Response of Stargrass to Fertilizer and Solid Cattle Manure in Puerto Rico[1]

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ABSTRACT

A field experiment conducted in 1981 and 1982 at the Corozal Substation to determine the effects of solid cattle manure on the green forage, dry forage, and crude protein yields of stargrass (*Cynodon nlemfuensis* var. *nlemfuensis*) and on soil composition, showed that after 720 days the maximum manure application, without supplemental nitrogen fertilization, increased dry forage and crude protein yields significantly over the unfertilized control. Solid manure 65% dry matter and 1.6% nitrogen, .10% phosphorus, and .34% potassium; was applied at six rates (2,800, 5,600, 11,200, 16,800, 22,400 and 31,360 kg/ha/year) Stargrass harvested every 45 days. Manure treatments were supplemented with commercial fertilizer to provide 504, 73, and 336 kg/ha/year of N, P and K, respectively. Two check treatments were included: one received 3,360 kg/ha/year of 15-5-10 fertilizer as a standard fertilization and the other received neither fertilizer nor manure. Surface-applied manure at rates of 2,800, 5,600, 11,200, 16,800 and 22,400 kg/ha/year, supplemented with N, P and K, and the fertilized control gave similar dry forage yields.

Stargrass P content tended to increase with manure applications, but K, Ca and Mg contents were similar to the standard fertilization. Soil available P and exchangeable K tended to increase with manure applications.

INTRODUCTION

According to Semple (5), a 591-kg cow produces 19047 kg of manure annually, 77% dung and 23% urine. One thousand kg of manure contain about 5.5 kg of elemental (N), 1.5 kg P_2O_5, 4 kg of K_2O, and 250 kg of dry organic matter. The organic matter of the manure is extremely valuable, since it improves tilth, makes it more absorptive to rainfall, improves drainage, and reduces erosion. Because of the increasing use and size of confinement systems in livestock operations, where land holdings are small, such as in Puerto Rico, manure is often available in large quantities.

The beneficial effects of cattle manure have long been known. Arteaga et al. (1) reported that 30,000 kg/ha of cattle manure at planting time sustained P concentrations in grasses and soils and produced dry forage (DF) yields equal to other commercial P sources or better. Jones and Robinson (2) reported that cattle manure at 49,400 kg/ha annually raised yields of Napiergrass (*Pennisetum purpureum*) consistently, and responses were more evident in a steep and eroded red loam soil. Sears et al. (4) reported that DF yields were more than trebled by returning cattle

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manure to pasture as compared to the control. Sutton et al. (7) reported that solid cattle manure applied at 49,000 kg/ha increased significantly corn yields over the control.

In spite of the great amounts of cattle manure available in the dairies of Puerto Rico, no local research has been conducted to study its potential as a fertilizer source. The objectives of this research were to determine the effects of different rates of solid cattle manure on the yield and chemical composition on Stargrass (*Cynodon nlemfuensis* var. *nlemfuensis* PRPI 2341)[3] and on soil composition in the humid mountain region of Puerto Rico.

MATERIALS AND METHODS

The experiment was conducted at the Corozal Substation in the humid mountain region of Puerto Rico. The soil is a Corozal clay (Ultisol) of medium natural fertility, according to the soil survey of the San Juan area.[4] Before beginning the study, the first 15 cm layer of soil had a pH of 5.0, with exchangeable K and P contents of 163 p/m and 0 p/m, respectively.

TABLE 1.—*Fertilization treatments*

Treatment	Solid cattle manure	Manure composition[1]			Supplemental nutrients added to manure		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
	kg/ha/yr		*kg/ha*			*kg/ha*	
1[2]	0	0	0	0	504	73	336
2	2,800	45	4	8	459	69	270
3	5,600	90	6	17	414	67	261
4	11,200	179	11	35	325	62	243
5	16,800	269	17	53	235	56	225
6	22,400	358	23	71	146	50	207
7	31,360	504	35	104	0	38	174
8[3]	0	0	0	0	0	0	0

[1] Dry cow manure contained 1.6, 0.10, and 0.34% of N, P and K, respectively.
[2] 3360 kg/ha/year of 15-5-10 fertilizer.
[3] No fertilizer and no manure.

A 1-year Stargrass stand was divided into 32 plots of 1.83 × 4.88 m each, in order to include 8 fertilization treatments (table 1). Each plot was surrounded by ditches. A complete block design with four replications was employed.

[3] Material was introduced through S-9 (H-94) Regional Project.

[4] Soil survey of the San Juan area of Puerto Rico, 1978. USDA. Soil Conservation Service in cooperation with the Agricultural Experiment Station, University of Puerto Rico.

Two-year old, sun-cured, solid cattle manure[5] from a private dairy farm in the lowlands of Manatí was utilized. Mean composition of manure applied over 2 years (1981–82) at 6 rates was 65, 1.6, .10 and .34% of dry matter (DM), N, P, and K, respectively. Manure treatments on a dry basis were: 2,800 (T2), 5,600 (T3), 11,200 (T4), 16,800 (T5), 22,400 (T6), and 31,360 (T7) kg/ha/yr. Manure treatments were supplemented with a 15-5-10 commercial fertilizer so as to provide 504, 73, and 336 kg/ha/yr of N, P, and K, respectively. Two additional treatments, 3,360 kg/ha/yr of a 15-5-10 fertilizer (T1), and no fertilizer nor manure (T8), were also included. Manure was surface-applied in December 1980, July 1981, November 1981, and May 1982. Calcium carbonate was surface-applied at a rate of 2,240 kg/ha/yr in one application to maintain the pH at approximately 5.7.

Stargrass plots were harvested at approximately 5-cm height above ground every 45 days during 2 consecutive years from November 1980 through November 1982. The forage was weighed, sampled, dried at 55° C in a forced air oven, ground in a Wiley mill[6] to pass a 1-mm screen, and stored in plastic bags. DM content was determined in all samples. Annual forage samples were composited by replicates of each treatment and analyzed for N, P, and K. Total N content was determined with a Technicon Autoanalyzer and P and K contents by the method described by Riera (3). Crude protein (CP) was calculated as N × 6.25. Ca and Mg contents were analyzed by flame photometry after digestion with nitric and perchloric acids.

During the first year (December 5, 1980 to November 13, 1981), total rainfall was 2,438 mm. Rainfall during the second year (Nov. 14, 1981 to Nov. 5, 1982) was 1,699 mm. No irrigation was used. Ambient mean temperatures were 24.7° C in 1981 and 24.8° C in 1982.

The data for green forage (GF), DF, and CP yields and for DM content were subjected to variance analysis and to Duncan's multiple range test (6). They were grouped for analysis into first year (8 cuttings), second year (8 cuttings), and both years combined (16 cuttings).

RESULTS AND DISCUSSION

Table 2 shows yields during the first 360 days of the study. The standard fertilization treatment (T1) outyielded significantly the maximum manure (T7) and unfertilized control (T8) treatments in GF, DF,

[5] Hereafter, manure refers to dung plus some decomposed 2-year sun-cured straw, stored at ambient temperature.

[6] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

and CP (table 2). The mean DM content of T8 (30.21%) was significantly higher than that of the remaining treatments. Treatments involving manure applications up to 22,400 kg/ha/year plus supplemental N (T2 through T6) significantly increased DF yields over T7 and T8 and produced similar yields as T1 (table 2). However, CP yields were lower in all of the manure treatments except T2. Apparently the C:N ratio in the manure was too wide, and decomposing bacteria competed with the grass for N. Hence, a pale yellow color was observed in the plants subjected to T7. DF and CP yields were normal for treatments up to T6, when compared to those reported at the same site with a fertilization rate of 2,240 kg/ha/year (8).

TABLE 2.—*Green forage, dry forage, crude protein yields, and dry matter content of stargrass, with and without surface applied manure, harvested between December 5, 1980 and November 13, 1981*

Treatment	Solid cattle manure	Green forage yield	Dry matter content	Dry forage yield	Crude protein yield
	kg/ha/yr	*kg/ha*	*%*	*kg/ha*	*kg/ha*
1[1]	0	105, 337 a[2]	25.62 c	26,782 a	3,925 a
2	2,800	92,098 ab	26.95 bc	24,469 a	2,892 ab
3	5,600	86,407 b	26.42 bc	22,664 a	2,564 b
4	11,200	96,761 ab	26.54 bc	25,687 a	2,710 b
5	16,800	86,140 b	27.22 bc	23,472 a	2,507 b
6	22,400	87,614 ab	26.82 bc	23,500 a	2,442 b
7	31,360	66,638 c	27.88 bc	18,380 b	1,791 c
8[3]	0	45,992 d	30.21 a	13,588 c	1,422 c

[1] 3,360 kg/ha/year of 15-5-10 fertilizer.

[2] Means in the same column followed by 1 or more letters in common do not differ significantly at the 5% probability level.

[3] No fertilizer and no manure.

Table 3 shows yields during the second 360 days of the study. During this period, DF yields in general decreased in relation to the previous cropping year, especially so for T8, where the decrease was 64%. Yields of CP showed the same trend. The main reasons for this decline were low rainfall and deterioration of the control plots as a result of lack of fertilization. In spite of the relatively low yields, the data in table 3 show that applications up to 11,200 kg/ha of manure (T2, T3, T4) produced as high DF yields as T1. However, T1 produced a significantly higher CP yield. Rainfall during the second 360-day period was 30% less than during the former period. Throughout the study, weeds such as *Amaranthus spinosus* and *Portulaca oleracea* germinated in plots of T2 through T7 but not in those of T1 and T8. Weeds were most prominent in T7. These

TABLE 3.—*Green forage, dry forage, crude protein yields, and dry matter content of stargrass with and without surface applied manure, harvested between November 14, 1981 and November 5, 1982*

Treatment	Solid cattle manure	Green forage yield	Dry matter content	Dry forage yield	Crude protein yield
	kg/ha/yr	*kg/ha*	*%*	*kg/ha*	*kg/ha*
1[1]	0	68,747 a[2]	26.50 b	17,758 a	2,765 a
2	2,800	65,215 ab	26.89 b	16,641 ac	2,390 b
3	5,600	62,191 ab	26.75 b	15,518 ac	2,096 b
4	11,200	66,917 ab	26.37 b	16,908 ab	2,100 b
5	16,800	56,715 b	26.97 b	13,912 cd	1,674 c
6	22,400	57,071 b	26.79 b	14,529 bd	1,597 c
7	31,360	45,890 c	26.94 b	11,821 d	1,221 d
8[3]	0	17,926 d	29.42 a	5,145 e	579 e

[1] 3,360 kg/ha/year of 15-5-10 fertilizer.
[2] Means in the same column followed by 1 or more letters in common do not differ significantly at the 5% probability level.
[3] No fertilizer and no manure.

TABLE 4.—*Total green forage, dry forage, crude protein yields, and dry matter content of stargrass, with and without surface applied manure, during 720 days*

Treatment	Solid cattle manure	Green forage yield	Dry matter content	Dry forage yield	Crude protein yield
	kg/ha/yr	*kg/ha*	*%*	*kg/ha*	*kg/ha*
1[1]	0	174,084 a[2]	26.06 b	44,615 a	6,070 a
2	2,800	157,313 ab	26.92 b	41,224 a	5,299 ab
3	5,600	148,597 ab	26.58 b	38,240 a	4,660 bc
4	11,200	163,678 ab	26.46 b	43,102 a	4,862 bc
5	16,800	142,855 b	27.09 b	37,637 a	4,209 c
6	22,400	144,685 b	26.80 b	38,593 a	4,098 c
7	31,360	112,528 c	27.41 b	30,678 b	3,059 d
8[3]	0	63,919 d	29.82 a	18,733 c	2,021 e

[1] 3,360 kg/ha/year of 15-5-10 fertilizer.
[2] Means in the same column followed by 1 or more letters in common do not differ significantly at the 5% probability level.
[3] No fertilization and no manure.

weeds are not common in Corozal but are considered principally weeds of the waterlogged lowlands where the manure was obtained.

Table 4 and figure 1 show the data accumulated during the 720-day period (16 cuttings). T7 increased DF and CP yields by 64 and 51% over T8, respectively. There were no statistically significant differences between standard fertilization (T1) and T2 through T6 (table 4) in terms of DF yields. Again, T1 yielded significantly more CP than T3 through T7.

Table 5 shows the mean percentage composition of stargrass of the 8 treatments harvested during the 720-day period in terms of CP, Ca, P, K, and Mg contents. In general, the CP content of stargrass was higher for T1 than for T2 through T8. However, P content for T3 through T7

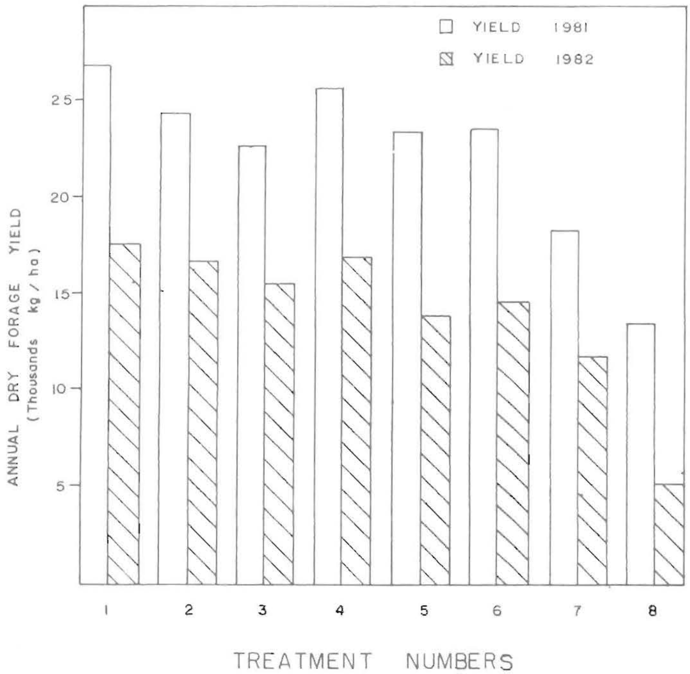

FIG. 1.—Annual dry forage yields as affected by solid cattle manure rates and fertilizer applications.

TABLE 5.—*Mean crude protein and mineral contents of stargrass, with and without surface applied manure, harvested during 720 days*

Treatment	Solid cattle manure	Crude protein	Phosphorus	Potassium	Calcium	Magnesium
	kg/ha/yr			%		
1[1]	0	14.0	.23	2.30	.51	.30
2	2,800	13.0	.23	2.26	.51	.28
3	5,600	12.5	.25	2.42	.52	.30
4	11,200	11.6	.26	2.47	.53	.32
5	16,800	11.4	.26	2.45	.53	.29
6	22,400	10.8	.28	2.46	.54	.29
7	31,360	10.0	.30	2.32	.55	.29
8[2]	0	11.0	.19	1.82	.51	.29
$\bar{x}$		11.8	.25	2.31	.53	.30

[1] 3,360 kg/ha/yr of 15-5-10 fertilizer.

[2] No fertilizer and no manure.

was higher to that for T1 and T2. This finding agrees with those of Arteaga et al. (1) in that high amounts of cattle manure (30,000 kg/ha) maintain P concentrations in the forage equal or higher to those resulting from the use of other commercial P sources. Cattle manure tended to increase the P and K contents of stargrass, whereas the contents of Ca and Mg remained unchanged.

Analyses of soil samples from individual plots after each 360-day period indicated that available P and exchangeable K tended to increase somewhat with manure applications as compared with T8 (table 6).

It can be concluded that sun-cured cattle manure can supply around 35% of the N and 10% of the K required for maximum dry forage production. Cattle manure at the highest rate of 31,360 kg/ha/year (T7) increased DF yields significantly (by 61%) over T8 without burning the grass (table 4). Lower amounts of cattle manure, 2,800, 5,600, 11,200,

TABLE 6.—*Soil pH, phosphorus and potassium changes in an Ultisol after receiving different manure rates*

Treatment	Original soil reaction and concentration			After first year 1981[1]			After second year 1982[1]		
	pH	Phosphorus	Potassium	pH	Phosphorus	Potassium	pH	Phosphorus	Potassium
1	4.92	0	153	5.01	3.0	66	5.08	1.5	58
2	5.15	0	170	5.64	3.5	60	5.53	3.0	77
3	4.91	0	156	5.30	2.8	72	5.19	2.0	76
4	5.26	0	206	5.69	4.0	74	5.25	1.8	82
5	5.28	0	150	5.86	5.0	77	5.70	5.0	78
6	5.07	0	165	6.15	3.0	121	5.79	7.8	91
7	5.41	0	180	6.40	6.5	131	6.47	7.3	147
8	5.00	0	122	5.52	1.5	40	5.46	2.8	50

[1] Mean of 4 replicates at 0-15 cm soil depth.

16,800, and 22,400 kg/ha/year, supplemented with commercial fertilizer to provide 504, 73 and 336 kg/ha/year of N, P, and K, respectively, gave similar DF yields as T1 during the 720-day period (table 4). However, the extra costs of fertilizer must be compared to extra costs in terms of hand labor for hauling and applying huge amounts of manure.

RESUMEN

En 1981 y 1982 se realizó un experimento en la Subestación de Corozal para determinar los efectos del estiércol de vaca en los rendimientos de forraje verde, forraje seco y proteína bruta de la yerba estrella (*Cynodon nlemfuensis* var. *nlenfuensis*) y en la composición del suelo. El estiércol contenía 65%, 1.6%, .10% y .34% de materia seca, nitrógeno, fósforo y potasio, respectivamente. Se aplicó a la yerba estrella en cantidades de 2,800, 5,600, 11,200, 16,800, 22,400 y 31,360 kg/ha y año y se segó cada 45 días. Los tratamientos se suplementaron con abono comercial N-

P-K, hasta alcanzar 504, 73 y 336 kg/ha y año de nitrógeno, fósforo y potasio, respectivamente. Se incluyeron además 2 tratamientos testigo, uno con 3,360 kg/ha y año de un abono 15-5-10, como abono corriente y otro sin abono y sin estiércol.

En los 720 días del estudio, la cantidad máxima de estiércol, sin abonamiento nitrogenado suplementario aumentó significativamente los rendimientos de forraje seco y proteína bruta sobre el testigo sin abonar. Los tratamientos de estiércol de 2,800 a 22,400 kg/ha y año produjeron rendimientos de forraje seco similares al tratamiento corriente. El estiércol aumentó los contenidos en fósforo y potasio, pero no en calcio y magnesio. También aumentó el fósforo disponible y el potasio cambiable del suelo al compararlos con el tratamiento sin abono.

Sin embargo, en futuros estudios a nivel de la finca, es necesario comparar los costos extraordinarios que se incurren en términos de labores necesarias para acarrear y aplicar grandes cantidades de estiércol en comparación con aplicar un abono comercial.

LITERATURE CITED

1. Arteaga, O., R. Chongo and A. Mojena, 1981. Utilización del estiércol vacuno como fuente de fósforo para los pastos, ALPA Mem. 16: 95 (Abs.).
2. Jones, P. A. and J. B. D. Robinson, 1965. Response of mature Napiergrass to fertilizers and cattle manure in Kenya, East Afr. Agric. For. J. 30 (3): 276–85.
3. Riera, A., 1955. The method of foliar diagnosis as applied to sugarcane, II. The chemical analyses of sugarcane-leaf samples, Univ. P. R. Agric. Exp. Stn. Bull. 123.
4. Sears, P. D., J. Melville and L. T. Evans, 1953. Pasture growth and soil fertility, N. Z. J. Sci. Technol. 35 Sect. A., Suppl. 1.
5. Semple, A. T., 1970. Grassland. Improvement, 1st. ed., C.R.C. Press, Cleveland, Ohio.
6. Snedecor, G. W. and W. G. Cochran, 1967. Statistical methods, 6th ed, The Iowa State Univ. Press, Ames, Iowa.
7. Sutton, A. L., D. W. Nelson, N. J. Moeller, and D. L. Hill, 1981. Application of cattle waste on sloping cropland. J. Dairy Sci. 64: 1742–8.
8. Vélez-Santiago, J., A. Sotomayor-Ríos, and S. Torres-Rivera, 1979. Effect of three harvest intervals and two fertilizer rates on the yield and HCN content of ten *Cynodon* cultivars, J. Agric. Univ. P. R. 63 (1): 35–44.