

LABORATORY 10

SOIL FERTILITY

I Objectives

Learn a method for measuring extractable soil P. Make fertilizer recommendations for a crop. Gain experience with calculations involving inorganic fertilizer materials.

II Introduction

Fertilizer recommendations based on soil tests are fairly straightforward in concept but a lot of work has gone into developing these recommendations. Basically, results of a chemical analysis for concentration of a nutrient in a soil are statistically related to crop yields on that soil. This takes years of field experiments to cover the range of variability in weather conditions during the growing season. These experiments must also be conducted on different soils. Furthermore, the correlation between nutrient concentration in a soil and crop yield depends on the specific methodology used to extract the nutrient from the soil. The extracting solution should provide a good correlation with yields for all soils within a limited geographic region like Louisiana.

In this laboratory you will chemically extract P from your soil, analyze its concentration and use this and previous K data to make fertilizer recommendations for several different crops.

You will also calculate what amounts (lbs / acre) of different fertilizer compounds would be needed to meet your recommendations and estimate costs. A little background information on fertilizers is needed.

Organic and inorganic materials may be used to supply essential elements. Organic fertilizers such as manures and sewage sludge are generally not as highly valued as inorganic fertilizers because these have lower nutrient content per unit mass. Thus, organic fertilizers must be applied in relatively large amounts and high transportation costs are incurred. Furthermore, since the nutrient composition of organic fertilizers is highly variable, addition of precise amounts of nutrients is not possible. On the other hand, organic fertilizers offer the advantage of supplying organic matter to the soil.

In contrast, inorganic fertilizers (whether mined or manufactured) have fairly exact composition. For example, ammonium nitrate (NH_4NO_3) or monocalcium phosphate (known as concentrated superphosphate, CSP, $\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O}$) obviously contain a certain fraction N or P per unit mass of ammonium nitrate or monocalcium phosphate. The compound in which a nutrient occurs is called the **fertilizer carrier**. Fertilizers, whether consisting of a carrier of a single nutrient, a carrier of more than one nutrient

(like diammonium phosphate, DAP) or a combination of carriers for different nutrients are identified by a **fertilizer grade** that gives the percentage of each of the nutrients. The percentage content of N is given directly, however, the percentages of P and K are given as percentages of the corresponding oxides, P₂O₅ and K₂O (these oxides, however, are never actually in the fertilizer). For example, if the grade of a fertilizer is 18-46-0, it contains 18 % N, the same percentage of P as would be found if it actually contained 46 % P₂O₅ but no K, as implied by 0 % K₂O.

It's a simple matter to convert from % P₂O₅ or % K₂O to actual % P or % K, just take the % P₂O₅ and multiply by (2 x atomic weight of P / molecular weight of P₂O₅ = **0.44**) or the % K₂O and multiply by (2 x atomic weight of K / molecular weight of K₂O = **0.83**).

Some major fertilizer carriers and their grades include urea ([H₂N]₂CO, 45-0-0), ammonium nitrate (34-0-0), ammonium sulfate ([NH₄]₂SO₄, 21-0-0), concentrated superphosphate (0-46-0) and muriate of potash (KCl, 0-0-60). However, due to impurities, percentages N, P₂O₅ and K₂O are somewhat lower than would be calculated for pure carrier substances.

A fertilizer that contains all three nutrients, N, P and K, such as 13-13-13, is called a **complete fertilizer**. To make a low grade fertilizer from high analysis carriers (high concentration of nutrient) requires addition of a **filler** (usually a lime material). On the other hand, it is impossible to make a high grade fertilizer from low analysis carriers.

Now, a few relevant calculations. First, to calculate the appropriate rate of a fertilizer to apply in order to add the recommended amount of a nutrient

$$\text{lbs of carrier / acre} = (\text{recommended rate [in lbs / acre]} \times 100 \%) / \% \text{ nutrient in carrier}$$

Assume you want to use urea to supply N at the rate of 90 lbs / acre, then

$$\begin{aligned} \text{lbs of urea / acre} &= (90 \text{ lbs / acre} \times 100 \%) / 45 \% \\ &= 200 \text{ lbs of urea / acre} \end{aligned}$$

To calculate fertilizer cost per acre using different fertilizers, just multiply the cost per ton of carrier by lbs / acre, then divide by 2000 lbs

$$\text{carrier cost / acre} = (\text{cost / ton}) \times (\text{lbs of carrier / acre}) / (2000 \text{ lbs / ton})$$

Assume urea costs \$ 360 / ton, then

$$\begin{aligned} \text{cost of urea / acre} &= (\$ 360 / \text{ton}) \times (200 \text{ lbs / acre}) / (2000 \text{ lbs / ton}) \\ &= \$ 36 \text{ of urea / ac} \end{aligned}$$

Cost of different fertilizers is variable. Since fertilizers are priced by the ton and different materials contain different amounts of nutrients, it is important to compare fertilizer costs per pound of nutrient, not per ton of carrier. It is the amount of nutrient supplied by the fertilizer that is important. Generally, higher analysis fertilizers cost more per ton than do lower analysis fertilizers but because the concentration of nutrients is higher, the cost per pound of nutrient is usually lower.

To calculate the cost per pound of nutrient in a fertilizer, divide cost per ton by pounds of nutrient per ton

$$\text{cost / lb} = (\text{cost of carrier / ton}) \times 100 \% / (\% \text{ nutrient in carrier} \times 2000 \text{ lbs / ton})$$

Again, using the urea example

$$\begin{aligned} \text{cost N / lb} &= (\$ 360 \text{ urea / ton}) \times 100 \% / (45 \% \text{ N in urea} \times 2000 \text{ lbs / ton}) \\ &= \$ 0.40 / \text{lb N} \end{aligned}$$

III Procedure

A *Extraction of Soil P*

1. Weigh 1 g soil (oven-dry equivalent) into a large disposable test tube and add 20 mL of extracting solution (0.10 N HCl + 0.03 N NH₄F).
2. Shake for 1 min and syringe-filter more than 5 mL into a second, smaller tube.
3. Pipette 5 mL of filtrate to a third test tube.

B *Preparation of Standard Curve and Analysis of Extract*

A single set of standards and standard curve will be used by the entire class. The standards are provided, pre-poured into test tubes. Their concentrations are: 0.0, 0.1, 0.2, 0.4, 0.7 and 1.0 µg P / mL (ppm) and there are 5 mL each of them.

4. To each add 0.8 mL of reagent (sulfuric acid, ammonium molybdate, potassium antimony tartrate and ascorbic acid), which reacts with phosphate to give a depth of blue color (light absorbance) proportional to phosphate concentration.
5. Also add 0.8 mL of mixed reagent to the 5 mL of filtered extract.
6. Let stand for 12 min but no more than 30 min then measure absorbance of each P solution at 880 nm and record in Table 1.

7. According to Beer's Law, concentration is directly proportional to absorbance. Therefore, prepare a standard curve by plotting P concentration (Y axis) versus absorbance (X axis) and draw a visual best-fit straight line through these data. This is the standard curve from which measured absorbance is used to estimate extractable P in your soil.
8. Determine P concentration ($\mu\text{g} / \text{mL}$) in the extract from the standard curve.

Calculate concentration of P in the soil as

$$\mu\text{g P} / \text{g soil} = 20 \times \text{concentration in extract } (\mu\text{g} / \text{mL})$$

If absorbance is out of the calibration range (too high, too much P in extract), dilute an aliquot of the extract with extracting solution. Note the dilution factor ($= [\text{mL filtrate} + \text{mL extracting solution}] / \text{mL filtrate}$) and proceed as above.

In this case, $\mu\text{g P} / \text{g soil} = 20 (\text{dilution factor}) \times \text{concentration in extract } (\mu\text{g} / \text{mL})$.

9. Convert from $\mu\text{g P} / \text{g soil}$ (ppm) to lbs P / acre assuming 2 million lbs per acre to 6 inches depth. Record in Table 2.

$$\text{lbs P} / \text{acre} = 2 \times \mu\text{g P} / \text{g soil}$$

C *Making Recommendations Based on Soil Test Results*

Use K concentration from earlier data, together with P concentration, to make recommendations for P and K fertilizer requirements for a Louisiana crop of your choice. Recommendations of the sort you are about to make were once made just this way but now are computerized.

To convert earlier K data (from LSU AgCenter Soil Testing and Plant Analysis Lab in part per million, ppm, in solution) to units of lbs K / acre use

$$\text{lbs K} / \text{acre} = 20 \times \text{ppm K}$$

Record in Table 2.

Recommendations in Louisiana depend on crop (and specific use or condition such as bermudagrass on athletic fields, cut for hay or grazed), soil type (texture and alluvial or upland origin) and whether the site is irrigated. **See notebooks** that give for recommendations for a dozen different crops. You make recommendations for a crop among those given. Record in Table 3.

IV Worksheet and Questions

A P Standard Curve and Extractable P and K

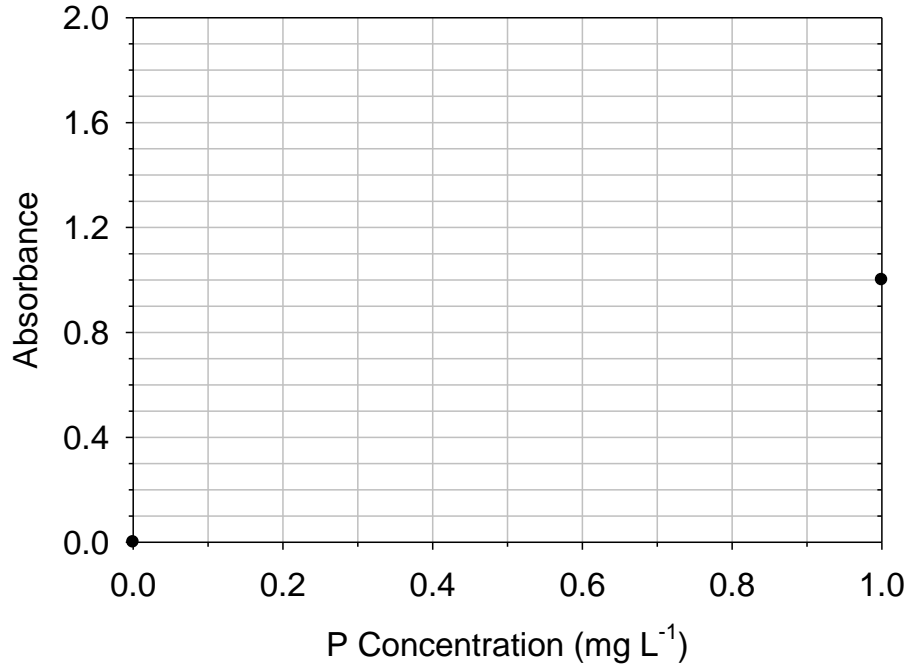


Table 1.

Solution	µg / mL	Absorbance
Standard		
Standard		
Standard		
Standard		
Unknown		

Table 2.

Nutrient	lbs / acre
P	
K	

B Fertilizer Recommendations (lbs / acre) for Crop

Table 3.

Crop	N Add	P Initial	P Add	K Initial	K Add

C Questions

1. Estimate costs of recommended N, P and K (part B, above) based on costs of urea, concentrated superphosphate and muriate of potash given below.

Carrier	Grade	Cost / ton
Urea	45 - 0 - 0	\$ 360
Concentrated superphosphate	0 - 46 - 0	\$ 480
Muriate of potash	0 - 0 - 60	\$ 480

Nutrient	Lbs / acre	Lbs carrier / acre	Cost / acre
N			
P			
K			

2. Compare the cost of N per pound in urea and ammonium sulfate (\$ 210 / ton).
3. If one wanted to supply 90 lbs of N per acre using manure that contained 1/2 % N by weight, how much manure is needed?