Management zones for more efficient liming strategies

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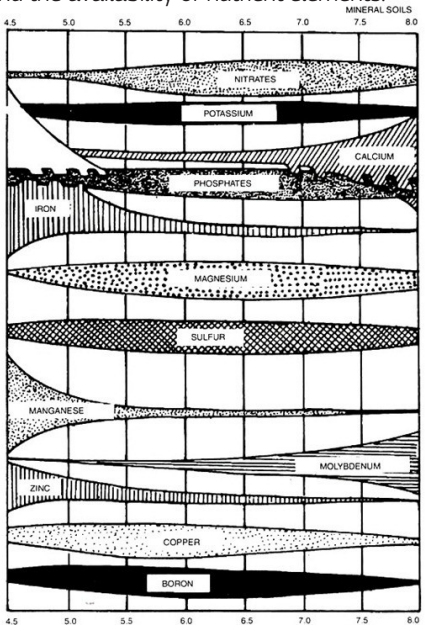
SoilCares (now part of AgroCares) is often confronted with questions from farmers and advisors on how to optimize their lime application. It seems that soil or crop specific liming recommendations are often lacking. Sometimes lime containing fertilizers are not available or only at high costs and moreover, the acid neutralizing capacity (ANC) of the available fertilizers (organic and inorganic) is unknown. In this new blog by dr. Peter van Erp, Director Research and Development at AgroCares, we discuss the background of lime recommendations and how the SoilCares concept of routine soil testing can contribute to more efficient liming strategies.

Why is pH so important?

The acidity of soil, expressed as pH, has a significant effect on the plant availability of soil nutrients (Figure 1) but also on plant root growth. Because of that farmers should strive for an optimal pH when they want to optimize crop growth and crop yield. When the soil pH turns out to be too low, they should lime towards the desired soil pH.

Figure 1. Relationship between pH of the mineral soil and the availability of nutrient elements.



How soil acidity is determined

Soil acidity is determined by the amount of hydrogen (H^+-ions) in the soil solution. Several soil testing methods are available to estimate the amount of hydrogen in the soil. Significant differences exist between the methods and therefore we will discuss pH soil testing methods in another blog.

The absolute amount of hydrogen present in a soil is expressed in mol per liter. However, in practice the negative logarithm of this amount is taken and the new value is called "pH." Due to this conversion the pH value often leads to miscommunication in practice: 1 unit pH increase means that the absolute amount of hydrogen ions in the solution decrease 10 times. For example: increasing soil pH from pH =3 to pH =5 means we have 2 pH unit increase and an amount of H+ in the soil solution which is 100 times (10*10) lower compared to pH 3.

When lime fertilizers are added to a soil the H^+ ions are neutralized because they are transformed in another chemical form. In case carbonate (CO_3^{2-}) containing lime fertilizers are used, the following chemical reaction takes place:

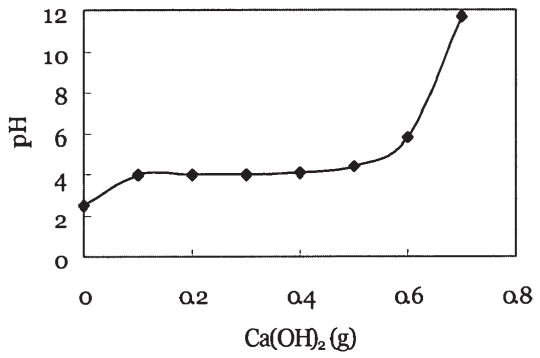
$$CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2$$

In this reaction H^+ reacts with CO_3^{2-} which leads to the formation of water (H_2O) and the gas CO_2 which volatilize out of the soil. So carbonates in lime fertilizers neutralizes H^+ and therefore carbonate content contributes to the acid neutralizing capacity (ANC) of that fertilizer.

How soil buffering works

As an example Figure 2 shows the relationship between the amount of ANC added to a soil via Ca(OH)2) (= lime fertilizer) and the resulting pH. It clearly shows that in the lower pH range pH increases significantly when ANC is added. However, when more ANC is added the relationship levels off. In this range the pH hardly changes (horizontal line) although ANC is added. This occurs when soil particles are able to release H^+ ions when pH tends to increase. This process of H^+ release is called soil buffering capacity. In the higher soil pH range the pH increases again when ANC is added. In this range buffer capacity is nihil.

Figure 2. Example of the buffer capacity of a soil. The X-axis shows the amount of acid neutralizing capacity added and Y-axis the resulting pH.



Lime recommendations have a comparable set up

Although lime recommendations seem to differ between countries and regions they often have a comparable set up.

Starting point in most of the recommendations is the actual soil pH and the desired end pH after liming. As the difference between both pH values increase, the lime applications rate will increase because more ANC needs to be added to neutralize H^+.

How much ANC (lime) is recommended depends on the buffer capacity of the soil in the pH range between the actual and desired pH. The buffer capacity increases when the content of the soil parameters organic matter, clay minerals and/or oxides increases. A higher buffer capacity means more ANC is needed to get a comparable pH increase.

The contribution of abovementioned parameters to the buffer capacity is often not investigated well. Therefore, ANC application rate is often related to soil type, texture class and/or organic matter classes. In this type of recommendation buffer capacity is included indirectly because soil type, texture and organic matter classes are defined based on clay content and organic matter content of the soils (see table 1).

Table 1. LIME APPLICATION RECOMMENDATIONS
(tonnes/hectare)*

Measured soil pH	Sand and loamy sands		Sandy loams and silt loams		Clay loams and clays		Organic soils (10-25% organic matter)		Peaty soils above 25% organic matter	
	Arable	Grass	Arable	Grass	Arable	Grass	Arable	Grass	Arable	Grass
7.0	0	–	0	–	0	–	–	–	–	–
6.9	2	–	2	–	2	–	–	–	–	–
6.8	2	–	2	–	2	–	–	–	–	–
6.7	2	–	2	–	2	–	0	–	–	–
6.6	2	–	3	–	3	–	2	–	–	–
6.5	3	0	4	0	4	0	2	–	–	–
6.4	4	2	4	2	5	2	3	–	–	–
6.3	4	2	5	2	6	2	4	–	0	–
6.2	5	2	6	2	6	2	5	0	2	–
6.1	5	2	6	2	7	2	6	2	3	–
6.0	6	2	7	3	8	3	7	2	5	–
5.9	7	3	8	3	9	4	8	2	6	–
5.8	7	3	8	4	10	4	9	3	8	0
5.7	8	4	9	4	10	5	10	4	10	2
5.6	8	4	10	5	11	5	11	5	11	2
5.5	9	5	11	5	12	6	12	5	13	4
5.4	10	5	11	6	12	7	13	6	14	5
5.3	10	5	12	6	13	7	14	7	16	6
5.2	11	6	13	7	14	7	15	7	18	7
5.1	11	6	13	7	15	7	16	7	19	7
5.0	12	7	14	7	16	7	17	7	21	7
4.9	13	7	15	7	16	7	18	7	22	7
4.8	13	7	15	7	17	7	19	7	24	7
4.7	14	7	16	7	18	7	20	7	26	7
4.6	14	7	17	7	19	7	21	7	27	7
4.5	15	7	17	7	20	7	22	7	29	7

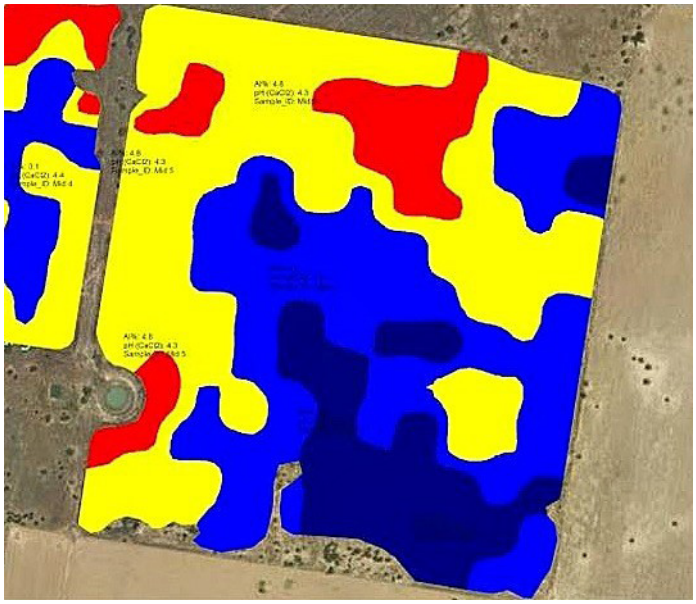
multiply by 0.4047 to obtain tonnes per acre

Liming strategy: field or management zone

Disadvantage of the current use of lime recommendations is that the actual field pH is determined on a mixed field sample consisting of many subsamples taken throughout the field. Such a mixed field sample will give an "average pH value" of that field. Knowing that the actual pH varies within a field this will lead to field parts where the calculated lime application rate is too high and other parts where it is too low based on the average pH value.

The SoilCares concept for routine soil testing via Scanner and Lab-in-a-Box, enables farmers and advisors to analyse soil pH, organic matter and clay content at relatively low costs. When they analyze soil samples from different field parts farmers and advisors are able to create management zones based on pH, organic matter and/or clay content. Then the optimal lime application rate is calculated per zone (Figure 3). In this way farmers optimize their lime use and lime costs, crop yield and their income.

Figure 3. Example of pH management zones.



Conclusions

- Soil pH is one of the most important soil parameter determining crop growth and crop yield.
- The optimal lime application rate depends on the actual pH, the desired end pH and the buffer capacity of the soil in this pH range.
- Buffer capacity of a soil is related with pH, organic matter content and clay content. Inclusion of buffer capacity parameters in the liming recommendations is needed.
- The SoilCares concept of soil testing enables farmers and advisors to create management zones within their field for more precise and efficient liming strategies.

References

Figures

1) Shreeja D., Notes on Buffering of Soil, available at http://www.soilmanagementindia.com/buffering-of-soil/notes-on-buffering-of-soil

2) Not available

3) John Small, Crop yield impacts and management of soil acidity in Central Western NSW, available at: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/crop-yield-impacts-and-management-of-soil-acidity-in-central-western-nsw

Tables

1) Editorial staff, pH value and lime requirements, available at http://www.aglime.org.uk/tech/ph_value_and_lime_requirements.php

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