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ANALYSIS OF THE MAPPING RESULTS USING SOILOPTIX® TECHNOLOGY IN CHILE AFTER TWO SEASONS

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Abstract.

Soil mapping is a key element to successfully implement Integrated Nutrient Management (INM) in high value crops.

SoilOptix® is a mapping service based on the use of gamma radiation technology that arrived in Chile in 2019. Since then, more than 2000 ha have been mapped, mainly in fruit orchards and vineyards.

The technology has demonstrated its value in determining the most limiting factors in new and established orchards, and the possibility of correcting them in a site-specific manner.

The identified limiting factors (LF) have varied widely and have included low P values, excess Na, high salinity, copper toxicity, and low buffer capacity, among others.

Another important use for the technology is the site-specific estimation of N mineralization as well as the available N, and from them a better N balance and a proper estimation of the Nitrification Inhibitor (NI) rates.

Finally, for new orchard plantations, a zoning based on gamma radiation (counts per second) or texture, is a useful tool for irrigation design.

Keywords. *Integrated nutrient management, soil mapping, SoilOptix, fruit orchards, Chile*

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Introduction

There are several soil mapping techniques, many of which are aided by proximal sensors. One of them is the gamma radiation sensor, commercially available since 2019, as SoilOptix® (SoilOptix, 2022).

All soils naturally emit gamma radiation, derived from their more stable isotopes such as potassium (40), cesium (137), thorium (232), and uranium (238). Gamma ray sensors can measure these signals, which represent soil mineralogy and are temporarily stable, not being affected by humidity or soil vegetation cover (Ortega, 2019).

Normally, these sensors are mounted on a vehicle, at a certain distance from the ground, and with the help of a global navigation satellite system (GNSS) collect georeferenced data. From these data, maps of gamma radiation of the soil are constructed, and samples are collected in strategic places in the study area. Finally, from the radiation map and the analytical results of the calibration samples, using appropriate algorithms, detailed maps of soil properties are constructed. To date, it is possible to derive more than 25 soil properties, with a high degree of detail, with an average of more than 700 measurement points/ha (SoilOptix,2022; Ortega, 2019).

This technology fits perfectly under the concept of integrated nutrient management (INM) (Ortega, 2015; Poblete et al. (2021) and can be used both in pre-planting and in orchards in production; In the latter case, the band that has been fertilized for years through drip irrigation is measured to determine potential nutritional problems. Based on the physicochemical properties evaluated, homogeneous management zones are constructed for irrigation design, the application of amendments and site-specific fertilization (Ortega and Santibañez, 2007).

The objective of the present work was to evaluate the agronomics behind the mapping results using the SoilOptix® technology in Chilean fruit orchards.

Materials and methods

Fifty-two fields located from the Bio-Bio (37.46° S, 72.36° W) to the Valparaiso (32.83° S, 70.59° W) regions were surveyed with a total area > 2000 ha.

In all cases, soil samples, for calibration purposes, were randomly collected with an intensity of 1 sample every 4 ha. The minimum number of samples per field was 4. Samples were analyzed for soil fertility and texture using standard laboratory procedures.

Detailed (> 700 data points/ha) soil maps for 29 soil properties were produced by SoilOptix® technology: clay, silt, clay + silt, leakability, loamability, pH, EC, SOM, available N, Olsen-P, extractable K, extractable S, Ca, Mg, K, Na, effective CIC, Ca sat., Mg sat., K sat., Na sat., Ca/Mg, K/Mg, extractable B, DTPA-Zn, DTPA-Fe, DTPA-Cu, and DTPA-Mn.

Using established critical levels for soils devoted to fruit production, the proportion of the total area of each field, either deficient in a given nutrient, or showing an excess of Cu or salinity was determined (Figure 1).

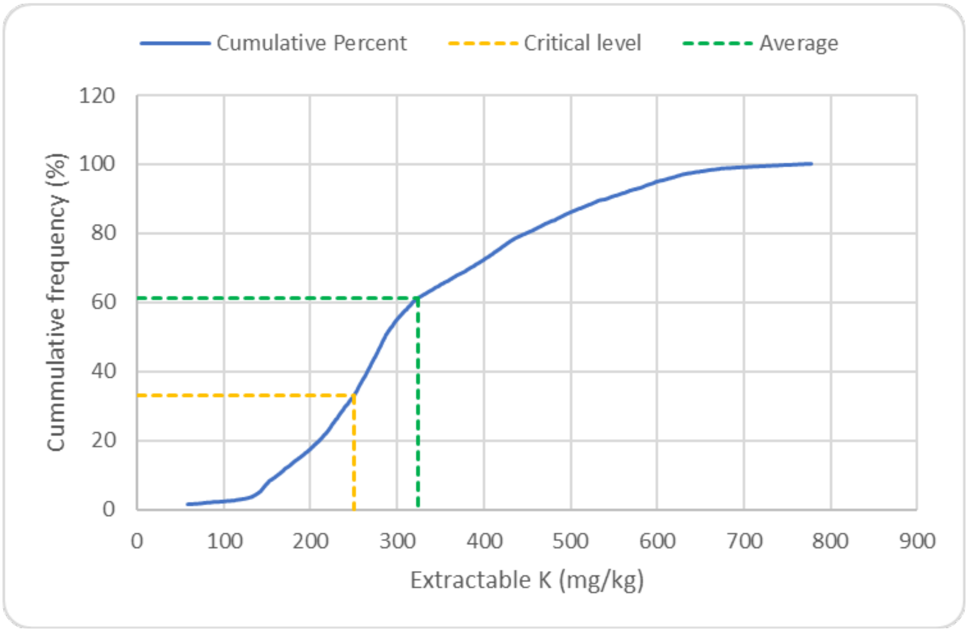

Figure 1. Cumulative distribution for extractable K showing % area under the critical level and under the average.

Selected critical levels are presented in Table 1.

Table 1. Selected critical levels

Property	Critical level	Unit	Observation
SOM	2(4)	%	depending on soil
pH	6.5	pH units	
Olsen-P	30	mg/kg	
Extractable K	250	mg/kg	
Extractable Mg	2	Cmol(+)/kg	
DTPA-Zn	1	mg/kg	
DTPA-Cu	>10	mg/kg	excess
DTPA-Cu	>50	mg/kg	toxic
EC (1:2.5)	>1	dS/m	excess

Data were analyzed by frequency analysis and descriptive statistics.

Results

Surveyed area by crop species varied from 0.4 to 22% for pear and walnut respectively.

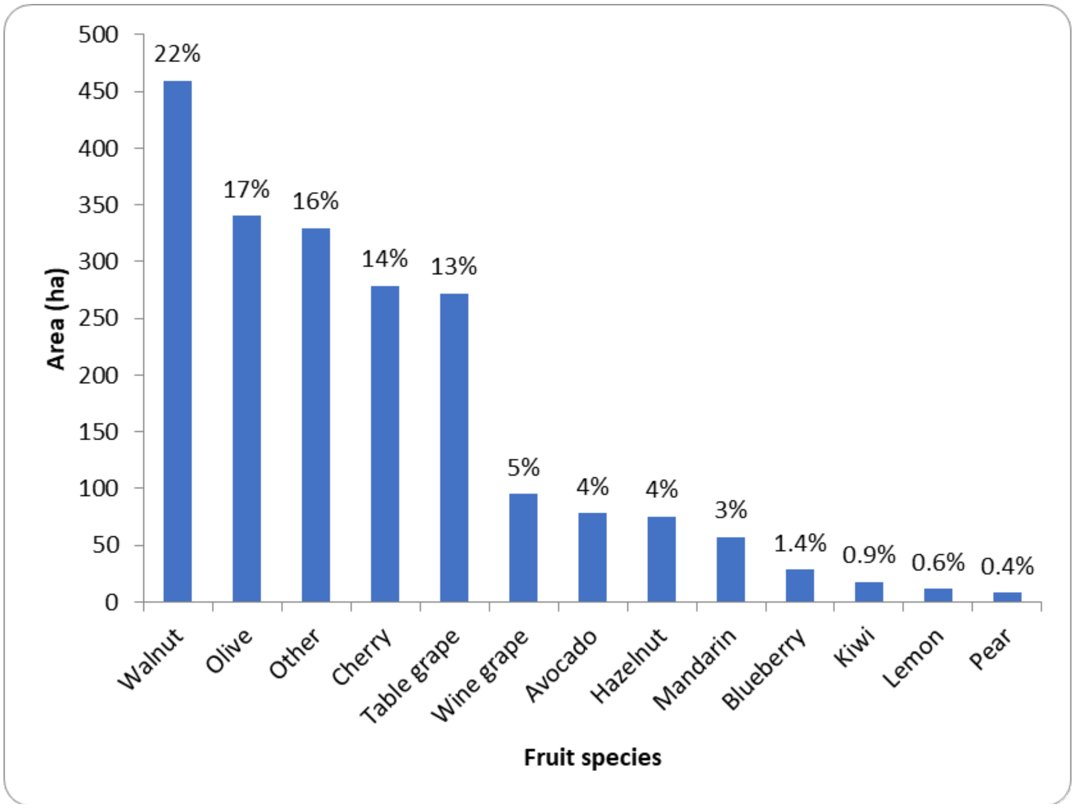

Figure 2. Surveyed area by crop species

A 59% of the studied area corresponded to established fruit plantations while the remaining were soils devoted to new plantations (Figure 3).

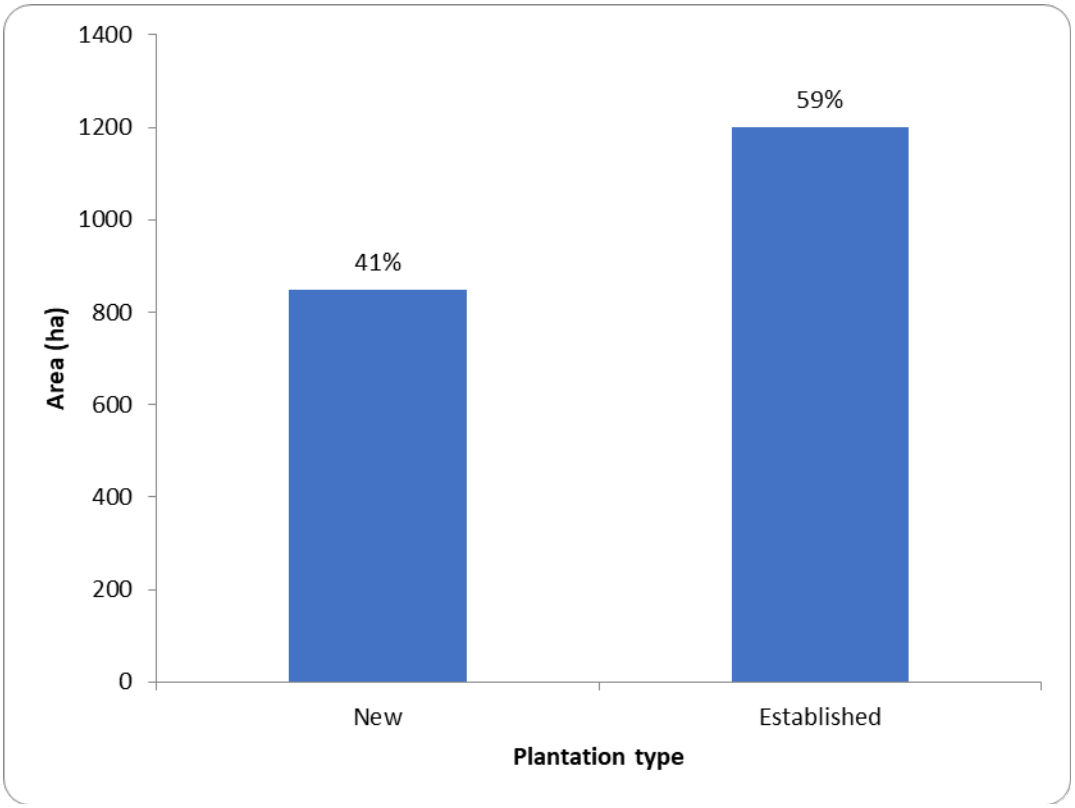

Figure 3. Surveyed area by plantation type.

The proportion of the surveyed fields presenting some limiting factor varied from 10 to 75% depending on the evaluated soil property. Soil pH was the most frequent limiting factor.

The degree of deficiency within fields also depended on the studied factor and, on average, varied between 42 to 72% for Mg saturation and pH, respectively. However, there was a large variance in terms of the proportion of the area affected (Table 2).

Table 2. Number of fields with deficiencies and percent deficient area within fields.

Soil property	n° fields with deficiency	% Deficient fields	% Deficient area			
			Mean	Median	Std. Dev.	CV (%)
pH	39	75	72	87	33	46
P	37	71	59	65	35	59
K	32	62	56	60	35	62
B	31	60	67	83	35	53
Ca Sat.	28	54	66	71	33	49
SOM	24	46	43	27	37	86
Mg	10	19	46	39	36	78
Zn	10	19	54	61	37	70
Mg. Sat	9	17	42	16	38	90
K. Sat.	5	10	72	88	38	53

Regarding limiting factors by excess, 40% of the surveyed fields presented salinity problems while 44% of them had excess Cu. Even more, 25% of the studied fields had toxic levels of DPTA-Cu. Average proportion of the affected area within fields varied between 32 and 92% for Cu toxicity and high Cu, respectively, showing a smaller variation compared to deficiencies (Table 3).

Table 3. Number of fields with excess and percent excess area within fields.

Soil property	n° fields with excess	% Fields with excess	% Excess area			
			Mean	Median	Std. Dev.	CV (%)
EC	21	40	89	100	25	28
High DTPA-Cu	23	44	92	100	16	18
Toxic DTPA-Cu	13	25	32	30	17	53

The proportion of the total studied area needing amendments are presented in Figure 4. About 60% of the surveyed area needed liming, while 38 and 44% needed potassium and phosphate amendments, respectively. On the other hand, 24% of the total studied area needed an organic amendment (Figure 4).

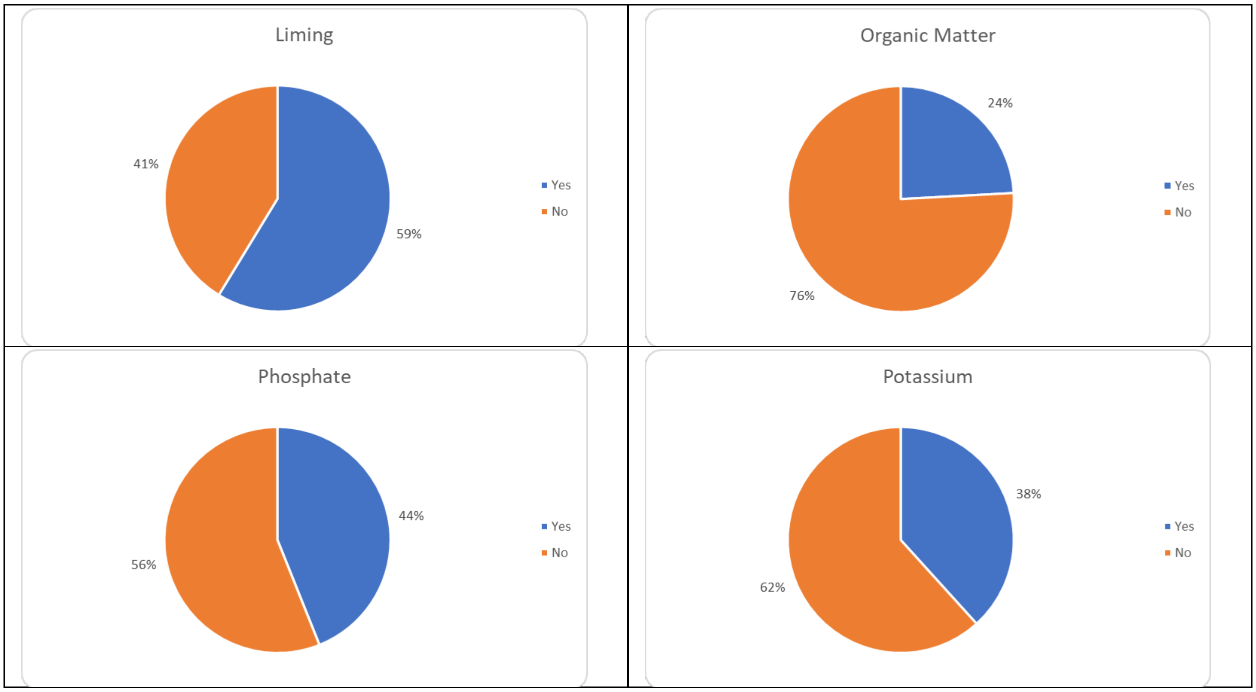

Figure 4. Proportion of the total surveyed area needing amendments.

The proportion of the total studied area affected by high levels of Cu was 35% (724 ha), out of which a 23% (8% of the total) had toxic Cu levels (Figure 5).

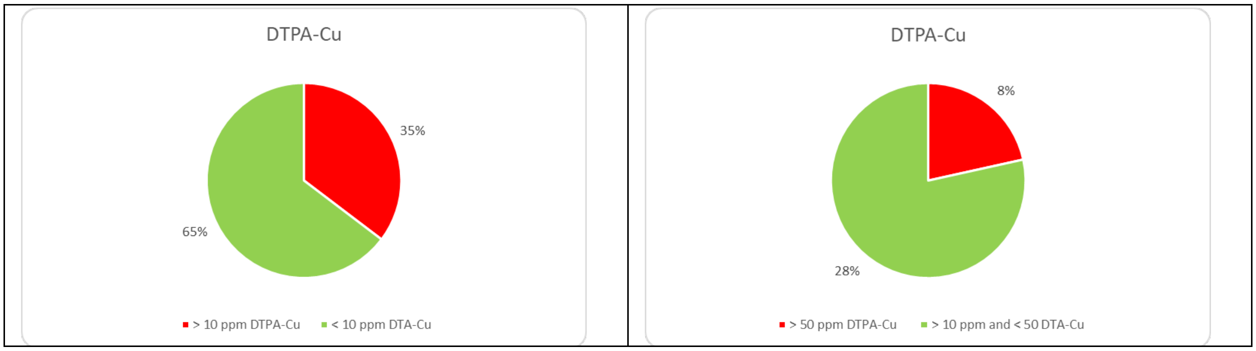

Figure 5. Proportion of the surveyed area with high levels of DPTA-Cu (left) and partitioning into high (>10 ppm) and toxic (> 50 ppm) DTPA-Cu levels.

Conclusions

Soil mapping technology has demonstrated its value in determining the most limiting factors, in new and established orchards, and the possibility of correcting them in a site-specific manner. Agronomically, most important limiting factor for fruit production is high extractable Cu, which can be controlled by high pH and sequestration with stabilized organic matter.
Other limiting factors are phosphorus and potassium which can be corrected in winter time, during recess, using conventional fertilizer sources.

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