SUBSURFACE INJECTION VERSUS SURFACE APPLICATION OF COMPOSTED MUNICIPAL SOLID WASTE IN COTTON PRODUCTION

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Abstract

Equipment was developed and tested for injection and broadcast application of municipal solid waste (MSW) compost at selected rates to agricultural land for cotton production. Replicated tests were conducted to determine the effects of injected vs. broadcast applied compost on soil parameters (organic matter, soil compaction, and soil fertility) and plant growth.

All broadcast application rates of compost significantly reduced hardpan formation in the top 6-in. of soil compared to no compost application. In addition, all rates of injected material significantly reduced soil compaction in the E- and B-horizons (6-18 in.). Injected applications did not affect compaction in the top 6-in. of soil. Broadcast application of compost significantly increased soil organic matter content 6- and 12-weeks-after planting proportional to the compost application rate. In addition, soil nitrogen content was significantly higher in the broadcast application plots 6-weeks-after planting. 12-weeks-after planting, only application of 12-tons/acre compost (broadcast) statistically increased soil nitrogen content averaged over the top 8 in. of the soil.

MSW compost (broadcast or injected) significantly increased plant N, P, and K contents compared to no compost application. Increases in plant nitrogen were proportional to application rates. In addition, injected application increased plant sulfur compared to no compost application. All rates of compost (injected or broadcast applications) significantly increased cotton lint yield compared to no compost application. Yield increase was proportional to application rates. For the 12 tons/acre injected application treatment, yield increases were 23%, 24%, and 44% in 1997, 98 and 99, respectively compared to no compost application. Compost significantly increased plant height. Height increase was proportional to application rate.

Vitazyme increased plant N, P, and K contents with no effects on Ca, Mg, and S. Vitazyme increased cotton lint yield 31 lb/acre or 3%. In addition, soil nitrogen content 6-weeks-after planting in plots treated with Vitazyme was 12% higher than no-Vitazyme plots.

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Introduction

Municipalities are facing a growing problem of how to safely dispose of their solid waste. Composting the organic fraction is possible solution to this problem. Biosolids are processed in composting facilities, which turn the waste by-products into a valuable resource. Industry is looking to expand towards composting the organic fraction of the municipal solid waste stream as evidenced by the development of Bedminster BioConversion Corporation in Sieverville, TN and Cobb County GA. The largest potential user of MSW compost is agriculture (Parr and Hornick, 1992; Slivka et al., 1992). Application of MSW compost usually increases yields of agronomic and horticultural crops, under both field and greenhouse conditions. Agricultural uses of composted MSW have shown promise for a variety of field crops (sorghum, maize, forage grasses) and vegetables sold for human consumption (lettuce, cabbage, beans, potatoes). Responses by plant systems have ranged from none to over twofold increases in yield (Shiralipour et al., 1992). In a replicated study in South Carolina, surface application of 15 tons/acre of MSW compost (broadcast or banded) resulted in a 30% increase in seed cotton yield (Khalilian et al., 1998).

Soil compaction limits root penetration below the plowing depth and is a significant problem in many soils in the Southeast. It reduces yields, limits productivity, and makes plants more susceptible to drought stress. Most upland sandy soils of the coastal plains have a compacted zone or hardpan about 6 to 14 in. deep and 2 to 6 in.es thick. This is called the E-horizon and must be broken so that root can grow into the subsoil or B-horizon to allow optimal crop performance. Trouse (1983) has explained the benefits of and requirements for effective under-the-row subsoiling. This practice has been shown to improve yields in those soils of the coastal plain which are subject to the formation of tillage pans (Garner et al., 1986; Khalilian et al. 1991). Garner, et al. (1989) reported that in-row subsoiling in coastal plain soils increased seed cotton yield by 189 lb/acre compared to non-subsoiled plots. An additional deep tillage operation with a Paratill ™ in the fall increased the seed cotton yield about 460 lb/acre. Composted MSW has the potential to increase organic matter content of sandy coastal plain soils. Organic matter acts as glue which helps keep soil structure more stable and resistant to compaction. Under laboratory conditions values of bulk density, penetration resistance and peak shear strength decreased with increasing organic matter contents in sandy loam and clay soils (Ekwue and Stone, 1995). Preventing soil compaction in coastal plain soils means fewer deep tillage operations and an $8 to $10 savings per acre.

Plant-parasitic nematodes cause over $250,000,000 in yield losses on cotton in the United States each year (Blasingame, 1996). Yield losses in individual fields may reach 30-50%. At the present, nematode management relies heavily on the use of nematicides, such as aldicarb (Temik 15G) applied in-furrow at-planting at a cost of approximately $16.00/acre. Higher organic matter content tends to increase the populations of many soil microorganisms, including those that are naturally antagonistic or parasitic to plant-parasitic nematodes. Khalilian et al. (1998) reported that application of MSW compost significantly reduced the Columbia lance nematode densities on a Faceville loamy sand soil. Compost treatments had nematode densities comparable to those found in the Temik 15G treatment.

Recently Vital Earth Resource Research Center (706 East Broadway, Gladewater, TX) has introduced a soil fertility booster called "Vitazyme" for improving the growth of plants. Many researchers have used this material for crop production. Yield increases ranging from 5 to 25% have been reported for different field crop such as cotton, corn, soybeans, etc. (Syltie, 1998).

Currently there is no equipment commercially available to inject MSW compost below the soil surface. The ability to inject solid waste material in a narrow band under the crop row is important since it optimizes plant nutrition and minimizes nuisance factors. Injection of compost will have a two-fold objective: placement of organic material in the root zone and fracturing the soil hardpan.

Objectives

The objectives of this project were a) to develop and test equipment for injection and broadcast applications of composted municipal solid waste at selected rates to agricultural lands for cotton production. b) To determine the effects of compost on soil parameters (organic matter, soil compaction, and soil fertility) and plant responses (yield, nutrition).

Methods and Materials

Equipment

In 1997, equipment was constructed for injecting MSW compost pre plant under the seed row at sufficient depth to place it in the compacted subsoil layer at different application rates. The equipment was modified in 1998 to increase efficiency of the system. The compost injector was a 2-row configuration and consisted of subsoiler shanks, which had been modified by attaching a 4-in. x 8-in. thin-wall rectangular tubing to the back of each subsoiler shank. These extended from the lower end of the shank to a position above the soil surface. The trailing edge of the rectangular tubing was cut away from the lower end of the tubing to allow the MSW compost to be deposited into the slot created by the subsoiler shank. Compost was funneled into the top of the rectangular tubing and fell by gravity flow to the bottom. As the tool moved through the soil, the MSW compost was placed into the bottom of the trench created by the subsoiler.

For preparing the test plots, the MSW was carried on the subsoiler. A hopper was constructed and attached to the subsoiler frame. This hopper was fitted with a drag chain, which pulled the MSW material toward a drop point above the injection tubes. Material was dropped by gravity from the hopper floor into the top of the injection tubes with transitions constructed from sheet metal. A hydraulic motor was used to run the drag chain. Compost application rates were adjusted by changing the speed of the hydraulic motor and utilizing an adjustable gate that was added to the spreader.

A conventional flatbed, chain conveyer type manure spreader was used for broadcast application. An adjustable gate was added to the spreader to control application rates. The spreader was adjusted to uniformly broadcast composted material the width of two rows (6.33 ft). A 4-shank subsoiler-bedder was used to disrupt the hardpan and incorporate the MSW compost.

Field Test

The Bedminster BioConversion Corporation's composting facilities in Sieverville, Tennessee provided the MSW compost for this study each spring. Analysis of the composted material is shown in Table 1. Tests were conducted from 1997 to 1999 at the Edisto Research and Education Center at Blackville, SC on a Varina sandy loam soil (clayey, kaolinitic, thermic Plinthic Paleudults). A randomized complete block design with four replications was the statistical model selected for comparing treatments. Two application methods (injection and broadcast), three application rates (4, 8, and 12 tons/acre), and a control (no compost) were used in 1997 and 98. The same treatments were used in 1999 except the test plots, after compost application, were split in half and one half received Vitazyme. Vitazyme was sprayed at 13 oz/acre over the soil surface directly behind the planter. A second application of 13 oz/acre was sprayed on the cotton leaves and soil at first bloom.

Cotton was planted with a 4-row John Deere MaxEmerge2 planter and carried to yield using recommended practices for seedbed preparations, seeding, fertilization, and insect and weed control. Plot size was 8 rows (25 ft X 80 ft). The two middle rows of each plot were machine harvested for yield determinations.

To determine the effects of compost on soil compaction, a tractor-mounted, hydraulically operated, microcomputer-based, recording penetrometer system was used to quantify soil resistance to penetration. Soil cone index values were calculated from the measured force required to push a 0.5 in.^{2} base area, 30^o cone into the soil at a constant velocity (ASAE, 1999).

Penetrometer data was taken before compost application and immediately after cotton harvest in 1999. Penetrometer readings were taken to a depth of 18 in. from two middle rows of each plot.

In 1999, each plot was sampled for Columbia lance nematodes, soil organic matter, and ammonium and nitrate contents at planting, 6-weeks-after planting and 12-weeks-after planting. Twelve cores 8-in. deep and 1-in. in diameter were taken from each plot on each date. Plant tissues (35 leaves/plot) were collected and analyzed for N, P, K, Ca, Mg, and S.

Results and Discussion

All rates of broadcast application of compost significantly reduced formation of the hardpan in the top 6-in. of soil for cotton rows compared to no compost application in 1999 (Table 2). In addition, all rates of injected material significantly reduced soil compaction in the E-horizon (9-12 in.) and in B-horizon (12-18 in.). Injected application did not affect the compaction in the top 6-in. of the soil.

Table 3 shows soil organic matter and nitrogen content averaged over the top 8 in. of soil for 1999. Broadcast application of MSW compost significantly increased the soil organic matter content 6- and 12-weeks-after planting proportional to compost application rate. In addition, soil nitrogen content was significantly higher in the broadcast application plots 6-weeks-after planting. 12-weeks-after planting, only application of 12-tons/acre compost (broadcast) statistically increased soil nitrogen content averaged over top 8 in. of the soil. Since the injected material was about 12 in. deep, it did not affect the soil organic mater and soil nitrogen content in the top 8 in. of the soil.

MSW compost (broadcast or injected) significantly increased plant N, P, and K compared to no compost application (Table 4). Increases in plant nitrogen were proportional to application rates. In addition, injected application increased plant sulfur compared to no compost application (Table 5). Application of compost did not affect plant Ca or Mg (Table 5).

All rates of compost (injected or broadcast applications) significantly increased cotton lint yield compared to no compost application in each year (Tables 6 and 7). Yield increase was proportional to application rates. In 1997, for 12 tons/acre injected application treatment, yield increase was 249 lb/acre lint or 23% more than compost application. In 1998 and 99, yield increases at this level of application rate were 24% and 44% higher than no compost application, respectively. There were no differences in yield between broadcast and injected application method for a given compost rate. Increased soil organic matter and nitrogen content combined with the potential increase in soil water-holding capacity and decreases in soil density associated with MSW compost, could be the contributing factors to yield increase. Compost significantly increased cotton plant heights (Table 7). Height increase was proportional to application rate.

Vitazyme increased percent N, P, and K in plant tissue with no effects on Ca, Mg, and S (Tables 8 and 9). Vitazyme increased cotton lint yield 31 lb/acre or 3% (Table 10). In addition, soil nitrogen content 6-weeks-after planting in plots treated with Vitazyme was 12% higher than no-Vitazyme plots (Table 11).

Conclusions

Equipment was developed and tested for injection and broadcast application of MSW compost at selected rates to agricultural land for cotton production. Replicated tests were conducted to determine the effects of compost on soil parameters (organic matter, soil compaction, and soil fertility) and plant growth.

All rates of broadcast application of compost significantly reduced formation of the hardpan in the top 6-in. of soil compared to no compost application. In addition, all rates of injected material significantly reduced soil compaction in the E- and B-horizons (6-18 in.). Injection application did not affect the compaction in top 6-in. of the soil.

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Vitazyme increased plant N, P, and K contents with no effects on either Ca, Mg, or S. Vitazyme increased cotton lint yield 31 lb/acre or 3%. In addition, soil nitrogen content 6-weeks-after planting in plots treated with Vitazyme was 12% higher than no-Vitazyme plots.

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Table 1. Analytical laboratory results of composted municipal solid waste at the time of application.

Year	pH	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Moisture (%)
1997	6.8	1.42	0.72	0.33	2.28	0.23	0.49	17.8
1998	7.3	1.19	0.62	0.37	2.22	0.26	0.37	30.7

Table 2. Effect of compost application methods and rates on formation of hardpan under cotton rows, 1999. Edisto Research and Education Center, Blackville, SC.

Application Method	Compost (tons/acre)	Cone Index (psi)		
		0 - 6 in.	6 – 12 in.	12 – 18 in.
Broadcast	4	60 c	137 b	269 ab
	8	59 c	131 b	312 a
	12	57 c	125 bc	394 ab
Injected	4	70 a	111 dc	268 bc
	8	65 ab	105 de	263 c
	12	66 ab	91 e	248 c
None	None	70 a	154 a	300 a

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 3. Effects of MSW compost on soil organic matter and nitrogen content 6- and 12-weeks-after planting, 1999.

Application Method	Compost Rate (tons/acre)	% Organic Matter		NO3-N ppm	
		6-week	12 week	6-week	12-week
Broadcast	4	1.75 c	1.69 b	11.88 c	6.9 ab
	8	2.06 b	1.95 a	13.00 b	6.51 ab
	12	2.59 a	2.01 a	15.25 a	8.94 a
Injected	4	1.10 e	1.18 c	8.75 d	4.93 bc
	8	1.33 d	1.14 c	8. 75 d	4.48 bc
	12	1.25 de	1.21 c	8.75 d	4.74 bc
None	None	1.19 de	1.06 c	8.38 d	3.54 c

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 4. Effects of MSW compost on plant tissue (%N, P, and K), 1999, (Samples taken 12-weeks-after planting).

Application Method	Compost Rate (tons/acre)	N (%)	P (%)	K (%)
Broadcast	4	3.97 d	0.30 a	1.96 b
	8	4.13 c	0.29 b	1.93 b
	12	4.32 a	0.33 a	2.14 a
Injected	4	4.01 d	0.32 ab	1.94 b
	8	4.18 bc	0.30 ab	2.11 a
	12	4.28 ab	0.33 a	2.16 a
None	None	3.54 e	0.26 c	1.61 c

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 5. Effects of MSW compost on plant tissue (%Ca, Mg, and S), 1999, (Samples taken 12-weeks-after planting).

Application Method	Compost Rate (tons/acre)	Ca (%)	Mg (%)	S (%)
Broadcast	4	2.61 a	0.48 b	0.76 bc
	8	2.62 a	0.51 ab	0.66 c
	12	2.67 a	0.50 ab	0.76 bc
Injected	4	2.78 a	0.55 ab	0.83 ab
	8	2.57 a	0.52 ab	0.88 a
	12	2.78 a	0.57 a	0.89 a
None	None	2.52 a	0.57 a	0.71 c

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 6. Effects of compost on cotton lint yield for 1997 and 1998 tests. (Edisto Research & Education Center).

Trt. No.	Compost (tons/acre)	Application Method	Yield (lb/acre) 1997	Yield (lb/acre) 1998
1	4	Broadcast	1228 b	940 c
2	8	Broadcast	1282 ab	1018 b
3	12	Broadcast	1343 a	1047 ab
4	4	Injected	1222 b	945 c
5	8	Injected	1293 ab	1013 b
6	12	Injected	1351 a	1076 a
7	None	-------	1103 c	868 d

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 7. Effects of MSW compost on cotton lint yield, plant height and population at harvest, 1999.

Application Method	Compost Rate (tons/acre)	Yield lb/acre	Plant height (in)	Plant Population (Plant/ft)
Broadcast	4	1016 c	31.5 d	2.7 a
	8	1083 b	33.3 b	2.5 a
	12	1203 a	34.4 a	2.6 a
Injected	4	1030 c	32.5 c	2.7 a
	8	1078 b	33.3 b	2.6 a
	12	1217 a	34.7 a	2.4 a
None	None	844 d	30.0 e	2.6 a

Values in a column followed with the same letter are not significantly different by the LSD test,, a = 0.05.

Table 8. Effects of Vitazyme on plant tissue (%N, P, and K), 1999, (samples taken 12 weeks after planting).

Vitazyme	N (%)	P (%)	K (%)
13 OZ at planting & 13 OZ at first bloom	4.22 a	0.31 a	2.08 a
None	3.91 b	0.29 b	1.88 b

Values in a column followed with the same letter are not significantly different by the LSD test,, a = 0.05.

Table 9. Effects of Vitazyme on plant tissue (%Ca, Mg, and S), 1999, (samples taken 12 weeks after planting).

Vitazyme	Ca (%)	Mg (%)	S (%)
13 OZ at planting & 13 OZ at first bloom	2.71 a	0.54 a	0.77 a
None	2.60 a	0.52a	0.74 a

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 10. Effects of Vitazyme on cotton lint yield, plant height, and population at harvest, 1999.

Vitazyme	Yield (lb/acre)	Plant height (in)	Plant Population (Plant/ft)
13 OZ at planting & 13 OZ at first bloom	1083 a	33.1 a	2.6 a
None	1052 b	32.6 b	2.6 a

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.

Table 11. Effects of Vitazyme on soil organic matter and nitrogen content 6- and 12-weeks-after planting, 1999.

Vitazyme	% Organic Matter 6-week	% Organic Matter 12 week	NO3-N ppm 6-week	NO3-N ppm 12-week
13 OZ at planting & 13 OZ at first bloom	1.61 a	1.45 a	11.32 a	5.73 a
None	1.60 a	1.47 a	10.07 b	5.71 a

Values in a column followed with the same letter are not significantly different by the LSD test, $\alpha = 0.05$.