Site-Specific Nutrient Management in the Highlands of Cartago Province

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A coffee/sugarcane plantation located in the highlands of Cartago Province in Costa Rica has overcome many obstacles and has successfully adopted the principles of site-specific nutrient management to its unique landscape.

Traditionally, the highlands of Central and South America have been excluded from large-scale implementation of technologies accompanying site-specific nutrient management due to problems of equipment availability and terrain accessibility. However, new ideas on how these challenges can be overcome may allow site-specific management to be adopted on all landscape types.

Aerial photograph of San Juan de las Viñas, Costa Rica.

The main objective of this project's site-specific system was to manage plantation crops according to site characteristics, maximize the use of available inputs and resources, and minimize any detrimental effects the cropping system might have on the environment. Several years of on-farm experience with extensive fields near San Juan de Viñas, Costa Rica, clearly demonstrated that fertility management based on mean nutrient contents has created more problems than it has solved. The first steps toward site-specific management produced interesting results and by 1999 it became obvious that this approach was the best option.

The study was initiated on 250 ha at El Sitio Farm located in the highlands of the province of Cartago, Costa Rica. The site's land relief is very irregular and the farm is occupied by 100 ha of coffee and 150 ha of sugarcane. Coffee is grown on the most irregular side of the farm, while sugarcane areas tend to be located on the flatter terrain (see photos on next page).

Land used for coffee production is divided into 20 fields that differ in size, crop variety, and shade level. Soil test information is available for the last five years and yield records have been kept for three years

Left: Land used in coffee cultivation in El Sitio farm, Viñas, Costa Rica.

Right: Land used in sugarcane cultivation in El Sitio farm, Viñas, Costa Rica.

for each field. The most difficult task has been to obtain reliable yield data due to the manual system used for fruit harvesting.

After much change in sugarcane field size and number, the land under sugarcane is now securely divided into eight fields. This stability is allowing for generation of consistent information from the fields. Soil test information has been gathered for the past five years using a 24 month production cycle. Yield information has been gathered for the last 11 years, but some limitations exist due to the various adjustments in field size in the past.

Both coffee and sugarcane areas have been in continuous cropping for more than 40 years. The effect of this use on the soil characteristics is shown in **Table 1**. Soils are classified as Udands in the Andisol order and it is probable that these soils were more or less uniform when farming began since they are derived from the same parental volcanic ash. However, more than 40 years of cropping has created measurable differences in some soil properties.

Table 1. Average soil tests for the coffee and sugarcane fields, El Sitio farm, Viñas, Costa Rica.

Crop	Year	No. of fields	pH	Acidity saturation, %	ECEC[1]	Total acidity	Ca	Mg	K	P	Mn	Zn
					----------		$cmol_{(+)}/L$	----------		-----	mg/L	-----
Coffee	1997	20	4.6	29	11.62	3.1	7.15	0.75	0.62	50	17	3
Sugarcane	1998	8	5.2	17	3.85	0.7	3.85	2.78	0.21	0.2	6	2

[1]ECEC = Effective cation exchange capacity.

Adequate levels of phosphorus (P) and potassium (K) in the coffee fields are the result of uniform and constant application of these nutrients to coffee – historically the most profitable crop. Sugarcane fields are generally lower in P and K since the extraction of nutrients is higher than the amount applied as fertilizer. **Table 2** compares nutrient application in the coffee and sugarcane fields before 1997.

Table 2. Nutrient uptake and application in coffee and sugarcane fields, El Sitio farm, Viñas, Costa Rica.

Crop	Yield	Nutrient uptake N	P_2O_5	K_2O	Mg
		-----	kg/ha/year	-----	
Coffee	45 fanegas[1]/ha	115	18	140	10
Sugarcane	180 t/ha	87	53	225	22

Crop	Date	Nutrient application N	P_2O_5	K_2O	Mg
		-----	kg/ha/year	-----	
Coffee	Prior 1997	216	62	108	94
Sugarcane	Prior 1997	97	57	83	26

[1]One fanega = 225 kg of recently harvested fresh mature fruit.

Preliminary Results of Site-Specific Management

Construction of a nutrient management database made it possible

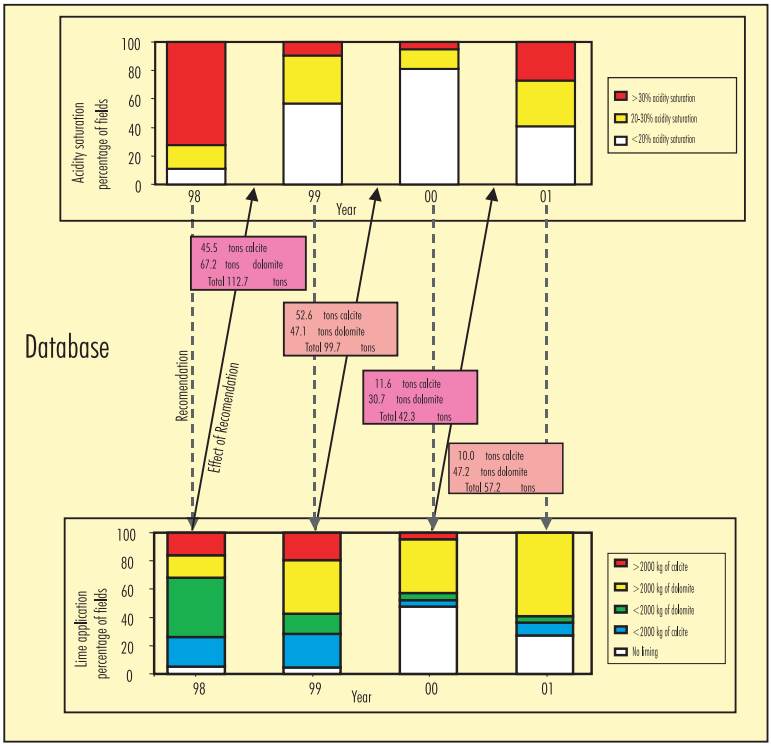
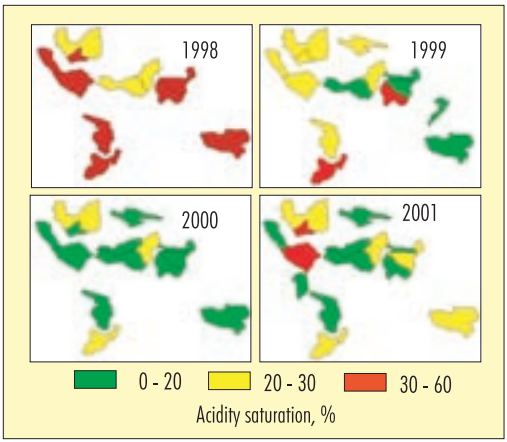


Figure 1. Distribution of acidity saturation on coffee fields in El Sitio, Viñas, Costa Rica.

Figure 2. Effect of site-specific management on acidity saturation in coffee fields of El Sitio farm, Viñas, Costa Rica.



for researchers to isolate the main nutritional problems at field scale. For example, database results (not fully presented) indicated that soil acidity problems were more intense in some fields and not present in others. This problem has been controlled over the years by calcite application based on average soil test results. Using this approach, based on the liming recommendations for tropical volcanic soils, more than 2,000 kg lime/ha would be needed for all fields. It was clear that site-specific management was the best way to approach this problem.

The effect of site-specific management of acidity is presented as the percentage of fields affected by different degrees of acidity, the amount of lime used to solve the problem, and the treatment's effect in the following year (**Figure 1**). The rate of lime applied equaled the amount needed to reduce the percentage of acidity to 15 percent and dolomite was applied when the magnesium (Mg) soil test was less than 0.6 $cmol_{(+)}$/L.

The trends can be observed when data are applied to Geographic Information System (GIS) software (**Figure 2**). The effect of this type of management on soil acidity is also observed in the average soil test results for each year of the study (**Table 3**), and demonstrate the effect of site-specific management for the whole coffee and sugarcane area.

The effect of controlling acidity problems in coffee is evident. However, lime application increased in 2001, which was the result of less than optimal liming rates in 2000 due to economic limitations of low coffee prices. The GIS can assure constant monitoring of the situation and management decisions can

Table 3. Average soil test results for coffee fields from 1999 to 2001, El Sitio farm, Viñas, Costa Rica.

Year	pH	Acidity saturation, %	ECEC	Total acidity	Ca	Mg	K	P	Mn	Zn
			----------	cmol$_{(+)}$/L	----------			-----	mg/L	-----
					Coffee					
1997	4.6	29	11.62	3.1	7.15	0.75	0.62	50	17	3
1998	4.7	33	5.62	1.9	3.02	0.70	0.31	25	9	2
1999	4.9	17	7.76	1.1	5.13	1.00	0.53	25	17	4
2000	5.1	11	8.39	0.7	5.81	1.27	0.61	31	9	7
2001	5.1	19	7.13	1.0	4.70	0.99	0.49	33	7	4
					Sugarcane					
1998	5.2	17	3.85	0.7	2.78	0.21	0.18	8	6	2
1999	4.7	15	4.43	0.6	3.18	0.43	0.18	14	6	3
2000	5.2	11	3.62	0.4	2.80	0.35	0.11	7	6	1
2001	5.5	10	4.90	0.5	3.78	0.50	0.16	21	10	4

be derived from this accurate knowledge base.

Control of soil acidity affects root performance and nutrient uptake which, in turn, promotes greater nutrient use efficiency. Site-specific management also improved the fertilizer recommendation system. Two or three different nutrient application options are designed each year for coffee and sugarcane based on nutrient requirements and the soil test results of each field. The effect of nutrient application is recorded in the database and management is normalized by the conditions of each field. The effect of site-specific management on soil P is shown in **Figure 3**.

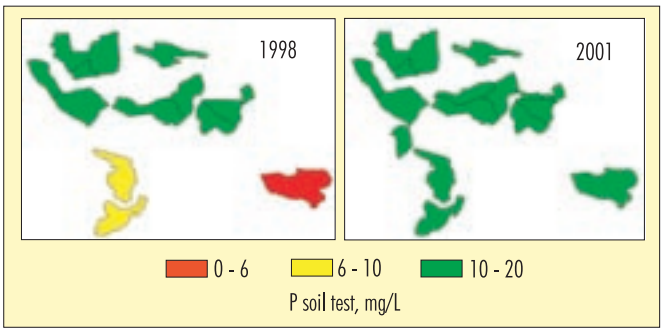


Figure 3. Effect of site-specific management on P soil test in coffee fields of El Sitio farm, Viñas, Costa Rica.

Finally, other important decisions can be made based on the information accumulated in the database. Disease problems like Corchosis (a condition caused by an interaction of *Meloidogyne arabica* and *Fusarium spp*), can be monitored and managed. Pruning and harvesting management can be improved using the information accumulated over the years. The system of harvesting is the major problem in terms of constructing a reliable database in crops like coffee where fruit collection is a manual operation. As well, imaginative recording methods for the harvested products are being developed to take advantage of the information provided by yield responses to different crop and nutrient management strategies. **BCI**

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