Phosphorus Fertilization and Phosphorus-Extraction Method Calibration for Sugarcane Soils

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This article reports on calibration work for the Mehlich 1 extraction method, its usefulness to diagnose phosphorus (P) availability, and its correlation with P fertilizer recommendations in sugarcane. This study also evaluated the economic responses to P fertilization levels in different soils of the region.

Sugarcane is cultivated on the southern coast of Guatemala in an area of about 180,000 hectares (ha). Soils in this region are derived from volcanic ash with different intemperate grades (i.e., an extreme range of physiochemical properties). They are characteristically low in P content and have high P fixation capacity. Currently, fertilization in many sugarcane fields is done with little accuracy and precision. Without a doubt, adequate use of soil analyses for diagnosing P deficiency, crop requirement, and the appropriate fertilizer recommendations is very important if increased productivity and sustainability of sugarcane are to be achieved in the region. Very little work has been done to evaluate or calibrate soil nutrient extraction methods for soil P conditions in local sugarcane soils. Nor has there been much guidance provided to growers on rational fertilization based on optimum economic returns.

Methodology

Data from various field and laboratory experiments were collected and analyzed to establish a set of soil P correlations for the region (**Table 1**). These data included exploratory studies on nitrogen (N), P, potassium (K) and other assays having at least two different P levels (no P and plus P application rates). In addition, other experimental field sites were initiated in 1998/99, wherein the laboratory methods were:

1. North Carolina (Mehlich 1) 0.05 M HCl + 0.0125 M H_2SO_4 (Mehlich, 1953).
2. North Carolina (Mehlich 3) 0.2 M Acetic Acid + 0.25 M NH_4-NO_3 + 0.015 M NH_4F + 0.13 M HNO_3 + 0.001 M EDTA (Mehlich, 1984).
3. Exchange Resin P (Cooperband and Logan, 1994).

Calibration was achieved with the correlation analyses of soil P (Mehlich 1) of the experimental sites vs. the corresponding relative yields for sugarcane (RY). Categories of RY were arbitrarily selected as: low (RY <90); medium (90< RY <95); and high (RY >95). Response functions

Table 1. Summary of field experiments that evaluated soil P levels in 20 different sites of the sugarcane growing region of Guatemala.

	Site	Soil	Variety	Exper. type	Soil P, ppm	P doses, kg P_2O_5/ha	RY, %
1	Concepción	Andisol	CP 722086	P Doses	2.9	0, 40, 80, 120, 160, 200, 240	85
2	Mangalito	Andisol	CP 722086	P Doses	3.5	0, 40, 80, 120, 160, 200, 240	84
3	Camantulul	Andisol	CP 722086	P Doses	3.2	0, 40, 80, 120, 160, 200, 240	67
4	Cristóbal	Andisol	CP 722086	P Doses	3.7	0, 40, 80, 120, 160, 200, 240	89
5	Manacales	Andisol	CP 722086	P Doses	5.6	0, 40, 80, 120, 160, 200, 240	90
6	P. Castaño, Bálsamo	Inceptisol	CP 722086	P Doses	6.7	0, 40, 80, 120, 160, 200, 240	88
7	P. Antonio	Mollisol	CP 722086	P Doses	14.7	0, 40, 80, 120, 160, 200, 240	95
8	P. Grande	Mollisol	CP 722086	P Doses	43.0	0, 40, 80, 120, 160, 200, 240	96
9	Camantulul	Andisol	CP 722086	Resid. Eff.	0.6	0, 30, 60, 90, 120, 150	83
10	El Baúl (Los Sujuyes)	Andisol	CP 722086	P-Cachaza	0.8	0, 50	87
11	Los Patos	Inceptisol	CP 722086	NPK	1.0	0, 50, 100, 150	90
12	Cañaverales del S.	Andisol	CP 722086	Semi-com.	1.0	0, 40, 80	86
13	Pantaleón (El Triunfo)	Andisol	CP 722086	P-Cachaza	1.7	0, 50, 100	75
14	Camantulul (Cal)	Andisol	CP 722086	P-Ca	1.9	0, 40, 80, 120, 160	86
15	El Baúl	Andisol	CP 722086	Explor NPK	0.8	0, 50, 100, 150	86
16	Cañaverales del S.	Andisol	Mex 68P23	Explor NPK	1.0	0, 50, 100, 150	86
17	Guatalón	Andisol	Mex 68P23	Explor NPK	2.7	0, 50, 100, 150	94
18	Irlanda	Mollisol	CP 722086	Explor NPK	30.5	0, 50, 100, 150	102
19	Bougambilia	Entisol	CP 722086	Explor NPK	40.0	0, 50, 100, 150	95
20	Belén	Inceptisol	CP 722086	P-Cachaza	5.5	0, 50	88

RY was estimated based on: RY (%) = (Y_0/Ymax) * 100; where: RY = relative yield; Y_0 = check yield (0 P); Ymax = maximum yield (various P rates).

to estimate optimum economic doses (OED) for P were individually created for all field assays with three or more P levels to estimate the quadratic function and the model adjustment (Pérez and Melgar, 1998; Pérez et al., 2001). The OED for P was determined from the regression model, when they had the adequate adjustment; when not, evaluated discrete levels were considered where maximum yields were obtained.

Results

High linear correlations were found between all three soil test methods. The highest correlation (r = 0.98) was found between Mehlich 1 and Exchange Resin-P. The high correlations found between all methodologies indicate that any of the methods could be used. This flexibility permits the fastest, least complicated, and most practical method. Mehlich 1 was finally chosen because it is also the most common extraction method used in Guatemala.

Sugarcane RY and the corresponding soil P levels in 20 different sites are shown (**Figure 1**). The lower RY is associated with low P levels [<8 parts per million (ppm)], but for practical purposes <10 ppm can be used to define low P soils. The middle category was associated with soil P levels between 10 to 30 ppm. Values above 30 ppm were well correlated with the highest relative yields in most fields and was selected as the level at which sufficient P is available for a good sugarcane yield for the conditions found in the region.

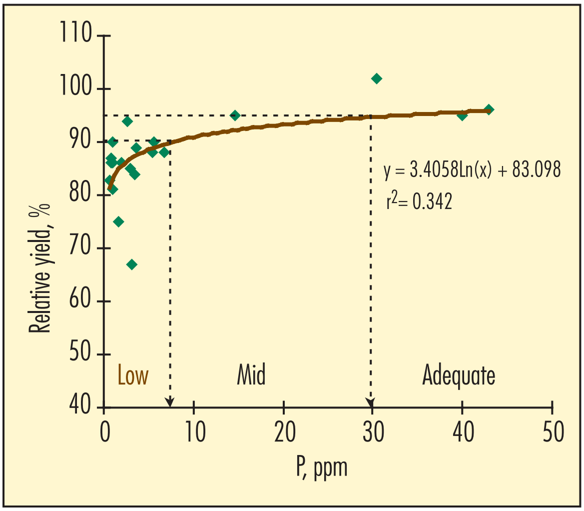

Figure 1. Extractable P (Mehlich 1) vs. relative sugarcane plant yield in 20 field experiments in Guatemala.

The optimum economic rate of P depended on the location. Optimal P levels were estimated using adjusted regression functions that were statistically significant (p=0.05). When functions were not significant, values were taken from P levels where maximum yield was reached. **Table 2** summarizes the information as a first approximation of P fertilizer recommendations for three different soil categories (i.e., soil type and depth). Blank spaces indicate few data or a lack of information for that site. Recommendations will be adjusted as more information becomes available as experimental and commercial results confirm or improve these data.

Table 2. Phosphorus recommendation (kg P_2O_5/ha) guideline according to soil P category.

Soil test category, ppm	Andisols and Inceptisols				Mollisols	
	Superficial & moderately deep soils		Deep soils			
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
P < 10	85	50	100 to 160	50	–	–
P 10 to 30	–	–	–	–	50	40
P > 30	–	–	–	–	0/50	0

Conclusions

A common method of soil P extraction (Mehlich 1) was calibrated for sugarcane soils of Guatemala. Three categories of soil P fertility were established: 1) low: <10 ppm; 2) medium: 10 to 30 ppm; and 3) adequate: >30 ppm. Recommendations were estimated taking into consideration the Mehlich 1 categories, soil type, and crop growing conditions.

More research emphasis should be spent on including sites with medium soil P levels in order to fill a data gap. Also, the residual effects of fertilization should be studied to get a better understanding of the complete crop cycle. New field experiments are currently under way and are comparing split P applications vs. one full P application in each crop cycle. This work will help to understand the precise P needs of sugarcane and the optimum economic doses for Guatemalan soils. **BCI**

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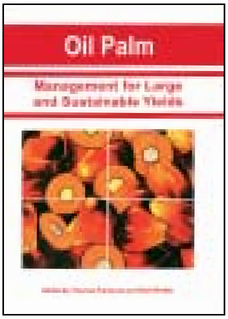

A new book on modern oil palm management was recently introduced by PPI/PPIC and the International Potash Institute (IPI). Recognized experts in the fields of oil palm management and plantation agronomy, primarily in Southeast Asia, were invited to contribute to the volume. It was edited by R. Härdter of IPI and Thomas Fairhurst, formerly with PPI/PPIC.

The 384-page book includes emphasis on important interactions between the plant's inherent capacity to convert solar radiation into palm oil and the crop's agronomic management requirements. Nutritional aspects and precision agriculture technology are also addressed. Other contents topics include: land selection, clonal oil palm, legume cover plants, fertilizing for maximum return, and utilization of field residues.

The book is available for purchase either as single copies, multiples, or in combination with other publications on oil palm management. For more information, contact:

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