ISU Three Sisters Intercropping Project
Soil Health Kit Manual

By

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Introduction & Purpose of This Manual

This manual is to be used in conjunction with the components contained within the soil health kit and is a feature of the ISU 3-Sisters Intercropping Project (ISU-3SI; website here when available). The purpose of the soil health kit and this manual is to help our Native collaborator gardeners analyze different soil health characteristics their gardens or fields. Monitoring soil health using inexpensive, yet scientifically robust, methods is key to observing positive change in soil. We at ISU hope that this kit and the overall 3-Sisters Intercropping Project will establish "community science" engagement within Native communities, where the ISU team and community-scientist collaborators can learn from one another about sustainable vegetable/crop production and soil health. In addition to engaging community scientists, our other goals with the ISU-3SI are to assess the cultural, historical, and agricultural impact of growing the 3-Sisters in our collaborator communities, and to determine the agronomic effects of the 3SI system (maize, beans and squash) on soil health.

Our primary goal is to help Native collaborators in providing healthy and culturally appropriate foods to their communities, while also creating a cross-cultural "living classroom" for cultural, historical, and scientific knowledge. We will also use the data we collect to inform conventional, industrialized agriculture, which relies heavily upon monoculture cropping systems and is shown to negatively impact soil health properties. Native American perspectives, and traditional ecological knowledge, of the agroecological benefits of intercropping over monocropping align with modern-day scientific observations. We would like to learn more about how growing the 3-Sisters, and intercropping in general, could help to diversify and improve productivity and environmental performance of modern monoculture agroecosystems.

General Supplies & Helpful Hints

General Supplies

- **Notebook** - to record measurements and observations on
- **Pencil or pen** – to record measurements and observations

OPTIONAL

- **Excel for PC or Mac Computer** – to record and do data calculations

Considerations & Helpful Hints

a) **Use your senses and record everything in notebook**
Make sure to use your senses to observe soil, current weather conditions, any details particular to your measurement, and record those in a notebook. They can be helpful to interpret results later.

b) **How many samples should I take?**
Greater replication of treatments or measurements is better. However, it comes at a cost of more time and resources in some cases. You have to decide how much time and resources to invest in your measurements. As professional scientists we usually replicate treatments randomly three to six times in a field

c) **Timing is everything**
The best time to conduct most of these measurements is right before planting or after harvest, due to normally favorable conditions to work with soil (i.e. not too dry or frozen). Whatever time you choose, be consistent and collect samples this time of year every year.

d) **More resources in the appendix of this document**
There is an itemized shopping list for the soil health kit (SHK) at the end of this manual. It may help you locate the items needed for the various tests if you do not already have these items.

e) **Consider sieving your soils**
This helps ensure soil samples are thoroughly mixed and is ideal for collecting precise and accurate data measurements from the tests performed.

f) **Read the directions of the test completely before beginning!**
It is best to understand each step of the test before conducting the analysis on your soil sample. This helps prevent unintended accidents which might require you to have to collect more soil samples.

g) **We are here to help**
Feel free to reach out to the ISU team if you have any questions about this manual or any of the tests!

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1. Earthworm Abundance and Midden Counts

based on (Stroud, 2019)

Earthworms have been shown to be an excellent indicator of soil health. Earthworm abundance and activity are generally increased with reduced tillage, diversified crop rotations, addition of manure, use of cover crops, and other soil conservation practices. Not only are earthworms indicators of soil health, but they can also help contribute to soil health by creating soil pores that increase water infiltration storage, and their activity can even increase microbial and plant growth.

Here we describe two methods for either measuring earthworm abundance (counting earthworm bodies), or activity (count *middens*). Counting earthworm bodies will require the community scientist to physically handle each earthworm in the area of interest while the earthworm midden counts require no worm handling. Choose whichever test you are most comfortable with!

Figure 1. Earthworm middens. a) close-up image of earthworm midden. Notice the pile of clumps. These piles average about 2 cm tall and 5 cm wide, with a burrow hole in found in near the pile center. More information available at (http://matoseuranta.it.helsinki.fi/instructions/sampling-methods). b) photo comparing the numbers of earthworm middens found in growing plots managed using conventional tillage methods versus growing plots managed using no-till methods. Notice the frequency of middens in the no-till system. More information can be found at (https://www.wisfarmer.com/story/news/2019/10/28/long-term-no-till-benefits-earthworms-leads-deeper-root-growth/2483949001/).

1.1. Earthworm Abundance - using pit excavation and hand sorting (based on Stroud, 2019)

Supplies needed

- **Garden fork or spade** - to turn soil
- **Meter stick -** to measure dimensions of soil pit
- **Ruler or measuring tape -** to measure exact size of pit
- **Small tarp or mat** - to put soil on top of
- **Pot or container with a lid** - to hold earthworms for counting
- **Bottle of water** - to keep earthworms from drying out

a) **Marking pit to excavate**. Using the ruler , measure out a square 18×18 cm (7×7") hole in the plot, from where you will dig to a depth of 18 cm (7"). Or in other words, you will excavate a 18×18×18 cm (7x7x7") soil cube.
b) **Digging**. With the garden fork or spade, remove and place all soil from this hole onto the small tarp or mat, which should be located close to the hole.
c) **Sort and collect earthworms (and eggs)**. Gently sort through the excavated soil looking for earthworms or earthworm eggs. All earthworms and eggs found should be put into the lidded container, with a small amount of water to keep them moist. Use the lid to prevent earthworms from escaping before being counted. Spend no more than roughly 15 minutes on this step. Earthworm eggs can be placed into separate container.
d) **Count and describe.** Count the number of earthworms and briefly describe their appearance, using the terms: small and red; pale or green; or plump and dark. Enter information into your notebook.
e) **Calculate abundance**. Calculation abundance by filling out the table below…

Table 1. Excel Data Sheet Template and Example Calculations for Earthworm Abundance

	A	B	C	D	E	F	G
1		# worms small and red	# worms plump and dark	Total # of earthworms found in plot	Volume of soil excavated in plot (L x W x H)	Volume of soil converted from cm^3 to m^3 (100cm = 1m)	# earthworms found per m^3
2	3-Sisters				$5832cm^3$	$.5832m^3$	=SUM(B1:D1)/F1
3	Maize				$5832cm^3$	$.5832m^3$	=SUM(B2:D2)/F2
4	Bean				$5832cm^3$	$.5832m^3$	=SUM(B3:D3)/F3
5	Squash				$5832cm^3$	$.5832m^3$	=SUM(B4:D4)/F4

Note: 5832 cm^3 comes from multiplying the Length X Width x Height of the soil you excavated!

1.2. Earthworm Midden Count – counting earthworm burrows (based on Stroud et al., 2016)

Supplies needed

- **Tape measure** - to measure out area for scientific observation
- **Count clicker or notebook -** to keep track of midden counts

a) **Identify ideal location.** Choose a random, but representative location of your garden, field, or research plot.
b) **Study site prep.** Measure out a 1x1 m (3×3') quadrat onto the ground and set a timer for 5 minutes.
c) **Conducting scientific observation.** After starting the timer, carefully but quickly scan the soil surface within the quadrat looking for evidence of earthworm middens (Figure 1). These look like small holes in the ground that are big enough for an earthworm to squeeze through and can also take on an appearance similar to an anthill.
d) **Data collection.** Write down in your notebook the number of earthworms found before moving onto the next plot.
e) **Further analysis.** Repeat steps a) through d), covering all plots in your research block. Make sure write down your observations.
f) **Activity level.** Calculate activity by filling in the table below

Other Helpful Resources
YouTube Video with J. Stroud - https://www.youtube.com/watch?v=bNxZqVtLPbs

Table 2. Excel Data Sheet Template and Example Calculations for Earthworm Midden Counts

	A	B	F
1	Treatment	Midden Count	Average Count of Earthworm Middens (#/m^{-2})
2	3-Sisters		= AVERAGE(B2:E2)
3	Maize		= AVERAGE(B3:E3)
4	Bean		= AVERAGE(B4:E4)
5	Squash		= AVERAGE(B5:E5)

2. Soil Bulk Density

Soil bulk density is one of the most important characteristics of soil health. It is simply the mass of dry soil divided by the volume it occupies – typically expressed in the units of grams/cm^3. Soil bulk density affects water infiltration and storage of water, root growth, plant nutrient availability, and even microorganism activity.

Put most simply – the lower the bulk density the better. The lower the bulk density of a soil, the better that soil will be able to support animal, plant, insect, and microbial life in the soil. An average bulk density for general agriculture soils in the Midwest US is 1.3 g/cm^3. However, soil texture (or distribution of particle sizes) can regulate the bulk densities that plant growth begins to be hindered.

Supplies needed

- **PVC ring with beveled edge -** to measure an amount of soil
- **Wooden block -** for pounding the PVC ring into the ground
- **Mallet** - for pounding the PVC ring into the ground
- **Soil knife or old large screwdriver -** for removing soil from ring
- **One-gallon plastic bags (pre-weighed and labeled) -** to store soil (weight is W_{PB} for calculations)
- **2-place balance**, **with good precision -** for weighing the soil extracted with PVC ring

a) **Collect Soil Sample.** In each plot, pound the 7.62 cm diameter × 7.62 cm tall (3x3") PVC ring with a hammer and wooden block until the ring is level with the soil surface. The outer edges of the soil core can be removed with a knife. After extracting the ring with its intact core, empty the contents into a clean plastic bag. If you are doing more than one sample, make sure plastic bags are properly labeled.

b) **Dry soil.** *Microwave*: Empty the soil sample from the plastic bag into a microwave-safe dish. Place this dish into a microwave, and use 2 × 7 minutes cycles on HIGH power, or until soil is bone dry. *Oven*: turn oven on at 200 ºF and dry soils for 6-8 hours until soils look very dry. Let cool. Transfer the dry soil onto the scale and record the weight of the ***dry soil only***.

c) **Calculations.** Calculate bulk density of the soil sample by using the following formula:
Value from Step b) / 21.21 cm^3
Example: 42 grams / 347.57 cm^3 -**Enter your information in the table below!**

d) ***SEE INSTRUCTIONAL VIDEO ASSOCIATED WITH THIS TEST FOR MORE INFORMATION.***

Table 3. Excel Data Sheet Template and Example Calculations for Soil Bulk Density

	A	B	C	D
1	Treatment	Weight of oven dry soil (g)	Volume of the PVC ring (cm^3)	Soil bulk density – g of soil /volume of PVC ring (g/cm^3)
2	3 Sisters		347.57 cm^3	= B2/C2 (g/cm^3)
3	Maize		347.57 cm^3	= B3/C3 (g/cm^3)
4	Squash		347.57 cm^3	= B4/C4 (g/cm^3)
5	Beans		347.57 cm^3	= B5/C5 (g/cm^3)

Note: 347.57 cm^3 is the volume of the PVC cylinder, and is calculated by squaring the radius, multiplying that by 3.14, and them multiplying that by the height of the cylinder. $V= (3.14) \times (r^2) \times H$

3. Decomposition

Decomposition of organic material in soils is a complex physical and chemical process that is made possible through interactions between soil organisms, the physical environment, and the material being decomposed. Through the decomposition process, complex organic molecules from dead materials are broken down into simpler organic and inorganic molecules that are easily taken up by plant life. Faster decomposition rates are indicators of healthy soil organisms, which help to boost crop productivity in that area.

Supplies needed

- **Green and rooibos teas in bag (1 each**) - to test as a decomposable
- **100% cotton handkerchief** - to test as a decomposable
- **Birch popsicle stick -** to test as a decomposable
- **Gardening hand trowel -** to bury and retrieve decomposable items
- **Flags (x4) -** to mark site of buried decomposable items
- **2-place balance with good precision** - for weighing the decomposable items after harvest

a) **Record initial weights.** Weigh each item to be buried in the garden (tea bags, cotton swatch, and popsicle stick). Record these values in the table provided.
b) **Identify ideal location.** Locate a suitable spot in the 3Sisters plot for the burial of all 4 items (teas, cotton, and popsicle stick). This spot will ideally be more in the center of the plot than towards the edges.
c) **Hole preparation.** Dig the holes for each item to be buried, using the diagram below to help guide the placement of each article. Using the hand trowel, dig a hole roughly 6.5 cm diameter and 9 cm deep (3x3.5") for each of the tea bags, a slice roughly 16.5 cm deep (6.5") for the popsicle stick, and a square roughly 15.25 cm wide X 15.25 cm long X 15.25 cm deep (6x6x6") for the cotton handkerchief.
d) **Burying of items.** Bury the decomposable items using the soil removed from the hole, making sure to allow the flag on the fishing line attached to each item to be visible from the soil surface.
e) **Marking locations.** Mark the position of all for items with a flag, for easier locating at the end of the project.
f) **Helpful hint.** Take notes during this experience! If you have to deviate from this protocol, write down in your observation booklet what you did and why.
g) **Harvesting items**. Using the hand trowel, gently dig up the items buried and place each one it its own baggy for analysis. Try and dig up any and all pieces of the items, taking care to not leave any pieces in the soil.

When to harvest decomposable items!	- Cotton handkerchief	=	50-60 days after burial
	- Tea bags	=	50-60 days after burial
	- Popsicle sticks	=	90-100 days after burial

h) **Recording harvest weight**. After harvesting items from the garden, weigh them and record their values in the table provided.

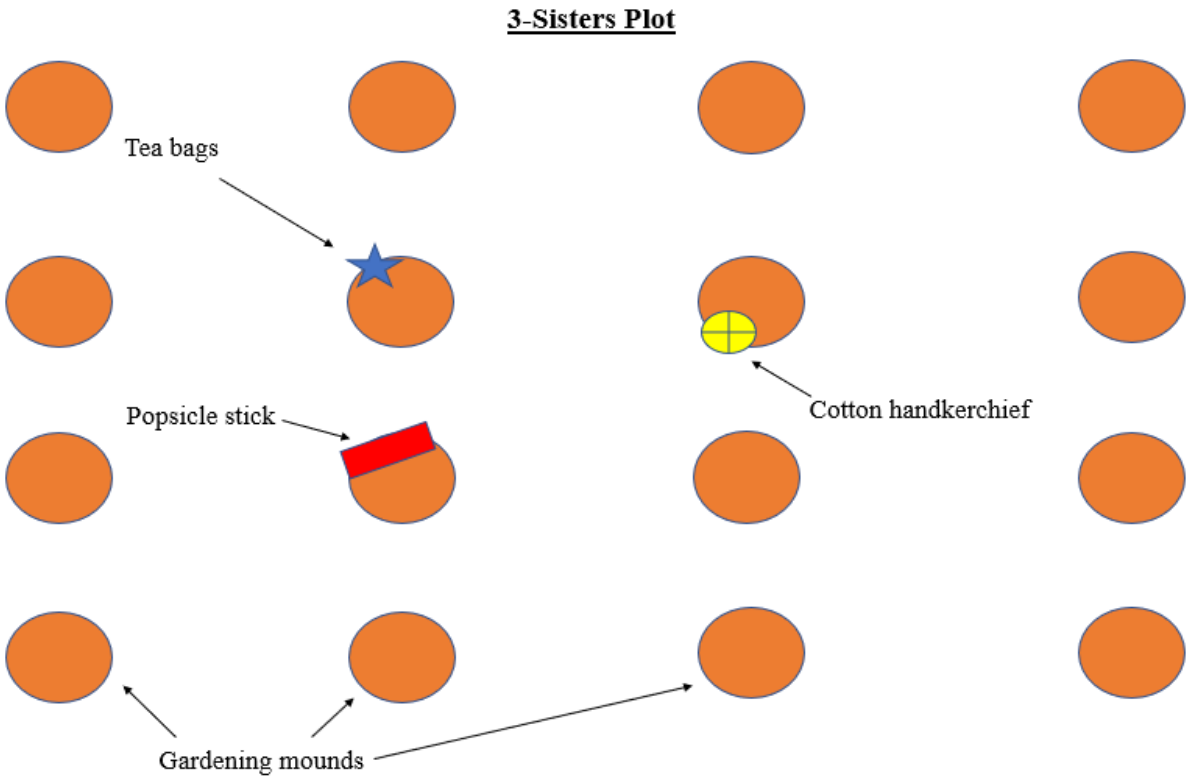


Figure 2. Site selection for burial of decomposable. Notice the sites for burial are in the mounds the center of the garden rather than the edges. Decomposables were buried in different gardening mounds for this demonstration because the mounds were too small to bury more than 1 item without intruding on the planting deck.

3-Sisters Research Block

Figure 3. Possible site selection schema for burial of decomposables. M=maize; B=bean; Sq= Squash; 3SI= 3-Sisters. Red bars indicate buried popsicle stick; Blue stars indicated buried tea bags; Yellow circles indicate buried cotton handkerchief. Notice each decomposable is located in each plot.

***NOTE. For more details about how to initially lay a research block, please see the 3SI Plot Layout document

Table 4. Excel Data Sheet Template and Example Calculations for Decomposition tests

	Grey Tea (preseason wt)	Grey Tea (postseason wt)	Green Tea (preseason wt)	Green Tea (post-season wt)	Popsicle stick (preseason wt)	Popsicle stick (post-season wt)	Cotton handkerchief (preseason wt)	Cotton handerchief (post-season wt)
Three Sisters	g	g	g	g	g	g	g	g
Maize	g	g	g	g	g	g	g	g
Bean	g	g	g	g	g	g	g	g
Squash	g	g	g	g	g	g	g	g

Table 5. Excel Data Sheet Template and Example Calculations for Decomposition tests

		A	B	C	D
		Popsicle Stick # days buried	Grey Tea # days buried	Green Tea # days buried	Cotton Handkerchief # days buried
A	Three Sisters				
B	Maize				
C	Bean				
D	Squash				

4. Aggregate Stability

The slaking test is a type of measurement that analyzes the stability of dry soil aggregates after they have been wetted. Soil slaking is a feature that is impacted by the amount and quality of organic matter in a soil and has use in determining a soil's water infiltration rate and erosion susceptibility. Higher values obtained in a slaking test are correlated with healthier and more biologically active soil.

Supplies Needed

- **Hand sieve (for powdered sugar or baking) -** used to hold soil sample in water bowl
- **Wide bowl deep enough to mostly submerge the sieve -** to analyze soil particle stability
- **5 grams of sieved to 4 mm and air-dried soil (roughly 30 days) -** for data collection purposes
- **Stopwatch (or phone app) -** important for keeping accurate track of time
- **Water to mostly fill wide bowl -** to analyze soil particle stability
- **Plastic squeeze water bottle (mostly full)** – to clean sieve of all soil

a) **Experiment preparation.** Fill the wide bowl with enough water to that there is only ½ inch of bowl left above the surface of the water.
b) **Wetting soil.** Put the 5-10 grams of air-dried >4mm soil into the hand sieve and dunk it underneath the surface of the water. Start the stopwatch and submerge the soil sample for 8 minutes.
c) **Performing experiment.** After step 2, raise the sieve out of the water for 5 second, and then completely dunked again 5 second. Repeat this step 4 times.
d) **Dry soil**. After the dunking process is completed, dump the soil remaining in the sieve into a microwavable-safe container. Flip the sieve over the microwaveable safe container and use the squirt bottle to lightly blast any soil remaining stuck to the sieve into the dish.
Microwave: Place the container (measuring cup or plastic dish) in the microwave and use 2 × 7 minute cycles on HIGH power, or until soil is dry; *Oven*: turn oven on at 200 ºF and dry soils for 6-8 hours until soils look very dry. Let soil sample cool to room temp and to record the weight of the dry soil.
e) **Notetaking.** Record your observations in the table provided.
f) **Calculations.** Take the weight of the dry soil (POST DUNK) and divide it by the weight of the dry soil (PRE-DUNK). Take this result and multiply by 100 to get a % aggregate stability
Ex. 45g / 50 g = .90 → .90 x 100 = 90% aggregate stability
g) ***SEE INSTRUCTIONAL VIDEO ASSOCIATED WITH THIS TEST FOR MORE INFORMATION.***

Table 6. Excel Data Sheet Template and Example Calculations for Aggregate Stability

	A	B	C	D
		Weight of soil pre- dunk (g)	Weight of soil post dunking and drying (g)	Percent Aggregate Stability ((B / C) x 100)
1	3SI			=(B1/C1)x100
2	Maize			=(B2/C2)x100
3	Bean			=(B3-C3)x100
4	Squash			=(B4-C4)x100

5. Water Holding Capacity

Water holding capacity measures the ability of a soil to hold onto and release moisture to growing plant life. Water holding capacity is majorly affected by the composition of a soil (percent sand, silt, and clay), as well as the percentage of organic matter in a soil. According to the USDA, a 1% increase in soil organic matter in a field can contribute to over 25,000 more gallons of water per acre available to plant life. Higher water holding capacity values are correlated with healthier growing systems.

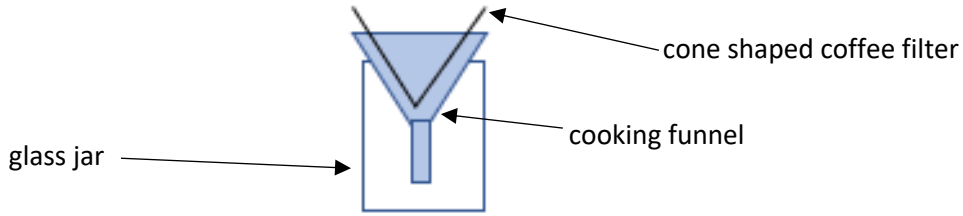
Supplies needed

- **Roughly 3 cups of soil -** from growing plot.
- **Home oven (or microwave)-** set at 200 degrees, used for drying soil sample
- **2-place scale with good precision -** used for weighing soil samples during analysis
- **Hand trowel -** for collecting soil sample
- **1-gallon plastic bag -** for containing soil samples after retrieving them from the plot
- **1 marker -** to label items when necessary
- **Funnel -** to hold coffee filter paper for analysis
- **Cone-shaped coffee filter -** to hold soil for water filtering and analysis
- **Sliced mushroom in glass jar (empty)-** to hold funnel
- **16 oz of water-** to conduct experiment

a) **Collecting soil samples.** Remove vegetation from the soil surface before using the hand trowel to scoop out approximately 3 cups of soil from the top 10 cm (4") of your research plot (garden). Place this into a one gallon plastic bag and label it according to the type of crop being grown in it. If possible, stir the soils in the bag to create an even mixture. Return to the lab and weigh out 20 grams of the homogenized soil mixture.

b) **Dry soil.** *Microwave*: Place the container with the soil in the microwave and use 2 × 7 minute cycles on HIGH power, or until soil is dry; OR *Oven*: turn oven on at 200 ºF and dry soils for 6-8 hours until soils look very dry. Let soil sample cool to room temp and to record the weight of the dry soil

c) **Wet filter.** Using the water, gently wet the coffee filter while it is still in the funnel. This can be done over a sink or Tupperware container to catch the excess. The filter paper needs to be totally saturated. Drain off any excess water and place the funnel + wet filter paper into the empty glass mushroom jar. (See schema below). Note how the jar keeps the tip of the funnel of the bottom



d) **Collecting data.** Place the assembled funnel and wet filter on the scale to weigh their combined weight. Record this value in the table below.

e) **Preparing equipment.** Place the wet coffee filter into the plastic baking funnel, then put these into the mushroom jar. Carefully pour the 20 grams of oven-dried soil on top of the wet filter paper inside the funnel.

f) **Conducting experiment**. Carefully and slowly, saturate the soil and until the water begins to drip through the funnel. At this point add a slight amount more water until the soil is slightly submerged about ¼- ½ inch. At this point, let the water drain through the funnel on its own to collect in the clear jar. *Cover the entire top of the funnel securely with a piece of plastic wrap and a rubber band*. Set the entire assembly aside for 6 hours.

g) **Data collection.** After waiting 6 hours, carefully remove the plastic wrap and rubber bands from the top of the funnel. Weigh the funnel + wet filter paper+ wet soil assembly and record this value in the table below.

h) **Calculations.** Subtract the weight of the wet filter + funnel, from the weight of the wet filter + 6-hour wet soil + funnel ((step g – step d)). You now have the mass of the wet soil.

FROM TABLE BELOW: D – C = mass wet soil (E)

i) **Calculations.** Subtract the weight of the dry soil (should be roughly 20 grams) from the mass of the wet soil, which was calculated in ((step h)). You now have the mass of the water *in* the soil.

FROM TABLE BELOW: E – B = mass water in soil (F)

j) **Calculations.** Take the mass of the water in the soil ((step i)) and divide it by the mass of the wet soil ((step h)). Multiply this answer by 100 to determine your water holding capacity (WHC).

FROM TABLE BELOW: (F / E) x 100 = water holding capacity (G)

k) ***SEE INSTRUCTIONAL VIDEO ASSOCIATED WITH THIS TEST FOR MORE INFORMATION***

Table 7. Excel Data Sheet Template and Example Calculations for Water Holding Capacity

	A	B	C	D	E	F	G
		Weight of dry soil (~20 g)	Weight of wet filter +funnel	Weight of wet filter + funnel + 6 hour wet soil	Mass of wet soil	Water Mass in soil	Water holding capacity
1	3SI				=D1-C1	=E1-B1	=(F1/E1) x 100
2	Maize				=D2-C2	=E2-B2	=(F2/E2) x 100
3	Bean				=D3-C3	=E3-B3	=(F3/E3) x 100
4	Squash				=D4-C4	=E4-B4	=(F4/E4) x 100

LIST OF MATERIALS NEEDED

Use	Item	Cost	Location	Item Number
General Equipment	Electronic scale	$17.90	Walmart	888327679
	Notebook	$4.24	Walmart	16671273
	Plastic Bags (gallon) × 60	$7.79	Walmart	580592045
	Garden Sieve	$29.51	Walmart	282092141
1. Earthworms	Tape Measure	$4.71	Walmart	19398714
	Ziplock Containers	$1.95	Walmart	39444456
2. Bulk density	PVC Pipe	$13.87	Walmart	149527172
	Tarp	$6.95	Walmart	158580963
3. Decomposition	Gray Tea (pk of 24)	$11.07	Walmart	891805172
	Green Tea (pk of 24)	$10.48	Walmart	891805172
	Cotton Handkerchief	$9.87	Walmart	854127057
	Birch Popsicle Stick	$6.98	Walmart	101030428
	Garden Flags	$9.90	Walmart	339930721
	Gardening Trowel	$7.49	Walmart	16930220
4. Aggregate Stability	Hand Sieve	$5.29	Walmart	495885673
	Squeeze Bottle	$.98	Walmart	797794747
5.Water Holding Capacity	Plastic Funnel	$2.39	Walmart	896290952
	Cone-shaped coffee filter	$4.38	Walmart	10535001
	Empty glass jar or glass	$1.38	Walmart	55428222
	Saran Wrap	$2.98	Walmart	12442827

General Equipment

Electronic scale= $17.80

https://www.walmart.com/ip/ESYNIC-0-01g-500-Gram-Digital-Pocket-Scale-Portable-Weight-Scale-Food-Scale-LCD-Display-Electronic-For-Kitchen-Silver/888327679

1-Gallon plastic bags= $7.79

https://www.walmart.com/ip/Ziploc-Brand-Slider-Storage-Gallon-Bags-with-Power-Shield-Technology-60-Count/33338041

Garden sieve= $29.51

https://www.walmart.com/ip/Tierra-Garden-Garland-2-in-1-Sieve/282092141

Notebook= $4.24

https://www.walmart.com/ip/Five-Star-3-Subject-Wide-Ruled-Wirebound-Notebook-Color-Choice-Will-Vary-04119/16671273

1. Earthworm and Midden Count:

Vinyl tape measure= $4.71

https://www.walmart.com/ip/Singer-Vinyl-Tape-Measure-60-1-ea/19398714

Ziplock 2 count large rectangular containers= $1.95

https://www.walmart.com/ip/Ziploc-2-CT-Large-Rectangle-Container-36-oz-Each-One-Press-Seal-Plastic-Storage-Container/39444456

2. Soil Bulk Density:

Schedule 40 PVC Solid Pipe 3inch X 2ft Plain end= $13.87

https://www.walmart.com/ip/Charlotte-Pipe-Schedule-40-PVC-Solid-Pipe-3-in-Dia-2-ft-Plain-End-260-psi/149527172

Balance= $15.99

https://www.walmart.com/ip/Nutrition-Digital-Kitchen-Scale-500g-0-01g-Mini-Pocket-Jewelry-Cooking-Food-Scale-Backlit-LCD-Display-2-Trays-6-Units-Auto-Off-Tare-Stainless-Steel-B/340494387

Plastic Bags (gallon size)= $7.79

https://www.walmart.com/ip/Ziploc-Brand-Freezer-Gallon-Bags-with-Grip-n-Seal-Technology-60-Count/281042661

All-purpose tarp= $6.95

https://www.walmart.com/ip/ALL-PURPOSE-TARP-5X7-FINISHED-SIZE-4FT-8IN-X-6FT-6-IN/158580963

3. Decomposition:

Teavana Earl Gray Tea Bags (box of 24)= $11.07

https://www.walmart.com/ip/Teavana-SBK12416721-Modern-Earl-Grey-Tea-24-Box/891805172

Teavana Radiant Green Tea Bags (box of 24) = $10.48

https://www.walmart.com/ip/Teavana-SBK12434016-Jasmine-Citrus-Green-Tea-24-Box/377819310

Cotton handkerchief= $9.87

https://www.walmart.com/ip/Solid-White-Handkerchiefs-EEEKit-100-Soft-Cotton-Hankies-13-Pieces-Classic-Pure-Handkerchiefs-Men-Women-Kids-Square-Sheets-Gift-Mother-Father-Daughte/854127057

Birch popsicle stick= $6.98

https://www.walmart.com/ip/100-pcs-Natural-Wood-Popsicle-Sticks-Wooden-Craft-Sticks-Wax-4-1-2-x-3-8-New/101030428

Garden flags= $9.90

https://www.walmart.com/ip/25-Piece-Neon-Orange-Outdoor-Marking-Flags/339930721

Gardening hand trowel= $7.49

https://www.walmart.com/ip/Fiskars-FiberComp-Trowel-100S-Series/16930220

4. Slaking test:

60 mesh screen flour hand sieve= $5.29

https://www.walmart.com/ip/60-Mesh-Screen-Stainless-Steel-Flour-Sieve-Kitchen-Baking-Tools-Durable-Handheld-Screen-Mesh-Strainer-Oil-Strainer-Colander/495885673

Plastic Squeeze bottle= $.98

https://www.walmart.com/ip/Way-To-Celebrate-Squeeze-Bottles/797794747

5. Water holding capacity

Plastic funnel set= $2.39

https://www.walmart.com/ip/Plastic-Funnel-Set/896290952

Cone-shaped coffee filters= $4.38

https://www.walmart.com/ip/Melitta-4-Natural-Brown-Cone-Coffee-Filters-40-Ct/10535001

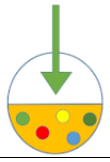
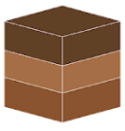
Empty glass jar= $1.38

https://www.walmart.com/ip/Great-Value-Organic-Whole-Mushrooms-7-oz/55428222

Saran Premium Wrap= $3.19

https://www.walmart.com/search/?query=saran%20wrap

MOBILE PHONE APPLICATIONS
for
GENERAL SOIL INFORMATION and DIY SOIL HEALTH MEASUREMENTS

Icon	Name of Mobile Phone Application	Measurement	Any Additional Hardware Needed	Link to App
	**Worm Tracker**	Earthworm abundance	None	https://play.google.com/store/apps/details?id=com.ualberta.edu.worms&hl=en_US&gl=US
	**Tea Bag Index**	Tea decomposition (biological activity)	Tea bags, trowel, 2-place balance	https://play.google.com/store/apps/details?id=com.spotteron.teabagindex&hl=en_US&gl=US
	**Micro-BIOMETER**	Soil microbial biomass estimate	Starter kit ($135)	https://play.google.com/store/apps/details?id=com.pes.microbiometer&hl=en_US&gl=US
	**Nix Color Sensor**	Estimate of soil organic matter content	Nix Color Sensor ($99)	https://play.google.com/store/apps/details?id=com.nix.nixsensor
	**Slakes**	Soil aggregate stability	Stand for phone, Petri dish, lamp	https://play.google.com/store/apps/details?id=slaker.sydneyuni.au.com.slaker&hl=en_US&gl=US
	**Visual Evaluation of Soil Structure (VESS)**	Description of soil structure	Shovel, white tote or tarp	https://play.google.com/store/apps/details?id=ch.hepia.vess&hl=en_US&gl=US
	**LandPKS**	Soil information (from SSURGO)	None needed to use, but to input data some materials are needed	https://play.google.com/store/apps/details?id=org.landpotential.lpks.landcover&hl=en_US&gl=US
	**SoilWeb**	Soil information (from SSURGO)	None	https://play.google.com/store/apps/details?id=com.casoilresourcelab.soilweb&hl=en_US&gl=US