DISTRIBUTION OF SOIL NUTRIENTS FOLLOWING FOUR YEARS OF DAIRY EFFLUENT APPLICATION

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INTRODUCTION

Estimates of nutrients not retained or utilized by dairy animals range from 60 to 80% (Thomas *et.al.*, 1995), indicating that a large portion of the nutrients consumed in the dairy ration become part of the animal waste system. Nutrients applied in an acre-inch of effluent from the traveling imgation gun provide a 38-23-33 fertilizer equivalent with a value of $37.79/A per application (Burcham *et al.*,.1997; Herndon *et al.,* 1998; Lang *et al.,* 1998). Application of nutrients in effluent generally provides critically needed fertilization since many pastures and hayfields test very low to medium in both potassium (K) and phosphorus (P) However, many of the fields currently receiving animal waste (particularly poultry litter) applications test high to very high in soil P and K and may be receiving excessive waste applications (Burdine *et al.,*1997). Forages utilized as hayfields provide ideal sites for dairy effluent application because of the tremendous nutrient removal capability. Long-term application of dairy lagoon effluent to the same fields (typically, those closest to the lagoon within range of the traveling gun pipe system) raises concerns about excessive quantities of nutrients building up in the soil, particularly at the soil surface. The objective of this study was to determine soil test levels of P and K at four soil depths following 4 years of dairy lagoon effluent application.

MATERIALS AND METHODS

Dairy waste effluent from two sand-bedded confinement houses representing 180 mature milking cows at the Dairy Research Center in Sessums, MS, was pumped onto a 25-acre permanent grass hayfield over a 4-year period. Soil was Freestone (fine-loamy, siliceous, thermic Aquic Paleudalfs). A traveling irrigation gun was used to distribute dairy lagoon effluent over a 1000- by 250-ft area of application. Distribution of effluent was bell shaped (Figure 1) and was applied five times each year. Four sampling locations of high (6 inches), low (2 inches), and zero rates of dairy effluent were established along the 1000-ft path of the traveling gun. Two permanent non-overlapping runs of the traveling gun provided consistent sampling sites for forage production evaluation, effluent analysis, and soil analysis. Soil samples were taken at depths of 0-1 inch, 1-2 inches, 2-4 inches, and 4-8 inches each winter for 4 years (1996-1999). Effluent was collected in pans and analyzed for total N, P, and K.

RESULTS AND DISCUSSION

An average of 200 lb N, 120 lb P_2O_5, and 30 lb of K_2O per acre per year were applied to the high effluent areas over five irrigation events. Table 1 shows typical values for 1997. Nutrient concentration was generally higher early in the spring. The quantity of fertilizer nutrients available from the lagoon generally declined through the summer. Late summer irrigation, however, may also provide significant moisture benefits during the *dry* months of September and October when forage production is generally limited.

Surface applied dairy effluent over 4 years to a summer grass hayfield resulted in accumulation of extractable P (159 ppm) at 0- to 1-inch soil depth under high effluent applications (6 inches/year) compared with areas receiving low effluent (2 inches/year; 56 ppm soil P) or 0 inches/year (28 mg ppm soil P) (Table 2). Phosphorus accumulation at 1-to 2-inch or 2- to 4-inch soil depth increased under high rates of effluent compared with 0- or 2-inch/year rates. Phosphorus movement down to a depth of 16 inches has been observed following surface applied animal wastes to a fine-loamy, siliceous, thermic Typic Kanphapludults soil (Liu et al., 1998). Potassium followed a similar pattern. Surface K (0-to 1-inch) increased from 121 to 184 to 276 ppm extractable K at 0-, 2-, and 6-inch annual effluent applications over a 4-year period.

Extractable zinc (Zn) also increased as effluent rate increased with the greatest increase at the 0- to 1-inch soil depth (Table 3). There were 14 ppm Zn in the plots receiving 6 inches effluentlyear, 8 ppm soil Zn in plots receiving 2 inches/year and 7 ppm soil Zn in control plots within the 0- to 1-inch soil depth. Copper (Cu) and Zn have both been observed to increase following application of swine lagoon waste (Liu *et al.,* 1996). Soil pH increased from 5.9 to 6.2 to 6.6 at 0, 2, and 6 inches of effluentlyear (Table 3). Based on a 0- to 8-inch soil sampling depth, there were 55 ppm extractable soil P for the high effluent rate, 19 ppm P for the low effluent rate, and 12 ppm P soil for the control. Extractable K, magnesium, and calcium within the 0- to 8-inch depth also increased as effluent rate increased (data not shown).

SUMMARY

Over the course of four summers of effluent application, soil test levels of soil P increased from 20 ppm to 159 ppm in the top inch of soil with a resulting increase in forage yield of over 40% (Lang *et al.,*1998). During the first year of dairy effluent application, there was an increase in forage production of 42% (1755 lb/A) or nearly 1 ton/A. There was a 54% increase in forage production the second year with almost 1.5 tons/A more produced. Initial soil test levels of P and K were low to very low and would be expected to respond to balanced fertilizer additions. Over the 4-year period, soil test levels of P and K increased from low to medium levels and pH increased from 6.0 to 6.6. Additional years of effluent application will likely continue to increase soil P levels. As soil test P levels increase, our current forages may not be able to remove enough P to sustain "long-term" application of effluent at 5 acre-inches per year. The long-term nutrient loading of P on a particular site will depend upon the particular soil's ability to adsorb P and the runoff susceptibility of the particular hayfield into a sensitive watershed. Soils that test high to very high in P need to have dairy effluent applications limited to expected nutrient removal (32-52 lb P_2O_5 or 2 to 3 inches of effluent/A. Dairy lagoon effluent application to an under fertilized hayfield obviously had a positive short-term impact on soil fertility and hay production on this particular field.

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Table 1. Fertilizer Nutrients Applied in Dairy Lagoon Effluent at the Dairy Research Center.

	Date of Application					
Nutrient	**4/8/97**	**5/6/97**	**6/24/97**	**7/23/97**	**7/31/97**	**Total**
	lb/Acre-Inch					
Nitrogen	**65**	**46**	**40**	**27**	**30**	**208**
P_2O_5	**41**	**41**	**18**	**14**	**9**	**123**
K_2O	**76**	**76**	**61**	**52**	**37**	**302**

Table 2. Levels of extractable soil P and exchangeable soil K at four soil depths following annual dairy effluent applications for four years, Dairy Research Center, Sessums, MS.

Effluent Rate	Soil Depth	P 1996	P 1999	K 1996	K 1999
	(inches)	----------------------------(ppm)----------------------------			
High	0-1	37.6	159.2	111.9	275.6
High	1-2	5.7	41.0	49.3	107.4
High	2-4	3.7	12.2	21.7	43.9
High	4-8	3.2	6.2	24.5	27.6
Low	0-1	24.8	56.5	92.7	183.9
Low	1-2	5.5	12.9	38.2	50.4
Low	2-4	4.4	4.9	25.1	25.5
Low	4-8	3.6	3.1	23.3	20.9
None	0-1	20.9	27.8	83.9	120.8
None	1-2	6.1	10.2	41.7	40.8
None	2-4	4.5	4.4	29.0	26.2
None	4-8	6.6	3.9	25.1	22.2
$LSD_{0.05}$		4.2	7.9	5.8	11.8

Table 3. Changes in soil pH and extractable Zn at four soil depths following 4 years of dairy effluent application, Dairy Research Center, Sessums, MS.

Effluent Rate	Soil Depth	pH 1996	pH 1999	Zn 1996	Zn 1999
	(inches)			-------------(ppm)-------------	
High	0-1	6.0	6.6	3.0	14.1
High	1-2	5.9	6.6	1.3	2.4
High	2-4	5.9	6.6	1.1	1.7
High	4-8	6.1	6.4	1.1	2.7
Low	0-1	6.0	6.3	3.0	8.1
Low	1-2	5.8	6.2	1.5	1.6
Low	2-4	5.9	6.1	1.2	1.3
Low	4-8	5.8	6.0	1.2	1.4
None	0-1	5.8	5.9	3 3	6.7
None	1-2	5.6	5.9	1.6	2.6
None	2-4	5.9	5.7	1.4	1.0
None	4-8	5.7	5.8	1.5	0.8
$LSD_{0.05}$		0.33	0.26	0.4	1.3

Pattern for Traveling Irrigation Gun, DRC

1997

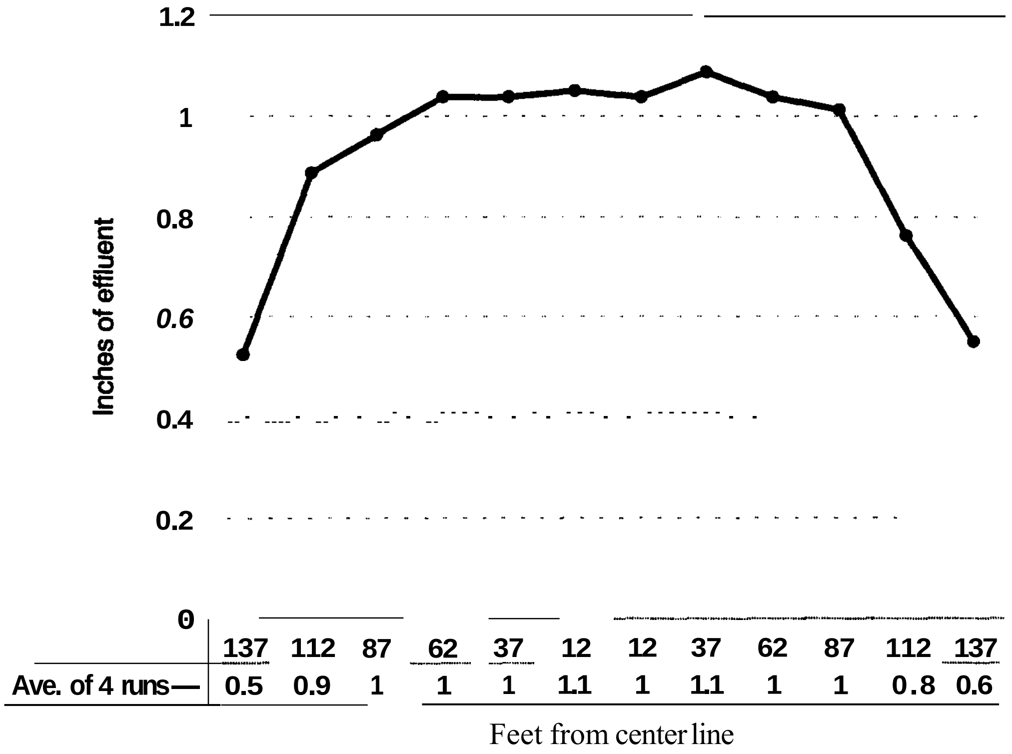

Figure 1