Sugar Cane Response to Nitrogen, Phosphorus and Potassium Application in Andisol Soils

By Ovidio Perez and Mario Melgar

Volcanic ash soils (Andisols) cover 25 percent of the sugar cane production area in Guatemala. These soils are rich in allophane minerals, which give them special abilities to accumulate organic carbon (C) and fix plant-available forms of phosphorus (P) and sulphur (S). Therefore, nutrient fixation is perhaps the main chemical constraint of Andisols, which demand special crop management practices in sugar cane.

Guatemala's sugar cane region is located on its southern coast and includes both the volcanic lowland (piedmont) and coastal valleys that extend from sea level to 800 m above. The total area producing sugar cane is approximately 180,000 ha, with potential for production on 320,000 ha.

Fertilization of Sugar Cane in Guatemala

Amounts, sources and method of fertilizer application vary according to the sugar factory policy and demand for their product. However, to date, sugar cane fertilization in Guatemala is largely concentrated on nitrogen (N). Phosphorus is applied only once every 5 to 6 years when plantations are renovated or when new fields are established. Potassium (K) application in this region is even less frequent. Within each sugar factory (Ingenio) field, generalized fertilizer recommendations are used for all soils and plantations.

Sugar cane response to 84 kg P_2O_5/ha is shown at Ingenio Madre Tierra, Guatemala.

In 1993-94, the Guatemalan Center for Research and Training on Sugar Cane (Centro Guatemalteco de Investigacion y Capacitacion de la Caña de Azucar, CENGICAÑA), initiated a series of field studies aiming to obtain detailed information on N, P and K. The specific objectives were to (1) determine the relative importance of N, P and K in Andisols; (2) determine the best rates of N, P and K for high yield sugar cane; (3) determine the magnitude of the effect of residual P and K on sugar and sugar cane yields in the second growing cycle; and (4) determine the effect of splitting 50 percent of the recommended P and K rates between the first and second crop cycles.

Sugar cane plants at left in photo show response to equally splitting P and K fertilizer over 2 years.

Research was conducted for 4 years in the fields of four sugar cane companies; ‘El Baul’, ‘Madre Tierra’, ‘Concepción’ and ‘Pantaleón’. Soils at each site were Typic Hapluand Medial or Pachic Melanudand with pH values ranging from 5.8 to 6.1 and organic matter levels ranging from 7.3 to 11.9 percent. Extractable soil P and K levels were less than 2.7 mg/kg and 0.27 to 1.40 meq/100 g, respectively. Twelve treatments were arranged using 4 levels of N (50, 100, 150, and 200 kg/ha) and 4 levels of P_2O_5 and K_2O (0, 50, 100 and 150 kg/ha). Four additional treatments were tested to evaluate the effect of splitting P and K applications. The study also included zero N (0-100-100) and control (0-0-0) treatments. Nitrogen was banded and covered in both years. Split N applications were made 30 and 90 days after sowing or after the first harvest. Phosphorus and K were applied at the bottom of the furrow before planting.

Table 1. Main effects of N, P and K for the first and second years of sugar cane in four Andisols in Guatemala.

		El Baul (var. CP 722086) t/ha		Madre Tierra (var. CP 722086) t/ha		Concepción (var. Mex 68P23) t/ha		Pantaleón (var. Mex 68P23) t/ha	
Nutrient	kg/ha	Year 1	Year 2	Year 1	Year2	Year 1	Year 2	Year 1	Year 2
N	0	137.2	116.8	143.2	121.1	159.5	150.2	178.6	123.6
	50	139.8	118.0	147.2	125.8	163.7	167.9	175.0	122.3
	100	—	121.7	—	131.2	—	179.8	—	122.3
	150	144.0	126.4	144.0	130.2*	172.6	172.5*	168.3	119.5
P_2O_5	0	131.7	121.7	131.1	125.6	169.9	166.4	167.1	120.2
	100	152.3	123.0	160.7	130.7*	166.4	173.8	176.0	121.4
K_2O	0	140.0	118.7	143.0	127.5	167.2	170.9	169.2	120.4
	100	143.8	125.3	149.0	128.7	169.2	169.8	175.0	121.3
Variation coef.	CV (%)	5.6	7.6	7.4	5.7	7.3	8.4	9.7	7.4
Yield avg.	t/ha	141.3	121.4	145.5	127.6	167.0	168.9	172.7	121.4

*Significant NP positive interaction.

Table 2. Statistically significant coefficients of the regression model (first harvest year).

		Terms and coefficients									
Place	Yield, t/ha	N	N^2	P	P^2	K	K^2	NP	NK	PK	Rate,[1] kg/ha
Concepción	157.12	0.217	-0.009								80 N
El Baul	131.6			0.307	-0.0018			0.0011			94 P_2O_5
Madre Tierra	132.0			0.707	-0.0039						84 P_2O_5

[1] Fertilizer rate for maximum economic yield with Q[2]4.60 kg/N (Concepción); Q 65.00/t sugar cane (Concepción); Q 4.46/kg P_2O_5 (El Baul and Madre Tierra); Q 75.00/t sugar cane (El Baul and Madre Tierra).

[2] Q refers to Quetzales, the official currency of Guatemala.

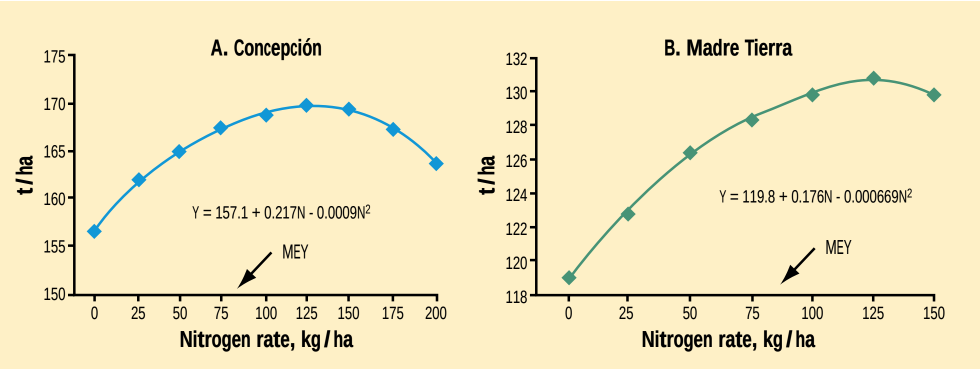

Figure 1. (A) Estimated sugar cane response to N fertilization (first year), variety CP-722086 in Concepción.
(B) Effect of N on sugar cane yield (ratoon crop, second year).

Results

The effects of N, P and K on sugar cane yield for the first year and second year are summarized in **Table 1**. Nitrogen fertilization resulted in a significant yield response in El Baul and Concepción with both sugar cane varieties (*CP 722086* and *Mex 68P23*). During the second year, a response to N was observed in Madre Tierra and Concepción.

Significant yield responses to N at these 2 locations were obtained despite organic matter levels greater than 9 percent. However, at Pantaleón an even higher organic matter level of 11.9 percent likely prevented a significant N response.

Highly significant responses to P fertilization were found in El Baul and Madre Tierra with sugar cane variety *CP 722086*. Phosphorus fertilization at 100 kg/ha of P_2O_5 increased the average first year sugar cane yield by 20.6 t/ha in El Baul and 29.6 t/ha in Madre Tierra and confirms the importance of annual P application in these soils.

The residual effect of P applied at 100 kg/ha of P_2O_5 was only significant at the Madre Tierra site where yield was increased by 5.1 t/ha. Small but not statistically significant residual effects on yield were observed with 100 kg/ha of P_2O_5 at all other sites. These results are not surprising due to the dominant presence of allophane minerals in the test soils. Allophanes adsorb and 'fix' fertilizer P over the crop year and further reduce fertilizer use efficiency and subsequent plant availability in the second crop year.

Fertilizer rates needed to achieve maximum economic yield (MEY)

Table 3. Effect of P and K split applications during the second cycle (year) in sugar cane yield.

P_2O_5	K_2O	Year applied,	-------------------Yield response, t/ha-------------------			
.... kg/ha	......	%	El Baul	Madre Tierra	Concepción	Pantaleón
100	100	Year 1 (100)	—	—	—	—
100	100	Year 1&2 (50/50)	4.55 ns	12.43[1]	8.4 ns	5.53 ns
		CV (%)	7.6	5.7	8.4	7.4
		X (t/ha)	123.0	128.8	169.2	121.0

[1] 150 kg N/ha in both years in each treatment.

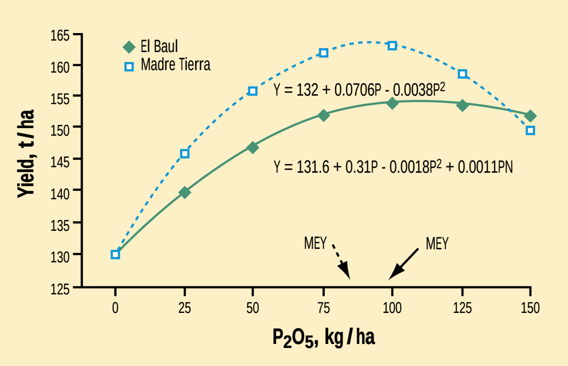

Figure 2. Regression models for P response in sugar cane in two Andisols used to estimate MEY.

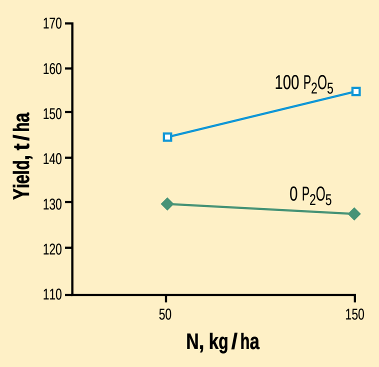

Figure 3. Effect of N in sugar cane yield (first year) with and without P fertilization in 'El Baul'.

are presented through regression analysis (**Table 2**). At Concepción, the most economic N rate was 80 kg/ha (**Figure 1**). In the case of P, the most economic rate ranged from 84 to 94 kg/ha P_2O_5 depending on the site (**Figure 2**). The El Baul site had a significant linear interaction between N and P (**Figure 3**).

Split Phosphorus and Potassium Applications

A 50-50 split of P and K between the first and second years increased sugar cane yield in Madre Tierra by over 12 t/ha. Sugar cane yield responses at Concepción (8.4 t/ha), Pantaleón (5.5 t/ha) and El Baul (4.5 t/ha) were not statistically significant (**Table 3**). However, these results do suggest that higher yields are possible through the practice of splitting P and K.

Potassium Response and Sugar Production

Small, but not statistically significant, increases in sugar content were found with the application of 100 kg/ha K_2O at all four sites. Sugar concentrations fluctuated between 9.1 percent (La Concepción) to 13.6 percent (Pantaleón). Therefore, any observed increase in yield was directly related to greater cane production. Further research is needed with higher K doses to study possible interactions between N and K. The effect of time of K application on sugar content and subsequent sugar produced also needs further study.

Guatemala's sugar cane region is on the southern coast, including the volcanic lowland and coastal valleys.

Conclusions

Phosphorus was identified as the key-limiting nutrient in sugar cane production and ratoon crops. Split P applications may significantly increase yields of sugar cane in Andisols with high P fixation capacity. Optimizing P rates near 94 kg/ha may increase yields by over 32 t/ha in low P soils. In these high organic matter soils, a 10 t/ha yield

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China: Balanced Fertilization for Sustained Yield and Quality of Tea

A survey of Chinese tea gardens revealed over half the sampled areas to be deficient in potassium (K). Deficiencies were concentrated in the southern provinces of Guangdong, Guangxi and Yunnan, which had an average available K content of 80 mg/kg. The northern regions appeared well managed, but only 16 percent of samples from Jiangsu, Anhui and Hubei had plant-available K levels greater than 150 mg/kg. The survey identified a close relationship between K deficiency and low magnesium (Mg) availability. Unbalanced fertilizer programs based on urea and other ammonium-nitrogen (NH_4-N) fertilizers promoted Mg uptake by tea and aggravated leaching losses due to increased soil acidity.

A 4-year field trial in southern China examined the effect of K and Mg fertilization on black, oolong and green tea yield and quality. The combination of K and Mg created greater nutrient use efficiency and increased yields by 17 to 28 percent for green tea, 9 to 38 percent for oolong tea, and 10 to 18 percent for black tea. Leaf quality characters such as free amino acids, polyphenols and caffeine were significantly improved by combining K and Mg. Reseachers recommend a post-harvest application during plant dormancy as the optimum time to adopt this balanced approach. **BCI**

Source: Hardter, R. 1997. ASIAFAB, 17: 31-33.

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response can still be expected with the application of 80 kg/ha of N. Annual banded applications of P_2O_5 and K_2O at 50 kg/ha each year would be preferable to a combined biannual application of 100 kg/ha at planting. This practice produced significant yield response at all sites and produced a highly significant response at Madre Tierra. Management of P fertiliser in Andisols utilizing split applications every year may become a very important tool to maximize sugar cane yields in Guatemala and other regions of Central America. **BCI**

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