Determining an Average Soil Test P or pH value from Grid Samples for Nutrient Management Planning

Introduction

Standard soil sampling practice for nutrient management planning involves collecting and combining multiple soil cores. It is recommended to take at least 10 cores per 10-15 acre field or management unit within a field.

To best capture the variability in fields, higher density soil sampling, where more cores are taken and combined into one sample, will improve the accuracy of the sampling result as a representation of the sampled area. A more meaningful approach in such fields is to conduct grid sampling or zone-based sampling. Grid sampling (as a way to obtain detailed information about nutrient distribution within a field) can better inform management decisions as it allows for identification of low versus high fertility or pH areas within fields. Grid sampling is often done at a 1-2 acre grid size but grids as large as 5 or 6 acres in size can be justified based on field variability, equipment size, and capacity to manage at within-field scale.

While grid- or zone-based sampling and managing beyond the average of the field is encouraged, intensive sampling raises questions about converting soil test results into field averages for manure and/or fertilizer applications and managing the New York P index. This is particularly important for concentrated animal feeding operations (CAFOs) and other farms that fall under state regulations for nutrient management. Here we describe how to determine average soil test P and pH values from grid sample results.

Field/zone/grid size

Generally, management zones should be 15 acres or less, though in various scenarios (larger and more homogeneous fields) larger zones are justifiable while smaller zones can be used when managers want to evaluate opportunities to refine inputs at a smaller within-field scale. Grid sampling can be done using regular grids (each grid about the same size) or irregular grids, taking into account other field features (slope, elevation, soil type, drainage, etc.).

Soil test P (or K, Ca, Mg, S, Fe, Al, Zn, Mn)

Combining multiple soil sample results collected from grids and calculating an area-weighted average to determine one soil test value for an existing management zone to use for P fertility and the New York P index (NY-PI) assessment is consistent with the current approach of one composite soil sample using cores from the whole field or zone within a field.

If all grids are the same size, a simple average is sufficient. For irregular grid sizes, an acre-weighted approach best represents the field soil test P for NY-PI assessment. Determining the acre-weighted average soil test P of a field requires knowing the size of the area/grid that the soil test results represent. An example of a calculation and the spreadsheet code is shown in Figure 1.

Soil test P (STP) example:		STP	
Mathematical average of STP ignoring grid size (lbs/acre):		21	INCORRECT
Average STP taking into account actual grid sizes (lbs/acre):		15	CORRECT
Soil test P (A)	Grid cell size (B)		
lbs/acre	acre		
35	0.5		
22	0.2		
16	1.5		
10	3.2		
30	0.8		
28	0.3		
12	2.5		
25	0.2		
10	0.8		
Weighted average:	15 lbs P/acre		
+SUMPRODUCT(A10:A18,B10:B18)/SUM(B10:B18)			

Figure 1: Example of a calculation of the field-average soil test P for a 10-acre field, taking into account irregular grid cells ranging from 0.2 to 3.2 acres. The soil test P values per sampled area shown here result in an area-weighted soil test P value of 15 lbs P/acre.

If soil test P results are converted from Mehlich-3 into Morgan P for nutrient management planning purposes, it is better to first derive the Morgan P equivalent per sample (using soil test P, Al, Ca, and soil pH), and then to use the equation shown in Figure 1. Keep in mind that conversion always adds uncertainty to the soil test P interpretations and guidance.

Averaging soil pH

Because pH is a negative logarithmic conversion of the hydrogen ion (H^+) concentration in the soil solution, pH values for each zone or grid need to be converted back to hydrogen ion concentrations before averaging. Once the average hydrogen ion concentration is determined, this value can then be reconverted to an average pH value. An area-weighted pH without the logarithmic conversion will result in incorrect averages as a soil pH of 5 is 10 times more acidic than a soil pH of 6 and 100 times more acidic than a soil pH of 7. An example for a 10-acre field with irregular grid cell and a soil pH ranging from 5.0 to 6.8 is shown in Figure 2.

pH example:	pH	
Mathematical average ignoring grid size and log scale:	5.9	INCORRECT
Average pH taking into account actual grid sizes and log scale:	**5.3**	CORRECT
pH (A)	Grid cell size (B)	H^+ activity (C)
	acre	10^(-pH)
7.1	0.5	7.9433E-08
6.8	0.2	1.5849E-07
5.6	1.5	2.5119E-06
5.0	3.2	1.0000E-05
5.1	0.8	7.9433E-06
5.4	0.3	3.9811E-06
5.7	2.5	1.9953E-06
6.2	0.2	6.3096E-07
6.5	0.8	3.1623E-07
Weighted average:	pH 5.3	
-log10(SUMPRODUCT(B29:B37,C29:C37)/SUM(B29:B37))		

Figure 2: Example of a calculation of the field-average pH for a 10-acre field, taking into account irregular grid cells ranging from 0.2 to 3.2 acres. The pH values per sampled area shown here result in an area-weighted pH of 5.3.

When the pH values obtained for a field are close to each other, the difference between the mathematical mean and the logarithmic mean will be very small but as the pH values across a grid show a wider range, the difference between the two means will be larger. In this example, the true average soil pH is 5.3, whereas the mathematical area-weighted average ignoring grid cell size and ignoring the logarithmic scale, would have given an incorrect average soil pH of 5.9. In fields where pH differences are larger, delineating areas within fields with pH levels below the optimal pH for the crop to be grown, and applying lime application at the appropriate rates to these areas, will benefit yields and save on costs associated with lime application.

In Summary

While grid- or zone-based sampling is encouraged, deriving field averages based on such grid cell data should take into account the area represented by each sample, and for pH include a conversion to H^+ concentration. Technology and knowledge will continue to evolve and improve our understanding of and ability to manage field variability for improved yields and nutrient use efficiency. Thus, guidance on grid sampling and management at within-field scale will evolve over time as well.

Additional Resources

- Cornell Nutrient Management Spear Program Agronomy Factsheet #5: Soil pH for Field Crops; Factsheet #15: Phosphorus Soil Testing Methods; and Factsheet #48: Buffer pH to Derive Lime Guidelines. http://nmsp.cals.cornell.edu/guidelines/factsheets.html.
- Soil Sampling Techniques. Proceedings of the 2006 Indiana CCA Conference, Advanced Soil Fertility, Indianapolis, IN. Ron Olson, Mosaic Crop Nutrition, LLC. https://www.agry.purdue.edu/CCA/2006/PDF/Olson.pdf

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For more information

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