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Crop Performance and Soil Properties of Sites Previously Used for Production of Beef Cattle Manure Compost

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Summary

This study was established on sites that had three or seven years of compost production history. Corn, wheat, barley, sorghum and alfalfa were planted in 2001. In the first year, wheat, barley and sorghum performed better than corn in the windrow areas while alfalfa did not even establish because of excessive salt in the soil. Soil electrical conductivity, K and Na in the 0-6 inch depth under windrows were high and caused soil crusting and poor germination and crop yields. Growing salt tolerant crops, such as barley, can rehabilitate sites used for composting and the process can be accelerated by appropriate field cultural practices.

Introduction

Composting manure is a useful method of producing a stabilized product that can be stored or spread with little odor or fly breeding potential. The other advantages of composting include killing pathogens and weed seeds, and improving handling characteristics of manure by reducing its volume and weight. Composting also has some disadvantages, which include nutrient and C loss during composting, the cost of land, equipment and labor required for composting, and odor associated with composting.

Composting manure on earthen sites can increase nitrate, phosphorus and salt levels in the soil under the compost windrows. When the composting operation is terminated, there is a need to reclaim the sites for agricultural crops. Salt tolerant crops such as barley or wheat can be established for one or two years before the site is ready for alfalfa establishment. Alfalfa has deep roots that can extract nitrate from deeper in the soil profile. The objective of this study was to evaluate soil properties and performance of corn, sorghum, barley, winter wheat and alfalfa on land previously used as composting sites, and to arrive at recommendations on how to best return such composting sites to agricultural production.

Procedure

Two sites identified as 3Y and 7Y had been used for 3 and 7 years of beef cattle manure composting, respectively. Every year, the composted manure was removed from the windrows and replaced with fresh beef cattle feedlot manure on the same area. Prior to initiation of the study in 2001, all compost windrows were removed from the sites. The 3Y and 7Y sites were made into 18 and 14 plots, respectively, with each plot 78 feet long and 15 feet wide). Each plot had length perpendicular to the windrows and inter-windrows and included 3 windrows and 4 inter-windrows. The windrows (12 to 15 feet wide, 300 to 400 feet long, and 4 to 5 feet high) were separated by inter-windrow alleys, 12 to 14 feet wide.

In the spring 2001 prior to disking and planting crops, soil samples from 0-3 feet depth were collected from 7 locations that were 13 feet apart in each plot (4 inter-windrows and 3 windrows). Deep soil samples to 12 feet also were taken from the windrows of three plots for sites 3Y and 7Y. Soil cores were divided into 6 or 12-inch depth increments.

Deep soil samples also were collected from four locations in an adjacent field (300 feet east of site 3Y) that has never been used for composting and could be considered as control. Deep samples were also taken from a site (30 feet south of 3Y) identified as 1Y that had been used for one year of composting. Soil samples were dried and ground and analyzed for K, Na, nitrate and electrical conductivity (EC). Electrical conductivity indicates the salt level in the soil.

Site 3Y and 7Y were assigned to two replications of 9 and 7 cropping sequences, respectively (Table 1). In spring 2001 (after soil sampling), each plot was field cultivated for seedbed preparation before planting. In spring 2002, all

Table 1. Crop sequences on abandon compost sites with a history of 3 and 7 year windrow composting at Mead, NE.

Treatment	Site 3 year Cropping system			Site 7 year Cropping system		
	2001	2002	2003	2001	2002	2003
1	A	A	A	A	A	A
2	B	A	A	B	A	A
3	B	B	A	B	B	A
4	C	A	A	S	A	A
5	C	C	A	S	S	A
6	S	A	A	W	A	A
7	S	S	A	W	W	A
8	W	A	A			
9	W	W	A			

A, alfalfa; B, Barley; C, corn; S, sorghum; W, wheat

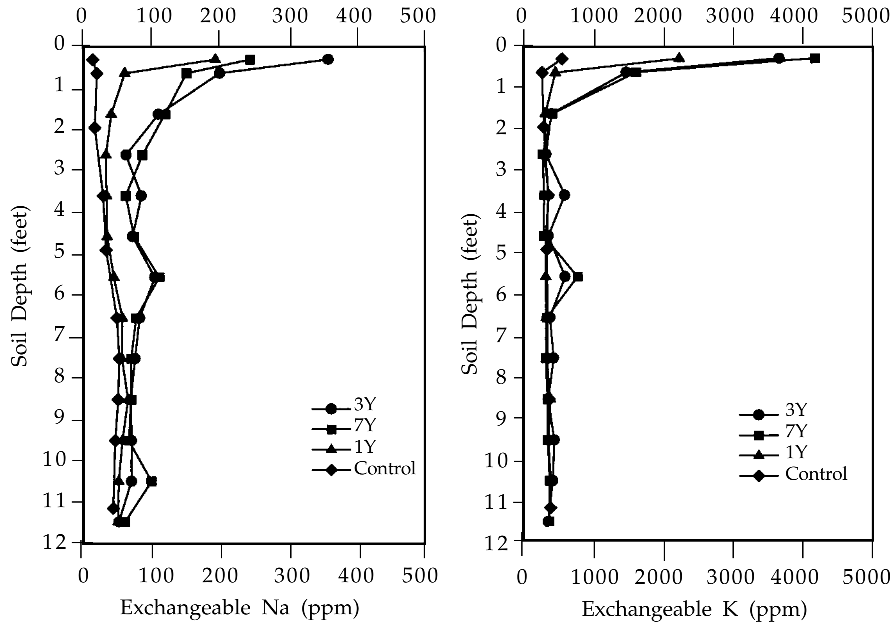

Figure 1. Exchangeable K and Na concentrations in soil under 3 and 7 years of composting beef cattle manure at various soil depths prior to planting crops. Horizontal bars are standard deviations of the means.

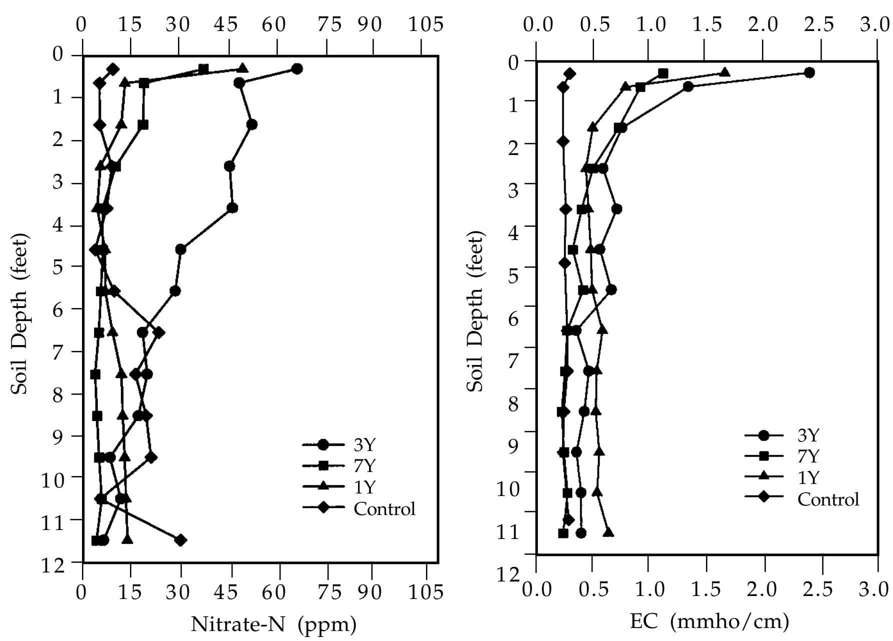

Figure 2. Nitrate-N and electrical conductivity (EC) in soil under 3 and 7 years of composting beef cattle manure at various soil depths prior to planting crops. Horizontal bars are standard deviations of the means.

plots were disked and field cultivated prior to crop planting. Replanting of alfalfa also was conducted to improve alfalfa stands. Each grain crop was planted for either a one- or two-year period. Alfalfa was planted on all plots after the last grain crop was harvested. Both sites were under dryland conditions.

Results

Soil variables

Exchangeable K was similar among the control, 1Y, 3Y and 7Y sites at soil depths > 1 foot (Figure 1). The effect of one year composting was limited within the top 6 inches of soil. The K levels of the 3Y and 7Y were extremely high (>0.35%) in the top 6 inches soil of the compost windrow areas. Soil exchangeable K in the 3Y and 7Y were similar. Sodium leaching in the soil was deeper than K and was to 3 feet soil depth in the 1Y and to 8 feet in the 3Y composting area. Soil exchangeable Na in the first 6-inch depth was higher in the 3Y than the 7Y. The high K and Na contents of the surface soil apparently dispersed the soil and resulted in low crop germination and growth.

Variability of soil nitrate for the 1Y and 3Ysites was high for the first 6-inch depth (Figure 2). Nitrate contents of the control, 1Y and 7Y sites were similar to 6 feet soil depth. Nitrate-N in the control site was higher than the 1Y and 7Y sites for soil depths > 6 feet due to nitrate leaching from applied N fertilizer. Nitrate in the 3Y site was greater than the other sites in the top 6 feet of soil. Analysis of soil stable nitrogen (^{15}N) indicated that the source of nitrate in the deep soil profile of 3Y site was manure, while this was inorganic fertilizer N in the 1Y and control cropland sites.

The EC of the control did not vary with soil depth (Figure 2). The EC of the 1Y did not vary with soil depth beyond 1 foot. The EC level of the 3Y area was higher than other sites to a soil depth of 6 feet.

Soil K, Na, Nitrate-N and EC levels in the windrow areas were significantly higher than those in the inter-windrows at 6 inch depth (Table 2). Extreme levels of K and Na cause soil surface dispersion and crusting, thus hindering seed germination, plant growth, and grain yield. Poor plant growth caused low grain yield in the windrows to less than 50% of those in the inter-windrows in 2001 (Table 3).

Crop response

The grain yields of all crops were reduced in the areas that were under composting windrows compared to inter-windrows areas (Table 3). Corn growth in the windrow areas was severely stunted, as grain yield was only 2.1 bu/acre,

(Continued on next page)

Table 2. Analysis of surface soil (6 inch depth) prior to planting crops for the windrows and inter-windrows of sites used for 3 or 7 years of windrow composting at Mead, NE.

Soil analysis	Windrow (R)	Inter-windrow (I)	R/I ratio
	Site 3 year		
Exchangeable K, ppm	3554 ± 121	2261 ± 91	1.6
Exchangeable Na, ppm	318 ± 14	159 ± 10	2.0
Nitrate-N, ppm	73 ± 15	35 ± 4	2.1
Electrical conductivity, mmho/cm	2.21 ± 0.15	0.92 ± 0.07	2.4
	Site 7 year		
Exchangeable K, ppm	4078 ± 178	3137 ± 180	1.3
Exchangeable Na, ppm	242 ± 12	181 ± 11	1.3
Nitrate-N, ppm	49 ± 7	20 ± 3	2.4
Electrical conductivity, mmho/cm	1.23 ± 0.07	0.77 ± 0.05	1.6

Table 3. Comparison of grain yield of windrow (WR) and inter-windrow (IWR) areas for the first year (2001) and the second year (2002) cropping.

Crop	2001			2002		
sequence	WR (R)	IWR (I)	R/I	WR (R)	IWR (I)	R/I
	bu/acre			bu/acre		
		Site 3 year composting				
B-B	5.4[b]	18.4[a]	0.29	47.8[a]	48.4[a]	0.99
C-C	2.1[b]	57.2[a]	0.04	61.1[a]	45.8[a]	1.34
S-S[c]	26.0[b]	56.0[a]	0.46	—	—	—
W-W	5.5[b]	22.2[a]	0.25	25.9[a]	23.8[a]	1.09
		Site 7 year composting				
B-B	8.4[b]	20.5[a]	0.40	51.2[a]	55.8[a]	0.92
S-S[c]	14.7[b]	63.5[a]	0.23	—	—	—
W-W	4.8[b]	10.6[a]	0.45	20.4[a]	28.4[a]	0.72

B, barley; C, corn; S, sorghum; W, wheat.
[a,b]Values with different superscripts within each row and each year are significantly different at 0.05 probability level.
[c]Excessive temperature during the reproductive stage and the subsequent diseases reduced the sorghum yield to near zero in 2002.

Table 4. Effect of previous cropping on alfalfa dry matter of the windrows (WR) and inter-windrows (IWR) for the second year (2002) cropping.

Previous crop	Alfalfa dry weight		
	WR (R)	IWR (I)	R/I ratio
	ton/acre		
	Site 3 year composting		
Alfalfa	0.88[a]	1.02[a]	0.87
Barley	1.04[a]	0.95[a]	1.09
Corn	1.15[a]	1.05[a]	1.09
Sorghum	1.14[a]	1.16[a]	0.98
Wheat	0.89[a]	0.90[a]	0.98
	Site 7 year composting		
Alfalfa	0.46[a]	0.52[a]	0.87
Barley	0.46[a]	0.53[a]	0.86
Corn	0.55[a]	0.46[a]	1.21
Wheat	0.66[a]	1.64[a]	0.90

[a]Values with the same superscript within each column and each site are not significantly different at 0.05 probability level.

while grain yield in inter-windrows was 57.2 bu/acre. Barley, wheat and sorghum provided better grain yields than corn in the windrow areas. Alfalfa was not even established in the windrow areas in the first year of planting. Excess salt in the soil as indicated by EC values (Figure 2) negatively influenced alfalfa germination. It must be noted that 2001 was a very dry year.

In the second year of cropping (2002), previous-year plant residue after harvest, fall disking, winter cover-crop, spring disking and spring field cultivation resulted in dilution of K, Na, Nitrate-N and EC, which improved soil surface structure. Yields of grain crops and alfalfa dry matter were similar between the windrows and inter-windrows in 2002 (Tables 3 and 4). Previous-year crops affected alfalfa dry matter equally in 2002 (Table 4). Fall tillage of first-year-crop residue and planting winter cover-crops followed by spring tillage resulted in similar alfalfa yields in the windrows and inter-windrows for plots under all grain crops.

Summary

Significant amounts of nitrate-N can be released when a soil under composting is tilled, and thus crops will be needed to extract this nitrate. Areas used for composting can be rehabilitated by using tillage and growing crops for at least one year before alfalfa can be established to remove excess nitrate deep in the soil profile. Our sites were under rainfed conditions, and when irrigation is available, crop performance can improve. Leaching of K, Na, NO3 and salts (EC) were time dependent and they moved deeper into the soil profile with increasing years of composting. Increased levels of K and Na in the topsoil caused soil dispersion and crusting, poor germination, and lower first-year crop yields. Based on the first-year crop, it seems that barley, wheat or sorghum can be used. Corn does not seem to be a good crop for the first year of cropping after cessation of composting. In the second year of cropping, the grain crops and alfalfa resulted in similar yields in the windrow and inter-windrow areas indicated effectiveness of cropping and field cultural practices in rehabilitating these sites.

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