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CHANGES IN SOIL QUALITY WHEN BUILDING RIDGES FOR FRUIT PLANTATION

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Abstract

Many fruit plantations are usually performed in ridges for various reasons including, escaping from a clay horizon, improving overall soil quality and drainage, among others. Normally ridges are built using the surface horizons, producing a mixture of soils layers, and therefore changing the quality of the soil at the rooting zone.

We were interested in studying the changes in soil properties when building ridges in a flat alluvial soil that was planted with avocado.

A detailed soil mapping using SoilOptix technology TM was performed at two times: 1) over bare soil before building the ridges and 2) after avocado planting over the ridges. Twenty-nine soil layers were produced in each case and compared pixel to pixel. As expected, significant changes were observed after building the ridges. Spatial differences were observed in most evaluated properties.

Keywords: Soil mapping, ridges, fruit, plantations

1. Introduction

Chile currently has 353,000 hectares of fruit plantations (Odepa-Ciren, 2021). To obtain high-quality fruit production, well-drained soils are needed, and, in the case of avocado, with at least 1 m of soil free of the water table (Avocado Source, 1990). Besides, soils should have neutral pH, low electrical conductivity (<1 dS m^{-1}), good organic matter content, and a proper sum of bases and CEC (Vidal, 2018). However, many soils devoted to avocado production present limiting factors that must be corrected before planting (Ortega 2018). These factors may be physical: shallow soils, clay texture, drainage problems, etc. or chemical: low pH, low organic matter content, P and K deficiencies, etc.

The use of ridges has been implemented to plant many fruit species, in particular avocado, with the main objective of improving soil drainage. Ridges are built by mixing the soil, forming an isosceles trapezium oriented in the direction of the plantation. The height of the ridges varies between 50 to 80 cm with a base of 1.5 to 2 m (Carrasco, 2010).

Ridge construction provokes changes in soil quality, which have not been quantified to date. The use of proximal sensors such as SoilOptix^{TM}, can be used to evaluate changes in soil properties. The objective of this work was to evaluate the changes in soil properties when building ridges in a flat alluvial soil that was planted with avocado.

2. Materials and methods

2.1 Location

The study was performed in Peumo commune (Rapel Valley, Chile) located at the coordinates
34º19'34.92'' South and 71º15'23.67'' West. The study area corresponds to a semi-arid, Mediterranean region, with a temperate climate. The soil belongs to the order Mollisol, which presents a silt loam texture, neutral pH, low organic matter content (~2%), and medium fertility. Temperatures are in the range of 5.5 to 27.6 ºC, while precipitation varies between 400 and 420 mm yr^{-1}.

2.2 Experimental design

A detailed soil mapping using SoilOptix technology ^{TM} was performed at two times: 1) over bare soil before building the ridges and 2) after avocado planting over the ridges. Twenty-nine soil layers were produced in each case and compared pixel to pixel.
Together with the ridge construction, chemical amendments of $CaCO_3$, Triple Superphosphate, Potassium Chloride, and Magnesium Sulphate were performed.

2.3 Statistical analyses

Maps were produced at the same pixel size (3 x 3 m) for each evaluation time.
The changes in soil properties before and after the ridge construction were evaluated using the following analyses:

- Mean and coefficient of variation (CV) before and after ridging, mean change (%), and CV change (%).

$$\%change = \frac{(before - after)}{before} * 100$$

- Correlation analysis for each property before and after ridging
- RMSE and % change according to the following equations:

$$RMSE = \sqrt{\frac{\sum(before - after)^2}{n}}$$

$$\%change = \frac{RMSE}{before} * 100$$

3. Results and discussion

As expected, building the ridges caused important changes in soil quality affecting not only nutrient contents but also their spatial variability. Some of the soil properties were increased in the surface layer, while some others decreased significantly. Similarly, their variability as measured by the coefficient of variation (CV) increased or decreased with ridging (Table 1, Figure 1).

The greatest changes after making the ridges were, surface EC, sand, DTPA-Cu, and Soil Organic Matter (SOM). Soil organic matter was diluted in the soil, dropping from levels above 4% to values below 1%. These values can be limiting for fruit production affecting soil water retention, root development, and microbial growth. Besides, the spatial variability of SOM content increased with ridging (Table 1, Figure 1).

In the case of potassium, that was amended in the soil before ridging, its content increased moderately (34%), however its variability was greatly reduced (-97% reduction), with average levels close to optimum (300 ppm).

A beneficial effect of ridging was the dilution of extractable Cu (DPTA-Cu), which was at toxic levels (> 50 ppm) before preparing the soil. The sand content of the surface layer increased from the original state of the soil when building the ridges; this could be a positive effect for avocado plantations since they need a more permeable soil.

The gamma radiation of the soil showed a slight variation between dates verifying the stability of the measurements. Besides, the correlation coefficient between the measurements before and after ridging was high and significant (Table 1).

In terms of evaluating the changes in soil properties, the use of % change in mean and RMSE as proportion of the initial mean change showed a strong correlation, indicating that either one can be used for the purpose of comparing maps pixel to pixel (Figure 2).

Table 1. Changes in soil properties with ridging.

Variable	Mean-Before	CV (%)	Mean-After	CV(%)	Change mean (%)	Change CV (%)	r	t	p-value	RMSE	% Change
Counts per second((1)/s)	815,9	4,1	931,8	4,6	14,2	10,7	0,8	142,3	0,0000	118,67	14,5
HZ1-% clay(%)	57,1	6,8	6,0	8,4	-89,5	22,8	-0,4	-45,1	0,0000	51,29	89,8
HZ1-% sand(%)	37,7	12,0	84,9	1,5	125,2	-87,3	-0,8	-142,2	0,0000	47,51	126,1
HZ1-% soil silt(%)	5,2	12,3	9,2	14,3	75,6	16,0	-0,6	-91,1	0,0000	4,33	83,0
Clay+Silt(%)	62,3	7,3	15,1	8,6	-75,7	17,9	-0,8	-142,2	0,0000	47,51	76,2
Leakability(unit)	72,7	7,9	7,8	9,9	-89,3	25,1	-0,7	-97,3	0,0000	65,22	89,7
Loamability(unit)	77,9	8,2	16,9	10,4	-78,3	27,3	-0,8	-125,0	0,0000	61,47	78,9
Elevation(m)	496,4	0,6	486,0	1,1	-2,1	95,4	0,2	17,8	0,0000	11,78	2,4
pH(unit)	6,4	0,9	5,9	0,7	-7,5	-22,5	0,8	124,4	0,0000	0,49	7,5
Surface EC(dS/m)	0,5	11,5	1,2	13,8	149,9	19,2	-0,5	-67,9	0,0000	0,72	155,6
Soil OM(%)	5,2	12,3	0,6	27,4	-88,4	123,1	-0,5	-60,9	0,0000	4,66	89,6
Available Nitrogen(ppm)	13,9	23,1	0,0	9,0	-99,7	-60,9	-0,3	-30,2	0,0000	14,21	102,4
P-Olsen(ppm)	61,3	34,2	53,3	16,6	-13,1	-51,6	-0,4	-49,8	0,0000	27,16	44,3
Extractable K(ppm)	253,3	21,2	321,6	0,7	26,9	-96,5	-0,8	-127,2	0,0000	88,00	34,7
Extractable S(ppm)	4,2	16,7	18,3	27,6	334,0	65,0	0,1	13,9	0,0000	14,95	354,5
Ca(cmol/kg)	13,8	8,0	3,2	10,1	-77,1	25,5	-0,4	-52,8	0,0000	10,75	77,7
Mg(cmol/kg)	2,3	12,7	1,1	4,6	-51,9	-63,8	-0,5	-59,0	0,0000	1,23	53,7
K(cmol/kg)	0,6	21,2	0,8	0,7	26,9	-96,5	-0,8	-126,8	0,0000	0,23	34,7
Na(cmol/kg)	0,1	3,8	0,1	3,6	-11,0	-4,0	-0,2	-16,5	0,0000	0,01	12,2
CICE(cmol/kg)	17,0	8,4	5,7	6,3	-66,3	-24,4	-0,5	-58,3	0,0000	11,39	67,0
SatCa(%)	81,5	2,1	55,2	3,8	-32,3	80,2	0,2	23,5	0,0000	26,42	32,4
SatMg(%)	13,4	4,4	19,2	1,8	43,4	-60,3	0,5	57,1	0,0000	5,83	43,6
SatK(%)	3,8	15,7	14,4	6,0	280,7	-61,7	0,4	42,8	0,0000	10,69	281,6
Rel Ca/Mg(unit)	10,2	6,1	4,8	5,6	-52,8	-7,3	0,4	48,5	0,0000	5,41	53,1
Rel K/Mg(unit)	0,3	14,3	0,8	4,3	165,5	-70,1	0,3	27,8	0,0000	0,47	166,3
Fe-DTPA(ppm)	76,0	10,5	21,8	25,7	-71,3	144,5	0,0	-2,2	0,0306	55,04	72,4
Zn-DTPA(ppm)	8,2	23,1	5,9	20,8	-28,0	-9,8	-0,2	-17,1	0,0000	3,32	40,6
Cu-DTPA(ppm)	129,7	18,7	2,0	22,1	-98,5	18,1	-0,1	-13,4	0,0000	130,06	100,2
Mn-DTPA(ppm)	10,8	21,4	28,3	18,7	162,2	-12,6	-0,5	-66,0	0,0000	18,79	174,0
Extractable B(ppm)	1,9	18,5	1,3	18,2	-30,3	-1,6	0,3	28,5	0,0000	0,70	36,1

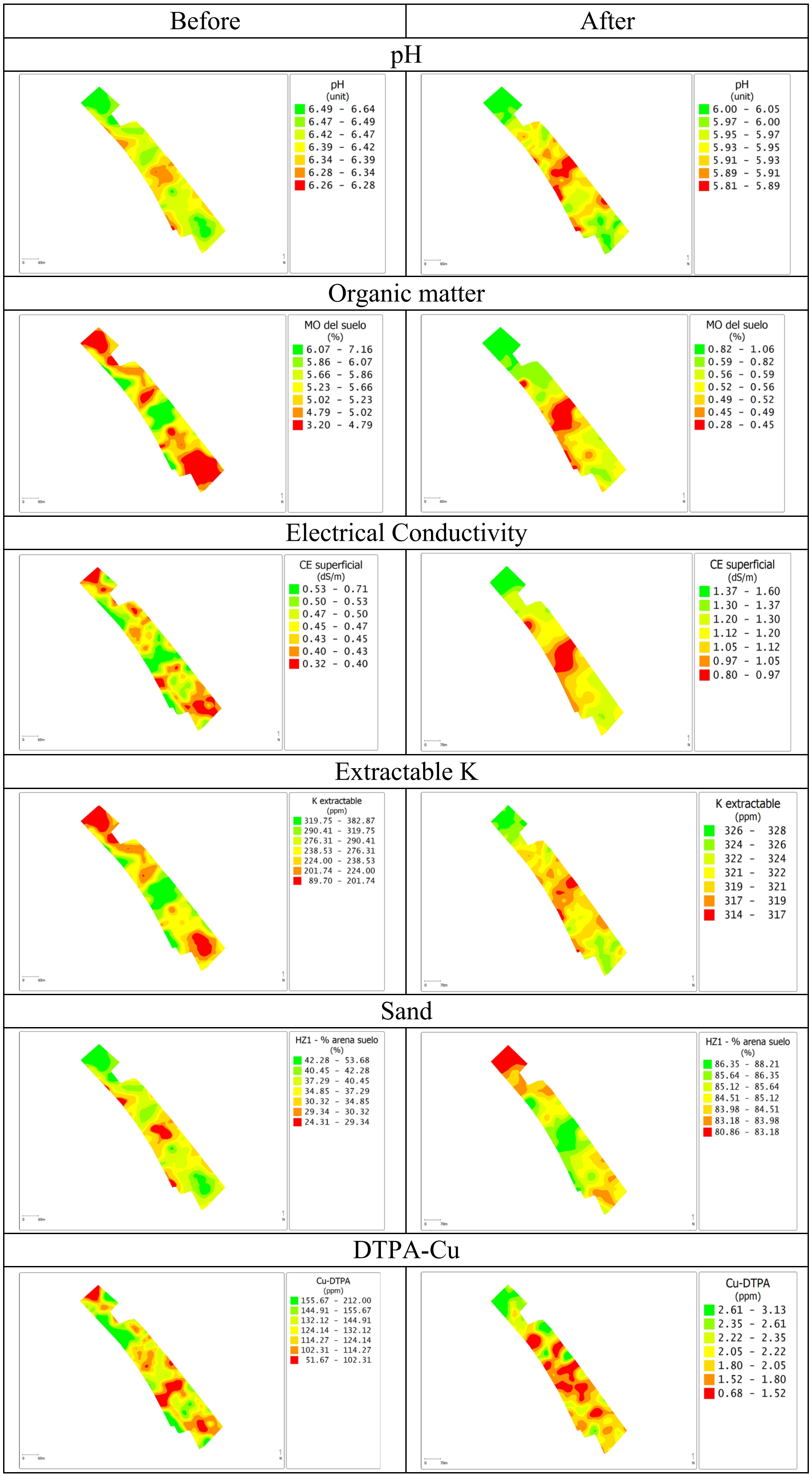

Figure 1. Spatial variability of selected soil properties before and after ridging the soil.

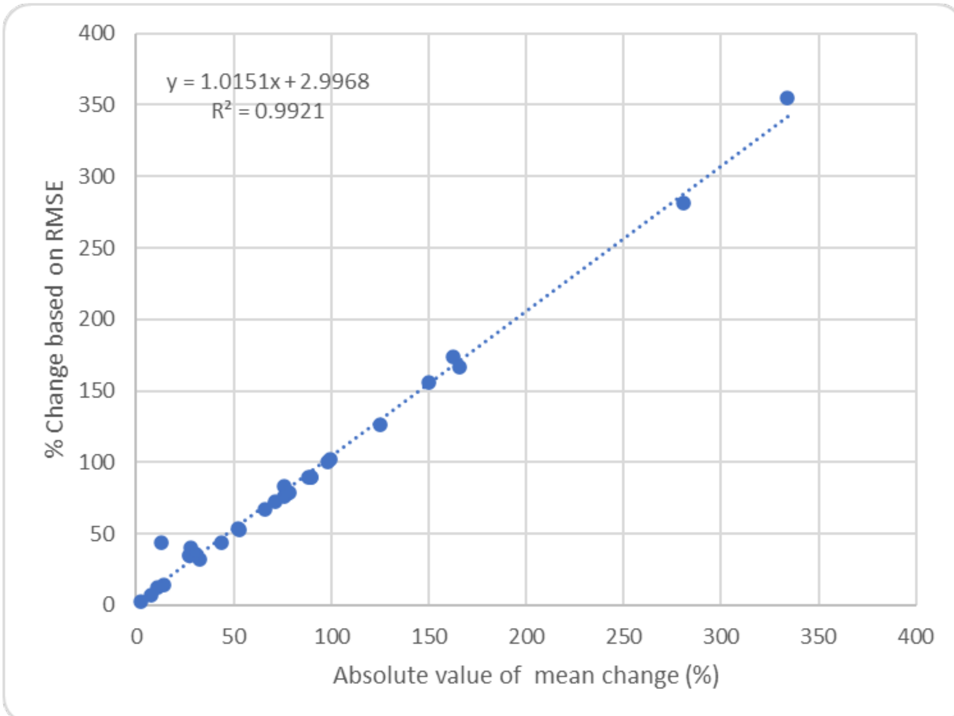

Figure 2. Relationship between absolute value of mean change and % change based on RMSE.

4. Conclusions

- The construction of ridges produced important changes in physical and chemical soil properties of the 0-30 cm horizon.
- Positive changes in soil properties after ridging were: decrease of DTPA-Cu toxic levels and increase of sand content which could improve soil permeability.
- Negative changes in soil properties after ridging were: decrease in organic matter and increase in electrical conductivity.
- Properties of the soil that were amended before ridging, such as potassium, showed an increase in their levels and homogeneity.
- Gamma radiation showed stability between dates of measurement.
- Percent change based on mean change or RMSE are as equal as effective to evaluate pixel to pixel changes.

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