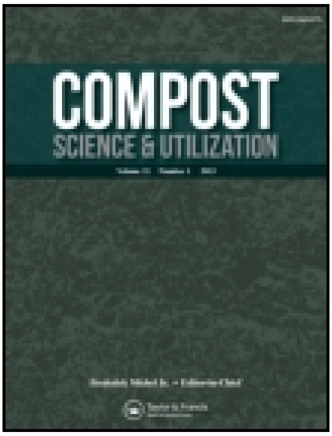

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Effects of Surface Application of MSW Compost On Cotton Production - Soil Properties, Plant Responses, And Nematode Management

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Effects of Surface Application of MSW Compost On Cotton Production – Soil Properties, Plant Responses, And Nematode Management

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Equipment was modified and/or developed for broadcast and banded applications of municipal solid waste (MSW) compost at selected rates to agricultural land for cotton production. Replicated tests were conducted for four years to determine the effects of compost on soil properties, crop yield, and nematode populations. Soil type in the test field was Faceville loamy sand. Broadcast application of compost significantly reduced soil compaction in the top 30 cm of soil in cotton rows and row-middles compared to no compost application. Banded application did not affect compaction in the row middles. Columbia lance nematode densities decreased in all compost-treated plots during all four years of study. Several plots treated with compost had nematode densities comparable to those found in the plots treated with Temik 15G nematicide. Compost application significantly increased the soil organic matter content and soil nitrogen content at six and 14 weeks after planting. However, the compost did not affect the leaf nitrogen content of the cotton plant during the same sampling periods. In 1996, 1997, and 1998, all rates of added compost significantly increased seed cotton yield. Yield increase was proportional to application rate. There were very few carry-over compost effects from each previous year's treatments on either soil organic matter, soil nitrogen, or seed cotton yield.

Introduction

The objectives of this project were: a) to modify and evaluate equipment for broadcast or banded applications of composted municipal solid waste at selected rates to agricultural lands for cotton production; b) to determine the effects of compost on certain soil parameters such as organic matter content, soil compaction, soil fertility and additive effects over years; c) to evaluate plant responses such as yield and nutrient content to compost application; and d) to evaluate the effects of compost application on Columbia lance nematode population density.

Methods and Materials

The Bedminster Bioconversion Corporation's composting facilities in Sevierville, Tennessee provided the MSW compost for this study. Analyses of the composted material are shown in Tables 1 and 2. Tests were conducted from 1995 to 1998 at the Edisto Research and Education Center at Blackville, South Carolina on a Faceville loamy sand (Clayey, kaolinitic, thermic) with soil properties listed in Table 3. A randomized complete block design with four replications was the statistical model selected for comparing different treatments. Two application methods (broadcast and banded), three application

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

		Percent							
Year	pH	Moisture	P	K	Ca	Mg	S	C	C/N
1995	7.5	23.4	0.47	0.31	1.85	0.20	0.38	24.5	24.7
1996	7.0	22.6	0.55	0.27	1.99	0.20	0.36	23.8	22.5
1997	6.8	17.8	0.72	0.33	2.28	0.23	0.49	27.4	19.3
1998	7.3	30.7	0.62	0.37	2.22	0.26	0.37	28.3	23.8

TABLE 2.
Annual heavy metal levels (kg ha^{-1}, dry weight) for highest application rate of MSW compost used in the project and EPA limits (CPLR and APLR) for land applications

	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
MSW	0.23	0.09	0.72	3.0	4.12	0.01	0.23	0.82	0.11	9.02
CPLR[1]	41	39	3,000	1,500	300	17	–	420	100	2,800
APLR[2]	2.0	1.9	150	75	15	0.85	–	21	5.0	140

CPLR= Cumulative Pollutant Loading Rates: Establish the maximum amount (mass) of each regulated pollutant that can be applied to a site (kilogram per hectare) during the life of the site (EPA CFR 503.13). APLR= Annual Pollutant Loading Rates: Establish the maximum amount (mass) of pollutants in compost that can be applied to a site during a 365-day period (EPA CFR 503.13).

TABLE 3.
Initial pH, soil extractable P, K, Ca, and Mg and organic C content for the test field

Year	pH	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Organic C (%)
1996	6.0	82	43	285	28	0.8
1997	6.2	72	56	358	47	0.9
1998	6.2	43	84	478	98	0.8

rates (11.2, 22.4, and 33.6 Mg ha^{-1}), and a control (no compost) were used in 1995. The same treatments were used in 1996, 1997 and 1998, except the broadcast application plots were split in half to determine the additive effects of compost over the years. No additional compost was applied to one-half of the plot while the other half received the same rate as in 1995. The cotton was grown using recommended practices for seedbed preparations, seeding, fertilization, and insect and weed control (Lege' *et al.* 1996). Plot size was 12 rows (10 m × 30 m). The two middle rows of each plot were machine harvested for yield determinations.

A commercially available spreader (Knight Pro Twin Slinger, model 8024) was used for broadcast application of compost in 1995. The spreader was adjusted to apply different rates of compost. With this system, swinging hammers deliver the material to the side resulting in a uniform coverage over 7.5-m width of the test plots. A 4-shank subsoiler-bedder was used to disrupt the hard pan and incorporate the composted material. Drift was a problem with this spreader under windy conditions. In 1996, 1997 and 1998, a conventional flatbed, chain-conveyer type manure spreader was used for broadcast application to eliminate the drift problem associated with the side delivering system. An adjustable gate was added to the spreader to control application rates.

A 4-row device for band application of the MSW compost was developed and mounted behind a John Deere MaxEmerge2 cotton planter. The unit consisted of a hopper with four fluted wheel metering devices at the bottom of the hopper. A hydraulic motor was used to run the metering system. Compost application rates were adjusted by changing speed of the motor using a flow control valve. This system dispensed the material in a band (20-cm wide) over each seed furrow.

To determine the effect of compost on soil compaction, a tractor mounted, hydraulically operated, microcomputer-based, digital 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 3.2 cm^2 base area, 30^o-cone into the soil at a constant velocity. Penetrometer data was taken before compost application and immediately after cotton harvest in 1996. Penetrometer readings were taken to a depth of 45 cm from crop rows and row-middles at four different locations in each plot (total of 16 probes per plot).

Each plot was sampled for Columbia lance nematodes, soil organic matter, and ammonium and nitrate contents at planting, six weeks after planting and 14 weeks after planting. Twelve cores 20-cm deep and 2.5-cm in diameter were taken from each plot on each date. Plant tissues (35 leaves/plot) were collected and analyzed for nitrogen. Nematodes were extracted using a combination of wet-seiving centrifugal flotation (Jenkins 1964).

Results

Cone index values before tillage and compost application indicated that the field had a hardpan in the E horizon at a depth of 17 to 25 cm. All rates of broadcast compost applications significantly reduced formation of the hardpan in the top 30-cm of soil for cotton rows compared to no compost application in 1996 (Table 4). In addition, all rates of broadcast application significantly reduced soil compaction in the top 30 cm of the row middles compared to no compost application (Table 5). Banded application did not affect compaction in the row middles. Similar results were obtained in 1997 and 1998.

Multiple broadcast applications of compost (1995 and 1996) significantly reduced formation of the hardpan in the top 30 cm of cotton row compared to no compost ap-

TABLE 4.
Effect of compost rate and application method on formation of hardpan under cotton rows at harvest during 1996. Clemson University, Edisto Research and Education Center, Blackville, South Carolina.

		Cone Index (kPa)			
Application Method	Compost ($Mg\ ha^{-1}$)	0-7.5 cm Depth	7.5-15 cm Depth	15-22.5 cm Depth	22.5-30 cm Depth
Broadcast		334.7 **B**	580.1 **B**	740.5 **B**	1116.0 **B**
	11.22	400.8 bc	605.0 b	706.2 b	1253.2 b
	22.43	302.0 c	549.3 b	754.6 b	808.2 c
	33.65	301.2 c	586.1 b	760.7 b	1286.5 b
Band		513.7 **A**	670.3 **B**	1091.2 **B**	1203.5 **B**
	11.22	535.7 ab	644.1 b	1146.3 b	1236.5 b
	22.43	495.2 ab	691.8 b	1097.0 b	1154.9 bc
	33.65	510.2 ab	675.1 b	1030.2 b	1217.5 bc
None		577.9 **A**	1198.6 **A**	2176.5 **A**	1909.3 **A**

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

TABLE 5.
Effect of compost rate and application method on soil compaction for row-middles at harvest during 1996. Clemson University, Edisto Research and Education Center, Blackville, SC.

Application Method	Compost ($Mg\ ha^{-1}$)	Cone Index (kPa) 0-7.5 cm Depth	7.5-15 cm Depth	15-22.5 cm Depth	22.5-30 cm Depth
Broadcast		888.7 **B**	1877.0 **C**	2332.0 **B**	1731.8 **B**
	11.22	1016.6 bc	1869.7 c	2374.2 b	1756.5 c
	22.43	858.4 c	2009.5 c	2330.5 b	1859.4 abc
	33.65	791.2 c	1751.9 c	2292.0 b	1579.5 c
Band		1815.5 **A**	3183.5 **B**	2852 **B**	2065.8 **A**
	11.22	1884.1 a	3143.0 b	3263.6 a	2214.4 a
	22.43	2018.5 a	3337.2 ab	2631.0 ab	2086.3 ab
	33.65	1544.0 a	3073.4 b	2663.8 ab	1896.7 abc
None		2024.1 **A**	3807.2 **A**	3233.8 **A**	2120.8 **A**

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

plication (Figure 1). Also, there were significant differences in cone index values between no compost application and a single application of compost. In row-middles, both a single application and multiple applications of compost significantly reduced soil compaction in the top 22.5 cm of soil compared to no compost application. Also, there was a significant difference in cone index values in the 7.5- to 15-cm depth of soil between compost applied only in 1995 versus 1995 and 1996 applications (Figure 2).

Recovery of Columbia lance nematodes (*Hoplolaimus columbus*) prior to planting in 1995 was minimal. By midseason reproduction in the untreated check plots was more than double that in all treatments except the 22.4 $Mg\ ha^{-1}$ (10 tons/acre) banded application (Table 6). Columbia lance nematode populations decreased in all treatments between harvest in 1995 and planting in 1996. By harvest in 1996, nematode population densities had again increased significantly, especially in the check, which had almost triple the density of any of the other treatments. Several of the compost treatments had nematode densities comparable to those found in plots treated with

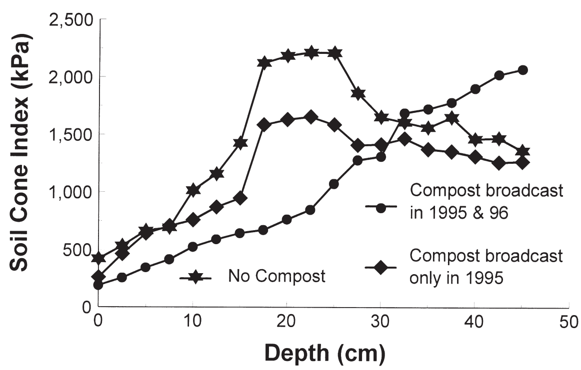

Figure 1. Effect of multiple compost applications on formation of hardpan from crop rows after cotton harvest in 1996 (33.6 $Mg\ ha^{-1}$).

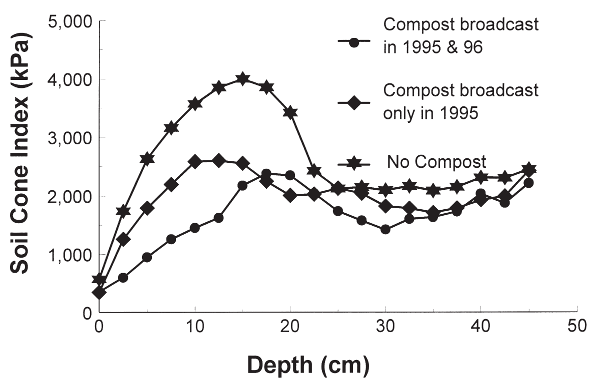

Figure 2. Effect of multiple compost applications on soil compaction from row-middles after cotton harvest in 1996 (33.6 $Mg\ ha^{-1}$).

TABLE 6
Effect of compost rate and application method on density of Columbia lance nematodes from soil

Application Method	Compost ($Mg\ ha^{-1}$)	Columbia Lance Nematodes/100 cm^3 soil: 1995 Midseason	1996 Harvest	1997 Midseason	1998 Harvest
Broadcast		19 **C**	12 **B**	14 **C**	3 **C**
	11.2	31 b	24 a	11 d	1 d
	22.4	22 b	13 a	8 d	6 cd
	33.6	3 b	0 a	24 cd	2 cd
Band		45 **B**	11 **B**	53 **AB**	17 **AB**
	11.2	13 b	5 a	52 ab	22 a
	22.4	71 a	13 a	41 bc	20 ab
	33.6	52 a	16 a	66 a	11 bc
None		125 **A**	61 **A**	61 **A**	29 **A**
Temik	In-furrow	19 **C**	13 **B**	39 **B**	13 **AB**

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

aldicarb. Aldicarb was applied in-furrow, at planting at the rate of 1.18-kg a.i./ha. At midseason in 1997 and harvest in 1998, only the broadcast applications provided level of control comparable to that provided by aldicarb.

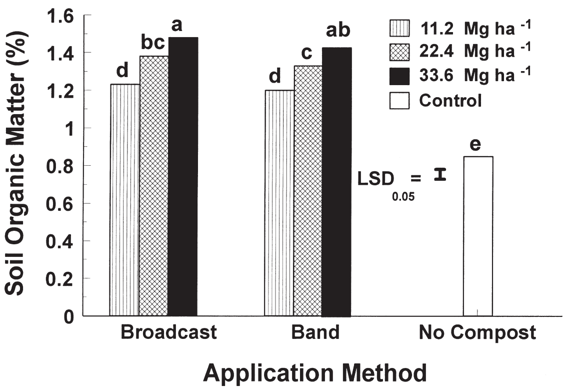

Figure 3. Soil organic matter content as affected by the rate and method of compost application six weeks after planting (1996).

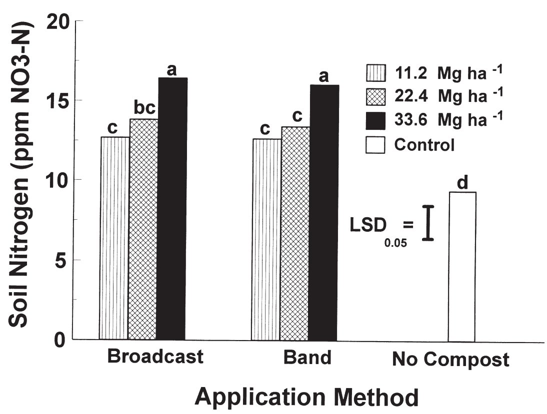

Figure 4. Soil nitrogen content as affected by rate and method of compost application six weeks after planting (1996).

Figure 3 shows soil organic matter content averaged over the top 20 cm of the soil for 1996. Application of MSW compost significantly increased the soil organic matter content and soil nitrogen content (Figure 4) 6-weeks-after planting proportional to compost application rate. However, these differences did not affect the leaf nitrogen content of cotton plants during the same sampling period (Figure 5). Similar results were obtained in 1995 and 1997.

Figure 6 shows soil organic matter content 14-weeks-after planting. Except for 11.2 $Mg\ ha^{-1}$ (5 tons/acre) banded application rate, MSW compost significantly increased soil organic matter in the top 20-cm compared to no compost application. Only application of 33.6 $Mg\ ha^{-1}$ (15 tons/acre) compost (broadcast or banded) statistically increased soil nitrogen content averaged over top 20 cm of the soil (Figure 7).

Table 7 shows seed cotton yields for the 1995 to 1998 tests. Application of 33.6 Mg ha^{-1} of MSW compost (broadcast or banded) significantly increased seed cotton yield (187 kg ha^{-1}) compared to no compost application in 1995. There were no significant differences in yield among the rest of the treatments. In 1996, 1997, and 1998 all rates of MSW compost significantly increased seed cotton yield for both application methods. Yield increase was proportional to application rate. In 1996, for 33.6 Mg ha^{-1} broadcast application treatment, yield increase was 498 kg ha^{-1} or 23% more compared to no compost application. In 1997 and 98, yield increases at this level of application rate were 30% and 29% higher than no compost application, respectively.

Table 8 shows carry-over and additive effects of compost on soil organic matter and soil nitrogen for both 6- and 14-weeks-after planting and seed cotton yield. There were very few carry over effects with all of these parameters except for soil organic matter content 6-weeks-after planting at 33.6 Mg ha^{-1} (15 tons/acre) application rate (treatment 3b, Table 8). Additive effects of compost were significant on soil organic matter, nitrogen content and seed cotton yield (treatments 1a, 2a and 3a as compared to 1b, 2b and 3b). Increased soil organic matter and nitrogen contents combined with the potential increase in soil water-holding capacity and decreases in soil bulk density associated with MSW compost, could be the contributing factors to yield increases.

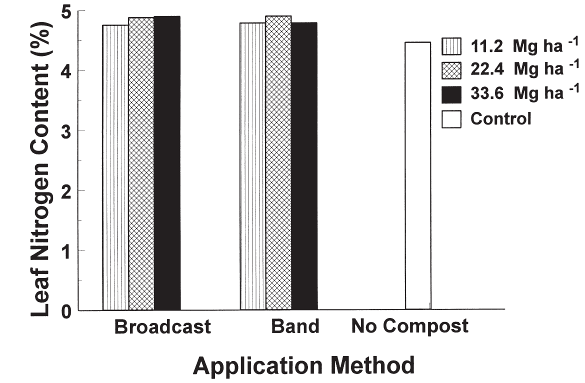

Figure 5. Leaf nitrogen content as affected by the rate and compost application method six weeks after planting (1996).

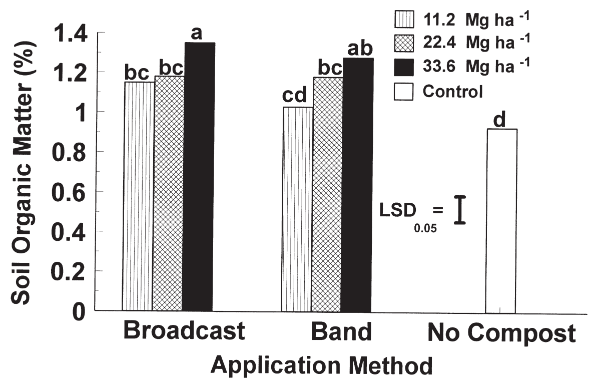

Figure 6. Soil organic matter content as affected by the rate and compost application method 14 weeks after planting (1996).

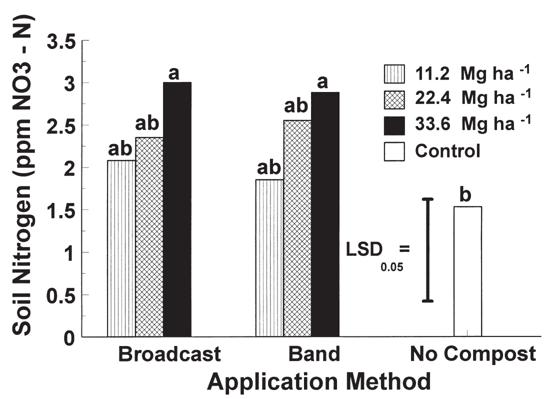

Figure 7. Soil nitrogen content as affected by the rate and compost application method 14 weeks after planting (1996).

TABLE 7
Effect of compost rate and application method on seed cotton yield.

Application Method	Compost ($Mg\ ha^{-1}$)	Yield ($kg\ ha^{-1}$) 1995	1996	1997	1998
Broadcast		2217 A	2452 A	3104 A	2004 A
	11.2	2063 c	2323 c	2814 c	1879 c
	22.4	2213 bc	2400 bc	3093 b	1990 bc
	33.6	2375 ab	2633 a	3406 a	2144 a
Band		2232 A	2385 A	3085 A	1967 A
	11.2	2084 c	2306 c	2831 c	1869 c
	22.4	2216 bc	2353 bc	3064 b	1951 bc
	33.6	2396 a	2495 ab	3361 a	2081 a
None	None	2208 A	2135 B	2617 B	1657 B

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

TABLE 8.
Carry over and additive effects of broadcast compost application on soil nitrogen and organic matter contents and seed cotton yield during 1996. Clemson University, Edisto Research and Education Center, Blackville, South Carolina.

Trt. No.	Compost ($Mg\ ha^{-1}$) 1995	1996	NO_3-N (ppm) 6 W*	14 W	Organic Matter (%) 6 W	14 W	Yield ($Kg\ ha^{-1}$)
1a	11.2	11.2	12.7 b	2.1 ab	1.23 b	1.15 b	2323 bc
1b	11.22	None	8.4 c	1.6 b	0.95 cd	0.95 c	2131 d
2a	22.4	22.4	13.8 b	2.4 ab	1.38 a	1.18 b	2400 b
2b	22.4	None	7.2 c	1.6 b	1.00 cd	0.88 c	2144 cd
3a	33.6	33.6	16.4 a	3.0 a	1.48 a	1.35 a	2633 a
3b	33.6	None	9.5 c	2.0 ab	1.05 c	0.98 c	2057 d
7	None	None	7.7 c	1.5 b	0.90 d	0.93 c	2135 d

*6 W and 14 W = 6 and 14 weeks after planting. Values in a column followed with the same letter are not significantly different (LSD, = 0.05).

Discussion

The results of this experimental study clearly indicate that all rates of broadcast applications of composted MSW significantly reduced soil compaction in the top 30-cm of soil for cotton rows and row-middles when compared to no compost application. These results are in agreement with other investigations using composted MSW as a broadcast application (Cook *et al.* 1979; De Smet *et al.* 1991; Sabrah *et al.* 1995; Spugnoli *et al.* 1993). In a study conducted in Washington D. C., composted MSW or biosolids were surface-applied in a restoration project in a heavily trafficked and compacted parkland (Cook *et al.* 1979). Compost application increased water infiltration rate, decreased bulk density and increased pore volume. De Smet *et al.* (1991) reported a decrease in soil infiltration resistance by application of pig slurry. Application of MSW compost to sandy soils of Saudi Arabia decreased soil bulk density and penetration resistance (Sabrah *et al.* 1995). A study by Spugnoli *et al.* (1993) indicated that soil treated with composted MSW was less compactable than untreated soil. The results in our experiments also indicated that the multiple broadcast applications reduced the compaction and hardpan formation in top 30 cm of seed furrow and top 22.5 cm of row-middles. From these results, it appears that broadcast compost application is an effective and probably an economically feasible method for reducing soil compaction and decreasing hard pan formation (Cook *et al.* 1979).

Over the four-year study, Columbia lance nematode densities decreased in all of the compost- treated plots. Many other investigators have obtained similar results utilizing various organics or composted MSW for control of other nematode species (Singh and Sitaramaiah 1970; Muller and Gooch 1982; Rodriguez-Kabana *et al.* 1987; Marull *et al.* 1997). It is difficult to pinpoint the exact mechanism by which compost application can reduce population densities of nematodes and other pests. Two classes of biological mechanisms known as "general" and "specific" suppression have been described for compost-amended substrates (Hoitink and Fahd 1986; Hoitink, *et al.* 1997). These mechanisms are based on "competition, antibiosis, hyperparasitism, and the induction of systematic acquired resistance in the host plant." Utilizing olive pomace, chicken litter and MSW, as soil amendments for the control of root-knot nematode (*Meloidogyne javinica*) in green pepper and tomato growth studies, Marull *et al.* (1997) demonstrated that amended soil had a lower densities of nematodes in roots than those grown in the control soils. Esterase activity was higher in amended soils than in control soils, regardless of whether or not the soils had been treated with methyl bromide. Nematode population per gram of root was inversely related to soil esterase activity in unfumigated soil but not in soil treated with methyl bromide. The increase in esterase activity was attributed to the increase in organic mater content of the soil by compost application. Therefore, it is possible to assume that the reductions in nematode populations in our study resulted from increased esterase activity of the soil by compost application and increased in organic matter and microorganisms population. However, the mechanism that reduced the Columbia lance nematode population by composted MSW shown in our study needs further study.

The increase in soil organic matter content by all rates of compost applications in our study is in agreement with the work of many investigators (Biswas and Khosla 1971; Gallardo-Laro and Nogales 1987; Knoop and Culter-Talbott 1990). The organic matter content of composted MSW exceeds 25% and its addition to most soils increases the organic matter content (Hernando *et al.* 1989; Shiralipour *et al.* 1992b). Also, the major benefits from the application of composted MSW to soil is derived from improved physical properties related to the increased organic matter content (Shiralipour *et al.*, 1992b). Therefor, it is reasonable to assume that the reduction in hardpan formation and decrease in soil compaction in our study is the result of the increased soil organic matter content by compost application. Compost application to cotton fields showed an increase in plant yield. Our results are similar to the yield increase obtained in a cotton crop farm in Lost Hills Valley, California (Shiralipour and Epstein, 1996). In that field experiment, the yield increases for 7.5 or 15 Mg ha^{-1} MSW compost in comparison to control plots were 24.3 and 37.2 percent, respectively. The researchers attributed the yield increase to improvements in both chemical and physical properties of the soil. They suggested that the compost nitrogen, which was in organic form, was released slowly by the mineralization process over the growing season and it supplemented the nitrogen provided through fertilization. They also believed that the increase of 7 to 10 percent in water content and additional micronutrients of compost-treated plots could have affected the cotton yields.

There were very few carry-over effects from the previous year's applications on soil organic matter, soil nitrogen and seed cotton yield due to a lack of compost application after the first year. It appears that in such cases the residual compost in following years was not considerable and the rate of nitrogen mineralization was negligible leading to very little carry-over effects.

Conclusions

The municipal solid waste compost product utilized in this field study was beneficial for cotton production in a number of ways. Its application significantly increased soil organic matter content, which resulted in benefits such as: a) significantly reduced soil compaction; b) nematode control; and c) increased soil nitrogen and seed cotton yield.

Reduced soil compaction occurred in the top 30 cm of soil in cotton rows and row-middles when compost was applied through broadcast application. Banded application was not effective in row middles. Based on the results, broadcast compost application is an effective methodology for reducing soil compaction in agricultural fields. Compost application was very effective in nematode control and in some cases, the reduction in density by compost application was comparable to the nematocide used in this study. Compost application appears to be a viable alternative to pesticides for the control of nematodes in agricultural fields, especially when land is used for vegetables or other food products. Lastly, the addition of MSW compost significantly increased soil nitrogen and seed cotton yield. It appears that compost could at least be used as a partial substitute for commercial fertilizers to increase yield. Unlike chemical fertilizers, compost application improves soil physical properties and its application is an environmentally benign method of waste reduction.

Acknowledgments

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References

Bauduin, M., E. Delcarte and R. Impens. 1987. Agronomic characterization and evaluation of two new municipal waste composts. *In*: M. De Bertoldi and M. P. Ferranti (eds). *Compost: Production, Quality and Use*. Elsevier Applied Science, London, pp. 479-486.

Biswas, T.D. and B.K. Khosla. 1971. Building up organic matter status of soil and its relation to the physical properties of soil. *J. Soc. Soil Sci.,* 19(1): 31-37.

Blasingame, D. 1996. Cotton disease loss estimate committee report. *In*: P. Dugger and D. A. Richter (eds). *Proceedings, Beltwide Cotton Conferences*. National Cotton Council of America, Memphis, Tennessee, pp. 227.

Cook, R.N., J.C. Patterson and J.R. Short. 1971. Compost saves money in parkland restoration. *Compost Sci. Util.,* 20(2): 43.

De Smet, J., M. De Bood and R. Hartmann. 1991. Effect of application of pig slurry on soil penetration resistance and sugar beet emergence. *Soil Tillage Res.,* 19:297.

Duncan L.W. and J.W. Noling. 1998. Agricultural sustainability and nematode integrated pest management. *In*: K. R. Barker, G. A. Pederson and G. L. Windham, (eds). *Plant and Nematode Interactions.* ASA, Inc. Madison, Wisconsin, pp. 252-287.

Ekwue, E.I. and R.J. Stone. 1995. Organic matter effects on the strength properties of compacted agricultural soils. *Transactions of the ASAE,* 38(2):357-365.

Gallardo-Laro, F. and R. Nogales. 1987. Effect of the application of town refuse compost on the soil-plant system: A review. *Biol.Wastes*, 19:35-62.

Hallmark, W.B., S.E. Feagley, X. Wan and L.P. Brown. 1994. Effects of composted MSW on sugarcane production and fertilizer requirements. *Compost Quality Documentation*, Bedminster BioConversion Corporation, Cherry Hill, New Jersey.

Hernando, S., M.C. Lobo and A. Polo. 1989. Effect of the application of a municipal refuse compost on the physical and chemical properties of a soil. *Sci. Total Environ.,* 81/82:589-596.

Hoitink, H.A.J. and P.C. Fahd. 1986. Basis for the control of soil born plant payhogens with composts. *Ann. Rev. Phytopathol.*, 24:93-114.
Hoitnk, H.A.J., A.G. Stone and D.Y. Han. 1997. Suppression of plant diseases by composts. *HortScience*, 32(2):184-187.
Hortenstine, C.C. and D.F. Rothwell. 1973. Pelletized municipal refuse compost as a soil amendment and nutrient source for sorghum. *J. Environ. Qual.*, 2(3):343 - 344.
Jenkins, W.R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. *Plant Disease Reporter*, 48:692.
Knoop, M. and K. Cutler-Talbott. 1990. *In*: C. L. Henry (eds.). *Technical information on the use of the organic materials as soil amendments.* The University of Washington, College of Forest Resources, pp. 1-71.
Lege', K.E., M.E. Roof, J.J. Camberato, E.C. Murdock, J.D. Mueller, G.D. Christenbury and C.E. Curtis. 1996. *South Carolina Cotton Growers Guide.* Clemson University Cooperative Extension Service, EC-589, Clemson, South Carolina.
Marull, J., J. Pinochet and R. Rodriguez-Kabana. 1997. Agricultural and municipal Compost Residues for control of root-knot nematodes in tomato and pepper. *Compost Sci. Util.*, 5(1): 6-15.
Muller, R. and P.S. Gooch. 1982. Organic amendments in nematode control. An examination of the literature. *Nematropic*, 12:319-326.
Mueller, J.D. and M.J. Sullivan. 1988. Response of cotton to infection by Hoplolaimus Columbus. Annals of Applied Nematology (Journal of Nematology 20, Supplement) 2:86-89.
Parr, J.F. and S.B. Hornick. 1992. Utilization of municipal wastes. In: B. Metting (eds.). Soil Microbial Ecology: Application in Agriculture, Forestry and Environmental Management. Marcel Dekker, New York.
Rodrigues-Kabana, R., G. Morgan-Jones and I. Chet. 1987. Biological control of nematodes: soil amendments and microbial antagonits. Plant and soil, 100:237-247.
Sabrah, R.E.A., H.H. Abdel Magid, S.I. Abdel-Aal and R.K. Rabie. 1995. Optimizing physical properties of a sandy soil or higher productivity using town refuse compost in Saudi Arabia. J. Air Environments, 29(2):253.
Shiralipour, A., D.B. McConnell and W.H. Smith. 1992a. Uses and benefits of MSW compost: a review and assessment. *Biomass and Bioenergy*, 3(3-4): 267-279.
Shiralipour, A., D.B. McConnell and W.H. Smith. 1992b. Physical and chemical properties of soils as affected by municipal solid waste application. *Biomass and Bioenergy*, 3(3-4): 261-266.
Shiralipour, A. and E. Epstein. 1996. Compost effect on cotton growth and yield. *In*: R. K. White (eds.). *Proceedings of the 1996 Conference, Composting in the Carolinas.* Myrtle Beach, South Carolina, October 23-25.
Shiralipour, A., P.B. Leege and K.M. Portier. 1998. Using compost products in vegetable production. *In*: S. Brown, J. Scott angle and L. Jacobs (eds.). *Proceedings, Beneficial Co-Utilization of Agricultural, Municipal, and Industrial By-Product.* Symposium XXII, U.S. Department of Agriculture, Beltsville, MD, pp. 363-375.
Singh, R.S. and Y.K. Sitaramaiah. 1970. Control of plant parasitic nematodes with organic soil amendments. *PANS*, 16:287-297.
Slivka, D.C., T.A. McClure, A.R. Buhr and R. Albrecht. 1992. Compost: United States supply and demand potential. *Biomass and Bioenergy*, 3: 281- 299.
Spugnoli, P., A. Partent and F. Baldi. 1993. Compaction of soil treated with municipal solid waste compost using low-pressure and traditional tyres. *J. Agric. Eng. Res.*, 56:189.