Composting Treatment for Cotton Gin Trash Fines

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ABSTRACT

IMPROPERLY handled cotton gin waste can be a source of foul odor when damp or a fire hazard when dry. The waste may be satisfactorily disposed of, with concomitant production of energy, through controlled incineration. Prior to incineration, however, the "fines" materials must be screened out. This fines material requires treatment before it is suitable for disposal onto agricultural land. In this study aerobic composting was investigated as a method of treatment of the fines in order to degrade chemical residues and destroy *Verticillium dahliae* and weed seeds. Six 0.5 m^3 pilot model composters were used. A combination of 40 percent water content and 4 d mixing frequency was optimal for composting. The composting process required approximately five weeks, over which period the *Verticillium dahliae* and weed seeds were destroyed. The chemical residues, DEF and Parquat, were not degraded; Kelthane was slightly degraded. Greenhouse tests indicated that the composted material exhibits no phytotoxicity to sorghum when applied at a rate of 44.8 t/ha.

INTRODUCTION

Approximately 1.7 x 10^6 t of cotton ginning waste are generated in the United States each year (Griffin, 1976). The waste, termed gin trash, is the material (leaves, sticks, burrs, lint, immature cotton seed and soil) separated from mechanically harvested cotton in the ginning operation. Gin trash is presently an unwanted byproduct for most ginners. Piles of gin trash are a fire hazard and can also produce foul odors if permitted to decompose. Some of the trash is spread on agricultural land and incorporated with the soil, however, this practice is not popular with many farmers because the trash may be a source of weed seeds and disease organisms.

Because of this disposal problem and because ginning plants require energy for cotton drying and machinery operation, the ginning industry is considering the use of incinerators or gasifiers for trash disposal and energy generation. The use of either of these methods currently results in an ash slagging problem which seriously impairs the operation. Analysis of this slag by Curley et al. (1978) indicates that silica, from soil material, is the chief ingredient. Therefore, the problem can be lessened by screening out the soil particles before combustion.

Approximately 4 to 7 percent of the original trash volume passes through the openings of a 20 mesh (openings 0.8 mm) screen (Curley et al., 1978; Lalor and Jones, 1979). The screenings, or fines, which are still high in *Verticillium dahliae*, weed seeds and chemical residues require disposal. Studies by Seiber et al. (1979a, 1979b) indicate that several of the more stable pesticides and harvest aid chemicals tend to be more concentrated in the fine, non-lint fraction than in the coarse lint fraction. The average values for California samples examined were: 13 and 60 ppm for toxaphene, 11 and 58 ppm for DEF, 5 and 10 ppm for Paraquat, and 7 and 19 ppm for Kelthane for the lint and non-lint fractions respectively. Additionally, there is little reduction in chemical residues during open storage of gin waste (Seiber et al., 1979b and Miller et al., 1975).

Albusa and Hurst (1964) and Parnell (1977) have shown that composting of ordinary gin trash to high temperatures inactivated both the wilt organism and the weed seeds. No investigations, however, are found in the literature regarding the fate of chemical residues during composting of cotton gin trash. The objectives of this study were (a) to evaluate the effectiveness of composting as a means of destroying or degrading chemical pesticide residues, *Verticillium dahliae*, and weed seed viability in fines obtained by 20-mesh screening of cotton gin trash and (b) to conduct tests to evaluate the composted material as a plant growth medium.

EXPERIMENTAL PROCEDURES

Approximately 2 m^3 of gin trash fines were obtained from each of two lots of seed cotton from fields treated with different chemicals. This material was composted in six 0.5 m^3 pilot model composters. Laboratory composters of this size are frequently used to determine composting parameters (Clark et al., 1978 and Schulze, 1958). Two separate investigations were conducted. The first study (Phase 1) was aimed at establishing an optimum composting procedure for use in the main body of the research. The second, more elaborate investigation (Phase 2) was designed to evaluate composting as a treatment process and to evaluate the composted material as a plant growth medium.

Each composter consisted of a rotatable, insulated steel drum, 850 mm in diameter and 850 mm long. In-

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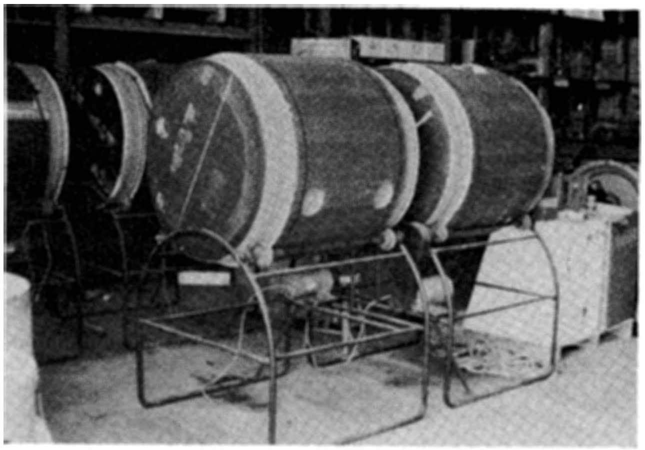

FIG. 1 Photograph showing two of the six pilot model composters.

sulation consisted of 25 mm urethane foam cemented to the outside of the drum. Each composter had a one-quarter horsepower motor which intermittently rotated the drum at 10 rpm. A photograph of several of the composters is shown in Fig. 1. The composters were placed inside a metal building to provide some shelter against climatic extremes.

Phase 1. Composting Guidelines: The objectives of the first investigation were to determine the optimum moisture content and frequency of mixing for good composting. Each composter was fed 0.1 m^3 of gin trash fines (0.05 m^3 from each of the two lots of seed cotton). The variables in the six composters, shown in Table 1, included controlled moisture content (40 or 60 percent), mixing frequency (1 to 3 d) and uncontrolled moisture content (60 percent). As noted in Table 1, the moisture content in composters 1-4 was held constant throughout the experiment by monitoring and adding water when necessary. The water content in composters 5 and 6 was initially brought to 60 percent and no water added during operation. To achieve sufficient mixing and aeration the drums were rotated for five minutes or a total of 50 revolutions once every 1 or 3 d.

Temperatures were monitored via thermocouples and were automatically recorded on a time activated strip-chart recorder. Samples were removed every third day and analyzed for moisture content and volatile solids. Analyses were performed according to "Standard Methods" (1975). The results of this phase established the optimal operating conditions which were then utilized in Phase 2 of this study.

Phase 2. Treatment Evaluation: The results obtained from Phase 1, which will be discussed in the next section, suggest that optimal composting under the conditions used occurs at 40 percent moisture and a mixing frequency of 4 d. These two variables were held constant throughout Phase 2. Each composter was fed 0.1 m^3 of fines. Three composters utilized fines from one lot of seed cotton, three composters utilized screenings from the second lot. There were no other variables.

The same parameters were again monitored as in Phase 1. Additionally, analyses were made for chemical residues, weed seeds, *Verticullium dahliae* and plant nutriment. Growth tests were later performed to evaluate phytotoxicity of the composted material.

Samples of 150 g were removed periodically and assayed for DEF, Kelthane and Paraquat. The analytical procedures were essentially as reported by Seiber et al.

TABLE 1. COMPOSTING VARIABLES FOR PHASE 1

Treatment	Moisture content	Mixing frequency
1	60% controlled	1 day
2	60% controlled	3 days
3	40% controlled	1 day
4	40% controlled	3 days
5	60% uncontrolled	1 day
6	60% uncontrolled	3 days

(1979). Approximately one-fourth of the DEF and Paraquat had already degraded during the 8 months between the time of collection and the start of Phase 2. During this interval the gin trash fines had been stored in a closed container and had a moisture content of about 10 percent. There was little degradation in Kelthane during storage. Although there was a reduced percentage of DEF and Paraquat in the material to be composted, it was felt that the results of this test would adequately relate to field composting of fresh gin trash.

Three types of weed seeds - Bermudagrass, watergrass and pigweed - were added to the fines before composting at the rate of 5g/22.7 kg. Samples were taken before and after composting for weed seed germination tests. Each sample, 35.7g, was spread in a thin layer on top of soil in a shallow planting dish and covered with a thin layer of soil. Moisture content was raised to field capacity and seed germination was observed. The addition of weed seeds was necessary because initial tests before composting indicated that the fines had a very low level of weed seed contamination.

Similarly, few viable propagules of *Verticillium dahliae* were detected in the fines after storage and prior to Phase 2. Inactivation of the indigenous wilt organism may have resulted from the relatively high ambient temperatures, 25 to 35°C, during storage. Two procedures were then used to investigate *Verticillium dahliae* destruction during composting. Limited amounts of original fines material which had been placed in cold storage still had viable wilt organisms. This material after thorough mixing, was placed in six nylon mesh bags, 100 g each, then one bag was placed within the material in each composting unit. The material within the nylon bags were assayed for *Verticillium dahliae* before and after composting. The second procedure involved grinding some existing safflower stalk which contained *Verticillium dahliae* and using this ground material (3.5 g per drum) to seed the gin trash fines before the composting trial. *Verticillium dahliae* was assayed according to the procedure of Butterfield and DeVay (1977).

Samples of gin trash fines before and after composting were assayed for plant nutriment and were used in growth tests. In addition to nitrogen, phosphorus and potassium, the following parameters were also assessed: sulfate, calcium, magnesium, sodium, chloride, boron, zinc, electrical conductivity and arsenic. Assays were performed according to standard procedures for soil analyses (Chapman and Pratt, 1961 and Jackson, 1958). Growth tests were conducted to observe nutrient and phytotoxic effects of composted and uncomposted gin trash fines on an indicator plant, sorghum. The gin trash was finely ground and uniformly mixed with sand at varying concentrations up to 2 percent on a dry weight basis (2 percent is equivalent to 44.8 t/ha - 150 mm depth). The sand had no nutrient value and only served

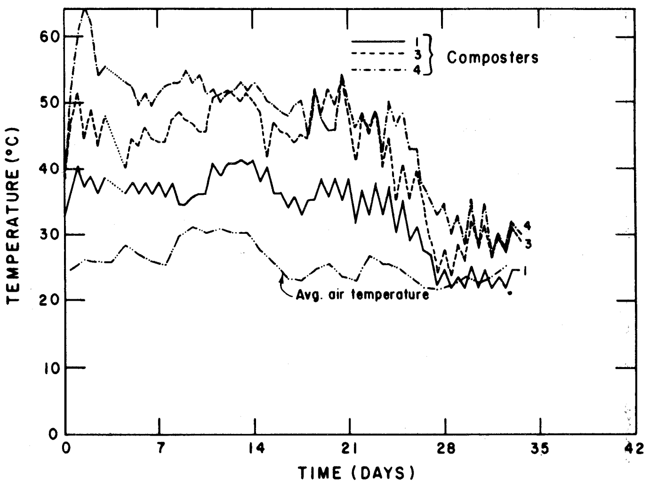

FIG. 2 Recorded temperatures for composters 1, 3 and 4 during phase 1 of study.

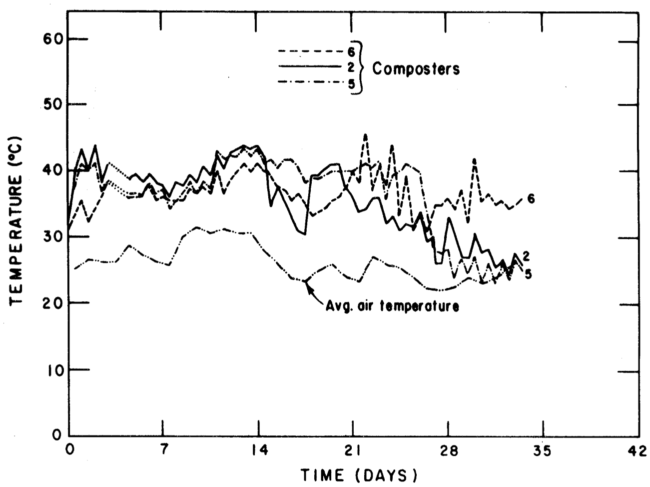

FIG. 3 Recorded temperatures for composters 2, 5 and 6 during phase 1 of study.

to hold water and provide support for the plants. Ten seeds were planted in each of 50 pots containing 3 kg sand and the gin trash amendment. Each pot received 113 mg nitrogen by using a modified half-strength Hoagland's solution. (This amount of applied nitrogen is equivalent to 75 kg N/ha). Germination was monitored for 13 d following seeding, then each pot was thinned to five seedlings. Plants were harvested 32 d after planting.

RESULTS AND DISCUSSION

Phase 1. Composting Guidelines

The composting process began spontaneously upon increasing the moisture content in the gin trash fines from its original 10 percent to either 40 or 60 percent treatment. As indicated in Figs. 2 and 3, temperatures were between 40 to 60°C within a day of initiating composting. Composters 3 and 4, both at 40 percent moisture content, continually had the highest temperatures throughout the four week experiment until the very end when their temperatures declined to ambient. Generally composter 4, which was mixed every third day, had the highest temperature of all the composters. This fact is indicative of greatest biological activity.

The temperatures of the remaining four composters which were started at 60 percent moisture content remained near 40°C through the first three weeks of the experiment before gradually declining. The frequency of mixing had little effect on the rate of composting at these water contents. Additionally, at these relatively low temperatures very little water evaporated from these composters so, although it had been hoped to simulate field conditions with the two uncontrolled moisture content composters, the moisture contents in composters 1 and 2 were very similar to those in composters 5 and 6 throughout the experiment.

The variability in temperature data is possibly due to different placement of the thermocouples after each mixing, changes in ambient temperatures, and rapid rise in temperatures caused by biological respiration following reaeration. It is, however, quite clear from the temperature data that a combination of 40 percent moisture content and a mixing frequency near three days is the best for composting of this material.

These two optimal criteria are further suggested by the volatile solids curves presented in Figs. 4 and 5. Although the data in these curves is also rather erratic, perhaps due to different personnel performing the tests, there is an overall trend toward substantial decrease in volatile solids or organic matter from the four week test. Assuming that there was no loss in ash, then this reduction in volatile solids resulted in approximately a one-third decrease in total solids for the 40 percent moisture

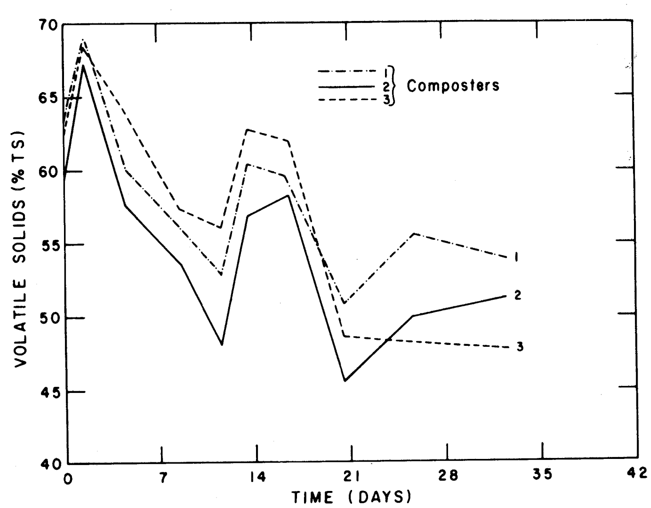

FIG. 4 Reduction in volatile solids from composters 1, 2 and 3 during phase 1 of study.

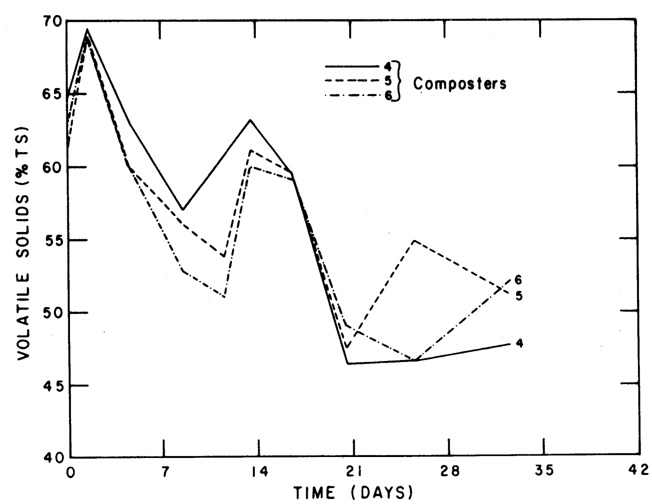

FIG. 5 Reduction in volatile solids from composters 4, 5 and 6 during phase 1 of study.

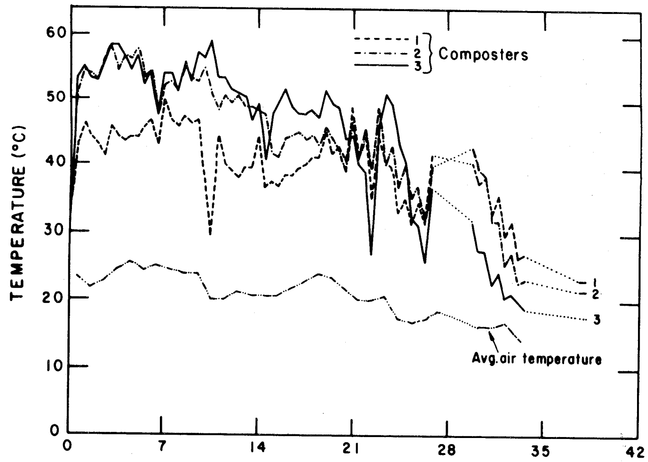

FIG. 6 Recorded temperatures for composters 1, 2 and 3 during phase 2 of study.

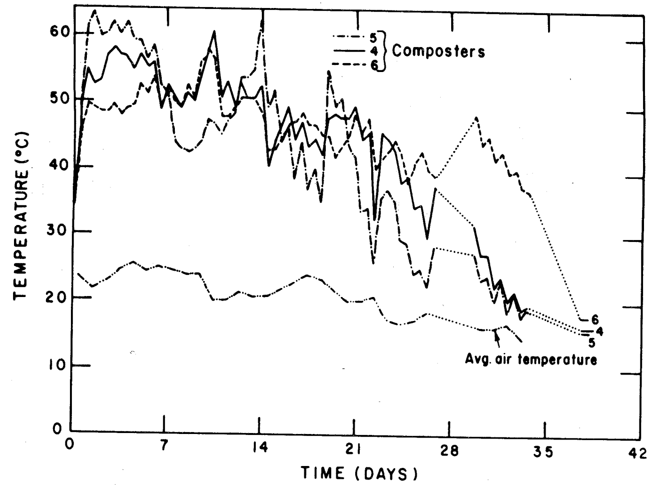

FIG. 7 Recorded temperatures for composters 4, 5 and 6 during phase 2 of study.

content composters (numbers 3 and 4) and a one-quarter decrease for the 60 percent moisture content composters (numbers 1, 2, 5 and 6).

The oxygen concentration in the air voids of the composting material was monitored on several occasions with an electronic oxygen probe. Oxygen concentrations of between 40 and 50 percent of normal air oxygen concentrations indicated that oxygen was not limiting the aerobic processes and that the mixing frequency could be decreased slightly. The results of this preliminary investigation, therefore, suggested that the composters in Phase 2 should be operated at 40 percent moisture content with a mixing frequency of four days.

Phase 2. Treatment Evaluation

Composting Data: Temperature data are presented in Figs. 6 and 7. Composters 1, 2 and 3 represented in Fig. 6, were operated as replicates using the gin trash fines obtained from lot one. Similarly, composters 4, 5 and 6, represented in Fig. 7, were filled with material obtained from lot two. As indicated, temperatures were generally between 50 to 60°C over the first two weeks then gradually decreased to ambient after the fifth week. This data indicates that for these conditions of operation the composting process is complete within five weeks.

The temperatures dropped during mixing, every fourth day, but rapidly rose to levels usually above those measured immediately prior to mixing. This phenomenon is common in composting operations and indicates that the oxygen concentrations are beginning to limit biological respiration during the later hours of the mixing cycle. This fact suggests that four days is indeed near the optimum mixing frequency. Other fluctuations in the curve reflects daily changes in ambient temperatures and possible changes in location of thermocouples when they were re-implanted in the composting material following extraction for drum rotation mixing.

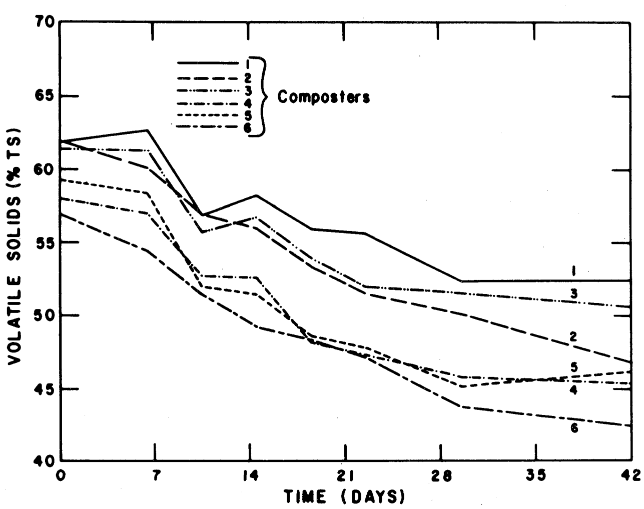

FIG. 8 Reduction in volatile solids for all composters during phase 2 of study.

The rate of organic material breakdown is indicated by the change in volatile solids concentration shown in Fig. 8. Data from each of the three replicates for each gin trash source closely correspond to each other. The average value for volatile solids from the first lot of materials (composters 1, 2 and 3) gradually decreased from an initial 62 percent to about 52 percent over the composting period; that of the second lot of compost (composters 4, 5 and 6) decreased from an initial value of 58 percent to a final value of 45 percent. These reductions in volatile solids correspond to an overall reduction in total solid matter of 31 and 32 percent for lots 1 and 2 respectively. A summary of this data is presented in Table 2.

The pH data is presented in Table 3. Generally, the pH was above the neutral value of 7.0 and peaked at around 8.0. At these high pH values a greater proportion of ammonia exists in a gaseous form which can be lost from the composting material. During this period of high pH an ammonia gas odor was detected near the composters.

In summary, in this experiment composting required about five weeks. During this time temperatures reached

TABLE 2. SUMMARY OF MASS-BALANCE $\left[\frac{\text{Total Solids}_{(initial)}}{\text{Total Solids}\ (\text{day}_n)}\right]$

Day of experiment	Composter number 1	2	3	4	5	6
0	1.00	1.00	1.00	1.00	1.00	1.00
7	1.98	1.05	1.00	1.02	1.02	1.06
11	1.13	1.13	1.15	1.12	1.18	1.13
15	1.10	1.15	1.12	1.13	1.19	1.18
19	1.15	1.22	1.19	1.23	1.26	1.20
23	1.16	1.27	1.24	1.25	1.28	1.23
30	1.25	1.31	1.25	1.29	1.35	1.31
50	1.25	1.40	1.29	1.30	1.32	1.34

TABLE 3. pH OF COMPOSTING MATERIAL

Day of experiment	Composter number					
	1	2	3	4	5	6
1	7.33	7.34	7.35	7.27	7.41	6.90
12	7.84	8.17	8.01	8.02	7.80	7.90
50	7.42	7.51	7.50	7.39	7.40	7.42

a maximum of 50 to 60°C and a reduction in total solid matter of about 32 percent was obtained.

Chemical Residues: A summary of the chemical residue concentrations is presented in Table 4. The values for DEF, Kelthane and Paraquat are in parts per million and calculated on a dry weight basis. The values for the fines fraction are those monitored immediately after screening; the precompost values are those assayed following the storage period and immediately prior to composting. The fact that the concentration of residues increases following composting is due to reduction in total solids resulting from the composting process; the absolute quantity of residue may decrease.

The increase in concentration due to reductions in composting material can be compensated for by relating the concentration to the mass balance data given in Table 2. The results of this relationship are indicated in line 4 of Table 4. As noted, there was no degradation of DEF or Paraquat; the plus values indicate either unrepresentative sampling or other unexplained phenomenon. A reduction of 23 percent was calculated for Kelthane.

In summary, for the composting conditions of this experiment, there was little, if any degradation of DEF or Paraquat and approximately a 23 percent reduction in Kelthane.

Weed Seeds: Data from the weed seed germination trial is presented in Table 5. As noted, the composting process was effective in destroying weed seeds. The general requirement for successful treatment is adequate moisture and warmth to cause seed germination and then sufficient temperature to destroy the plummule or cotyledon. These conditions apparently existed within the composters for the three weed seeds tested.

In summary, pig weed, watergrass and Bermudagrass seeds were successfully destroyed by the composting treatment.

Verticillium dahliae: The results of the *Verticillium dahliae* trial are summarized in Tables 6 and 7. As indicated, for both investigations the composting process destroyed the wilt organism. High temperatures are important. Studies by Pullman (1979) indicate that most propagules of *Verticillium dahliae* are destroyed within 15 minutes at 50°C or within 3 h at 45°C.

TABLE 5. GERMINATION OF WEED SEEDS

Composter	Weed counts			Total
	Pigweed	Watergrass	Bermudagrass	
Pre-compost				
1	5	7	9	21
2	1	5	9	15
3	0	2	8	10
4	3	5	8	16
5	0	11	5	16
6	3	6	1	10
Post-compost				
1	0	0	0	0
2	0	0	0	0
3	1	0	0	1
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0

TABLE 4. CHEMICAL RESIDUES IN COMPOSTING MATERIAL

	Source of gin trash					
	Lot 1			Lot 2		
	DEF	Kelthane	Paraquat	DEF	Kelthane	Paraquat
Fines*	98.8	19.0	—	93.7	0.49	23.0
Pre-compost*	110.0	17.8	—	65.0	0.70	12.6
Post-compost* (30 days)	149.5	18.4	—	86.1	—	18.4
Change in absolute value†	+ 7.0%	− 23.0%	—	+ 0.4%	—	+ 10.8%

*In ppm.
†Corresponding to Table 2.

In summary, *Verticillium dahliae* was successfully destroyed by the composting treatment.

Plant Nutrients and Growth Tests: Chemical analyses of the gin trash fines before and after composting are presented in Table 8. Of interest is the increase in the concentrations of nutrients: nitrogen, phosphorus and potassium. Apparently there was little loss in nitrogen during composting despite detectable odor from volatilization of ammonia during the mixing periods. Both phosphorus and potassium are expected to be conserved during composting so their concentration increase should correlate to the total solids decrease. As stated earlier, total solids decreased by 31 and 32 percent during composting of lots 1 and 2 respectively. Phosphorus increased by 50 and 31 percent for the two lots respectively, while potassium increased by 60 and 54 percent. Nitrogen was observed to increase by 36 and 62 percent respectively. The discrepancy in the fertilizer concentration increases and the total solids decrease may be due to the difficulty in obtaining representative samples, although the precision of the data in Table 8 is fairly good. Increases in zinc concentration during composting may be due to contamination from the galvanized components of the mechanical composter.

The electrical conductivity (EC) of the composted material was about 2.35 S/m for both lots. Using this value an estimate of total salt content is 3.4 percent. For comparison, beef manure ranges from 4 to 14 percent. For land application in arid regions, therefore, the salt content must be considered as in using livestock manure.

TABLE 6. *VERTICILLIUM DAHLIAE* – NYLON MESH BAG TRIAL

	Propagules of *Verticillium dahliae* per g of material
Pre-composting	139
Control at room temperature during composting period	120
Post-composting for all composters	0

TABLE 7. *VERTICILLIUM DAHLIAE* – SEEDED MATERIAL

Composters	Propagules of *Verticillium dahliae* per g of material	
	Pre-composting	Post-composting
1	4	0
2	20	0
3	24	0
4	8	0
5	12	0
6	0	0

TABLE 8. CHEMICAL CHARACTERISTICS OF GIN TRASH FINES BEFORE AND AFTER COMPOSTING

Description	Composter no.	NO_3-N ppm	PO_4-P ppm	SO_4-S ppm	N %	P %	K %	Ca %	Mg %	Na %	Cl %	B ppm	Zn ppm	EC S/m
Lot 1 before	—	310	1040	8800	1.81	0.22	0.65	5.40	1.00	0.42	0.92	135	28	1.53
Lot 1 after	1	75	—	6400	2.52	0.34	1.09	6.70	1.75	0.64	1.09	190	835	2.20
	2	45	—	6400	2.55	0.31	0.94	6.75	1.65	0.58	1.14	186	495	2.61
	3	85	—	3840	2.33	0.34	1.09	6.65	1.80	0.80	0.90	190	210	2.31
	Mean	68	—	5550	2.47	0.33	1.04	6.70	1.73	0.67	1.04	189	513	2.37
Lot 2 before	—	380	1140	23300	1.76	0.26	0.69	4.80	0.98	0.32	0.86	125	26	1.44
Lot 2 after	4	60	—	6240	2.86	0.33	1.09	8.20	2.08	0.64	1.39	190	380	2.23
	5	70	—	6400	2.91	0.36	1.12	8.55	2.00	0.62	1.37	190	510	2.29
	6	50	—	5900	2.80	0.32	0.96	7.20	1.55	0.56	1.38	186	550	2.47
	Mean	60	—	6180	2.86	0.34	1.06	8.00	1.88	0.61	1.38	189	480	2.33

Notes: 1. No arsenic was detected in the fresh uncomposted samples.
2. Average Carbon/Nitrogen Ratio = 20.2 for uncomposted samples.
3. Percent and ppm based on total dry solids.
4. Electrical conductivity 1 S/m = 10 milli-mhos/cm.

The results of the sorghum growth tests are summarized in Table 9. As indicated, there was germination difficulty at the highest loading rate (44.8 t/ha) when the uncomposed material was applied three weeks prior to seeding. Although the cause of this low germination was not investigated, it could perhaps be attributed to toxic gases or lack of oxygen in the soil pores due to the biological breakdown of organic matter. The composted material appears stable and did not exhibit this effect when applied three weeks prior to planting.

Plant dry matter production in pots amended with either composted or uncomposted gin trash was approximately 40 percent higher than the control. This may be due to the additional nitrogen; however, all plants showed some firing of the lower leaves, a typical symptom of nitrogen deficiency. Plants growing in composted gin trash (2.86 percent N) produced 13 percent more dry matter than plants growing in uncomposted gin trash (1.76 percent N). Nitrogen appears to be the limiting nutrient. Land application rates should, therefore, consider both salt loading and nitrogen loading when deciding on quantities of composted gin trash fines to be spread.

CONCLUSIONS

Data obtained and observations made under the conditions described in this study support the following conclusions for composting cotton gin trash fines passing a 20-mesh screen:

1 The optimum water content is near 40 percent.

2 The optimum frequency of mixing is near four days.

3 The time required for composting is approximately five weeks.

4 Both DEF and Paraquat are not degraded by this composting process; Kelthane is slightly degraded.

5 Bermudagrass, watergrass and pigweed seeds are destroyed.

6 *Verticillium dahliae* is destroyed.

7 The nitrogen concentration is increased from about 1.8 to 2.7 percent.

8 The composted material appears to exhibit no phytotoxicity for sorghum when applied at 44.8 t/ha.

TABLE 9. SUMMARY OF SORGHUM GROWTH TESTS IN SAND AND VARYING CONCENTRATIONS OF GIN TRASH FINES

Amendment	Rate of trash applied % by wt	Rate of trash applied t/ha	Dry matter yield, g/pot	10-day germination %
Control	0	0	7.08	96
Uncomposted trash				
Applied at planting	0.5	11.2	7.26	84
Applied at planting	1.0	22.4	9.58	94
Applied at planting	2.0	44.8	9.32	96
Applied 3 wk before	1.0	22.4	9.68	76
Applied 3 wk before	2.0	44.8	9.08	54
Composted trash				
Applied at planting	1.0	22.4	10.98	98
Applied at planting	2.0	44.8	8.96	92
Applied 3 wk before	1.0	22.4	10.48	94
Applied 3 wk before	2.0	44.8	12.36	85

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