Acidification in Cropland Soils – Depth Matters

Dr. Mark Liebig, USDA-ARS Research Soil Scientist

In the northern Great Plains, surface sampling depths of 0-6 or 0-8 inches are suggested for testing soil pH. Soil acidification, however, can be most pronounced near the soil surface. This is especially the case on croplands where no-tillage is practiced and N fertilizers are surface applied.

To evaluate sampling depth effects on soil pH, researchers at the USDA-ARS Northern Great Plains Research Laboratory quantified soil pH change in two long-term dryland cropping studies at the Area IV SCD Cooperative Research Farm. Soils were sampled at multiple depths in both studies for more than 15 years, allowing for evaluation of pH change at surface (0-3 inch) as well as deeper (0-6 and 0-12 inch) depths.

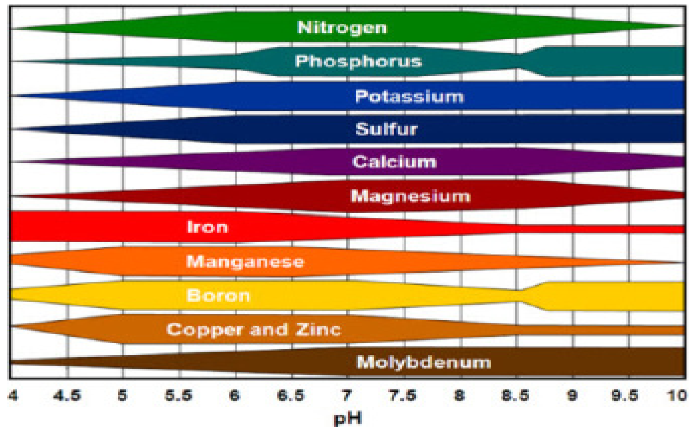


Figure 1. Relative nutrient availability at different pH values (after NRCS, 1993).

Significant differences existed between sampling depths for both final soil pH and change in pH (ΔpH) in both experiments (Table 1). In the majority of cases, all three sampling depths were significantly different than each other for both pH metrics examined. Final pH values were higher (and pH changes smaller) as sampling depth increased.

Implications for soil sampling were evident from the evaluation. If the regionally suggested depths for fertility testing were used for soil pH, pH readings were likely to be confounded (increased), as acidification was most pronounced at the soil surface.

Soil acidification can affect herbicide persistence, decrease nutrient availability, and contribute to metal toxicity, all of which can compromise crop production (Fig. 1). Potential negative outcomes from low soil pH underscore the importance of mitigating negative impacts of surface acidification through efficient lime application. Applications directed to specifically address acidification in near-surface soil depths will foster more efficient use of liming materials, as recommendations encompassing deeper soil depths contribute to higher application rates. Additionally, recommendations mitigating soil acidification based on measurements at near-surface depths will detect potential problems earlier than if recommendations were based on deeper soil depths.

In summary, findings from this evaluation suggest the regionally-recommended sampling depths of up to 8 inches may be too deep for early detection of surface acidification. Adoption of surface sampling depths 3 inches (or less) is recommended for testing soil pH in the northern Great Plains.

Crop Rotations and Soil Acidification

Outcomes from a complementary study on the Area IV farm found cropping sequence had differential impacts on soil pH in near-surface depths. In the study, soil pH was evaluated in small grain – fallow and three continuously cropped rotations (three year, five year, and dynamic). Soil pH was also evaluated in a nearby grazed pasture with the same soil type as the crop rotations.

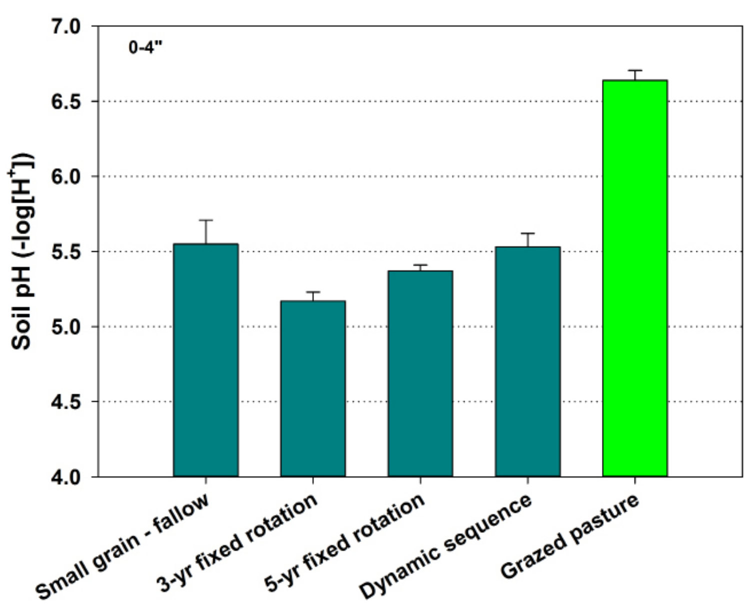
Soil acidification was found to be greater in the three year rotation compared to the small grain – fallow and dynamic rotations. Acidification is expected to be greater where N is applied each year compared to crop-fallow, where N is applied biannually. Decreased acidification in the Dynamic versus the 3-yr rotation was likely the result of differences in applied N over time. Soil pH in cropped sites was over one pH unit lower than under grazed pasture.

Mark Liebig 701.667.3079 mark.liebig@ars.usda.gov

Table 1. ANOVA results for comparisons of final pH and ΔpH by sampling depth within fertilizer N and tillage treatments for two long-term cropping experiments at the Area IV SCD Research Farm near Mandan, North Dakota. Values for final and ΔpH represent mean ± 1 standard error. Different letters represent significantly different values among the three sampled depths (adapted from Reeves and Liebig, 2016)

Depth (inch)	Final pH	ANOVA *F* (*P*)	Tukey HSD	ΔpH	ANOVA *F* (*P*)	Tukey HSD
------------ Conservation Tillage-Cropping Systems Experiment ------------						
67 kg N ha^{-1} yr^{-1}; Minimum tillage						
0-3	5.97 ± 0.07	8.54 (0.0019)	A	-0.37 ± 0.09	4.13 (0.0307)	A
0-6	6.16 ± 0.08		AB	-0.20 ± 0.10		AB
0-12	6.47 ± 0.11		B	0.01 ± 0.08		B
67 kg N ha^{-1} yr^{-1}; No-tillage						
0-3	6.00 ± 0.05	16.59 (<0.0001)	X	-0.42 ± 0.06	5.94 (<0.0080)	X
0-6	6.20 ± 0.06		X	-0.18 ± 0.08		XY
0-12	6.49 ± 0.07		Y	-0.08 ± 0.07		Y
101 kg N ha^{-1} yr^{-1}; Minimum tillage						
0-3	5.69 ± 0.07	27.58 (<0.0001)	A	-0.71 ± 0.07	16.93 (<0.0001)	A
0-6	6.00 ± 0.07		B	-0.40 ± 0.06		B
0-12	6.44 ± 0.08		C	-0.13 ± 0.08		C
101 kg N ha^{-1} yr^{-1}; No-tillage						
0-3	5.72 ± 0.06	29.63 (<0.0001)	X	-0.82 ± 0.08	16.78 (<0.0001)	X
0-6	6.03 ± 0.06		Y	-0.47 ± 0.07		Y
0-12	6.39 ± 0.07		Z	-0.24 ± 0.06		Y
----------------- Soil Quality Management Experiment -----------------						
67 kg N ha^{-1} yr^{-1}; Minimum tillage						
0-3	5.54 ± 0.07	28.11 (<0.0001)	A	-0.98 ± 0.06	31.44 (<0.0001)	A
0-6	5.78 ± 0.06		B	-0.64 ± 0.04		B
0-12	6.20 ± 0.06		C	-0.44 ± 0.04		C
67 kg N ha^{-1} yr^{-1}; No-tillage						
0-3	5.37 ± 0.04	73.63 (<0.0001)	X	-1.14 ± 0.07	28.75 (<0.0001)	X
0-6	5.64 ± 0.03		Y	-0.78 ± 0.04		Y
0-12	6.06 ± 0.04		Z	-0.58 ± 0.05		Z

Reeves, J.L., and M.A. Liebig. 2016. Depth matters: Soil pH and dilution effects in the northern Great Plains. Soil Sci. Soc. Am. J. 80:1424-1427.



Crop diversity effects on pH at 0-4" for long-term cropping treatments near Mandan, ND (Liebig et al., 2014).