DATE: MARCH 2012

Available Phosphorus

1. Application

This procedure covers the extraction and analysis of plant available phosphorus (P) from soil.

2. Summary of Methods

Plant available phosphorus (P) is extracted from the soil with 0.03 N NH_4F in 0.025 N HCl (Bray P1 extract). This extractant primarily measures P adsorbed by Al compounds. The Al is complexed by F^- ions, liberating P. Lesser amounts of Fe^-, MN^-, and Ca-P may be extracted, along with water-soluble P. Extracted P is reacted with ammonium molybdate to form a blue phosphomolybdate compound in the presence of a reducing agent.

The concentration of P is determined colorimetrically or by UV – Vis spectrophotometer.

Potassium is extracted simultaneously with P and analyzed separately.

3. Safety

Each chemical compound should be treated as a potential health hazard. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material handling data sheets should be made available to all personnel involved in the chemical analysis.

4. Interferences

Color development is complete in 15 minutes but will continue at a slower rate. For this reason, samples should be read within two hours. Arsenic forms a blue molybdate complex but is usually present in very low amounts unless an arsenical pesticide has been applied in the past.

Very high soil pH interferes with phosphorus by this extraction method.

The Bray test for P is less reliable in alkaline soil containing free $CaCO_3$. The carbonate reacts with HCl in the Bray extract, forming $CaCl_2$, and the Ca^{++} ions react with F^-, precipitating CaF_2. Where alkaline soils predominate, $NaHCO_3$ (Olsen) is the preferred extractant.

5. Apparatus and Materials

5.1 Soil scoop calibrated to hold 1.5 g of light-colored silt loam soil.
5.2 Erlenmeyer flasks (50-ml)
5.3 Pipette banks (3-ml)
5.4 Time-controlled oscillating shaker (Eberbach) set at 160 excursions per minute.
5.5 Filter paper (9-cm Whatman no. 2 or equivalent)
5.6 Funnel tubes (15-ml)
5.7 Matched colorimetric tubes (10-ml)
5.8 UV-Vis spectrophotometer
5.9 Brewer Automatic Pipetting Machine (SEPCO Model #40A)

6. Reagents

6.1 Stock P-A solution (1.25 N HCl, 1.5 N NH_4F): Add 54 ml of 48% HF to 700 ml of deionized water. Neutralize to pH 7.0 with NH_4OH. Add 108 ml of concentrated HCl (11.6 N) and dilute to 1 liter
6.2 Dilute P-A solution (0.025 N HCl, 0.03 N NH_4F): Dilute 20 ml of stock P-A solution to 1 liter with deionized water.
6.3 P-B solution (0.87 N HCl, 0.38% ammonium molybdate, 0.5%H_3BO_3): Dissolve 3.8 g ammonium molybdate, $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$, in 300 ml of deionized water at about 60° C. Cool. Dissolve 5.0 g boric acid, H_3BO_3, in 500 ml of deionized water, and add 75 ml concentrated HCl (11.6 N). Then, add the molybdate solution and dilute to 1 liter with deionized water.
6.4 P-C powder: Thoroughly mix and grind to a fine powder 2.5 g of 1-amino-2-napthol-4 sulfonic acid, 5.0 g sodium sulfite (Na_2SO_3), and 146 g of sodium metabisulfite ($Na_2S_2O_5$).
6.5 P-C solution: Dissolve 8 g of dry P-C powder in 50 ml of warm deionized water. Let stand overnight, if possible. A fresh reagent should be prepared every three weeks. (Upon standing, some material may crystallize out, but this is still satisfactory.)
6.6 Standard P solution (1000 ppm P, 500 ppm P)
6.7 Working standards (0, 1.0, 2.5, 5, 10, 20, 40 ppm P, prepares with same matrix as the samples.)

7. Methods

7.1 Place a 1.5 g scoop of soil into a 50-ml Erlenmeyer flask.
7.2 Add 15 ml of P-A solution with Automatic Brewer Pipette.
7.3 Shake the suspension on oscillating shaker for 5 minutes.
7.4 Filter through filter paper into a 15-ml funnel tube.
7.5 Pipette a 3.0-ml aliquot of filtrate with constant suction pipette apparatus and transfer to a 10-ml colorimeter tube.
7.6 Add 3.0 ml of P-B solution with the same pipette apparatus and mix well.
7.7 Add 3 drops of P-C solution, and mix immediately.
7.8 Read color after 15 min., but before two hr., with a photoelectric colorimeter or a UV-Vis spectrophotometer.

Note: UV – Vis spectrophotometer should be set at 645 nm.

7.10 Calibrate the instrument to read directly in ppm P in soil using working standards. These standard preparations are treated in the same manner as the soil extracts. (color development is complete in 15 minutes. and standards should be read within two hours.).

8. Calculations

In lieu of direct calibration of the colorimeter scale, calculate extractable P,
ppm P in soil = ppm P in solution x 15 ml/1.5 g = ppm P in solution x 10.

9. Quality Control

9.1 Laboratory Reagent Blank (LRB) – At least one LRB is analyzed with each batch of samples to assess contamination from the laboratory environment. Contamination from the laboratory or reagents is suspected if LRB values exceed the detection limit of the method. Corrective action must be taken before proceeding.

9.2 Standard soil – One or more standard soils of known extractable P content is analyzed with each batch of samples to check instrument calibration and procedural accuracy.

10. Reporting

Results are reported as ppm P in soil. (Strictly speaking, the results should be reported as Mg P per dm^3 of soil because a known volume, rather than a weight is used. This is not a familiar unit, however. Use of a volume of soil is reasonable because it represents a volume-fraction of an acre plow layer.)

11. References

11.1 Bray, R.H., and L.T. Kurtz. 1945. Determination of total, organic, and available forms of phosphorus in soil. Soil Sci. 59: 39-45

11.2 Munter, R.C. 1988. Laboratory factors affecting the extractability of nutrients. Pp. 8-10. *In* W.C Dahnke (ed.), Recommended Chemical Soil Test procedures for the North Central Region. NCR Publ. 221 (revised). ND Agr. Exp. Sta., Fargo, ND.

11.3 Frank, K., D, Beegle, and J. Denning. 1998. Phosphorus, pp. 21-26. *In* J.R. Brown (ed.) Recommended Chemical Soil Test Procedures for the North Central Region. NCR Publ. No. 221 (revised). Missouri Agr. Sta. SB 1001. Columbia, MO.