Effects of Six Sources of Nitrogen on Yields, Soil Acidity, and Leaf Composition of Coffee[1]

Fernando Abruña and José Vicente-Chandler[2]

INTRODUCTION

Intensively managed coffee in Puerto Rico requires heavy fertilization with nitrogen to produce high yields. Abruña, Vicente-Chandler, and Silva (*1*)[3] found that intensively managed coffee responded strongly to applications of 150 pounds of nitrogen per acre every year on Alonso clay at Castañer, with strong evidence of a response to heavier applications during years of abundant rainfall. These investigators (*2*) also found that similarly managed coffee on Los Guineos clay at Jayuya responded strongly to applications of 150 pounds of nitrogen per acre yearly during the first heavy crop, and to applications of 300 pounds per acre during subsequent crops.

Very little information is available on the effects of the various sources of nitrogen, particularly when applied at such heavy rates, on yields and leaf composition of coffee. McClelland (*3*) in field experiments in Puerto Rico, found that coffee responded more in yield to ammonium sulfate than to sodium nitrate applications.

The present work was carried out to compare the effects of heavy applications of nitrogen from different sources on yields and leaf composition of coffee, and on soil acidity, under conditions typical of the Coffee Region of Puerto Rico.

MATERIALS AND METHODS

The experiment was carried out near Jayuya at an elevation of about 2,500 feet, with mean monthly temperatures varying from about 70° to 80° F., and about 75 inches of annual rainfall.

The soil is steep, eroded Los Guineos clay, the upper 6 inches of which contain about 3 percent of organic matter, with a pH of 5, and an exchange capacity of 16 m.e. per 100 gm. of soil. The soil is well drained and has good physical condition.

Arabica coffee of the Bourbon variety was planted 3 feet apart in rows 10 feet apart, or 1,400 trees per acre, in the spring of 1958. The rows were

[1] This paper covers work carried out cooperatively between the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, and the Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

[2] Soil Scientist and Project Supervisor, respectively, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, stationed at Río Piedras, P.R.

[3] Italic numbers in parentheses refer to Literature Cited, p. 46.

kept free of weeds, but grass was allowed to grow between rows to control erosion. No shade was used. The trees were sprayed periodically to control insects and diseases and were otherwise well cared for.

The upper 6-inch layer of soil was limed to about pH 6.2 and 4 pounds of ground limestone and 2 pounds of 20-percent superphosphate were applied in each large planting hole. The trees were lightly fertilized with ammonium sulfate and potassium sulfate for 1 year until they were well established. Thereafter, 600 pounds of potassium, as potassium sulfate, were applied per acre yearly in three equal applications to all plots except those receiving nitrogen as potassium nitrate. Boron and zinc were applied twice yearly to all trees as a foliar spray and 300 pounds of magnesium sulfate were applied per acre yearly to the soil.

Nitrogen sources tested were: Ammonium sulfate, sodium nitrate, ammonium nitrate, ammonium nitrate-lime, potassium nitrate, and urea, all applied at the rate of 200 pounds of nitrogen per acre yearly in three equal applications. All treatments except urea were replicated six times in a randomized-block design with individual plots of eight trees. The urea treatment was not included in the experimental design. Hence, data for this treatment, which was replicated only four times, are presented only as an illustration and were not included in the statistical analysis.

Yields produced by each plot were determined over the first two heavy crops. After the second crop, 1961, a sample of the mature, healthy leaves from the third or fourth pair from the tips were taken from the four trees in the center of each plot and analyzed for nitrogen, calcium, potassium, sodium, magnesium, phosphorus, and manganese.

Soil samples were also taken at this time in each plot of four replications. Six borings were taken in each plot under the rows where the fertilizer was applied and composited for analysis. Samples were analyzed for pH and for exchangeable calcium, magnesium, potassium, and sodium.

RESULTS

Lowest yields of coffee were obtained when nitrogen was applied as sodium nitrate (table 1). About 1,400 pounds per acre of market coffee were produced with this source of nitrogen compared to an average of 2,330 pounds for all other nitrogen carriers. Yields produced with the other five sources were similar, nitrogen apparently being utilized equally well by coffee whether applied in urea, ammonia, or nitrate form.

Sodium, to which coffee seems very sensitive, is apparently responsible for the lower yields with sodium nitrate, since high yields were produced with potassium nitrate. Coffee leaves from the sodium nitrate plots contained much more sodium, 921 p.p.m. *vs.* an average of 586 p.p.m. for all other nitrogen sources (table 1). Sodium also accumulated in the soil pro-

TABLE 1.—*The effect of 200 lb. of nitrogen per acre yearly from 6 different sources on yields and foliar composition of intensively managed coffee growing on Los Guineos clay at Jayuya*[1]

Nitrogen source	Yields of market coffee per acre yearly	Foliar composition, dry-weight basis						
		N	Ca	K	Na	Mg	P	Mn
	Pounds	*Percent*	*Percent*	*Percent*	*P.p.m*	*Percent*	*Percent*	*P.p.m.*
Ammonium sulfate (21-percent N)	2,409	2.55	1.55	1.62	563	0.30	0.14	172
Ammonium nitrate (35-percent N)	2,503	2.31	1.39	1.51	622	.25	.16	65
Potassium nitrate (13-percent N 36-percent K)	2,352	2.50	1.47	1.65	603	.22	.14	107
Ammonium nitrate-lime (20.5-percent N)	2,332	2.58	1.31	1.55	532	.25	.14	76
Sodium nitrate (16.5-percent N)	1,415	2.59	1.14	1.69	921	.21	.16	97
Urea[2] (46-percent N)	2,052	2.44	1.21	1.65	610	.25	.14	84
L.S.D. 0.01	725	N.S.	N.S.	N.S.	120	N.S.	N.S.	51

[1] Yields are averages of 2 heavy crops. Leaf samples were taken after the second crop was harvested.

[2] Data for urea not included in statistical analysis.

TABLE 2.—*The effect of nitrogen from 6 sources, applied over a 2½-year period to intensively managed coffee, on the acidity and base status of the surface 6 inches of a Los Guineos clay*

Nitrogen source	pH	Base status per 100 gm. of soil			Exchangeable sodium		
		Ca	Mg	K	0–6 in.	6–12 in.	12–18 in.
		M.e.	*M.e.*	*M.e.*	*P.p.m.*	*P.p.m.*	*P.p.m.*
Ammonium sulfate	5.6	8.10	1.27	1.15	21	19	17
Sodium nitrate	6.4	10.21	.58	1.58	48	43	52
Potassium nitrate	6.1	6.71	1.48	1.78	23	16	17
Ammonium nitrate	5.8	9.16	1.39	1.24	21	18	17
Ammonium nitrate-lime	6.3	14.41	2.44	1.10	25	19	16
Urea	5.4	6.85	1.95	1.18	19	18	20
L.S.D. 0.01	0.3	N.S.	N.S.	N.S.	14	N.S.	32
Original soil after liming	6.2	11.80	1.39	0.66	19	18	16

file (table 2) averaging 48 p.p.m. in the upper 18 inches of soil, compared to 19 p.p.m. for all other nitrogen sources.

Leaves from trees fertilized with the different sources of nitrogen were similar in nitrogen, calcium, potassium, magnesium, and phosphorus content (table 1). However, leaves from the ammonium sulfate plots were highest in manganese content, averaging 172 p.p.m. *vs.* 86 p.p.m. for all other sources of nitrogen (table 1).

Soil pH was highest in the plots fertilized with sodium nitrate, ammonium nitrate-lime, and potassium nitrate, averaging 6.31, and lowest in those fertilized with urea, ammonium nitrate, and ammonium sulfate, averaging 5.6.

DISCUSSION

Manganese toxicity can be a serious problem with coffee on some soils of the Mountain Region which, unlike the Los Guineos clay in this experiment, have a high content of this element. When heavy applications of nitrogen are used on such soils without proper liming, soil pH drops, rapidly increasing the availability of manganese. Under such conditions coffee leaves have been found by the authors to contain as much as 1,500 p.p.m. of manganese. Such high contents of manganese interfere with the use of iron by the coffee trees resulting in chlorosis, heavy leaf, and fruit-drop, and "die-back" of the young branches. Manganese toxicity can be prevented or corrected by proper liming to maintain a desirable soil pH and by using a source of nitrogen other than ammonium sulfate which, as shown above, increases uptake of manganese by coffee.

Ammonium sulfate and urea are the only sources of nitrogen now available commercially in Puerto Rico. Although the price per pound of nitrogen from these sources is about the same, urea is to be preferred. As shown above, ammonium sulfate furthers the uptake of manganese, which can be toxic on many soils of the Coffee Region of Puerto Rico. Urea is also cheaper to apply, particularly on steep coffee lands, since it contains about twice as much nitrogen per unit as does ammonium sulfate (table 1). In addition, urea has a less acid residue, as shown by Pearson, *et al.* (*4*), and thus requires less lime to maintain a desirable soil pH. Urea should be prilled and distributed in plastic bags to avoid caking, which is a serious problem in the humid Tropics.

It is evident that sodium nitrate should not be used as a source of nitrogen for coffee.

Ammonium nitrate does not seem to have any advantage over urea. Similarly, there is little to be gained by using ammonium nitrate-lime, if a proper liming program is practiced.

Potassium nitrate would seem to be an excellent source of nitrogen to use with coffee since all the fertilizer would be used and little residue would remain in the soil. It is possible to make heavy applications of phosphorus and lime at planting, and then to limit fertilization to applications of potassium nitrate supplemented by some additional nitrogen and by magnesium and minor elements as required.

SUMMARY

The effects of heavy applications of nitrogen from six different sources on yields and leaf composition of intensively managed coffee, and on acidity of a Los Guineos clay, were determined under typical conditions in the Coffee Region of Puerto Rico.

Lowest yields were obtained when nitrogen was applied as sodium nitrate, while applications of ammonium sulfate, ammonium nitrate, potassium nitrate, ammonium nitrate-lime, and urea resulted in the production of similar high yields of coffee.

Coffee leaves from plots on which the different sources of nitrogen were used were similar in nitrogen, calcium, potassium, magnesium, and phosphorus contents. However, leaves from the sodium nitrate plots were highest in sodium content and those from the ammonium sulfate plots were highest in manganese content.

Soil pH was lowest in the ammonium sulfate, urea, and ammonium nitrate plots, and highest in the sodium nitrate, potassium nitrate, and ammonium nitrate-lime plots. Soil from the sodium nitrate plots was highest in exchangeable sodium.

It is evident that sodium nitrate should not be used as a source of nitrogen for coffee. The desirability of using nitrogen sources other than ammonium sulfate on soils with a high content of manganese where this element can cause severe toxicity of coffee is also discussed.

RESUMEN

Se estudió el efecto de las aplicaciones de nitrógeno de varias fuentes sobre el rendimiento y composición de las hojas de cafetos cultivados intensivamente y sobre la acidez de un suelo Los Guineos bajo condiciones típicas de la región cafetalera de Puerto Rico.

Se obtuvieron rendimientos mucho más bajos cuando se aplicó el nitrógeno en forma de nitrato de sodio, mientras que las aplicaciones de sulfato amónico, nitrato amónico, nitrato de potasio, nitrato amónico-neutralizado con cal, y urea, produjeron rendimientos similares de café.

Las hojas de los cafetos abonados con distintas fuentes de nitrógeno tuvieron contenidos similares de nitrógeno, calcio, potasio, magnesio, y fósforo. Sin embargo, las hojas de los cafetos que se abonaron con nitrato de

sodio tuvieron un contenido más alto de sodio, mientras que las que se abonaron con sulfato amónico demostraron tener mucho más manganeso.

El pH del suelo fué más bajo cuando se aplicó sulfato amónico, urea, o nitrato amónico, y más alto cuando se aplicó urea, nitrato de sodio, o nitrato amónico-neutralizado con cal. El suelo abonado con nitrato de sodio tuvo un contenido mayor de sodio intercambiable.

Es evidente que no debe usarse el nitrato de sodio como fuente de nitrógeno para el café.

Se discuten los méritos de las otras fuentes de nitrógeno. En suelos con un alto contenido de manganeso, en los cuales este elemento puede ser tóxico al cafeto, parece ser conveniente usar otra fuente de nitrógeno que el sulfato amónico.

LITERATURE CITED

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