costs, since fresh manure can contain up to 80% liquid by weight. The weight problem can be reduced by composting. Compost as an end product is a humus-like material that can provide nutrients, organic matter and other soil improving qualities. Compost contains less N than raw manure and the N is in a different form. Mobile nutrients in compost are more stable and less likely to contribute to environmental pollution through leaching or runoff losses. Since southern Idaho soils are low in soil organic matter, they would likely benefit from compost additions.

Recent (2008-2010) fluctuations in fertilizer prices and input costs for crop production systems have increased the desire for knowledge on how composted dairy manure can effectively fit into cropping systems in southern Idaho. Previous research completed by the University of Idaho and Agricultural Research Service on composted dairy manure can address some of these questions on optimum economic, agronomic, and environmental compost application rates for sustainable irrigated crop production in southern Idaho.

METHODS

A four-year study was initiated in 1996 on a grower-cooperator's field near Kimberly, Idaho. The soil was a silt loam and the crop rotation was sweet corn for seed, potatoes, malting barley, and sugarbeets. Dry beans were grown in 1995. Irrigation was furrow in 1996, sprinkler in 1997, and a center pivot in 1998-99, with the corners irrigated by solid set. All cultural practices including irrigation amounts and scheduling were controlled by the producer. Commercial fertilizer was not applied on the study site, except for a N fertilizer variable started in 1997 to achieve optimum production.

The concept of the study was to evaluate initial compost rates to 'jump start' the soil-plant-water system, and then determine yearly application rates needed to maintain the system for optimum crop production. The experimental design was a completely, randomized block with the treatments arranged as split-split blocks. The initial compost applications were the main blocks, which were further split for the yearly applications, and in turn were split for the N fertilizer treatments. The experiment contained four replications. All data was analyzed with SAS.

<u>Initial</u> compost rates of 0, 2.5, 5.0, 10, and 20 T/A were applied in the spring of 1996 before pre-plant tillage operations. <u>Yearly</u> compost rates of 0, 2.5, and 5.0 T/A were applied in the fall of 1996, 1997 and 1998. All compost applications were applied on an oven-dried weight basis, with commercial application equipment, and incorporated by disking or plowing. A sub-sample of compost was taken from each truck load at the time of application for chemical analysis. The N fertilizer (urea) was applied at a single (or in-season), recommended rate at the optimum times for each specific crop. If applied to the growing crop, the urea was immediately followed with irrigation to incorporate the fertilizer.

Nutrient uptake was monitored during each growing season by sampling whole plants two or three times. Standard plant tissue analysis samples for nutritional monitoring were also obtained. Final crop yields were determined with plot or commercial harvesting equipment at the appropriate time for each crop. Economic analysis was performed using cost information for inputs and crop market value and quality incentives at the time of the study.

Initial soil samples from each block and subsequent samples from each plot were taken in 12-24 inch increments in the spring of each year before tillage and any fertilizer applications. Standard soil tests were performed on these samples, including a laboratory estimate of N mineralization. The buried plastic bag technique was used to estimate N mineralization under field conditions by installing 18-inch bags filled with soil from the plot shortly after planting the respective crop and determining soil nitrate concentrations in the bags during the season. Additional soil characteristics measured at the mid-point of the study included infiltration rate and organic matter characterization.

RESULTS AND DISCUSSION

Compost characteristics

As delivered, the dairy compost contained the range of nutrients shown in **Table 1**. The iron levels were higher than expected, presumably from soil being mixed with the compost during handling. The mineralizable N values in the treated soil are determined by measuring plant available N (ammonium (NH_4-N) and nitrate (NO_3-N)) concentrations over time in a laboratory incubation. Average amounts of nutrients per ton of compost only reflect the total amount in the compost and not plant-available nutrients. Approximately 184 lbs P_2O_5/A, 228 units of K_2O/A, and smaller amounts of micronutrients were added by applying 10 T/A of compost on a dry weight basis.

N mineralization during the season

Part of the benefit from a compost application will be from the N mineralized and made available to the crop. The mineralized N increased as the compost rate increased during the growing season in which the compost was applied. An average of about 10 lbs of N was mineralized between April 1 and September 12 from each ton of compost applied. This combined with the initial NO_3-N and NH_4-N in compost provided 12-15 lbs N/T for plant growth the year of application.

Residual soil NO_3-N and NH_4-N and mineralization

N released from compost is not readily susceptible to early season leaching losses, since it must be mineralized to nitrate from an organic form. Mineralization rates tend to parallel soil temperatures under irrigation. So when crop growth slows in the early fall, mineralization rates decrease.

Soil samples taken after harvest in 1996 and 1997 showed low (3 to 5 ppm) NO_3-N and NH_4-N concentrations. No apparent differences occurred between treatments. The crops apparently removed nearly all the available N during the growing season, suggesting the potential for residual NO_3-N leaching following dairy compost application is low.

Table 1. Nutrient concentrations of composted dairy manure on a dry weight basis.

Property	Range	Average/Ton
Water, %	20-30	
Total N, %	0.7-1.45	20 lb
Phosphorus, %	0.33-0.40	8 lb
Potassium, %	0.93-2.04	19 lb
Calcium, %	1.36-2.61	27 lb
Magnesium, %	0.54-0.95	11 lb
Sulfur, %	0.31-0.75	6 lb
Sodium, %	0.25-0.52	6 lb
Zinc, ppm	69-171	0.1 lb
Iron, ppm	8500-10500	17 lb
Manganese, ppm	180-400	0.4 lb
Copper, ppm	20-530	0.04 lb
Boron, ppm	10-40	0.05 lb
Molybdenum, ppm	8-77	0.02 lb
Nitrate-N, ppm	500-900	1.5 lb
Ammonium-N, ppm	8-27	0.03 lb
Mineralizable N, ppm	300-500	0.8 lb

Infiltration

Infiltration data using a single ring infiltrometer was obtained in late summer of 1997. There were no statistically significant differences between treatments for the total water volume infiltrated or steady state infiltration rate. However, there was a trend for the highest compost rate to have a slightly higher infiltration rate than where no compost was applied.

Soil organic matter

Soil organic matter from selected compost treatment plots prior to planting in spring 1997 was fractionated into non-polar (fats, oils, and waxes), hemicelluloses, lignin, cellulose, starch and sugar compounds. There were no significant treatment differences for the relative distribution of these fractions, but the relative amount of cellulose, starch and sugar compounds tended to increase at the higher compost rates.

Sweet corn for seed yield

Spring soil levels for P (25 ppm), K (180 ppm), and Zn (3.1 ppm) were apparently sufficient for crop yields as there was no response to any compost rate. The top 2 feet of soil contained about 120 lb N/A as NO_3-N and NH_4-N before planting. There also was more than 180 lb N/A mineralized where no compost was applied. No fertilizer N was applied to the sweet corn.

Potato yield from <u>yearly</u> compost applied in the previous fall

Russet Burbank potatoes were planted in April 1997. The N and yearly compost effect will be discussed only at the zero initial compost rate to separate the discussion of treatment effects (**Table 2**). Compost tended to increase yields, particularly at the 5 ton rate in the absence of N application. In the presence of N, highest yields were obtained at either the 2.5 or 5 T/A compost rate. Tuber yields increased from 469 cwt/A to 529 cwt/A when 5 T/A of compost was applied the previous fall and 150 lbs N/A applied during tuber growth. Yield with N fertilizer and no compost was 513 cwt/A, while yield from only the 5 T/A compost treatment without N fertilizer was 518 cwt/A.

A fall application of dairy compost is a good way to prepare for the next year's crop production. This allows nutrients time and environmental conditions necessary to be available for crop uptake in the spring. Utilizing dairy compost can be more cost effective for cropping systems that are farther away from the dairies in comparison to straight manure because of the hauling costs for the water in the manure. Spreading dairy compost in 2010 can be accomplished in much the same way as commercial fertilizer by calling with a certain T/A to apply and the timing, then it is completed and a spread map using GPS (global positioning system) is generated for each field.

Potato yield from <u>initial</u> compost applied in April of 1996

A significant yield response occurred from commercial N (150 lb N/A) split applied during the growing season. Main effects from the initial 1996 compost applications were not statistically significant for any measured yield parameter. However, high initial compost rates (10-20 T/A) tended to reduce N application effects (**Figure 1**). There was a positive effect of compost during the second cropping year after application. Total tuber yields in 1997 were 503 and 533 cwt/A where 10 and 20 T/A had been applied in April of 1996, respectively. The addition of N fertilizer increased the tuber yields at only the lower initial rates, i.e. 2.5 and 5 T/A.

This information is beneficial for an organic producer because it shows the yield potential without commercial fertilizer. The hauling and spreading costs per crop would be less applying compost every other year, or every few years, compared to yearly applications. A crop of sweet corn for seed had already been grown in 1996 and there were still nutrients becoming available from the compost for the potato crop.

Table 2. Effect of N and <u>yearly</u> compost on potato yield and quality at the zero initial compost rate.

Yearly Compost Ton/Acre	Fertilizer N Rate lb/A	Total Yields cwt/A	Tubers % ones	Tubers % > 10 oz.	Specific Gravity
0	0	469	83.4	28.3	1.089
2.5	0	474	86.1	24.2	1.088
5.0	0	518	85.4	27.3	1.089
0	150	513	83.2	37.3	1.086
2.5	150	528	90.2	36.9	1.082
5.0	150	529	85.9	37.3	1.083

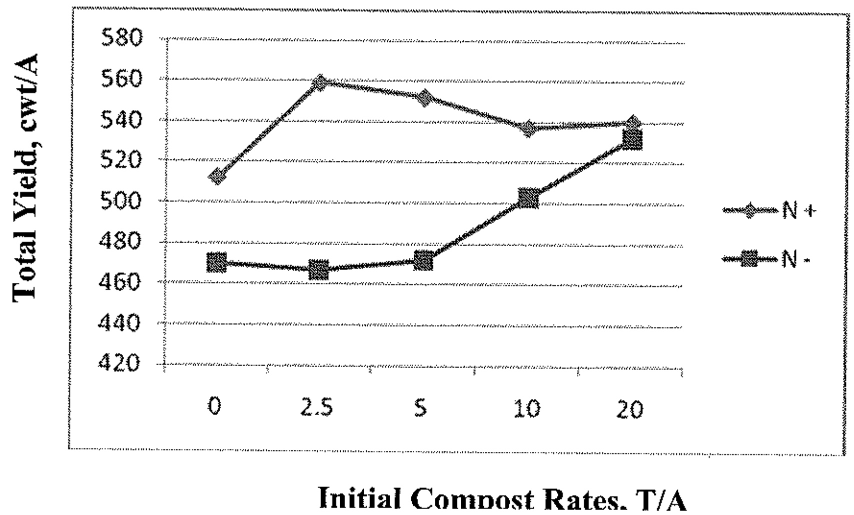


Figure 1. Potato yields with <u>initial</u> 1996 compost application rates and zero yearly compost additions on 1997 total potato yields. N+ had 150 lb N/A split applied during the growing season. N- had no commercial fertilizer applied.

Potato Quality

Tuber quality parameters were generally high. Percentage large tubers (> 10 oz.) were increased by the N application. Highest specific gravity (SG) occurred where compost was applied without N fertilizer, but application of N fertilizer and compost together reduced SG. There was no effect of compost on internal tuber quality parameters (hollow heart, brown center, and brown spot).

Economic returns with fertilizer and potato price considerations for 2008

Dairy compost provides a realistic option for potato growers to help meet the nutritional needs for their potato crops using limited commercial fertilizer. Economic evaluations showed the highest return from 2.5 T/A initial compost (April 1996) + 150 lb N/A of urea. Price adjustments were made for the percentage of number-one tubers above 50%, the percentage of 10 oz. tubers above 11%, and for SG higher than 1.077. **Table 3** provides an example showing average nutrients in compost, fertilizer prices, and the nutrient value compost could provide.

Table 3. Compost average nutrient content, early 2008 fertilizer costs, and nutrient value per ton of compost.

Nutrient	Compost Nutrient Units/Ton	Fertilizer Unit Cost	Nutrient Value/T of Compost
N - urea	14.5	0.65	$9.42
P_2O_5	12.0	0.95	$11.40
K_2O	26.0	0.58	$15.08
Elem. S	3.0	0.45	$1.35
1 Ton Compost	**Value for just NPKS**		**$37.25**

This serves as a snap shot in time and can be modified for various products, compost analysis and fertilizer prices.

Malt barley production

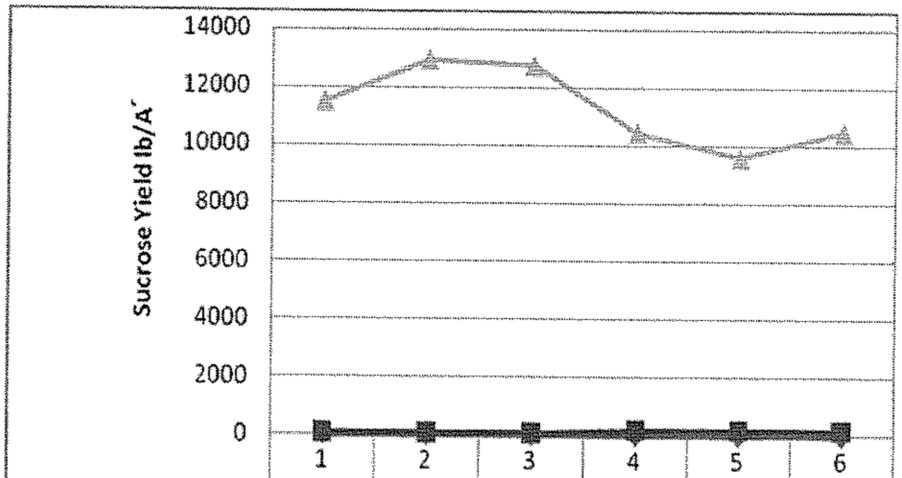
There was a significant response to N fertilizer (60 lb N/A, preplant) and a significant N * yearly compost interaction on yield, screenings, protein concentration, (**Table 4**) and net returns. The optimal annual compost rate for malt barley was 2.5 T/A with N fertilizer. However, maximum profits were obtained with no compost and 60 lb N/A fertilizer.

Table 4. Effect of N and yearly compost on malt barley yield and quality.

Yearly Compost Tons/Acre	N rate lb/acre	Yields lb/A	Test Weight lb/bu	Screen %	Adjusted Protein %
0	0	4387	50.0	8.2	11.95
2.5	0	5221	50.8	7.8	11.68
5.0	0	4792	50.7	7.8	11.85
0	60	6053	50.6	14.5	11.98
2.5	60	5951	50.0	19.9	12.00
5.0	60	6189	50.4	14.9	11.95

Sugarbeet production

The major compost response was related to annual compost at the 100 lb N/A fertilizer rate. Yearly applications of 2.5 T/A produced the highest root and sucrose yields (**Figure 2**) and net economic return. The 200 lb N/A rate reduced sugarbeet yields overall compared to the 100 lb N/A rate, possibly due in part to the lower, less uniform plant stands in the high N plots. There were no residual effects of the initial 1996 compost application treatments on root or sucrose yields. Brei nitrates were not significantly affected by annual compost rates, but brei conductivity increased at the 5 T/A compost rate (data not shown).



	1	2	3	4	5	6
Compost Yearly	0	2.5	5	0	2.5	5
Fert N lb/A	100	100	100	200	200	200
Sucrose lb/A	11491	12928	12735	10446	9579	10465

Figure 2. Sugarbeet sucrose yield with yearly compost at 100 or 200 lb N/A of fertilizer.

ACKNOWLEDGMENTS

The financial support from Magic Valley Compost and United Dairymen of Idaho is gratefully acknowledged, as well as the excellent support and cooperation of Kip Wooten and Chuck Coiner, farmers/cooperators, and John O'Connor, Farm Management, Inc. The authors also wish to thank all other research and extension personnel who contributed time and effort in conducting this study.