REFERENCE SHEET: SOIL HEALTH ASSESSMENT TOOLKIT

METHOD TO MEASURE AVAILABLE PHOSPHORUS (P) IN SOIL USING THE OLSEN EXTRACTION

MATERIALS:

1. Sodium Bicarbonate (Baking Soda), $NaHCO_3$
2. Sodium hydroxide, NaOH, small amount to adjust the pH of Olsen solution.
3. Acidulant: 1M sulfuric acid (H_2SO_4, prepared by diluting concentrated sulfuric acid (18M) or analyzing and diluting battery acid (see separate method in the manual available at the website); Sodium bisulfate or $NaHSO_4$ is another option, prepared as 15g/100 mL in water.
4. Hanna Instruments brand low range phosphate reagent packet, catalog number 93713.
5. Graduated cylinder, 25 mL or 30 mL, graduated to 1 mL or less.
6. Centrifuge tubes, 50 mL, or similar small bottles, for shaking soil samples with Olsen extraction solution.
7. Filtering equipment: #1 or #5 filter paper depending on soil. A filtering apparatus such as a press may be useful to speed up filtering; see method below.
8. Plastic droppers, also known as transfer pipets, and simple disposable plastic cups, for moving and mixing solutions. Ideally one would have 1 mL droppers and another 3 to 5 mL dropper, for maximum ease and to avoid contamination of clean solutions with samples.
9. Hanna Colorimeter, model HI-717, for high range phosphate measurement (note that it is intentional that we use low range reagents with the high range colorimeter).
10. 11 mL vials with diameter 17 mm (3/4 inch) for use with the colorimeter.

PROCEDURE:

PREPARATION OF OLSEN SOLUTION (0.5 M $NAHCO_3$ ADJUSTED TO PH 8,5):

For each 100 mL of solution:

1. Measure or weigh 100 mL (equal to 100 g) water in a bottle or beaker.
2. Add 4.2 g sodium bicarbonate ($NaHCO_3$) per 100 mL
3. Mix the solution well until all the $NaHCO_3$ is dissolved. Slightly warming the solution can help the baking soda dissolve.
4. To this same solution and measuring the pH with a pH meter or pH strips., Add sodium hydroxide to raise the pH to 8.5. This will be about 0.1 g or less of NaOH per 100 ml of solution. When starting this process and without adding NaOH, the solution will have a pH of approximately 8 or a little less.
5. You can achieve greater precision in the concentration by making a larger volume of the solution, for example 500 mL of solution (with 21 g $NaHCO_3$). In this way, baking soda weighing errors will not affect the concentration as much.

EXTRACTING AVAILABLE PHOSPHORUS FROM THE SOIL:

1. Add approximately 2.5 g of sieved soil (2mm) to 25 ml of Olsen solution in a centrifuge tube (50 ml) or similar container. Record the exact weight of the soil, for example, 2.54 g.
2. Close the tube or container and shake for 10 min. If there are many samples, an electric shaker or other system can be used.
3. When letting it settle, wait a few seconds, and swirl the tube once or twice while keeping upright, to wash the remains of soil on the lid and sides of the tube towards the bottom.
4. Let the solution settle upright for 10 minutes, so that some of the clay will settle out.
5. Carefully open the tube or container to remove the suspension necessary for the next step with a dropper.
6. Remove 12 to 15 mL of soil suspension from the upper part of the tube, without touching the settled clays below, and transfer it to be filtered. There are two ways to filter this suspension which are detailed in the following steps. For many soils, a Whatman's #5 filter is needed, which has small

pores to filter clay, although for some soils, a #1 filter with larger pores is sufficient to achieve a transparent extract.

METHOD 1 FOR FILTERING: TRADITIONAL FILTER PAPER FOLDED IN A CONE

a. Transfer the solution to a filter folded into a cone shape (Fig. 1, left)
b. Observe that the solution begins to drip and that it is transparent, without cloudiness.
c. Wait for the sample to filter 7 mL of filtrate, which can take up to 30 minutes.

METHOD 2 FOR FILTERING: USING A FILTERING BOTTLE AND A PRESS:

a. See the video on the website for details on this method (https://smallholder-sha.org)
b. Transfer the suspension to a plastic bottle modified for filtering (small holes in the cap with a needle, a filter paper inside the cap for the solution to filter)
c. Close the bottle firmly but not too hard (so as not to rip the filter inside the lid)
d. Invert the bottle into a press (Fig. 1, right) and compress it with the wingnuts to express the solution filtered from the bottle, which is captured with a plastic cup.

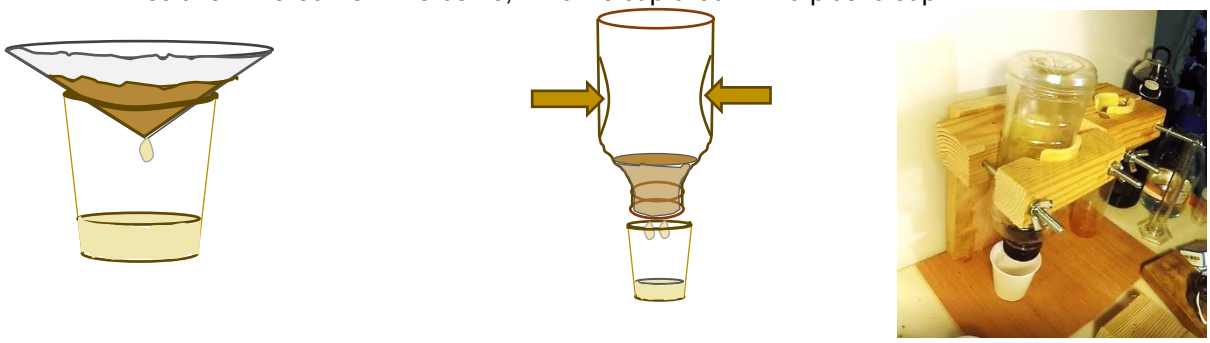

Figure 1. Two filtering options: On the left, traditional passive filtering, with a folded cone of filter paper. In the center, filtered by exerting pressure on a bottle on the right, using a mechanical press**. On the right,** a version of a bottle press built with wood and ¼-inch screws with wing nuts.

ANALYZING THE FILTRATE FOR PHOSPHATE AND CALCULATING RESULTS:

7. Filter the soil suspension until you have captured 7 ml of solution for analysis. 5 and 6 mL are also acceptable if filtering is difficult.
8. In a graduated cylinder, measure 7 mL (or 5 or 6 mL, see table below) of the filtered solution. Then pour it into a small disposable plastic cup to acidify it (you put it in a cup because the solution will bubble when acid is added, and the wider cup will prevent it from overflowing)
9. **Two ways to acidify:** Acidify the solution with 1.95 mL of 1M sulfuric acid (1 molar), or 3.1 mL of sodium bisulfate solution (the solution is made as 15g $NaHSO_4$ in 100 mL water). See the table below to acidify other amounts of soil solutions. The quantities may need to be adjusted upwards when analyzing calcareous soils with high pH, in quantities of 0.05 to 0.1 ml.

Quantity of filtered solution used for analysis	Quantity of 1M sulfuric acid to add for acidifying (mL)	(alternative) Quantity of sodium bisulfate solution to add for acidifying (mL)
7 ml	1,95	3.10
6 ml	1,65	2.75
5ml	1.40	2.25

10. Pour the acidified solution back into the graduated cylinder and make up to a volume of exactly 20 mL with distilled or P-free water. As you add this water you can use it to rinse out the disposable cup used for acidifying, with small amounts of water.

11. **IMPORTANT:** Mix the sample with the water added for top-up to 20 mL by pouring it back and forth between the cylinder and the cup. This will also capture any extract left in the cup.
12. Pour 10 mL of the acidified extract from the graduated cylinder into an 11 mL vial for the colorimeter. Add the contents of one reagent packet, close and shake well. Pour the remaining contents of the graduated cylinder (the other 10 mL) into another vial as a blank (see Fig. 2 below). *Note: if the extract bubbles vigorously when the reagent pack is added, then for soils of this type, further acidification may be necessary because of higher soil pH* - for example, 0.15 mL more of 1M sulfuric acid. However, small amounts of bubbling are normal when you add the reagent package.
13. Read the level of phosphorus in the extract as follows using the colorimeter:
    a. Turn on the colorimeter with the button and wait for 'C1' to display.
    b. Insert the blank vial (the one containing soil extract not reacted with the reagent packet). Press the button.
    c. Wait until 'C2' appears.
    d. Insert the sample to read. Press the button again.
    e. Wait for the phosphate level reading and then record it, for example '6.3'.
    f. You should try to capture the reading at the maximum level of blue colour, which generally takes between 8 and 15 minutes. With the first few samples in a batch, you can take 2 or 3 successive readings of the solution in this way, starting in 8 minutes, until the rate of color development is understood, and you can analyze the other samples using this timing.

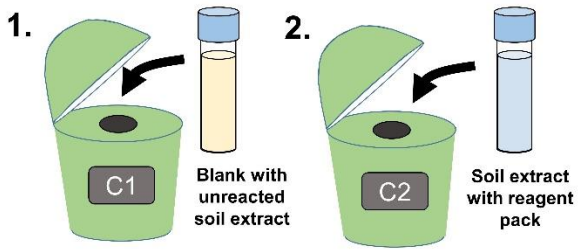

Figure 2. Reading the level of phosphate in the extract using a control vial and one with a color reagent added.

14. To calculate the amount of available P in soil from the reading, you can use the online calculator found on the page for this Olsen P method with a link at https://smallholder-sha.org The steps for the calculation can also be found in the full manual for the toolkit found at this site. You can also use the ODK survey app and forms available to perform the calculation and record results in an online database, which can be found at https://soils.stats4sd.org/. Then to interpret the results, use the interpretation table found below.

SCORING AND INTERPRETATION TABLE FOR THE OLSEN AVAILABLE P TEST:

Value of Olsen-extractable P	Qualitative Score	Description
0 to 5	**Very Low**	Biomass, vigor, and flowering of many crops will be seriously limited. Deficiency symptoms may appear, especially if phosphorus is the only limiting nutrient. If phosphorus and other nutrients are also low, it can show up as a general lack of vigor and biomass.
5 to 10	**Low**	Crops are limited by a lack of phosphorus, however if fertility inputs are applied (manure, phosphorus fertilizer, etc.) they can respond very positively because there is already a minimum level available.
10 to 20	**Medium**	Many crops will continue to respond to additional inputs of manure, compost, or P fertilizer, especially legumes and vegetables whose production involves flowering and fruiting (e.g. broccoli, tomato, squash). Some P-efficient cereals (e.g. barley, wheat) can already achieve sufficiency.
Above 20	**High**	Most crops will not be limited by phosphorus fertility. However, some vegetables, as well as agricultural weeds, can continue to increase their production to even higher levels, for example up to 30 to 50 mg/kg. Values greater than 50 may indicate inefficiency in a farming system, in that excessive phosphorus is being allocated to these fields that could be applied elsewhere, and potentially contaminating local waterways with excess phosphorus.