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Organic Matter Removal from Liquid Peach Waste by Percolation Through Soil and Interrelations with Plant Growth and Soil Properties[1]

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ABSTRACT

Peach cannery waste of three concentrations was applied to Cecil sandy clay loam and Lakeland sand in lysimeters on which Coastal bermudagrass was growing. The soil was artificially placed in the lysimeters to simulate subsoiling to a depth of 50.8 cm. The waste was applied at a rate of 2.54 cm/hr with total amounts of 7.62 cm twice a week. No ponding was observed, indicating an infiltration rate of at least 2.54 cm/hr. A total of 82.55 cm of waste was applied during the season. The BOD (biochemical oxygen demand) was reduced 98% by the Cecil and 64% by the Lakeland soil. Yield of the grass decreased somewhat as the waste concentration increased but was larger in all cases than non-irrigated grass. Application of the waste increased the exchangeable sodium in the soil but no appreciable effect on soil structure was found.

Additional index words: Cecil sandy clay loam, Lakeland sand, irrigation, aggregation, biochemical oxygen demand.

THE disposal of liquid peach waste from seasonally operated peach canneries presents serious water pollution problems. Pollution from these canneries is due principally to the high organic matter content and high sodium content of the liquid waste. Conventional sewage treatment is not practical in many instances because of the seasonal operations, high volume of waste, and location of the canneries in rural areas.

Lagoons have been used extensively by small canneries, but in many instances have failed to be a satisfactory method of waste disposal, probably due mainly to inadequate size of the lagoons. Reports of spray irrigation systems used alone or in conjunction with lagoons as a waste disposal method of various types of canneries with different topographies, soils, vegetative covers, and climates have been published (3, 4, 6, 8, 9, 11, 12, 13, 14, 18). Unfortunately, many of the data are from observations of commercial cannery disposal operations rather than from experimentally designed tests and fail to give specific information on the effects of the soil on the waste solution or the effects of the waste on the soil.

Reduction in peach waste BOD (biochemical oxygen demand) by percolation through undisturbed cores of Cecil soil was reported by Hanks et al. (6). However, some soil cores and plots have shown reduction in infiltration rates when cannery waste was applied (5, 6, 16). Calcium and magnesium applications have been recommended to combat reduced infiltration caused by the dispersing effect of sodium in waste, but on some acidic lateritic soils calcium and magnesium may decrease the infiltration rates (7, 15).

The purpose of this study was to determine the effectiveness of the soil in reducing the BOD of liquid peach waste and interrelations of the waste with soil properties and plant growth.

METHODS AND MATERIALS

Twenty lysimeters made from 208-liter metal barrels cut to a height of 61 cm were placed in soil. A plastic pipe was attached to a short outlet at the bottom of each barrel to allow drainage of percolate. Small gravel was placed in each barrel to a depth of 5.08 cm and glass wool was placed over the drainage opening.

Ten barrels were filled to a height of 50.8 cm above the gravel layer with a Cecil sandy clay loam. The other 10 barrels were filled to a height of 30.5 cm above the gravel layer with a Lakeland sand subsoil and from 30.5 to 50.8 cm height with a Lakeland sand topsoil. The soil placed in each barrel simulated field conditions in which the soil had been loosened to a depth of 50.8 cm by subsoiling.

The soil textural classification was determined by the pipette method (10). Cation exchange capacity was determined by the sodium acetate centrifuge method (19). Available soil nutrients were determined using a 1:4 ratio of soil to extracting solution,

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Table 1. Available nutrients, pH, and cation exchange capacity of soils before use in the lysimeter study.

Soil	Available nutrients K	P	Ca	Mg	pH	Cation exchange capacity
	ppm					meq/100g
Lakeland sand (topsoil)	46	86	170	50	6.2	2.93
(subsoil)	13	7	32	4	5.0	1.34
Cecil sandy clay loam	117	6	282	38	5.4	7.88

which was 0.05*N* HCl and 0.025*N* H_2SO_4. The pH determinations were made on a 1:1 soil to water mixture. Chemical data on both soils before the experiment was started are presented in table 1.

'Coastal' bermudagrass (*Cynodon dactylon* (L.) Pers.) was sprigged in the lysimeters after mixing 841 kg/ha of a 4-12-12 fertilizer with the upper 15.2 cm of soil. Two applications of 336 kg/ha of ammonium nitrate were applied later. The bermudagrass was allowed to become well established and was cut to a height of 10 cm in all lysimeters before waste applications began.

Five liquid treatments in duplicate were used on each soil. Peach waste, which contained a high organic matter content from peach juice and tissue and a high alkaline content from lye peeling, comprised three of the liquid treatments. The peach waste was obtained from a local cannery and had an average BOD of 8,640 ppm and an average sodium content of 800 ppm. The peach waste liquid treatments were one-third, one-fourth, and one-fifth the concentrations obtained from the local cannery. The cannery was using only about 162 liters of water per hectoliter of processed peaches due to a limited water supply. The dilutions represent approximately 483, 644, and 806 liters of water used per hectoliter of processed peaches; and are in the range of the national average of about 536 liters of water per hectoliter of processed peaches. The other two liquid treatments were distilled water and a control which received only natural rainfall except for one irrigation with distilled water to prevent severe drought injury. A sprinkler can was used for liquid application to simulate a spray irrigation system. All treatments received the natural rainfall which occurred during the period of the test.

The distilled water and waste treatments received 7.62 cm of liquid two times per week except the first application which was 6.35 cm. Each application of liquid was applied at a rate of 2.54 cm/hr. A total of 82.55 cm of liquid was applied to the waste treatments and the distilled water treatment. The natural rainfall during the period of liquid application was 13.56 cm but 8.69 cm fell during one 24-hour period. When the grass appeared to be wilting excessively in the control lysimeters during a drought period, 3.0 cm of distilled water was added to them.

Samples of percolate were taken after sufficient liquid had been added to establish a fairly constant flow of percolate. BOD values were determined by the sodium azide modification of the Winkler method (1), except a Beckman Model 777 Oxygen Analyzer was used for dissolved oxygen analysis.

Bermudagrass was harvested twice during the experiment and air-dried in a greenhouse. The first harvest represented 24 days' growth and the second harvest 22 days' growth.

Soil samples were taken at the 0 to 7.62-, 7.62 to 15.24-, 15.24 to 30.48-, and 30.48 to 45.72-cm depths at the end of the experiment. The samples from all of the Lakeland soil treatments and the control treatment of the Cecil soil were taken with a 10.16-cm bucket auger. The other Cecil soil samples were taken with a 7.62-cm diameter steel tube. While at field moisture, all soil samples were passed through an 8-mm sieve. The soil was allowed to air-dry and then half the sample was passed through a 2-mm sieve. The 2-mm fraction was used in the determination of exchangeable soil sodium by the neutral ammonium acetate method (19). Sodium was determined with the Beckman Model 2400 DU Spectrophotometer.

Aggregate analysis of soil samples was made on the 8-mm fraction. Aggregates larger than 1 mm were determined by wet sieving, and smaller aggregates were determined by a hydrometer procedure similar to that described by Day (2) for mechanical analysis.

RESULTS AND DISCUSSION

Exchangeable soil sodium as reported in Table 2 was significantly higher in treatments receiving liquid peach waste than those receiving only water. The exchangeable sodium was also significantly higher in the Cecil sandy clay loam than the Lakeland sand. These results would be expected since the waste has a high sodium content and the fine textured Cecil soil had a higher cation exchange capacity than the coarse textured Lakeland soil. The possibility of structural damage in a Cecil sandy clay loam from the sodium applied in peach waste must be considered, but it is doubtful that the concentration of sodium in peach cannery waste would affect the structure of a Lakeland sand. No definite trend for exchangeable soil sodium with depth existed for either soil. In a climate such as that of South Carolina, it is probable that much of the exchangeable soil sodium will be leached by the winter rains.

The pH values reported in Table 2 show that the waste applications appreciably increased the pH values of both soils whether compared with the original soil pH values in Table 1, the distilled water treatment or the control treatment pH values in Table 2. The peach waste effluent at the cannery usually had a pH value in the range 11.5 to 12.0 which tended to decrease with time. When applied to the lysimeters, the pH of the waste was about 10.5.

The percentages of soil aggregates for the Cecil sandy clay loam are shown in Table 3. The waste treatments had higher percentages of water stable aggregates larger than 1 mm at the 0 to 7.62-cm depth than the control or distilled water treatments. The waste treatments also had a slightly higher percentage of water stable aggregates less than 0.02 mm at all depths. After 82.55 cm of peach waste had been applied, a layer of organic matter had formed on the soil surface of both the Cecil and Lakeland lysimeters. Previous observations had shown that most of the organic mat-

Table 2. Exchangeable sodium content (meg/100g) and pH of soils from four depths of lysimeters in which different types and amounts of liquids percolated.

Soil	Soil depth, cm	1/3 waste Na	1/3 waste pH	1/4 waste Na	1/4 waste pH	1/5 waste Na	1/5 waste pH	Distilled water Na	Distilled water pH	Control* Na	Control* pH
Lakeland sand	0- 7.6	.63	7.6	.38	7.1	.41	7.5	.11	6.1	.10	5.9
	7.6-15.2	.58	7.9	.57	7.1	.38	7.5	.10	6.2	.12	6.3
	15.2-22.9	.68	8.1	.30	7.2	.36	7.2	.09	5.9	.11	5.7
	22.9-30.5	.44	8.0	.30	6.7	.29	7.0	.11	5.7	.08	5.2
Cecil sandy clay loam	0- 7.6	.89	7.3	.97	7.2	.66	7.0	.07	5.8	.13	5.6
	7.6-15.2	.52	7.3	.71	7.1	.47	7.1	.06	6.0	.14	5.9
	15.2-22.9	.61	7.3	.54	6.9	.41	6.8	.06	5.9	.16	5.7
	22.9-30.5	.90	7.2	.67	6.7	.35	6.5	.13	5.8	.12	5.5

LSD (.05) = Na 0.24, pH 0.61; (.01) = Na 0.34, pH 0.86.

* The control treatment received natural rainfall plus one irrigation with 3.0 cm of distilled water during a drought period.

Table 3. Percentage of different size aggregates from four depths in lysimeters in which different types and amounts of liquids percolated.

Size of soil aggregates	Soil depth, cm	Liquid type 1/3 waste	1/4 waste	1/5 waste	Distilled water	Control

Table 4. Yield of Coastal bermudagrass hay in lysimeters through which different amounts and types of liquids percolated.

Soil	Liquid type				
	1/3 waste	1/4 waste	1/5 waste	Distilled water	Control
	kg/ha				
Lakeland sand	7,394	7,408	7,616	8,174	5,672
Cecil sandy clay loam	7,893	8,915	9,248	9,761	6,583
LSD Level	Soil	Liquid type	Soil × liquid type		
.05	319	506	NS		
.01	456	719	NS		

Table 5. Biochemical oxygen demand of peach waste before application to the lysimeters.

Waste concentration	Application time			
	5th	6th	7th	9th
	ppm			
1/3 waste	3,790	3,595	2,841	4,698
1/4 waste	2,124	2,625	2,438	3,400
1/5 waste	1,208	2,050	1,925	1,730

Table 6. Biochemical oxygen demand of percolate from peach waste applied to the lysimeters.

Soil	Waste concentration	Application number			
		5th	6th	7th	9th
		ppm			
Lakeland sand	1/3 waste	1,648	1,438	2,020	1,268
	1/4 waste	1,380	743	971	743
	1/5 waste	647	274	338	284
Cecil sandy clay loam	1/3 waste	114	61	137	202
	1/4 waste	38	33	52	83
	1/5 waste	13	18	14	19
LSD (.05) 256					
LSD (.01) 375					

ter in peach waste was removed in the first few inches of percolation (Peele and Hunt, unpublished data, 1965). In the present experiment, the slight increase in water stable aggregates larger than 1 mm in waste treated Cecil at the 0 to 7.62-cm depth was probably due to microbial by-products formed during decomposition of organic matter in applied peach waste. The slight increase in water stable aggregates less than 0.02 mm at all depths is probably due to the dispersing effect of the sodium ion on the larger aggregates. However, the effect of peach waste on the overall soil aggregation was small. During the application of waste at a rate of 2.54 cm/hr. with a 7.62 cm total per application, no ponding of liquid peach waste was observed.

Coastal bermudagrass yields, as reported in Table 4, were significantly lower for the waste treatments than the distilled water treatment and decreased as the concentration of waste increased. However, all the waste treatments had higher yields than did the control treatment. The increased yields of the waste treatments over the control probably represented a plant response to the water in the waste. These results are in agreement with observations of crops sprayed with both cannery and dairy wastes during droughty periods (3, 17). The Cecil soil had higher yields on all treatments than did the Lakeland. This was probably due to a lower nitrogen leaching loss and a lower percentage of sodium saturation in the Cecil soil.

The BOD values of waste applied to the lysimeters are shown in Table 5 and the values for the percolates from the waste applications are presented in Table 6. Since the cannery wastes for different applications varied in BOD, the comparison of BOD values in Table 6 should be restricted to a given application. The BOD values of the Lakeland sand percolates were significantly higher than those of the Cecil sandy clay loam. The average reduction in BOD was 98% for the Cecil soil and 64% for the Lakeland. The Cecil soil removed organic matter so completely that the BOD values of the waste percolates for a particular waste application were not significantly different. The BOD values of the Cecil percolate were low enough that the percolate would pose no pollution threat. Satisfactory reduction in BOD of the waste by passage through the Lakeland soil might be obtained by percolation through greater depths of soil.

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