WIU

Soil Health Bucket Manual

draft 1.0

Dr. Joel Gruver

School of Agriculture

Western Illinois University

(309) 298 1215 – office

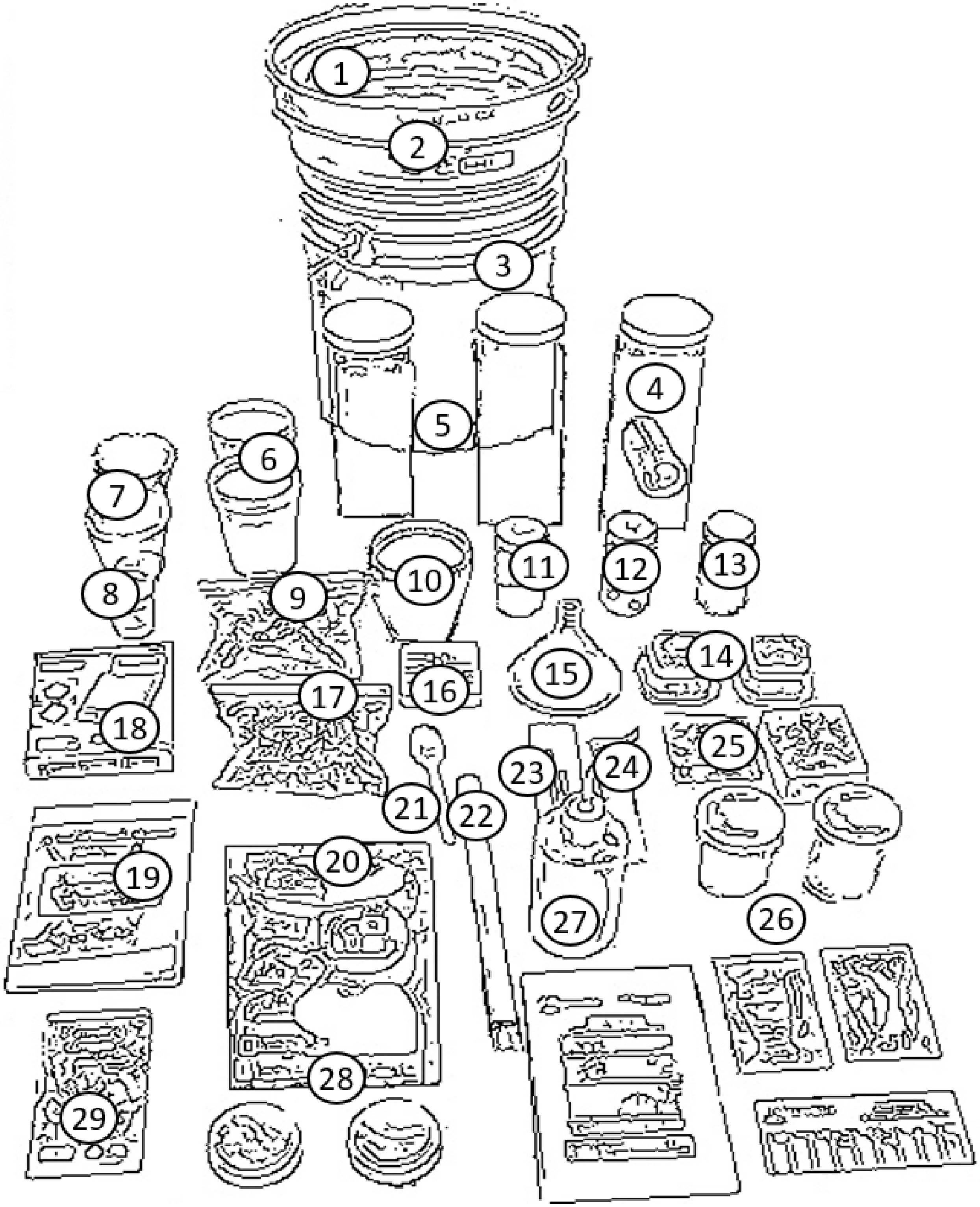
(309) 569 0817 – cell

j-gruver@wiu.edu

Acknowledgments

This project would not be possible without financial support from the Illinois Corn Growers Association, leadership from Dr. Andrew J. Baker – Director, School of Agriculture at Western Illinois University, assistance from Ms. Megan Wurth, Mr. Andy Clayton and Ms. Morgan Lemley and the collaboration of Agriculture Instructors across the state of Illinois.

What's in a **S**oil **H**ealth **B**ucket?


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Key to Soil Health Bucket photo/diagram

1	Sieve w/ 1/4" openings
2	Sieve w/ 1/12" openings
3	5 gallon bucket
4	Rectangular PVC canister for soil preference test
5	2 intact rectangular PVC canisters w/ lids
6	PP cups (12 oz, purple and gold) w & w/o mesh
7	PETE cups (9oz) w/ and w/o holes and filter paper
8	Polystyrene weighing cups (3 oz)
9	Alfalfa meal
10	8 horticultural pots (4")
11	Digi-tube w/ Calgon
12	Digi-tube w/ marbles
13	Digi-tube w/ annual ryegrass seed
14	Square Ziploc containers w/ purple & gold mesh
15	Powder funnel (150 ml)
16	Filter paper (#417, 5.5 cm diameter)
17	Shredded office paper
18	Electronic balance (500 g capacity, 0.01g sensitivity)
19	Soil Owner's Manual by Jon Sitka
20	Smart phone microscope
21	Plastic spoon
22	Polycarbonate hydrometer
23	Digital thermometer
24	Ruler (6"/15 cm)
25	Cellulose sponges, purple and gold
26	Solvita soil respiration kit
27	Squirt bottle (500 ml)
28	Tinplate sample cups (4 oz) w/ lids
29	Midwest Cover Crops Field Guide (Purdue Ext)
Not shown	disposable transfer pipette (3 ml)

More detailed summary of SHB contents

2 sieves that stack and fit on top of a 5 gallon bucket

- sieve w/ larger mesh has 1/4” openings
- sieve w/ smaller mesh has 1/12” openings

3 x 52 oz PVC rectangular canisters

- 2 intact containers w/ lids
- 1 container modified for earthworm soil preference test

2 square cups with honeycomb mesh bottoms (1 purple and 1 gold)

8 x 4” plastic pots

2 ziploc bags

- 1 containing alfalfa meal
- 1 containing shredded paper

4 x 100 ml digi-tubes

- 1 intact tube w/ lid containing ~20 g of soil dispersing agent (sodium hexametaphosphate)
- 1 intact tube w/ lid containing 2 marbles
- 1 intact tube w/lid containing ~ 30 g of annual ryegrass seed
- 1 tube modified for earthworm soil preference test

1 ruler (6”/15 cm)

1 electronic balance (500 g capacity, 0.01g sensitivity)

2 x 3 oz (88 ml) polystyrene cups for weighing

4 x 9 oz polypropylene cups

- 2 intact cups (1 purple and 1 gold)
- 2 sieve cups (1 purple and 1 gold)

4 clear PETE cups

- 2 intact cups
- 2 filter cups (1 marked w/ a purple band, 1 marked w/ a gold band)
- 1 pack of 50 filter papers (# 417, 5.5 cm diameter)

1 smart phone microscope

1 digital thermometer

1 hydrometer (Herculometer)

1 x 150 ml powder funnel

1 x 500 ml squirt bottle

2 sponges (1 purple and 1 gold)

1 white plastic spoon

1 disposable transfer pipette

2 sample cans with lids

Solvita supplies

- 2 incubation jars
- 2 CO_2 absorption paddles
- 1 color card
- 1 manual

2 books

- A Soil Owner's Manual by Jon Sitka
- Midwest Cover Crop field guide. 2nd edition (extension publication ID-433 from Purdue)

Important supplies not included:

Paired soils (same soil type, contrasting management histories)

Containers for storing whole soils and soil fractions

3% hydrogen peroxide

Earthworms

Collecting soil for evaluation using SHB methods

The SHB methods described in this document were designed for comparing soils mapped as the same soil type (e.g., Drummer silty clay loam) but potentially differing in SOIL HEALTH because of differences in management history. Management contrasts that you may want to investigate include a) crop field vs. fence row b) long-term no-till vs. regularly tilled c) long term use of cover crops vs. no cover crops d) long-term history of manure vs. no manure and e) organic farming vs. conventional farming

Soils mapped as the same soil type i.e., same soil series (i.e., the most specific level of classification in USDA Soil Taxonomy system) with the same surface textural class (i.e., zone on a textural triangle such as silt loam). Web soil survey (https://websoilsurvey.sc.egov.usda.gov/) or a traditional county soil survey book can be used to identify the soil type mapped at locations of interest. Keep in mind that soil variation small than ~ 2 acres is NOT shown on a county soil survey map.

It is IMPORTANT that you compare soils that are mapped as the same soil type because SOIL HEALTH = soil functional capacity RELATIVE to a soil type's potential. Comparison of soil health parameters across different soil types also has value but is a different approach.

Start by collecting soil from 2 sites with close proximity (e.g., less than 20 feet apart and same landscape position) but VERY different management histories (e.g., crop field vs. fence row). Once you are familiar with the SHB testing methods, you may want to compare soils with more similar management histories.

Use a shovel to collect soils from a comparable depth (e.g., top 6") and moderate moisture content. Soil should be friable (i.e., crumble easily when mechanically stressed). If the soil molds rather than crumbles, it is too wet for sieving. Excessively wet soil can be collected in a bucket, gently spread on newspaper and allowed to dry until friable before sieving.

A small shovelful of friable soil should be added to the top of a pair of stacked sieves with 1/4" and 1/12" mesh openings (sieve with smaller openings on bottom) on top of a clean 5 gallon bucket. Before proceeding with sieving, observe soil and collect some ~ 1" diameter peds (natural structural units) if present. These will be used for the slake test. Next, remove large pieces of residue and gently crumble the remaining soil. Next, rock the stacked sieves and bucket back and forth for ~ 15 seconds so that the soil peds (aka aggregates) separate into size fractions. Unless the soil is very sandy, some soil should pass through both sieves into the 5 gallon bucket, some soil should pass through the 1/4" mesh but be retained on the 1/12" mesh and some soil should remain on top of the 1/4". Repeat manual crumbling and rocking as needed. Do not force all of the soil through the sieves.

The 3 size fractions of soil (peds ~ 1" in diameter, soil aggregates < 1/4" but > 1/12" and soil aggregates < 1/12" that passed into the bucket) should be spread on newspaper and air dried. After air drying for a minimum of 72 hours, the 3 soil fractions can stored in cups or boxes. A fan can be used to accelerate air drying.

In addition, fill a 1 gallon Ziploc bag with gently crumbled but unsieved field moist soil. This soil can be kept at room temperature if tests will be performed within a few days but should be refrigerated if kept much longer.

Photos should be taken of the sites when soil is collected and the site locations should be marked on a soil survey base map. In addition, ephemeral soil characteristics at the time of sampling (e.g, temperature of the soil at 4”, smell, activity of organisms, roots, macro-structural features) should be documented.

The soil size/moisture fractions isolated using the procedures described above are needed for the following methods:

Field moist gently crumbled whole soil

field moisture content
earthworm soil preference
weed seed bank
annual ryegrass biomass production

Air-dry soil fractions

~ 1” diameter peds
slake test

1/4" < > 1/12” soil aggregates
aggregate stability
aggregate resilience
saturation moisture content
field capacity moisture content
soil permeability
biomass digestion
Solivita CO2 burst

< 1/12” soil aggregates
particle size analysis
clay dispersibility
total OM (loss on ignition)

Additional Note: On all the lesson plans listed below, for supplies, the number listed after each component corresponds to the Soil Health Bucket photo/diagram key.

Particle size analysis (hydrometer method)

This method quantifies the proportions of sand (2-0.05 mm), silt (0.05-0.002 mm) and clay (<0.002 mm) in a soil suspension by using a hydrometer to monitor changes in suspension density as particles settle. Particle settling rates as predicted by Stokes' Law are proportional to particle size squared (i.e., particles that are twice as big fall 4 times as fast). Hydrometer measurements made when sand particles have finished settling (~ 40 seconds) and when silt particles have finished settling (~ 7 hours) allow a good estimation of sand and clay content (and calculation of silt content).

Soils that are the same soil type should have similar proportions of sand, silt and clay (aka texture). Paired soils that classify as different USDA textural classes (e.g., silt loam vs. silty clay loam) are not appropriate for soil health comparisons. Keep in mind that measured differences in clay content may be indicative of differences in clay dispersibility rather than actual differences in clay content. Soil treatment with hydrogen peroxide may be necessary to disperse the clay in soils with very stable microaggregates.

Supplies: (# in parenthesis corresponds with itemized list on page 5)

Herculometer hydrometer (22)
Sedimentation canister (4)
100 ml digi-tube and cap (12)
2 marbles (12)
Sieve cup (6)
1 powder funnel (15)
500 ml squirt bottle (27)
Digital thermometer (23)
Electronic balance (18)
Sodium hexametaphosphate (HMP), 4% dispersing solution (11)

Procedures:

Place designated digi-tube (that will only be used for aggregate dispersion) on electronic balance. Add a powder funnel to the top of the digi-tube and tare the balance to 0.00 g. Add 50.0 g of air-dried soil (1/12") to the digi-tube.

If 4% HMP solution has not already been prepared, dissolve 20.0 g of Calgon in 500 ml of tap water.

Add 100 mL of HMP solution and 2 marbles to the digi-tube. Securely cap the digi-tube and shake vigorously end-to end for 2 minutes. Wait 5 minutes and then shake vigorously end-to end for 2 minutes. Wait 5 minutes and then shake vigorously end-to-end for 2 minutes.

Fit the small end of sieve cup into the top of a sedimentation canister and pour in the soil suspension. Use a squirt bottle to transfer all soil from the digi-tube into the sieve cup and down through the sieve cup into the sedimentation canister.

Repeat above steps, so that the total soil added to the sedimentation canister = 100.0 g.

Add tap water to the sedimentation canister until it is filled to the bottom of the lip below the threads at the top of canister.

Allow the suspension to equilibrate to room temperature for at least 1 hour.

Lay 1 plastic Ziploc bag flat on top of canister and carefully secure the lid. The purpose of the bag is to act as a gasket preventing leakage during shaking. Turn canister upside down and shake vigorously, making sure that no soil remains stuck on the bottom of the canister. Turn canister back up right and set it gently down on a table top. Remove lid and add hydrometer to the suspension. Begin timing. After 40 seconds of settling, read the density on the hydrometer stem @ the surface of the suspension.

After 6 hours, measure temperature of the suspension to the nearest ±1 degree C.

Read the hydrometer at the appropriate temperature corrected time (Table 1) to determine the g of clay in suspension.

Calculations

% sand = [100 – (soil in suspension after 40s)]

% clay = soil in suspension after ~ 7 hours

% silt = 100 – (% sand % + % clay)

Table 1: The influence of suspension temperature on the hydrometer determination of soil clay (2 µm) based on a particle density of 2.65 g cm-3 and a solution density of 1.0 g L^{-1}.

Temperature ^{o}C	Settling time for clay (hours and minutes)
18	8:09
19	7:57
20	7:45
21	7:35
22	7:24
23	7:13
24	7:03
25	6:53
26	6:44
27	6:35

Table 2: Interpreting hydrometer readings

(#s 1-100 = g of soil in suspension, #s 1.005- 1.0477 = suspension density read from hydrometer)

100	1.0477	75	1.0360	50	1.0242	25	1.0122
99	1.0472	74	1.0356	49	1.0237	24	1.0117
98	1.0468	73	1.0351	48	1.0233	23	1.0112
97	1.0463	72	1.0346	47	1.0228	22	1.0107
96	1.0459	71	1.0342	46	1.0223	21	1.0103
95	1.0454	70	1.0337	45	1.0218	20	1.0098
94	1.0449	69	1.0332	44	1.0213	19	1.0093
93	1.0445	68	1.0327	43	1.0209	18	1.0088
92	1.0440	67	1.0323	42	1.0204	17	1.0083
91	1.0435	66	1.0318	41	1.0199	16	1.0078
90	1.0431	65	1.0313	40	1.0194	15	1.0073
89	1.0426	64	1.0309	39	1.0189	14	1.0069
88	1.0421	63	1.0304	38	1.0185	13	1.0064
87	1.0417	62	1.0299	37	1.0180	12	1.0059
86	1.0412	61	1.0294	36	1.0175	11	1.0054
85	1.0407	60	1.0290	35	1.0170	10	1.0049
84	1.0403	59	1.0285	34	1.0165	9	1.0044
83	1.0398	58	1.0280	33	1.0161	8	1.0039
82	1.0393	57	1.0275	32	1.0156	7	1.0034
81	1.0389	56	1.0271	31	1.0151	6	1.0029
80	1.0384	55	1.0266	30	1.0146	5	1.0025
79	1.0379	54	1.0261	29	1.0141	4	1.0020
78	1.0375	53	1.0256	28	1.0136	3	1.0015
77	1.0370	52	1.0252	27	1.0132	2	1.0010
76	1.0365	51	1.0247	26	1.0127	1	1.0005

Slake test

Introduction

Slaking is the disintegration of large air-dry soil structural units (often called peds) into fragments during rapid wetting. Slaking occurs when soil structural units are not strong enough to withstand the internal stresses that occur during rapid wetting. Internal stresses include differential swelling of clay particles, compression of trapped and escaping air in soil pores, and the mechanical action of moving water.

Soils that slake readily tend to be prone to run-off, erosion, crusting and compaction. Resistance to slaking indicates that the soil's structure is reinforced by a network of binding agents (principally organic materials such microbial glues, fungal hyphae and roots) that can withstand the internal stresses that occur during rapid wetting.

This single <u>qualitative</u> but visually compelling test is a good predictor of the results of many of the more quantitative methods in this manual.

Supplies: (# in parenthesis corresponds with itemized list on page 5)

2 x 52 oz PVC rectangular canisters (5)
2 x square ½ cup containers w/ open bottoms covered w/ purple & gold mesh (14)
2 air-dried soil peds approximately 1" in diameter (not provided)

Procedures:

2 rectangular canisters should be set up side-by-side on a desk top where both can be easily viewed by students.

Fit square ½ cup container w/ purple mesh into the top of one canister and square ½ cup container / gold mesh into the top of the other canister.

Fill both canisters nearly full with tap water. Water should be within ½" of the lip of the square containers.

Simultaneously drop air-dried peds representing contrasting soils into designated canisters. Drop distance should be less than ½" to minimize splashing water out of the canister.

Observe and take notes about the following:

- size and rate of air bubbles exiting from soil peds as water infiltrates
- slaking (*aka disintegration or fragmentation during rapid wetting*) of the ped and settling of fragments to the bottom of the canister
- turbidity of water as dispersed clay remains in suspension

After observing for several minutes, lift square ½ cup containers w/ mesh above the water surface and then set back in the water. Observe any additional slaking.

Aggregate stability

Introduction

Aggregate stability is the ability of soil crumbs aka as aggregates to resist disintegration when outside forces (usually associated with water) are applied.

Aggregates that easily disintegrate in water or when struck by raindrops release soil particles that can seal the soil surface and clog pores restricting air and water movement, root extension and emergence of seedlings.

This method is a quantitative assessment of the phenomena observable during the slake test.

Supplies: (# in parenthesis corresponds with itemized list on page 5)

2 sieve cups (purple and gold) (6)

2 catchment cups (purple and gold) (6)

2 x 100 ml digi-tubes (12)

3ounce polystyrene cup (8)

500 ml squirt bottle (27)

3 ml transfer pipette (not pictured)

Electronic balance (500 g x 0.01g) (18)

10.00 grams of air dry soil aggregates (1/12-1/4”) of 2 contrasting soils – NOT PROVIDED

Procedures:

Carefully perform the following procedures for 2 contrasting soils. Use the purple colored supplies for 1 soil and the gold colored supplies for the other.

Place clean dry 3 ounce polystyrene cup on electronic balance and tare to 0.00 g. Use plastic spoon to carefully add 10.00 g of air dry soil aggregates (1/12-1/4”) to the cup.

Add 150 g/ml (measured using electronic balance or graduated digi-tube) of tap water to catchment cup. Place clean sieve cup in catchment cup and pour 10.00g of air dry aggregates into the sieve cup.

Wait 60 seconds and then gently move screen cup up and down 10 times (~ 1 oscillation per second) submerging the soil each time. Unstable soil that passes through the screen will be caught in the catchment cup.

At this point you have 3 options.

A) If you have access to a drying oven:

Place catchment cups in a drying oven set to 200 F and dry off all the water.

Weigh catchment cups with oven dry unstable soil as well as clean and dry. Calculate mass of oven dry unstable soil.

Use following equation to calculate % aggregate stability:

% aggregate stability = [(10.00 – mass of dry unstable soil)/10.00] * 100

B) If you are willing to wait ~ 5 days:

Allow suspension in catchment cup to settle for 10 minutes. Carefully pour off supernatant (i.e., top of suspension that contains minimal soil) but stop BEFORE you start pouring off soil. Use the provided transfer pipette to remove additional supernatant. Set catchment cups in a secure place and allow them to air dry. Allow cup to sit 1 additional day after the unstable soil appears to be dry. Weigh catchment cups with dry unstable soil as well as clean and dry. Calculate mass of oven dry unstable soil.

Use following equation to calculate % aggregate stability:

% aggregate stability = [(10.00 – mass of dry unstable soil)/10.00] * 100

C) If you want to complete the lab in 1 class session:

Allow suspension in catchment cup to settle for 10 minutes. Carefully pour off supernatant (i.e., top of suspension that contains minimal soil) but stop BEFORE you start pouring off soil. Use the provided transfer pipette to remove additional supernatant.

Use squirt bottle to wash ALL unstable soil from catchment cup into a pre-weighed clean digi-tube. If digi-tube has not yet been weighed, weigh a clean dry 100 ml digi-tube and write the weight (x.xx g) on the outside of the digi-tube using an indelible marker.

Use squirt bottle to carefully add water until suspension in digi-tube is exactly 100.0 ml in volume. Weigh digi-tube containing soil/water suspension and record weight (xx.xx g). Calculate mass of suspension of soil/water suspension by subtracting mass of clean dry digi-tube.

Use following 2 equations to calculate % aggregate stability:

$U = S – [(265 – S)/1.65]$

$\% \text{ aggregate stability} = [(10.00 – U)/10.00] * 100$

Where U = dry mass of unstable soil
And S = mass of suspension of unstable soil + water

Soil permeability and field capacity

Introduction

Soil permeability is a soil's capacity to allow water to move through it. Permeability is a complex property that varies with particle size, total pore space, size and continuity of pores, depth, initial soil moisture content and even direction of water flow.

Field capacity is a soil's moisture status when the soil stops being drained by gravity. All large pores have been emptied but small pores are still full of water.

This method quantifies permeability and field capacity of a disturbed soil consisting of a specific size fraction (1/12 -1/4") and thus generates very different results than methods that use intact soil.

Supplies: (# in parenthesis corresponds with itemized list on page 5)

2 filter cups – purple and gold rimmed clear plastic 9 oz. cups with 5.5 cm diameter filter paper glued to bottom of cup w/ additional filter paper as needed (7)
2 intact clear plastic 9 oz. cups (7)
2 sponges (purple and gold) (25)
Graduated digestion tube (12)
Plastic spoon (21)
Electronic balance (18)
50 g. of air dry soil aggregates (1/12-1/4"size fraction) – NOT PROVIDED

Procedures:

Carefully perform the following procedures for 2 contrasting soils. Use the purple colored supplies for 1 soil and the gold colored supplies for the other.

Check filter cups to make sure that the filter paper is well attached. If the filter paper is not well attached, remove the filter paper, use sandpaper to roughen the surface of the bottom of the cup and then use rubber cement to attach the filter paper. If filter paper is damaged, replace with 5.5 cm diameter filter paper provided in the SHB.

Place clean dry filter cup on electronic balance and record weight before taring to 0.00 g. Use the plastic spoon to carefully add 50.0 g of air dry soil aggregates (1/12-1/4"size fraction) to the filter cup. Tap the filter cup on a flat surface until aggregates are level and settled.

Measure 100 ml of tap water using the graduated digestion tube and transfer the water to an intact clear plastic 9 ounce cup.

Gently place the filter cup containing air dry aggregates in the cup containing water and observe water moving up through the soil.

When water has stopped moving upward (i.e., filter cup has fully settled), lift the filter cup a few inches so that water can drain back into the intact cup. Time how long it takes for all of the free water to dissipate from the soil surface. Stop timing when the soil surface no longer looks shiny.

Pour out the water in the intact cup and refill with 100 ml of water.

Gently place filter cup back into the intact cup and wait for the filter cup to fully settle a second time. If the soil structure has collapsed significantly, it may take more than 5 minutes for the water to move up through the soil. When water has stopped moving up through the soil, transfer the filter cup to the top of a dry sponge. Time how long it takes for all of the free water to dissipate from the soil surface. Stop timing when the soil surface no longer looks shiny.

Allow filter cup to drain into the sponge for 24 hr.

Transfer filter cup to electronic balance and record the weight of the filter cup + soil at field capacity.

Observe soil in filter cups and describe physical appearance.

Calculate gravimetric water content at field capacity using the following formula:

Gravimetric water content = mass of water retained in soil / dry mass of soil

Soil color

Introduction

Just as paint stores use pages of color chips to compare and name paint colors, soil scientists use the color chips on pages in Munsell color books to name soil colors according to the Munsell system of color notation.

The color chips on the pages in a Munsell book have names consisting of 3 components: hue (primary color or intermediate color between 2 primary colors = pages in Munsell books), value (lightness of color), and chroma (intensity of color) assembled as follows hue value/chroma (e.g., 10YR 3/2).

The process of identifying a soil's color involves holding a sample of the soil behind a Munsell color page with the appropriate hue and viewing the soil through holes below each color chip. The Munsell color name associated with the color chip that best matches the soil sample is assigned to the soil feature being described.

Munsell color can be used to document the impact of management history on OM content because darker Munsell colors (i.e., lower values) are generally indicative of higher OM contents.

Supplies:

Munsell color book

Smart phone or digital camera

Graphics software like "Paint"

Soils with contrasting management histories (not provided)

Procedures:

If a Munsell color book is available, Munsell colors (hue value/chroma) can be determined by color chip comparison and then differences in SOM can be inferred.

If a Munsell color book is not available, digital photos can be taken of the soils of interest under equivalent lighting. A graphics program like "Paint" can be used to determine the RGB values for the dominant color (select dominant color with eyedropper and then look at color properties) and then the following table can be used to estimate Munsell color.

Munsell color translation to/from RGB (http://pteromys.melonisland.net/munsell/)

Hue	Value	Chroma	R	G	B
10YR	2	1	54	48	41
10YR	2	2	60	46	33
10YR	3	1	78	70	62
10YR	3	2	84	69	53
10YR	3	3	88	68	44
10YR	3	4	93	67	34
10YR	3	6	99	64	8
10YR	4	1	103	95	85
10YR	4	2	110	93	75
10YR	4	3	115	92	64
10YR	4	4	120	91	54
10YR	4	6	127	89	33
10YR	5	1	128	120	111
10YR	5	2	135	119	100
10YR	5	3	141	118	90
10YR	5	4	146	116	79
10YR	5	6	155	114	55
10YR	5	8	162	112	27
10YR	6	1	154	146	136
10YR	6	2	161	145	125
10YR	6	3	167	144	114
10YR	6	4	172	143	103
10YR	6	6	182	140	80
10YR	6	8	190	138	54
10YR	7	1	180	172	162
10YR	7	2	188	171	150
10YR	7	3	193	170	139
10YR	7	4	199	169	127
10YR	7	6	209	167	104
10YR	7	8	217	164	80
10YR	8	1	207	199	187
10YR	8	2	214	198	175
10YR	8	3	220	197	164
10YR	8	4	226	196	152
10YR	8	6	236	193	129
10YR	8	8	245	191	104

Earthworm soil preference test

Introduction

Sentient organisms demonstrate preference and avoidance behavior. Earthworm movement when given equal access to soils with contrasting management histories may be a useful indicator of differences in soil health.

Supplies: (# in parenthesis corresponds with itemized list on page 5)

9 oz. polypropylene cups (purple and gold) (6)

Soil preference testing system consisting of 52 ounce rectangular canister with 3 holes and entrance tube (4)

2 field moist soils with contrasting management histories

Earthworms or other test organisms

Procedures:

Fill purple and gold polypropylene cups (9 ounce) completely full with field moist soils with contrasting management histories. Soils should be allowed to warm up to room temperature if soils were stored in a refrigerator. Make sure that you document which soil is added to the purple vs gold cup.

Place the rectangular canister that was modified for soil preference testing on top of the purple and gold cups full of soil, such that the canister holes are directly above the middle of the cups and the entrance tube is pointed directly upward.

Add 1 earthworm (e.g., night crawler purchased from a bait shop and stored in a refrigerator if not used within a few hours) to the entrance tube. Observe and document the worm's movement. You may want to use a camera to capture still or video imagery. It may take multiple hours, but healthy worms are likely to eventually move from the entrance tube to one of the soils. The worm may circle around the entrance tube many times before choosing a soil. If worm activity is not watched continuously, the worm may move into one of the soils between observations and it may be necessary to empty the cups to find the worm.

In addition to testing soil preference with single worms, multiple worms can be added at the same time or in sequence but use of multiple worms complicates interpretation of the results. Soil preference testing can also be performed using other types of organisms (e.g., Oniscus spp., Diploda…). Keep in mind that earthworms are normally only active in the dark so the intensity of ambient lighting is likely to impact worm movement.

Soil preference testing can also be performed using 1 soil with and without the addition of a soil amendment (e.g., alfalfa meal), 2 different soil amendments (e.g., alfalfa meal vs. shredded office paper) or 2 different rates of a single amendment.

Key questions to consider:

Why would earthworms or other species prefer one soil over another?

Is the observed preference for one soil actually an aversion for the other soil?

How do earthworms sense soil differences?

How could the soil preference test be improved?

Does the scientific literature discuss soil preference testing?

Additional reading:

Ecology of Earthworms under the 'Haughley Experiment' of Organic and Conventional Management Regimes

http://orgprints.org/30000/1/Haughley.doc

The following brief descriptions of methods will be expanded in future drafts of this manual:

Weed seed bank
Soils from agricultural fields and natural areas contain a seed bank. Differences in the seed bank between sites can be compared by filling pots with soil and observing what grows when the pots are kept warm and moist.

Annual ryegrass biomass production
Soils differ in their ability to support plant growth. Differences in soil productivity can be compared by filling pots with soil, planting annual ryegrass seeds, maintaining equal moisture contents and observing differences in growth.

Aggregate resilience
Soil particles reassemble into aggregates after structural disruption. This resilience is influenced by abiotic processes (e.g., wetting and drying, freezing and thawing) and biological processes (e.g., decomposition of residues, production of organic binding agents). Impact of management history on aggregate resilience can be tested by subjecting soils to equal disruption (e.g., shaking of 50g of dry aggregates for 1 minute with a marble in a digestion tube), incubating the soil w/ or w/o organic amendments and then measuring aggregate stability.

Saturation moisture content
Impact of management history on total soil porosity can be evaluated by bringing soils of interest to saturation (add water until soil surface glistens) and then measuring moisture content @ saturation.

Biomass digestion
Impact of management history on soil ability to digest an organic amendment can be compared by amending soils of interest with equal rates of specific amendments (e.g., alfalfa meal and shredded office paper) and then tracking changes in the mass of the amendments over the course of an incubation. Changes in the appearance of decomposing amendments can be observed using a smartphone microscope.

Solivita CO2 burst
Soil respiration during 24 hours after wetting a dry soil is an indicator of soil microbial activity. Guidelines for this method accompany the Solvita supplies.

Clay dispersibility
Impact of management history on clay dispersibility can be measured using the particle size analysis procedure after a mild incomplete dispersion process (e.g., omit the SMP and/or marbles).

Total OM (loss on ignition)
Impact of management history on total OM can be measured by comparing mass loss after subjecting soil to temperatures hot enough to completely or partially combust organic matter. More than 2/3rds of the OM in most soils will combust during 2 hours @ 500 F in a standard baking oven. The metal tins provided in the SHB can be used for this purpose.

Appendices

https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_066790.pdf