Spraying for Leaf Spot and Liming Increase Yam (*Dioscorea Alata* L.) Yield[1, 2]

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ABSTRACT

When yams were not sprayed to control leaf spot disease caused by *Colletotrichum* sp. essentially no yams were produced regardless of lime rates. When leaf spot was controlled by spraying, yam yields increased with increasing lime rates up to 36 t/ha, the highest level tested. The combined effect of spraying and liming increased yields from 1.4 to 30.6 t/ha. Yields were increased threefold when Al saturation of the soil exchange capacity was decreased from 37% to 0 by liming. Yields were decreased by 30% when Al saturation of the soil was increased only from 0 to 9%, a level at which most crops will not show a response to Al. This decrease illustrates the extreme sensitivity of yams to exchangeable Al in the soil. Composition of the leaves 6 months after planting was affected neither by lime rates nor spraying. The pH, Al saturation percentage of the soil exchangeable capacity, and lime rates applied were closely correlated with yam yields.

INTRODUCTION

Yams are an important source of carbohydrates in the diets of subsistence farmers throughout the tropics, but there is relatively little research information available on their culture. Most researchers have reported evaluations of varieties and planting systems (2, 3, 5). There is little information on the effects of soil acidity on yam yields. Nye and Greenland (10) found a small response in yields of yams to liming after 8 years of continuously farming an Oxisol with an original pH of about 6.0 in the savanna region of East Africa. Abruña et al. (1) found a strong response by yams to liming on Ultisols of Puerto Rico.

The leaf spot disease caused by *Colletotrichum* sp., generally described as "scorch" or "lightning," is a major limiting factor in yam production. The etiology of the disease has not been adequately determined, but its incidence has been associated with ecologic, physiologic, and soil factors. However, the International Institute of Tropical Agriculture at Ibadan, Nigeria (7) has been unable to correlate incidence of leaf spot disease with such factors as early appearance of necrosis, tuberization of the seed before planting, root necrosis, maturity of the tuber or natural and artificial shade. They found the species *D. alata* to be especially suscep-

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tible to the disease, and benomyl applications at a 14-day interval over a period of 90 days did not reduce its prevalence or severity.

The present study evaluated the possible interaction between soil acidity factors and the spraying of a fungicide for control of leaf spot on yam yields.

MATERIALS AND METHODS

The work was carried out at the Corozal Substation on a moderately eroded Corozal clay (Aquic Tropudults) on a 10% slope. A split-plot randomized block design was used with lime rates of 0, 4.5, 9.0, 18.0 and 36 t/ha applied as ground limestone and mixed with the upper 15 cm of soil as the main plots; spraying or no spraying treatments served as subplots, and all treatments were replicated five times. Main plots were 4.5 × 8 m and subplots 4.5 × 4 m. All plots were surrounded by ditches to prevent runoff from one plot to another.

Tuber sections weighing around 200 g each of the yam cultivar Smooth Statia (*Dioscorea alata* L.) were planted 0.3 m apart in ridges 1.5 m apart. Wire trellises 2 m high were provided to support the vines. All plots received 500 kg/ha of 10-10-10 fertilizer containing 30 kg/t of a mixture of 6% Mg, 7.7% Mn, 4.8% Cu, 7% Fe, 8% Zn, and 2.5% B, at planting time and 5 mo later.

The fungicidal treatment was applied by a knapsack sprayer and consisted of spraying the foliage every 3 weeks with a solution containing 1 kg of benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate) (Benlate)[4] in 400 liters of water. During spraying foliage in the untreated plots was protected with plastic sheeting.

We sampled the soil in all plots 4 months after liming by taking eight borings to a depth of 15 cm. The samples were air dried and sieved through a 10-mesh screen. The samples were leached with normal neutral NH_4OAc and Ca and Mg were determined by the Versenate method (4), K by flame photometry; and Mn, colorimetrically as permanganate after oxidation with KIO_4. Exchangeable Al was determined by extracting with *N* KCl and determining Al by the double titration method (9). Percent Al saturation of the soil was calculated considering the sum of exchangeable Ca, Mg, K, Al and K as the effective cation exchange of the soil (6). Soil reaction was measured with a glass electrode pH meter with a 1:1.5 soil-water ratio.

The third and fourth leaves of plants growing in the center of each

[4] 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.

plot were taken as samples 6 months after planting; they were washed with distilled water, dried, and wet-digested with a mixture of HNO_3 and $HClO_4$. Phosphorus was determined colorimetrically (8), K by flame photometry, Ca and Mg by the Versenate method (4), and Mn colorimetrically after oxidation with KIO_4.

Tubers were harvested 10 months after planting and yield of each plot was determined.

Analyses of variance were used to compare plot yields at the various lime levels with and without spraying. Yield and foliar analysis data were correlated to soil acidity factors through regression analyses.

TABLE 1.—*Effect of five lime rates on yields and foliar composition of yams.* (**Dioscorea alata** *L.*) *with and without spraying with fungicide to control leaf spot disease in Puerto Rico*

Lime rate	Yields of marketable tubers	Foliar composition					
		N	P	K	Ca	Mg	Mn
t/ha	*t/ha*			%			
			Sprayed				
0	13.8 c[1]	2.37	.11	2.63	1.90	.27	136
4.5	18.1 bc	2.74	.10	2.64	1.90	.30	150
9.0	21.2 bc	2.68	.13	2.84	2.00	.33	142
18.0	27.2 ab	2.66	.12	2.94	1.81	.32	109
36.0	30.6 a	2.73	.12	2.87	1.89	.39	26
			Not sprayed				
0	1.4 a	2.57	.10	2.57	1.49	.36	129
4.5	1.8 a	2.58	.09	2.69	1.48	.27	69
9.0	2.9 a	2.78	.12	2.97	1.66	.27	116
18.0	3.2 a	2.80	.12	2.90	1.70	.25	72
36.0	5.4 a	2.92	.12	3.00	1.75	.33	87

[1] Means in columns for sprayed or for unsprayed plots followed by a letter in common do not differ significantly at the 5% probability level according to Duncan's multiple range test.

RESULTS AND DISCUSSION

Yields of yams increased with increasing lime levels from 13.8 up to 30.6 t/ha (table 1) when the plants were sprayed periodically for the control of the leaf spot disease. Without spraying, yields were almost nil but tended to increase with lime rates.

When no lime was applied, the unsprayed plants produced only 10% as much as the sprayed plants, and at the 36 t/ha lime rate the unsprayed plants yielded only 18% as much as those sprayed. The combined effect of spraying and liming increased marketable yields from 1.4 to 30.6 t/ha (table 1).

Composition of the leaves sampled 6 months after planting was not affected by lime rates or spraying, and there was no significant interaction between lime rates and spraying (table 1).

Because of high variations in soil acidity levels among plots receiving the same lime rate, plots were grouped into categories according to the percentage of the soil exchange-complex saturated with Al. Table 2 shows that yields dropped as the Al saturation of the soil increased from 0 up to 37% of the soil's cation exchange capacity. At this level of soil acidity yams produced only 34% of the yield obtained when there was no

TABLE 2.—*Effect of soil acidity on yields and foliar composition of yams* (**Dioscorea alata** *L.) grown on an Ultisol and sprayed with fungicide to control leaf spot disease in Puerto Rico*

Soil acidity factors		Yields of marketable tubers	Foliar composition					
pH	Saturation with exchangeable Al		N	P	K	Ca	Mg	Mn
	%	*t/ha*			*%*			*p/m*
6.2	0	26.1	2.68	.12	3.07	1.82	.38	164
4.8	9	18.4	2.63	.12	2.56	1.82	.36	187
4.7	17	17.2	2.91	.12	2.69	1.92	.34	180
4.6	25	13.7	2.73	.10	2.59	1.81	.32	115
4.5	37	8.5	2.15	.10	2.75	1.60	.22	130

TABLE 3.—*Relationship between liming and soil acidity factors and yields of yams* (**Dioscorea alata**)

Soil acidity factors and liming	Marketable yield (t/ha)	
	Plants sprayed to control leaf spot disease	No spray applied
pH	$Y = 417.06 + 157.25X - 13.83X^2$ $r = .99^{**}$	$Y = -38.75 + 13.47X - 1.06X^2$ $r = .98^{**}$
Percent Al saturation	$Y = 24.58 - .44X$ $r = .98^{**}$	$Y = 3.65 - .19X + .003X^2$ $r = .92^{*}$
Lime rates	$Y = 13.74 + .99X - .014X^2$ $r = .99^{**}$	$Y = 1.10 - .006X + .0027X^2$ $r = .96^{**}$

exchangeable Al in the soil. There was a 30% reduction in yam yields when the Al saturation of the soil was increased from 0 to only 9%, a level at which most crops would not show a response to Al. This response illustrates the extreme sensitivity of this variety of yams to exchangeable Al in the soil.

Chemical composition of the leaves was not significantly affected by soil acidity factors (table 2), although N, Ca and Mg decreased at the highest level of acidity.

Regression analysis of the data (table 3 and figures 1 and 2) show that pH, percent Al saturation of the soil's exchange capacity, and lime rates applied were closely correlated with yam yields with or without spraying to control leaf spot disease.

The data presented clearly show that the two main factors limiting increased yam production in Puerto Rico are leaf spot disease and high levels of acidity in the Ultisols where yams are usually grown. Yams are

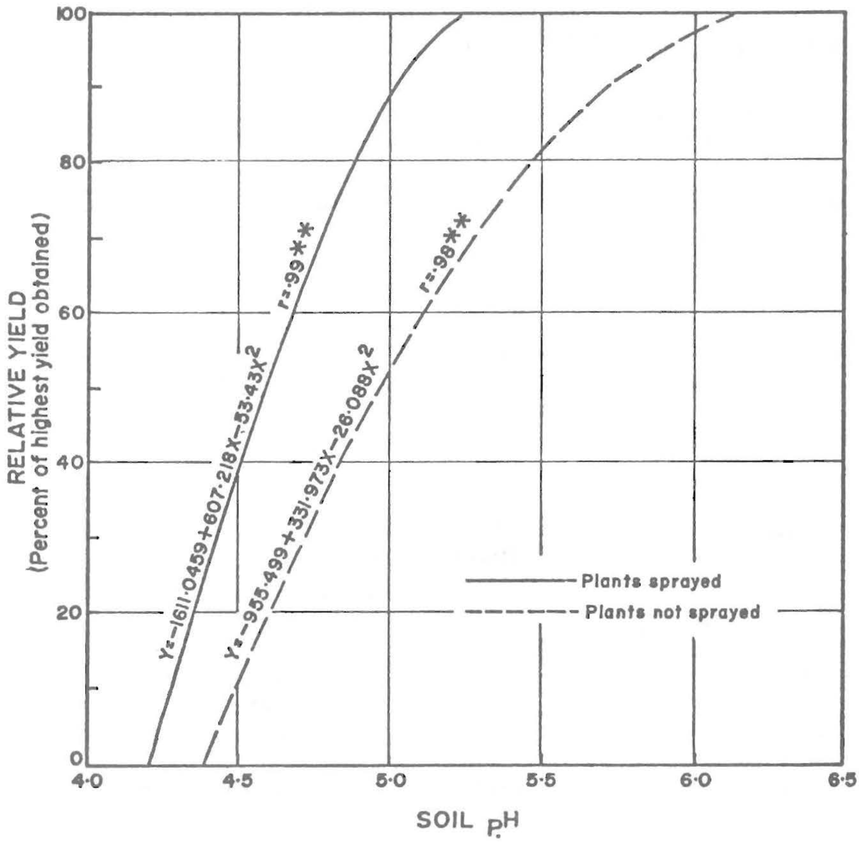

FIG. 1.—Relationship between soil pH and relative yield of yams in Puerto Rico with and without spraying with fungicide to control leaf spot disease caused by *Colletotrichum* sp.

extremely sensitive even to low exchangeable Al content in the soil. The species studied (*D. alata*) is known for its sensitivity to leaf spot disease, yet it produced high yields of edible carbohydrates when sprayed periodically. Liming had no effect in ameliorating the damage caused by leaf spot disease.

In order to produce yams profitably in Puerto Rico the soil must be limed to precipitate essentially all the exchangeable Al, and the foliage of the plants should be sprayed with an appropriate fungicide.

RESUMEN

El efecto de las aplicaciones de cal y de las aspersiones con fungicidas para controlar la mancha de la hoja o "candelilla" en la producción de

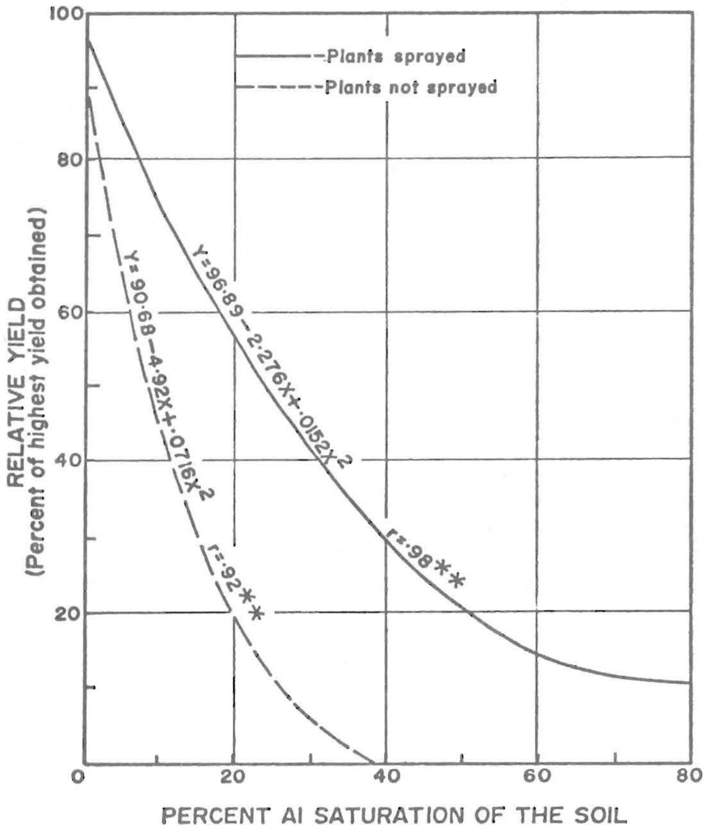

FIG. 2.—Relationship between soil percent Al saturation of the soil and yield of yams in Puerto Rico with and without spraying with fungicide to control leaf spot disease caused by *Colletotrichum* sp.

ñames se determinó con la variedad Smooth Statia (*Dioscorea alata*).

Apenas se cosecharon ñames comerciales cuando no se asperjó para controlar la candelilla.

Cuando se asperjaron, las plantas respondieron en producción a incrementos de piedra caliza molida hasta 36 Tm/ha. La combinación de aspersión para el control de la candelilla y el encalado aumentaron el rendimiento de ñames de 1.4 a 30.6 Tm/ha.

Hubo una relación directa entre el contenido de Al cambiable en el suelo y la producción de ñames. El rendimiento disminuyó en un 30% cuando el nivel de Al en el suelo se aumentó al 9% de las bases cambiables, nivel que rara vez afecta la producción de otras cosechas, lo cual ilustra la sensitividad del ñame al Al en el suelo.

Hubo correlaciones altamente significativas entre el rendimiento de ñame con el nivel de cal aplicada, el pH del suelo y el contenido de Al cambiable en el suelo.

El contenido de distintos nutrimentos en las hojas no se afectó por cambios en los niveles del encalado ni por las aspersiones fungicidas.

Estos datos demuestran que los dos factores más limitativos en la producción del ñame en Puerto Rico son la candelilla y los altos niveles de acidez de los Ultisol, donde usualmente se siembra en Puerto Rico.

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