The Journal of Extension

Volume 39 | Number 4 Article 23

8-1-2001

How to Diagnose Soil Acidity and Alkalinity Problems in Crops: A Comparison of Soil pH Test Kits

Gene Stevens
University of Missouri, stevensw@missouri.edu

David Dunn
University of Missouri, dunnd@missouri.edu

Bobby Phipps
University of Missouri, phippsb@missouri.edu

Recommended Citation

Stevens, G., Dunn, D., & Phipps, B. (2001). How to Diagnose Soil Acidity and Alkalinity Problems in Crops: A Comparison of Soil pH Test Kits. *The Journal of Extension, 39*(4), Article 23.
https://tigerprints.clemson.edu/joe/vol39/iss4/23

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August 2001 // Volume 39 // Number 4 // Tools of the Trade // 4TOT3

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How to Diagnose Soil Acidity and Alkalinity Problems in Crops: A Comparison of Soil pH Test Kits

Abstract
Extension agronomists are often asked by farmers to determine why crop plants are stunted or have abnormally colored leaves. Soil acidity and alkalinity are common fertility problems that can cause these symptoms. In a study to measure the accuracy of in-field pH test kits, hand-held pH meters and pH color indicator kits provided fast and reliable results. Soil pH probes gave poor measurements of soil acidity and should not be used by Extension agents. Results by untrained personnel with hand-held pH meters varied by individual. Agents using pH test kits should read instructions carefully before using these instruments.

Gene Stevens
Crop Production Specialist
Internet Address: stevensw@missouri.edu

David Dunn
Soil Test Supervisor
Internet Address: dunnd@missouri.edu

Bobby Phipps
Cotton Specialist
Internet Address: phippsb@missouri.edu

University of Missouri Outreach and Extension/Commercial Agriculture Program
Delta Research and Extension Center
Portageville, Missouri

Farmers often bring sick crop plants into county Extension offices requesting that agronomy agents provide a quick diagnosis of the problem. Sometimes, agents are able to determine from leaf symptoms whether the crop is suffering from a specific pest or fertility problem. In other cases, agents have difficulty determining the cause of poor plant health.

Extension agents usually consider soil acidity or alkalinity first because it is a common fertility problem and is easy to measure in the field with a pH test kit. Soil acidity (low pH) is common in the eastern United States. Soil alkalinity (high pH) is more common in low rainfall areas of the West. Low soil pH causes aluminum and manganese toxicity in plants and reduces the availability of soil phosphorus. High soil pH also reduces soil phosphorus availability and reduces micronutrients such as zinc and boron to plants.

Soil acidity is a major limiting factor to crop production in Southeast Missouri. Approximately 35% of the soil samples submitted to the Delta Regional Soils Testing Lab from cotton producers have a soil water pH values less than 5.5. The soil test recommendation for these soils is to apply agricultural lime to prevent yield reductions.

Cotton plant symptoms from low soil pH include crinkled leaves, stunted plants, and low boll counts. Sometimes these same symptoms can be caused by insects or diseases. To help Extension agronomists diagnose pH problems in the field, all agents in Southeast Missouri were supplied with hand-held pH meters in 1995. A study was recently conducted to answer questions concerning the accuracy of these meters compared to other soil pH test kits.

Weaknesses in pH Test Methods

Inherent weaknesses in test methods are a possible source of error with in-field pH tests. To evaluate test methods, soil pH was measured in limed and no lime cotton plots at the University of Missouri-Delta Center at Portageville, Missouri (Figure 1). In limed plots, agricultural lime was incorporated before planting in 2000. Cotton yields in limed plots averaged 155 kg lint ha^{-1} more than in plots without lime.

Figure 1. Three methods of measuring soil pH in the field.

(a) hand held meter (b) color test kit (c) test probe

Four pH meters, kits, and probes were purchased and used in the field on each cotton plot in 2001 (Table 1). Instructions supplied with the units were followed. For comparing in-field and laboratory results, soil samples were collected from plots and tested at the Delta Center Soil Laboratory. Samples were tested in the lab for water pH using an Accumet Bench top pH meter.

Table 1
Manufacturers of In-Field soil pH Test Kits

(a) pH Pro hand-held meter	Shindengen Electric Manufacturing Company, Limited, Shin-ohtemachi-Building, Ohtemachi, Chiyoda-ku, Tokyo, Japan
(b) Soil color test kit Model EL	LoMotte Company, Chestertown, Maryland, 21620
(c) Mini pH Rapidtest probe	Luster Leaf Products, Incorporated, 2220 Techcourt, Woodstock, IL 60098

In-field measurements with hand-held pH meters and color kits showed that lime increased pH (Table 2). Despite careful attention to moistening the soil and shining the tip of pH test probes, all four probes read 6 in limed and non-limed soils. More graduations on the color chart are needed. Color chips are only in whole pH units (4.0, 5.0, 6.0, and 8.0). Interpolations were made to the nearest 0.5 pH unit but this increases the potential for human error.

Table 2
Soil pH Measurement in Cotton Field Plots

pH Measurement	**No Lime Soil**	**Limed Soil**
Soil Lab bench pH meter	5.6	6.8
Handheld pH meter	5.5	6.5
Color kit	5.8	7.0
Mini pH probe	6.0	6.0

Soil samples provided by the North American Proficiency Testing (NAPT) Program were also used to evaluate the test methods. Eighty-two labs had previously participated in testing of the soil samples.

All in-field pH test methods, except the test probe, produced satisfactory measurements of soil pH as compared to results from 82 laboratories testing the same soils (Table 3). Results from the Accumet bench top pH meter and a single hand-held pH meter were similar. Both were found to be accurate to within 2.5 X Median Absolute Deviation (MAD) for 89% of the analysis performed. Median readings from both types of meters compared favorably with the median from 82 soil labs participating in the NAPT program. When four different hand-held pH meters were used, the hand-held meter had a higher MAD than the 82 NAPT labs for eight of the nine analysis preformed. The MAD value for the labs was 0.08, while the value for the four hand-held meters was 0.11.

Table 3
Soil pH Measurements on North American Proficiency Test Soils

pH Measurement	**Soil 00-103**	**Soil 00-107**	**Soil 00-113**
82 other soil labs	7.9	6.3	5.6
Bench pH meter	7.8	6.5	6.0
Handheld pH meter	7.7	6.3	5.5
Color kit	8.0	6.5	5.5
pH probe	6.0	6.0	6.0

Human Error in Using Hand-Held Meter

Extension agents should learn how to calibrate and test soil samples with hand-held pH meters before going to the field. To determine how large of an error inexperience can cause, one hand-held meter and one NAPT soil were selected. Seventeen untrained personnel were given an instruction sheet, a soil sample, standard pH solutions, and distilled water. Each person measured the pH of the soil without supervision. Results were compared to results from 82 NAPT labs (Figure 2). Some persons followed the instructions and calibrated the meter with pH 4.0 and 7.0 standards. Others did not. The median pH from the group was 6.3, and the MAD value was 0.15. This is very close to the median from 82 soils labs, which was 6.34. However, the MAD value from the inexperience group was more than twice as great as the soil labs.

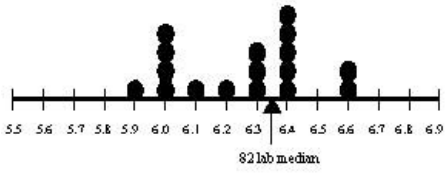

Figure 2. Distribution of soil pH results from 17 people testing the same soil(00-107) with the same handheld meter.

Conclusion

Soil test pH kits can be used by Extension agents to quickly determine whether soil acidity or alkalinity is a probable cause of poor crop health. Hand-held pH meters and pH color indicator kits were found to provide reliable in-field soil pH measurements. Personnel using a pH color kit were able to distinguished between soils with and without lime. However, interpolating between whole pH values with the color kit was difficult. A soil probe that was inserted into moist soil in plots provided poor response to soil pH and is not suitable for diagnosis of soil pH problems.

Extension agents should use soil pH test kits primarily as fast-response diagnostic tools. If a problem is found, a soil sample should be sent to a qualified soil test laboratory for recommendations on rates of material to adjust soil pH to optimum levels for the specific crop.