Analysis of Probable Relationships Between Leaf-Potassium Percentage and Sucrose Content and Maturity of Sugarcane[1]

Gilberto Acevedo-Ramos[2]

INTRODUCTION

It is generally recognized that the sucrose content of sugarcane may be influenced by a number of factors. Lugo-López and Capó (*5*, *6*)[3] emphasized the effect of weather, climate, and elevation on the sucrose content of sugarcane. Others (*7*, *8*, *15*, *18*) have shown the importance of soils, fertilizers, varieties, and other factors.

In Puerto Rico most of the progress of the sugarcane industry can be related to the use of proper varieties, control of weeds, insects, and diseases, and application of fertilizer. Most of the fertilizer research results have emphasized the important role of nitrogen in sugarcane production (*11*, *12*, *16*).

Potassium is also a nutrient element of great importance in the fertilization of sugarcane in many areas of Puerto Rico. Experimental data have shown that potassium is essential to produce high sucrose yields and its omission results in low sucrose concentrations (*9*, *10*, *13*). According to Samuels (*14*) potassium deficiencies produced highly significant reductions in available sugar in the juice and cane, polarization, brix, and purity.

This paper deals with the possible relationships that may exist between leaf-potassium percentage at different ages and the sucrose content and maturity of the sugarcane crop.

METHODS AND MATERIALS

The data herein reported were obtained from experiments conducted by the Department of Soils which were designed to determine the possible correlation of leaf-potassium content at different ages with cane and sugar yields. The results of this work have been published by Bonnet, *et al.* (*2*). Sugarcane plants were grown in 28 concrete pits under greenhouse conditions in which inert sand was used as substratum. Variety M. 336 was planted in October 1955, while variety P.R. 980 was planted in December

[1] Contribution from the Gurabo Substation.

[2] Research Assistant in Soils, Gurabo Substation, Agricultural Experiment Station, University of Puerto Rico, Gurabo, P.R. Appreciation is expressed to the Assistant Director in Charge of the Gurabo Substation, M. A. Lugo-López for his help in the preparation of this manuscript.

[3] Italic numbers in parentheses refer to Literature Cited, p. 21–2.

1957. Seven different potassium levels replicated four times, were used as shown in table 1.

Nitrogen and phosphorus were kept at constant levels for each variety. Sugarcane seed pieces of varieties M. 336 and P.R. 980 were inmersed in water at 52° C. for disinfection. Four one-eye nodes were planted in each pit.

Sugarcane leaves 3, 4, 5, and 6, counted from the top, were taken monthly from the third to the eleventh month, both inclusive. Composite leaf samples were prepared and analyzed for potassium. Variety M. 336 was harvested in September 1956, while P.R. 980 was harvested in December 1957. The weight of the canes and the sugar content were recorded.

TABLE 1.—*Levels of N, P, and K fertilization used, in pounds per acre, in the experiments on sugarcane varieties M. 336 and P.R. 980*

Treatment No.	M. 336			P.R. 980		
	N	P	K	N	P	K
1	180	150	5	400	150	5
2	180	150	10	400	150	15
3	180	150	20	400	150	30
4	180	150	60	400	150	90
5	180	150	100	400	150	160
6	180	150	140	400	150	210
7	180	150	180	400	150	270

RESULTS AND DISCUSSION

Data on the mean potassium content are presented graphically in figures 1 and 2. In both varieties a higher potassium content was obtained when the plants were 3 months old. A tendency for potassium to decrease with age up to a definite point was registered especially at the high-potassium levels. Then potassium levels tended to increase again with maturity. In M. 336 (fig. 1) the increase in mean potassium content under almost all treatments tended to start at about 5 months, while in P.R. 980 (fig. 2) the same tendency started at around 7 months.

Data obtained from sugarcane field experiments by Samuels (*17*) show a decrease of the nitrogen and phosphorus content of the cane leaves with age, whether irrigation was used or not, but the potassium content did not decrease with age throughout the growing cycle of the sugarcane. The results indicate that the increase of potassium contents for the nonirrigated experiment started at about 5½ months and at about 15 months for the irrigated field, as shown in figure 3. The increase of potassium in sugarcane at a definite period of growth under field conditions can perhaps be related

to an increase in available soil potassium as a result of probable variations in climatic factors such as rainfall and maybe others. However, the data obtained under greenhouse conditions tend to indicate that the increase in potassium probably can be related more to a reduction of growth with age

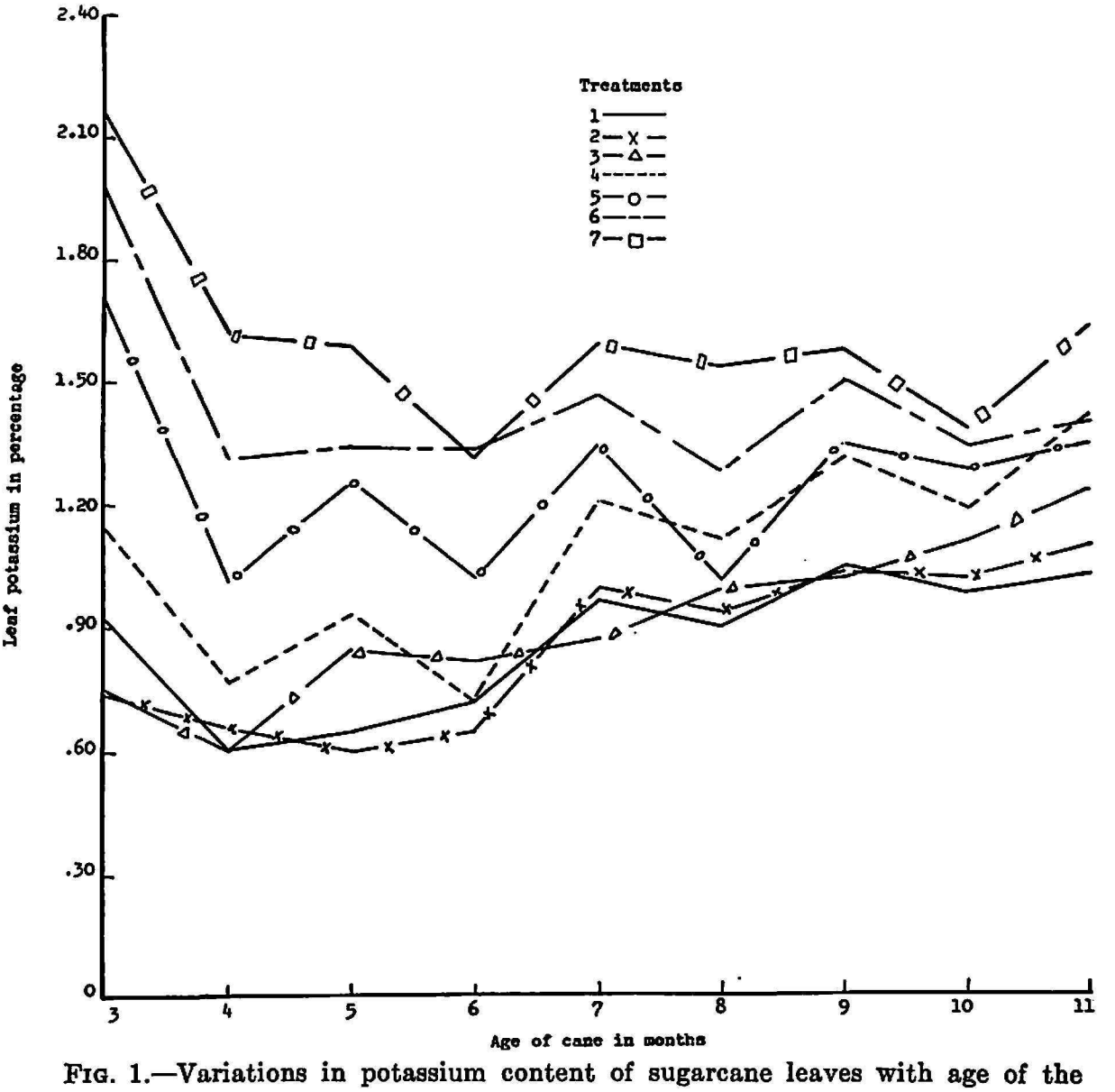

FIG. 1.—Variations in potassium content of sugarcane leaves with age of the variety M. 336.

or maturity, while potassium absorption continues without change, rather than to increases in available potassium in the medium, since it is expected that in a sand substratum the availability of potassium is more or less equal throughout the whole period of growth.

Whether the absorption of potassium is a direct result of changes in weather and climate which, in turn, affect some physiological processess of

the sugarcane plant needs to be studied. Data obtained from Hawaii regarding the effect of potash fertilization in relation to plant composition and age can be summarized as follows (*1*): Regardless of the nature of the tissue

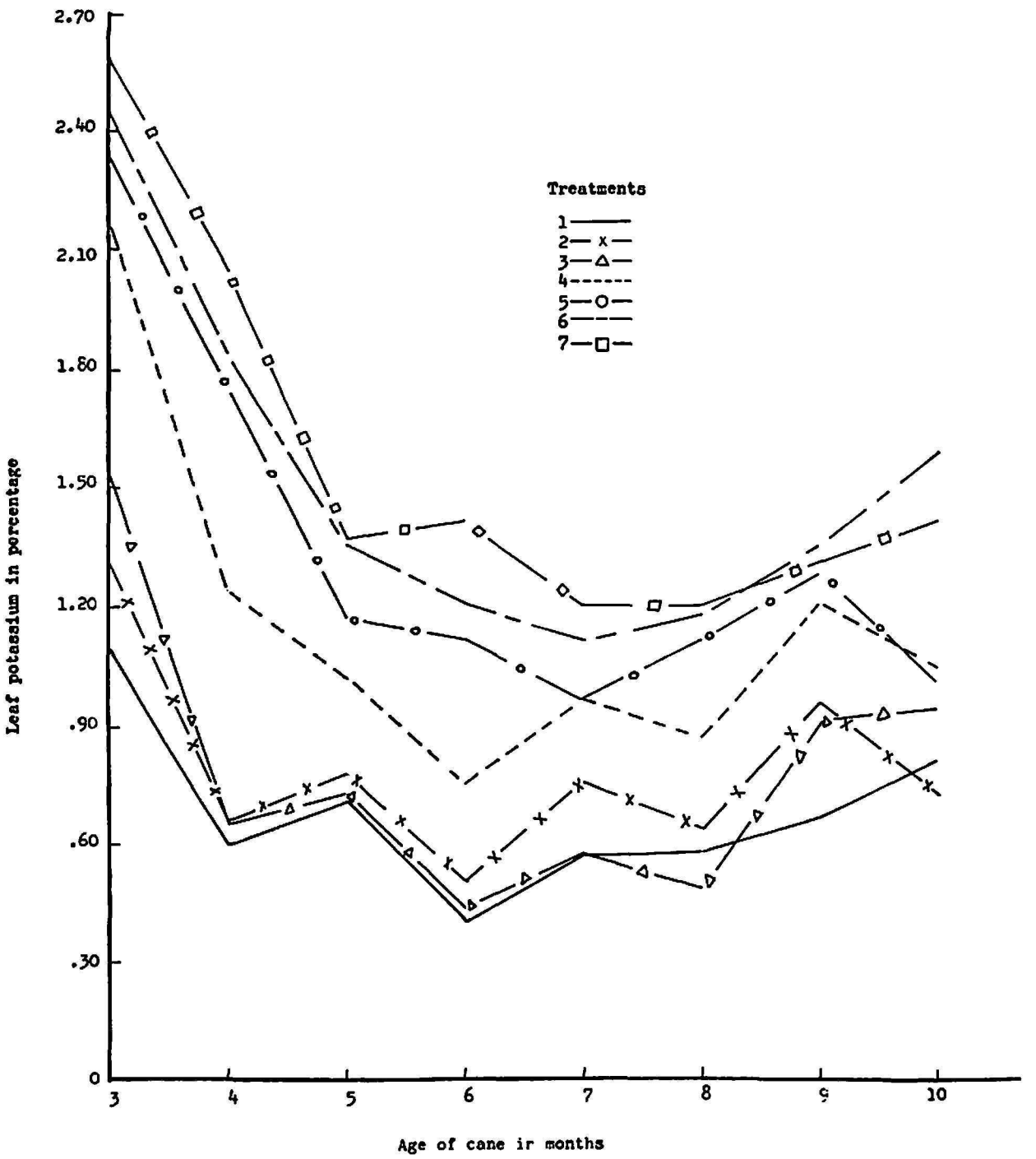

FIG. 2.—Variations in potassium content of sugarcane leaves with age of the variety P.R. 980.

analyzed, potash fertilization increased the potassium composition of the plant and tended to level out the composition values with time; there were no gradual decreases in potassium composition with time as was the case

of nitrogen; at Kekaha both sheath potassium and the 8–10[4] potassium increased with age, while at Oahu and Pioneer the plant potassium in the latest stage of growth was nearly the same as in the earlier months, with a drop in composition in the middle of these two values.

In regional variety trials it has been shown that M. 336 generally has a higher sucrose content at harvesttime than P.R. 980 (*8*). As shown in figure 1, M. 336 starts to increase in potassium content at early stages of growth, indicating that reduction in growth due to maturity may be related to the increase of potassium in the leaves while in P.R. 980, a late-maturing

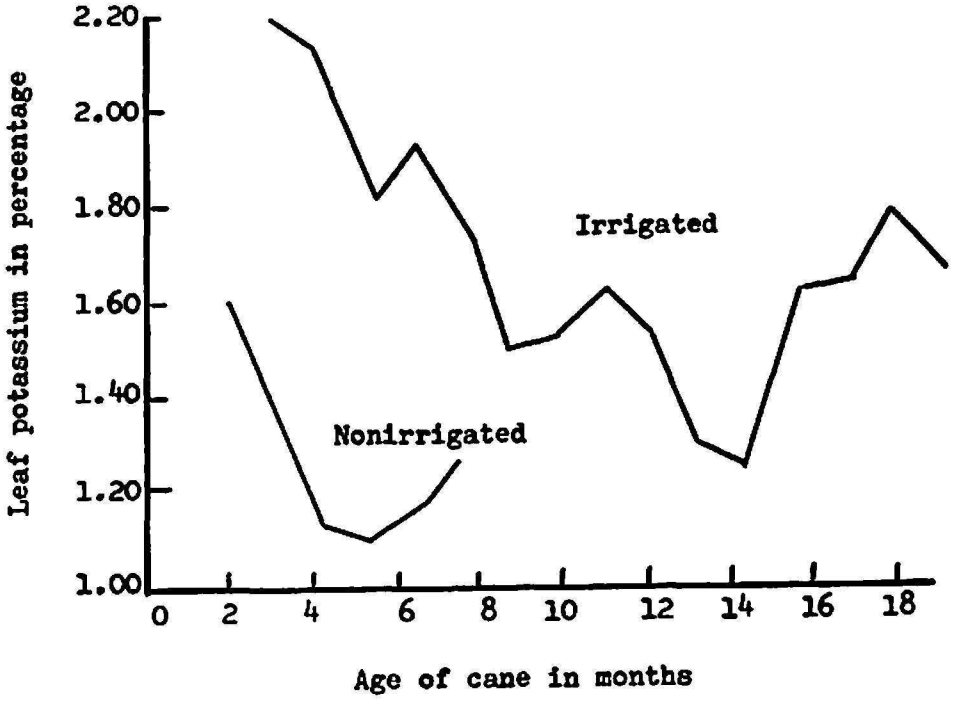

FIG. 3.—Influence of the age of irrigated and nonirrigated sugarcane at sampling on its leaf-potassium content.

variety which continues growing vigorously for a longer time, the increase in potassium content as indicated by the leaves takes place at a later date. In relation to this fact Humbert (*3*) showed the importance of N/K ratio in the 8–10 tissue in relation to cane quality at harvest, and presented evidence, as shown in table 2, which emphasizes the necessity of available potassium in order that the plant can utilize the unused nitrogen so as to produce a stage of maturity where the reducing sugars are converted to sucrose. Probably, maturity can be accelerated under our conditions by applications of potassium at definite periods of growth, especially on late-maturing sugarcane varieties. As it is difficult to apply fertilizer to sugarcane at this stage of the growing period, air applications of dry fertilizer

[4] 8–10 refers to the young tender tissues between the eighth and tenth leaves.

could be made. In Hawaii, applications of dry muriate of potash are usually made by airplanes due to the low solubility of this salt in water (*4*).

However, if the increase of potassium at the late stage of growth cannot be related to maturity, it can probably then be explained by the following facts:

1. That the high content of potassium at the early stages of growth (3 months) occurs because the sugarcane plants are small and there is a large available quantity of the nutrient.

2. The decrease of potassium in the leaves, as shown by the pattern in figures 1 and 2, can be related to the dilution effect expected to occur in those rapid-growing months of the cane. In Hawaii, this decrease has been attributed to two factors related to the ratio of top growth to root growth

TABLE 2.—*Preharvest analyses of the 8–10 tissue, sugarcane variety 37-1933 from Lihue, Hawaii, 1955*

Field yields (tons)	Moisture	N	K	Sugar	Reducing sugar	Sucrose	Sugarcane	TC/TS[1]	Sugar	Purity
	Percent	*Percent*	*Percent*	*Tons (TS)*	*Percent*	*Percent*	*Tons/acre (TCA)*		*Tons/acre (TSA)*	*Percent*
7.00	80.70	0.42	0.68	49.2	11.8	37.5	72.2	10.62	6.80	81.7
7.00–9.99	77.10	.25	1.22	48.4	6.4	41.7	86.9	9.64	8.94	85.2
10.00–12.99	75.30	.19	1.47	51.9	5.7	46.2	79.8	7.13	11.20	88.2

[1] Reported by Humpert (3). TC/TS = ratio used in Hawaii to indicate the number of tons of net cane required to produce 1 ton of 96° sugar.

which are the following: Decrease of potassium just as a matter of dilution, and inability of the absorbing root surfaces at the soil-root interface to supply the demands of the upper portion of the plant (*1*).

3. The increase of potassium in the leaves at the late part of the growth period can be explained on the basis that sugarcane continues absorption of potassium while the rate of vegetative growth decreases as the plant approaches maturity, increasing the potassium percentage in the plant leaves.

4. As sugarcane reaches maturity the older leaves dry and probably the potassium may move from older tissues to the young growing tissues, thus increasing the potassium content of the more active leaves.

The data presented indicate that there are some unanswered questions in relation to the direct effect of potassium fertilization on the behavior of sugarcane plants. More detailed studies are needed to determine the relationship that exists between the mineral nutrition and accumulation of potassium and sugarcane growth and development.

SUMMARY

Data are presented on the potassium content of sugarcane leaves at specific ages from experiments performed under greenhouse conditions.

A comparative study was conducted on the role of potassium in the sugarcane varieties M. 336 and P.R. 980 in an attempt to explain some relationships that probably exist throughout the physiological growth of the sugarcane plant. The results obtained indicate that there is first a marked decrease and later on a moderate increase in potassium content of the sugarcane leaves during its growth cycle.

These data indicate that this fact may be related to sugarcane maturity. However, other facts are evaluated and discussed which can also explain such increases.

RESUMEN

Se presentan datos sobre el contenido de potasio en las hojas de caña a distintas edades, según dos experimentos realizados en invernaderos.

Se hizo un estudio comparativo con relación al efecto del potasio en las variedades de caña M. 336 y P.R. 980, pata explicar las relaciones que probablemente existen a través del crecimiento y desarrollo fisiológico de la caña de azúcar.

Los resultados indican que, a principio, hay una reducción pronunciada y luego un aumento menos pronunciado en el contenido de potasio en las hojas de la caña de azúcar durante su ciclo de crecimiento. Estos datos indican que este factor puede estar relacionado con la madurez de la caña. Sin embargo, se han evaluado y discutido otros factores que pueden explicar este aumento.

LITERATURE CITED

1. Baver, L. D., *Hawaiian Planters Rec.*, **56** (1) 1–153, 1960.
2. Bonnet, J. A., Riera, A. R., and Roldán, J., Yield responses to different N-P-K levels and correlations with foliar analysis, in sand-culture studies with corn, sugarcane, and cotton, *J. Agr. Univ. P.R.* **42** (3) 168–84, 1958.
3. Humbert, R. P., Potash Fertilization in the Hawaiian Sugar Industry, Potash Symposium, Fourth Congress of the International Potash Institute, Berne, Switzerland, 319–44, 1958.
4. ——, Fertilization by aircraft in the Hawaiian sugar industry, *Hawaiian Planters Rec.*, **55** (4) 301–11, 1960.
5. Lugo-López, M. A., and Capó, B. G., The effect of weather and climate on the sucrose content of sugarcane, *J. Agr. Univ. P.R.* **38** (4) 149–69, 1954.
6. ——, The effect of elevation on the sucrose content of sugarcane, *J. Agr. Univ. P.R.* **43** (3) 128–31, 1954.
7. Lugo-López, M. A., The effect of soil conditions on the sucrose content of sugarcane, *J. Agr. Univ. P.R.* **38** (3) 132–46, 1954.

8. Méndez-Roig, F., Samuels, G., and Colón, A., Sugarcane variety trials in Puerto Rico, 1952–57, *J. Agr. Univ. P.R.* **43** (1) 1–18, 1959.
9. Samuels, G., Lugo-López, M. A., and Landrau, P., Jr., Factors affecting the sucrose content of sugarcane fertilizers, *J. Agr. Univ. P.R.* **36** (3) 194–202, 1952.
10. Samuels, G., and Landrau, P., Jr., The response of sugarcane to fertilizers; the Arecibo cycle, *J. Agr. Univ. P.R.* **36** (3) 203–29, 1952.
11. Samuels, G., Landrau, P., Jr., and Capó, B. G., The response of sugarcane in Puerto Rico to various nitrogen sources, *J. Agr. Univ. P.R.* **36** (3) 203–9, 1952.
12. Samuels, G., Capó, B. G., and Bangdiwala, I. S., The nitrogen content of sugarcane as influenced by moisture and age, *J. Agr. Univ. P.R.* **37** (1) 1–12, 1953.
13. Samuels, G., and Landrau, P. Jr., The influence of potassium on the yield and sucrose content of sugarcane, *J. Agr. Univ. P.R.* **38** (4) 170–8, 1954.
14. ——, Influence of fertilizers on the components of available sucrose-percent-cane, *J. Agr. Univ. P.R.* **39** (2) 84–91, 1955.
15. Samuels, G., Landrau, P., Jr., and Capó, B. G., The influence of fertility levels on the varietal response of sugarcane, *J. Agr. Univ. P.R.* **40** (3) 129–43, 1956.
16. Samuels, G., and Capó, B. G., Research with sugarcane fertilizers in Puerto Rico, 1910–54, Tech. Paper No. 16, Agr. Exp. Sta., Univ. P.R., pp. 5–104, 1956.
17. Samuels, G., Influence of the age of sugarcane on its leaf nutrient (N-P-K) content, *J. Agr. Univ. P.R.* **43** (3) 159–70, 1959.
18. Samuels, G., Alers-Alers, S., and Landrau, P., Jr., Influence of time of harvest and age of sixteen sugarcane varieties on their sucrose content, *J. Agr. Univ. P.R.* **44** (1) 1–10, 1960.