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Predictive analysis of pH response to aglime in a Salvadorian field

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Abstract
Constant misuse of fertilizer and bad agriculture practices lead to a decrease of soil pH, affecting fertility conditions for crop production. In El Salvador, calcium hydroxide is the cheapest source of aglime to correct this problem. However, since this compound is caustic, there is controversy about its effects in the short term. In this study, a predictive analysis of response of an agricultural field to this kind of treatment was performed by collecting 120 samples of 250 grams of dry soil at different positions across a rice field, recording its coordinates and general characteristics in order to create a Kriging model of the spatial variability by the use of a Geographic Information System (GIS). The initial value of acidity was included in the data. To each sample, 100 ml of distilled water and 0.5 grams of calcium hydroxide were added and mixed, then measuring pH after 15 minutes and again after 48 hours, in order to create a spatial variability model of the resulting acidity of the soil through the time. The results indicated that a violent caustic reaction occurs during the first minutes after the treatment, reaching temporally high alkaline values, but descending to its final value after 48 hours. Acidity values could be increased by the treatment in no more than 1 unit in the pH scale, depending on the type of soil.

Keywords: Geographic Information system, soil acidity, fertility, crop production, predictive analysis

1. Introduction
El Salvador is a country with sub tropical weather and its soils never become frozen or excessively hot. Many plant pathogens like phyllophaga, nematodes, and fungus can easily over summer and quickly reproduce when the next crop starts to grow, often causing great damage that compromises profitability. This problem is difficult to control because available pesticides tend to have limited effects and their costs are relatively high in the local market. One alternative is to apply lime, which is proven to decrease pathogen population due to the change of pH (Kurtzweil et al., 2002; Wright, 1965) [1] and considering that Salvadorian soils are usually acid, it could contribute to maintain soil fertility. Locally, the cheapest source of agricultural lime is calcium hydroxide, which is known for being very caustic. Many farmers are reluctant to use it, because they are not certain about its possible effects in the sort term over soil and crops.

The present document summarizes the results of an experiment in which the responses of soil samples to aglime were measured to simulate open field conditions and therefore to establish a predictive analysis of how caustic the reaction could be in the short and middle term. A great spatial variability was expected in the results, firstly because soil texture varies considerably within short distances over the field and secondly, several different crops are usually rotated every year in a small scale due to according to market demand, causing that every little project receive a completely different agronomic management.

2. Methodology
The amount of 120 samples were taken over a field of 201,000 m 2 (49.7 acres). The place is called “Las Piedritas” and it is located in Cantón San Cristóbal, El Porvenir, El Salvador (14° 2' 20.518" N, 89° 37' 38.518" W).

Each sample was a 100 cm3 portion of the top layer of the field, of approximately 250 grams. Samples were collected trough a transect walk and labeled with its position according to its GPS coordinates and a predesigned hypothetical grid. Types of soil were categorized according to the following parameters: texture, compaction, substrate composition and drainage.

Samples were individually mixed and put in a labeled plastic container. Then, 100 ml of distilled water were applied to each container, then mixed during one minute and rested for 15 minutes to then measure the actual acidity value of the soil.

After the first measurement set, 0.5 grams of calcium hydroxide were added per container and mixed during 1 minute, in order to simulate a lime treatment at field conditions. Those 0.5 grams of lime per sampling area of 21.54 cm2, are equivalent to the dose of 0.0232 grams per cm2 of field, or 0.232 Kg/m2. This dose represents to a treatment of 1 Ton per Acre, which is the indicated to theoretically increase the value of pH in 0.5, for example, from 5.5 to 6.0 in the case of calcium carbonate (Mallarino et al., 2017; Schwab et al., 2007; Alley, 1996) [3-5]. In the case of calcium hydroxide use, the increase of pH was expected to be of 0.65.

Once the sampling containers were left resting for 15 minutes, a second measure of pH was taken to see how caustic the solution cold be in the top 5 cm of the soil in such a period of time. After 48 hours, more distilled water was applied to each sampling container to meet the initial level which was slightly decreased by evaporation. Then, each solution was mixed and left by another 15 minutes for measurement of pH, in order to obtain information about the final acidity of the soil substrate after such a period of time.

The results were tabulated according each sample location, and finally the data was subject of statistic analysis and then spatial variability analysis using Kriging procedure in ArcGIS Pro® software.

3. Results

Table 1 describes the types of soil identified across the whole field, including proper names assigned for the present study.

Table 1: Soil types identified in the field

ID	Name	Type	Color	Compaction	Drainage
1	Polvillo	Silt loam	Gray	Low	Poor
2	Poza	Silty clay loam	Dark brown	Medium	Poor
3	Noche	Clay	Black	Very High	Medium
4	Chiva	Clay loam	Reddish brown	Medium	Medium
5	Tunte	Silty clay loam	Dark reddish brown	High	Poor and medium
6	Bordo	Silty clay	Reddish brown	High	High

Figure 1 shows the area of the field with the position of sampling points taken during the transect walk. The different cultivation patterns correspond to different uses of land, which is usually variable depending on irregular market opportunities. Each crop is managed independently from the others.

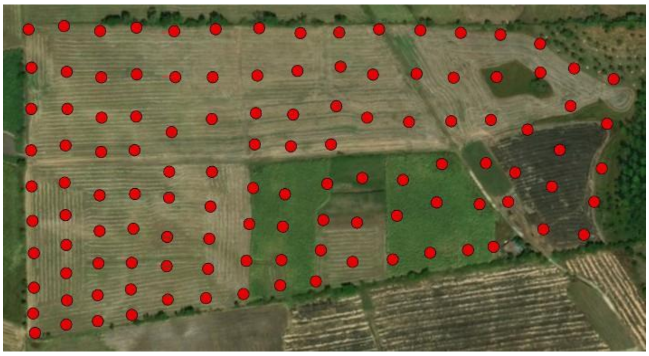

Fig 1: Field map and sampling points. (Martinez, C. 2018).

Figure 2 illustrates the variability of soil types. Rice are cultivated during rainy season in Polvillo, Poza, Noche, Chiva and Tunte. Instead, Bordo is cultivated with Corn and beans. During the dry season, Polvillo and Poza use to be cultivated with watermelon (using residual humidity). Chiva y Tunte are used to produce tomato, cucumber or other crops in a micro scale, using drip irrigation. Noche and Bordo require too much water to irrigate during the dry season, so are planted with cover crops like Canavalia Gladiata.

Respecting to tillage, the whole field requires deep plowing to maintain favorable conditions but with double effort and cost for Tunte and Bordo due to their respective hardness; in El Salvador, flat lands tend to compaction in a scale that no tillage means no yield because crop root system can not properly develop.

Respecting to field elevation, as shown in Figure 3, there is a difference of approximately 16 meters between the highest and the lowest point of the field. Such an irregular topography is common in the area, which is a valley surrounded by many small and middle size hills. Poza and Tunte use to accumulate more water during heavy rains, however, only half of Tunte remains flooded due to drainage direction.

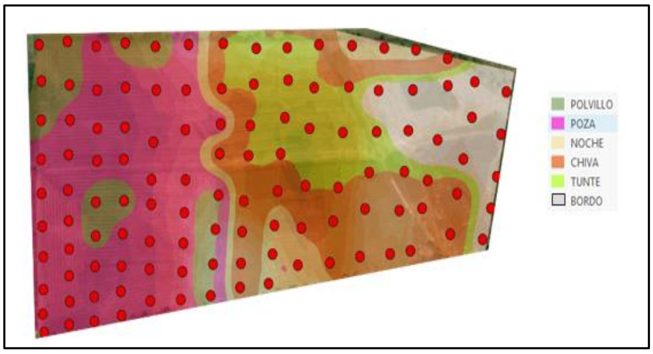

Fig 2: Soil types distribution. (Martinez, C. 2018).

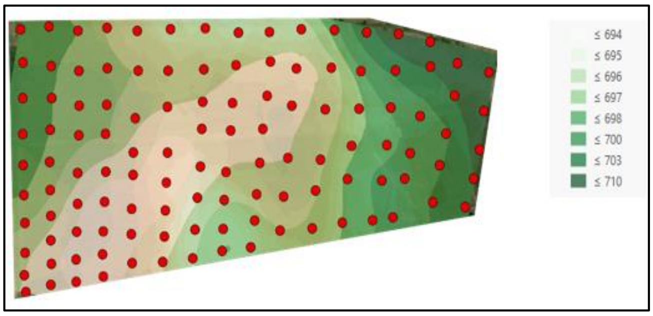

Fig 3: Elevation variability in the field. (Martinez, C. 2018).
Scale on the right is in masl

In Figure 4 is presented the actual variability of pH across the field. Those areas which tend to accumulate more water are also more acid, like in the case of Polvillo, Poza and Tunte. It is possible that an extra amount of fertilizer could be deposited there due to runoffs.

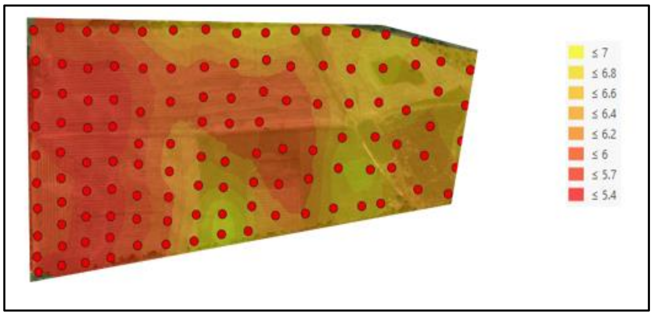

Fig 4: Current pH variability in the field. (Martinez, C. 2018).

Soil acidity raged from 5.4 to 8.0 according to measurements, however, only a small part of the samples were above 7. More than the 75% of the field was considered to have a pH below 6.4, and the global pH was 5.9 because the majority of points were located in the acid zones of Polvillo and Poza. Those values can be considered representative as their variation coefficient is no more than 10%. Table 2 present individual statistic values by each soil type and the global field.

Table 2: Actual pH values

ID	Name	pH Mean	pH Std Dev.	pH Min	pH Max	Var. Coef.
1	Polvillo	5.7	0.5	5.0	6.6	0.1
2	Poza	5.5	0.5	4.9	7.5	0.1
3	Noche	6.3	0.2	6.0	6.6	0.0
4	Chiva	6.3	0.6	5.3	7.3	0.1
5	Tunte	6.2	0.7	5.4	8.0	0.1
6	Bordo	6.5	0.4	6.0	7.2	0.1
GLOBAL		5.9	0.6	4.9	8.0	0.1

Figure 5 represents the dispersion in the measure of pH for each soil type. For Polvillo, Poza and Tunte, high pH values are very disperse and the majority of them range from 5.5 to 6.5.

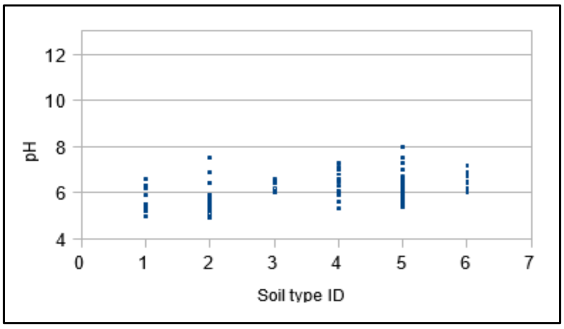

Fig 5: Scatter chart showing dispersion of actual pH values of the entire field.

15 minutes after lime treatment, pH of samples was almost two times bigger than the initial values. Figure 6 is the predictive simulation of what can happen to the top layer of the field right immediately after calcium hydroxide is dissolved by water (preferably rain). The reaction with soil particles is not fast, so water remains very alkaline for a certain period of time, which is the main reason why many pathogenic species are affected by this kind of treatments. Polvillo and Poza, the soil types with major acidity, had also the greatest increase of pH probably due to a poor C.E.C. and buffer power.

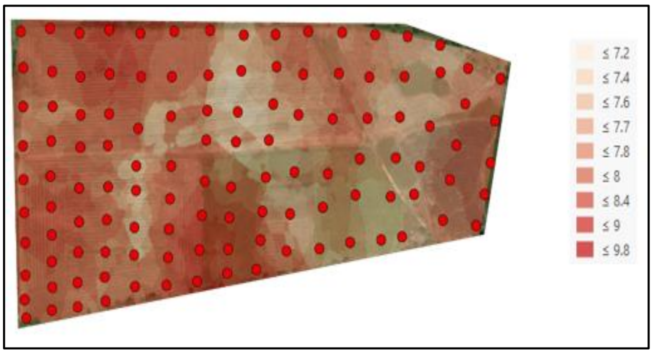

Fig 6: pH prediction, 15 minutes after treatment. (Martinez, C. 2018).

Table 3 summarizes the resultant pH right after treatment. The global pH raised from 5.9 to 8.0. It is noticeable that this reaction could vary greatly across the field because the standard deviation and the variation coefficient have nearly duplicated. Soil properties are not uniform and samples had different responses to the same treatment. Figure 7 shows how scattered the new values of pH can be, where the majority of them range from 6.5 to 10.0 and only a few can surpass 11.5.

Table 3: pH + calcium hydroxide, measured 15 minutes after mixed.

ID	Name	pH Mean	pH Std Dev.	pH Min	pH Max	Var. Coef.
1	Polvillo	9.0	2.1	5.5	11.8	0.2
2	Poza	8.0	1.3	6.7	11.6	0.2
3	Noche	7.4	0.7	6.7	9.0	0.1
4	Chiva	7.4	0.5	6.7	8.6	0.1
5	Tunte	7.9	1.2	6.0	11.3	0.2
6	Bordo	7.9	0.6	7.3	9.0	0.1
GLOBAL		8.0	1.3	5.5	11.8	0.2

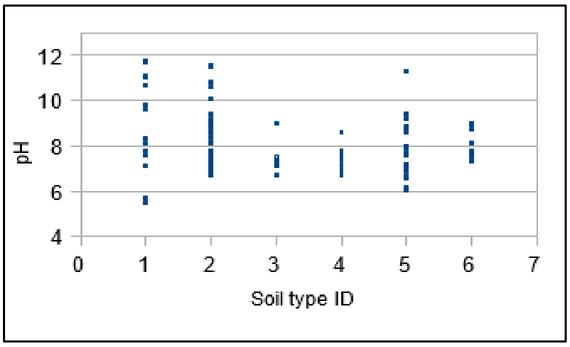

Fig 7: Scatter chart showing dispersion of pH values, 15 minutes after treatment.

48 hours after treatment, most of the chemical reactions had already finished and pH comes close to its finale value (see Figure 8). In contrast with chaotic the pattern of pH right after the treatment, this measurement reveals a part of the global acidity had considerably declined from its first stages. At this moment, global pH had changed from 5.9 to 6.6, meaning a difference of 0.70 (remember that the theoretical increase was 0.65, which is a very close result). Table 4 shows that every type of soil changed its pH proportionally to itself. The average of this new measurement series was more representative as the standard deviation and variation coefficient decreased to a more acceptable value.

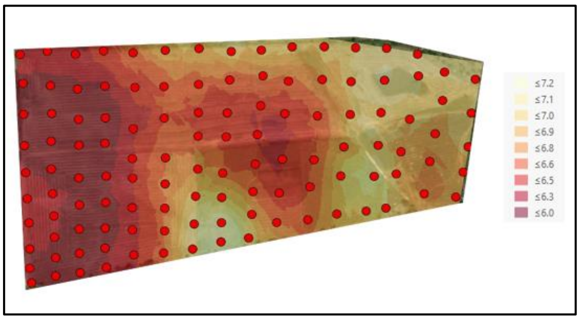

Fig 8: pH prediction, 48 hours after treatment. (Martinez, C. 2018).

Table 4: pH + calcium hydroxide, measured 48 hours aft er mixed.

ID	Name	Mean	Std Dev.	Min	Max	Var. Coef
1	Polvillo	6.1	0.5	5.5	7.0	0.1
2	Poza	6.2	0.6	5.5	8.3	0.1
3	Noche	7.5	0.3	7.1	8.0	0.0
4	Chiva	7.0	0.7	5.9	8.1	0.1
5	Tunte	7.1	0.7	6.0	8.9	0.1
6	Bordo	7.0	0.4	6.5	7.8	0.1
GLOBAL:		6.6	0.7	5.5	8.9	0.1

Figure 8 shows that pH had increased for the samples of every soil type and the resulting values are less disperse after waiting 48 hours than only 15 minutes after treatment.
However, clear changes could be appreciated from actual pH values due to the neturalization of acidity. As the global pH of the samples were 6.6 at this moment, it is expected that the real pH value decrease after a few days, because of natural diffusion and the soil mixture by tillage usually done before planting.

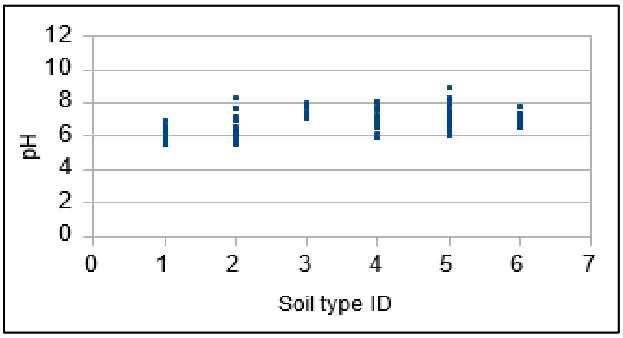

Fig 8: Scatter chart showing dispersion of pH values, 48 hours after treatment.

Due to the immediate reaction of calcium hydroxide is caustic and very irregular, the data series of pH after 15 minutes from treatment, have an altered tendency: its standard deviation, Kurtosis and Skewness are increased (see Table 5). After 48 hours, those parameters normalize and the tendency of the data resembles the pattern of the initial values (compare Figures 4 and 8)

Table 5: Statistics summary of pH measures

	PH (actual)	pH (15 m)	pH (48 h)
Mean	5.9	8.0	6.6
First Quartile	5.4	7.2	6.0
Third Quartile	6.4	8.6	7.2
Std Deviation	0.6	1.3	0.7
Kurtosis	0.0	1.3	-0.3
Skewness	0.7	1.2	0.5

4. Discussion
The global pH of the field was 5.9. This value is representative of all measurement results, but there is variation according to soil types. Lower and softer soil types are more subjected to flooding and also more acidic than heavier and higher soils. Lower soil types had a pH of 5.6 and higher soils a pH of 6.3.
In this study, predictive simulation of response to calcium hydroxide liming revealed that lower soils have a more caustic response in the short term (average pH of 8.5), compared to higher soils (average pH of 7.6). The neutralization process in the first 5 cm layer of the soil occurred slowly and reached its final value about 48 hours after lime treatment. At that last moment, the lower soils reached an average pH of about 6.2, and higher soils a pH of 7.6. At the end of the dry season (april), it is recommended to apply and superficially incorporate 1.75 Ton of calcium hydroxide per "Manzana" (equivalent to 1 Ton per Acre) to increase pH in 0.7 units. After the first rain of may, humidity will start a temporary caustic condition that will partially disinfect the top layer of the soil and this process is considered to finalize about 48 hours later, meaning that any crop can be safely planted three days after treated soil is adequately humidified by rain. With this increase of pH across the field, important minerals like phosphorus and zinc will be more available and the acidity induced by nitrogen fertilizers will be partially reduced.

5. References
1. Kurtzweil NC, Grau CR, Mac Guidwin AE, Gaska JM, Kazubowski AW. Soil pH in relation to brown stem rot and soybean cyst nematode. In 2002 Midwest Soybean Conference, 2002.
2. Wright JM. Biological control of a soil-borne Pythium infection by seed inoculation. Plant and Soil. 1956; *8*(2):132-140.
3. Mallarino A, Haq M, Lawson V. Evaluation of the Efficiency of Aglime and Pelleted Aglime in an Iowa Sandy Soil. Farm Progress Reports, 2016, 2017; 1:48.
4. Schwab G, Murdock LW, Ditsch DC, Rasnake M, Sikora FJ, Frye W. Agricultural lime recommendations based on lime quality, 2007.
5. Alley M. Short-term soil chemical and crop yield responses to Aglime applications. Better Crops. 1996; 80(1):6-7.