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CHICKEN MANURE: AN ORGANIC NITROGEN FERTILIZER FOR PLANTAINS (*Musa acuminata* x *M. balbisiana* AAB)

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ABSTRACT

A field experiment was established on Corozal clay (Aquic Tropudults) to evaluate the effect of periodic applications of chicken manure on plantain (cv. Maricongo) performance and yield. Plantain plants receiving periodic applications of manure, up to 7.26 kg/plant/crop, showed similar growth and yield to the check plants fertilized with the fertilizer formula 10-5-15 + sulpomag. Plantain bunch weight of the manure treated plots ranged from 13.44 to 18.91 kg and the number of fruits ranged from 41.7 to 49.4 fruits/bunch. Average bunch weight and average number of fruits of the check treatment was 13.04 kg and 41.7 fruits/bunch, respectively. Among leaf samples collected at four and nine months after planting, very little variation in nutrient concentration and content was observed among treatments.

INTRODUCTION

Chicken manure has long been recognized as a valuable fertilizer source (Hileman, 1973; Perkins et al., 1964). This material is currently used in the United States as fertilizer on corn and small grains, and in vegetable production systems (Carreker et al., 1973; Liebhardt, 1976; Segars, 1981; Sims, 1987). The nutrient content of the manure will vary depending on the age, type, and condition of the birds, storage conditions, and moisture content. Strong and Segars (1981) reported nutrient content values for broiler manure of 2.72, 2.34, 1.50, and 1.48 per cent for N, P_2O_5, K_2O, and Ca, respectively. Klausner and Bouldin (1983) reported lower values, 1.1-2.0% N, 1.9-3.0% P_2O_5, and 0.75-1.25% K_2O. Muñoz et al (1990) observed nitrogen contents in the range of 2.47 to 3.75% N, depending on the age of the material. The lowest N value was observed on the oldest (24 months) manure studied. The authors also observed an increase in available P with age of manure. Available P represented 10, 68, and 97 per cent of total P in fresh, two-month-old and 24 month-old manures, respectively.

Chicken manure is readily available in considerable amounts in Puerto Rico (Muñoz et al., 1990) with approximately 72,000 metric tons produced annually. At present there is no efficient way to dispose of this material that in many instances represents an environmental hazard (EQB Report 1984-85). The use of chicken manure as fertilizer provides a useful and practical approach for its disposal. The material is used to a small extent as fertilizer for plantain, banana, papaya, and chayote, among other crops. However, no research data on appropriate application rates, mode and frequency of application, or crop response have been reported in Puerto Rico.

Plantains (Musa acuminata x M. balbisiana, AAB) rank second only to coffee in economic importance in Puerto Rico (Ortiz, 1989). During 1988-89 plantains contributed $40.65 millions to the gross national income, which represents 5.56 per cent of the total gross income generated by agricultural commodities. The response of plantains to fertilization has been studied by several workers in Puerto Rico. Vicente-Chandler and Figarella (1962) found that plantains growing on a Humatas clay (Typic Tropohumults) responded to applications of 224 kg of N/ha and 98 kg of P/ha, but no response to K, Ca, or Mg was observed. Del Valle et al. (1978) also reported a significant response in yield with the application of 56 kg of P/ha. On the other hand, Caro-Costas et al. (1964) reported a significant increase in plantain yield on the same soil type with the application of 224, 98, 448 and 112 kg/ha of N, P, K, and Mg, respectively. Irizarry et al. (1981a) evaluated the nutrient uptake of intensively managed plantains on two soil types, an Inceptisol and an Ultisol, and suggested that about 338, 58, 780, and 100 kg/ha of N, P_2O_5, K_2O, and MgO, respectively, must be applied to plantains to obtain maximum yields.

The study herein reported was conducted to evaluate the use of chicken manure as a nitrogen source for plantains. An estimate of the amount of chicken manure needed to fulfill the N requirement of plantains was calculated based on previously reported data (Irizarry et al., 1981; Muñoz et al, 1990).

MATERIALS AND METHODS

A field experiment was established at the Corozal Agricultural Experiment Substation located on the central part of Puerto Rico, using the plantain cultivar Maricongo as the test crop. Annual rainfall at the test site is about 1,600 mm, elevation is about 200 m, and the maximum and minimum temperatures are 20 and 30ºC, respectively. The experiment was established on a Corozal clay (clayey, mixed, isohyperthermic, Aquic Tropudults). A composite soil sample was collected at the beginning of the experiment for routine analysis (Page et al., 1982). The pH of the soil was measured in a 2:1 water:soil ratio. Available P was determined by the Bray II method. Exchangeable cations (Ca, K, Mg) were extracted with 1 N ammonium acetate (pH 7) and determined by atomic absorption spectroscopy using a Perkin Elmer 2380 atomic absorption spectrophotometer. The soil has a pH of 5.82, an available P content of 14.30 µg/g, and 0.68, 10.68 and 1.15 $cmol_c$/kg of K, Ca, and Mg, respectively.

Duplicate samples of chicken manure were analyzed for total and available nutrient content. For total nutrient content, the samples were digested in a mixture of sulfuric acid and hydrogen peroxide with selenium as a catalyst. Nitrogen and P were analyzed colorimetrically using a Technicon II Autoanalyzer. Potassium, Ca, and Mg were analyzed by atomic absorption spectroscopy. Available P and exchangeable K, Ca, and Mg were analyzed as described previously for the soil.

The estimate of the amount of chicken manrue to be applied per plant was performed based on the assumption that a plantain plant will require about 109 g of N per growing season (Irizarry et al., 1981). Since the N

content of the manure may range from 2.5 to 4.0 per cent, we based our estimate on a 3.0 per cent N value. Taking the average N value of 3.0 per cent and assuming that only 50 per cent of the total manure nitrogen will be available during the first year of application the following estimate was obtained:

$$X = 0.109/(0.03)\ (0.5)$$
$$X = 0.109/0.015$$
$$X = 7.26 \text{ kg of manure}$$

Based on this estimate, six manure treatments were established based on the frequency of application, but all of them adding up to a total manure application of 7.26 kg/plant. The recommended fertilizer rate for the region (1.16 kg/plant/year of 10-5-15+Sulpomag) was included as the check treatment. A total of seven treatments were arranged in a complete randomized block design with four replications. Each experimental plot consisted of 18 plants (three rows of 6 plants each), spaced 1.8 m between and within rows, for a total plant population of 2,989 plants/ha.

Treatment description was as follows:

(1) 7.26 kg/plant mixed with soil at planting.

(2) 1.36 kg mixed with the soil at planting, 2.27 kg two months after planting, 2.27 kg six months after planting, and 1.36 kg nine months after planting.

(3) 3.18 kg mixed with the soil at planting and three applications of 1.36 kg at two, six, and nine months after planting.

(4) 1.86 kg mixed with the soil at planting and two applications of 2.72 kg at two and six months after planting.

(5) The same treatment as #3, but the 3.18 kg were not mixed with the soil at planting.

(6) Check treatment of 1.16 kg/plant/year of 10-5-15+Sulpomag divided in four applications.

(7) A broadcast applciation of 9.08 kg/plant incorporated into the soil prior to planting.

The manure treated plots also received an application of 198 g of K_2O/plant/crop as Sulpomag, divided in four applications, at 2, 4, 6, and 9 months after planting. Pest control was performed in accordance with the Agricultural Experiment Station recommendations (Irizarry and Montalvo-Zapata, 1986).

Whole leaf samples (third upper leaf) were collected for nutrient analysis at four and nine months after planting. The leaves were placed into paper bags, dried in an oven at 70ºC, ground, and analyzed for N, P, K, Ca, and Mg. Total nutrient content was determined as described previously

for the chicken manure. Data on yield (bunch weight and number of fruits/bunch) and nutrient content of leaves was statistically analyzed using analysis of variance and Duncan Multiple Range tests.

RESULTS AND DISCUSSION

The application of 7.26 kg/plant of chicken manure at planting (treatment 1) adversely affected germination and so some replanting was necessary. The significantly lower leaf dry weight observed for this treatment at four months after planting was the result of the delay in germination (table 1).

Table 1. Dry weight and nutrient concentration of leaf samples collected four months after planting.

Treatment	Sample dry weight (g)	Nutrient concentration (%)				
		N	P	K	Ca	Mg
1	14.9b[1]	3.19a	0.16a	4.96a	1.07ab	0.26a
2	25.7ab	2.64b	0.12b	3.36c	1.07ab	0.21a
3	29.1a	2.80ab	0.13b	4.44ab	1.08b	0.27a
4	30.9a	2.86ab	0.13b	3.98bc	1.12a	0.26a
5	25.6ab	2.95ab	0.13b	4.81a	0.84b	0.25a
6	30.7a	2.55b	0.12b	3.57c	0.98ab	0.21a
7	31.3a	2.78ab	0.12b	3.87bc	1.20a	0.25a

[1]Means followed by the same letter or sequence of letters do not differ significantly at the 5% probability level.

Once germination took place, however, plant growth was similar to that of the other manure treatments and no significant differences were observed in leaf dry weight samples collected nine months after planting (table 3). Treatment 1 also showed higher N, P, and K concentration on leaf samples collected four months after planting (table 1). However, when the nutrient content (mg/sample) was considered, this treatment showed the lowest nutrient content values (table 2). This indicates a dilution effect resulting from higher growth of the other treatments.

Values of 3.2-3.9 per cent N, 0.17-0.20 per cent P, 3.0-3.6 per cent K, 0.6-0.8 per cent Ca, and 0.3 per cent Mg on seven-month-old plants have been associated with optimum yields (Caro-Costas et al., 1964; Vicente-Chandler and Figarella, 1962). The N content in the present study is close to the lower limit of the indicated optimum range. The fact that the midrib, which has a lower N content than the blade, was included in the sample may be the reason for the apparently low N content observed.

No significant differences in N, P, and Ca content (mg/sample) of leaf samples collected nine months after planting was observed among treatments

Table 2. Nutrient content of leaf samples collected four months after planting.

Treatment	Nutrient content (Mg/sample)				
	N	P	K	Ca	Mg
1	479b[1]	24a	764a	157c	40b
2	671ab	31a	849a	275ab	54ab
3	822ab	39a	1305a	307ab	80a
4	875a	40a	1219a	347a	79a
5	736ab	33a	1253a	216bc	61ab
6	778ab	35a	840a	284ab	70ab
7	867a	36a	1200a	360a	78a

[1]Means followed by the same letter or sequence of letters do not differ significantly at the 5% probability level.

Table 3. Dry weight and nutrient concentration of leaf samples collected nine months after planting.

Treatment	Sample dry weight (g)	Nutrient concentration (%)				
		N	P	K	Ca	Mg
1	84.6a[1]	2.97b	0.22a	3.68a	0.87a	0.30a
2	106.3a	2.86b	0.22a	3.69a	0.66b	0.27ab
3	93.5a	2.86b	0.22a	3.53a	0.84a	0.32a
4	117.1a	2.82b	0.21a	3.40a	0.86a	0.30a
5	103.5a	2.84b	0.22a	3.48a	0.88a	0.30a
6	79.1a	3.26a	0.22a	3.41a	0.82a	0.25b
7	108.9a	2.72b	0.22a	3.57a	0.80a	0.28ab

[1]Means followed by the same letter or sequence of letters do not differ significantly at the 5% probability level.

(table 4). However, treatments 2, 4, and 7 resulted in significantly higher K content than the check treatment. Treatments 2 and 4 differ from the other manure treatments because they received lower manure rates at planting, 1.36 and 1.86 kg, respectively. Although treatment 7 received the highest manure rate (9.08 kg/plant), the material was broadcast applied and incorporated into the soil. This practice reduces damage to the suckers as a result of high manure applications, as it was the case for treatment 1.

Table 4. Nutrient content of leaf samples collected nine months after planting.

Treatment	Nutrient content (Mg/sample)				
	N	P	K	Ca	Mg
1	2483a	183a	3109ab	737a	254ab
2	3032a	234a	3814a	738a	298ab
3	2682a	204a	3209ab	796a	312ab
4	3289a	241a	3971a	1008a	352a
5	2990a	224a	3587ab	914a	309ab
6	2612a	171a	2539b	657a	189b
7	2967a	236a	3778a	893a	311ab

[1]Means followed by the same letter or sequence of letters do not differ significantly at the 5% probability level.

Data on plantain bunch weight, number of fruits per bunch and average fruit weight is presented on Table 5. Plantain bunch weight ranged from 13.1 to 18.7 kg and the number of fruits from 41.7 to 49.2. Average fruit weight ranged from 380 to 294 g. Yield parameters were similar to the optimum values reported by Irizarry et al., (1978) and Irizarry et al., (1981). The authors reported number of fruits per bunch ranging from 30-60 and an average weight for marketable fruits of 270 g.

There is no clear explanation for the higher yields obtained with treat ment 1. Since flowering in these plots ocurred later in the growing season, there is the possibility that climatic conditions influenced the nubmer of fruits per bunch. The other manure treatments showed similar yield to the check treatment, which suggests that the nitrogen requirement of the crop was satisfied with the application of 7.26 kg of manure per plant.

Broadcast application of the manure and incorporation in the soil seems to be the most practical and efficient way for the farmer. Since only one application is made, labor costs are reduced. Also the incorporation of the manure into the soil will reduce nutrient lost as result of runoff, volatilization and leaching. These processes may account for the heavy losses of nitrogen and potassium. However, the future incorporation of the manure to the soil will be limited to areas where mechanization is feasible.

Table 5. Effect of manure treatments on plantain yield.

Treatment	Bunch Weight (kg)	# Fruits/ Bunch	Average Fruit Weight
1	18.7a[1]	49.2a	380
2	14.2a	42.5b	334
3	13.5a	42.1b	321
4	14.7a	43.7b	336
5	13.4a	41.7b	321
6	13.1a[2]	44.6b	294
7	14.1a	42.3b	333

[1]Means followed by the same letter are not significantly different at the 5% probability level.

[2]Check treatment consisting of 1.16 kg of 10-5-15 + Sulpomag/plant/year.

Any farmer who might directly apply manure to the suckers at planting should be aware that germination may be adversely affected. Applications around 1.5 kg/plant at planting seems adequate. Since a per cent of the nutrients in the manure is not readily available to the crop, it is advisable to apply the manure no later than the sixth month after planting. The farmer should also be aware that the K content of the manure is not enough to satisfy the demand of plantains and some potassium fertilizer should be applied.

REFERENCES

Caro-Costas, R., Abruña, F., and Vicente-Chandler, J. 1964. Response to fertilization of strip-cultivated plantains growing on a steep latosol in the humid mountain region of Puerto Rico. J. Agric. Univ. P.R. 48(4): 312-17.

Carreker, J.R., Wilkinson, S.R., Box, J.E., Jr., Dawson, R.N., Beaty, E.R., Morris, H.D., and Jones, J.B., Jr. 1973. Using poultry litter, irrigation, and tall fescue for no-till corn production. J. Environ. Qual. 2: 497-500.

Del Valle, R., Scott, T.W., Rodríguez, J., and Lugo-López, M.A. 1978. Response of plantain to banded and broadcast N and to P applications at planting and to residual P on an Ultisol. J. Agric. Univ. P.R. 62(1): 29-39.

Environmental Quality Board. 1984-85. Goals and progress of state wide water quality management planning, Puerto Rico. Commonwealth of Puerto Rico, Office of the Governor.

Hileman, L.H. 1973. Response of orchardgrass to broiler litter and commercial fertilizer. Arkansas Agric. Exp. Stn., Rep. Ser. 207.

Irizarry, H. and Montalvo-Zapata, R. 1986. Conjunto tecnológico para la producción de plátanos y guineos. Publ. 97, 2da ed., Esta. Exp. Agric., Univ. P.R.

Irizarry, H., Abruña, F., Rodríguez, J., and Díaz, N. 1981a. Nutrient uptake by intensively managed plantains as related to stage of growth at two locations. J. Agric. Univ. P.R. 65(4): 331-345.

Irizarry, H., Rodríguez-García, J., and Díaz, N. 1981b. Effect of three population densities and fertilization levels on yields of high yielding clones of plantains at two locations. J. Agric. Univ. P.R. 65(4): 395-400.

Irizarry, H., Rivera, E., Rodríguez, J.A., and Green, J.J. 1978. Effect of planting pattern and population density on yield and quality of the horn type Maricongo plantain (Musa acuminata x M. balbisiana, AAB) in north central Puerto Rico. J. Agric. Univ. P.R. 62(3): 214-223.

Klausner, S. and Bouldin, D. 1983. Managing animal manure as a resource Part I: Basic principles. Cooperative Extension Cornell Univ. Ithaca, N.Y.

Liebhardt, W.C. 1976. Soil characteristics and corn yield as affected by previous applications of poultry manure. J. Environ. Qual. 8: 211-215.

Muñoz, M.A., Colberg, O., and Dumas, J.A. 1990. Chicken manure as an organic fertilizer. J. Agric. Univ. P.R. 74(2): 139-144.

Ortiz, J. 1989. Informe de Empresa de Plátanos y Guineos. Empresas Agrícolas de Puerto Rico en 1988-89. Esta. Exp. Agric., Univ. P.R., Río Piedras.

Page, A.L., Miller, R.H., and Keeney, D.R. 1982. Methods of Soil Analysis Part 2: Chemical and Mineralogical Properties.. Second Edition. American Society of Agronomy, Madison, Wisconsin. 1159p.

Perkins, H.F., Parker, M.B., and Walker, M.E. 1964. Poultry manure; its composition and use as fertilizer. Georgia Agr. Exp. Sta. Bull. NS-123.

Sims, J.T. 1987. Agronomic evaluation of poultry manure as a nitrogen source for conventional and no-tillage corn. Agron. J. 79: 563-570.

Strong, C.F., Jr., and Segars, W.I. 1981. Poultry waste. Cooperative Extension Service Leaflet 206. University of Georgia College of Agriculture. Athens.

Vicente-Chandler, J. and Figarella, J. 1962. Experiments on plantain production with conservation of the mountain region of Puerto Rico. J. Agric. Univ. P.R. 46(3): 226-36.