



College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

School Garden Basics Workshop For Educators



Soils and Composting Module

by O'ahu Master Gardeners in cooperation with Kōkua Hawai'i Foundation

Soil versus Dirt



Soil =
Dynamic, composed of loose organic
and inorganic materials on Earth's surface



Without Soil we could not live on Earth



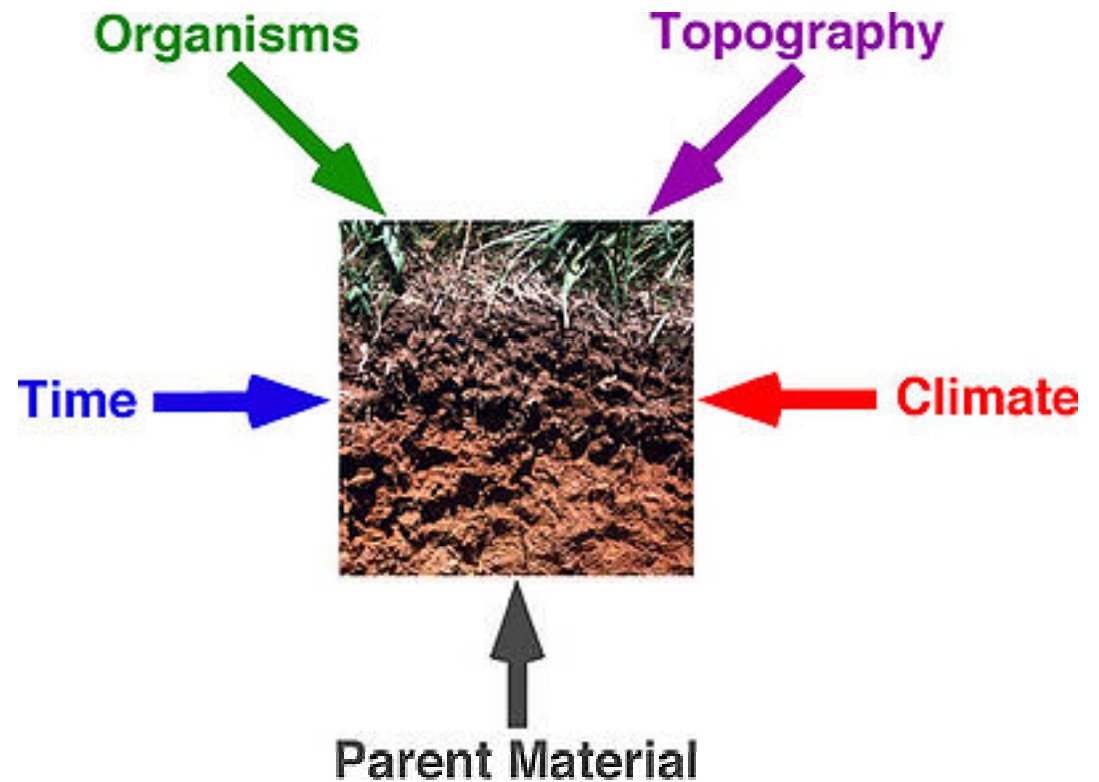
**Our Designated State Soil
is Hilo Soil**



Soils of the Hawaiian Islands



Born of Fire



Incredible Diversity over Short Distances



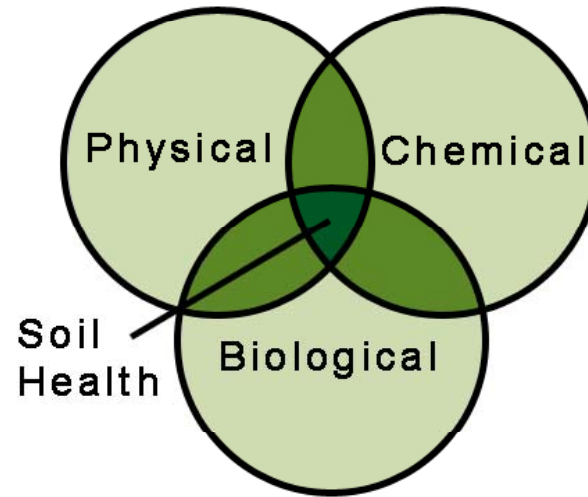
Soil is Critical for Plant Growth



- **Physical support**
- **Essential nutrients**
- **Water and oxygen**
- **Buffer from excessive pH, toxic substances, disease causing organisms**



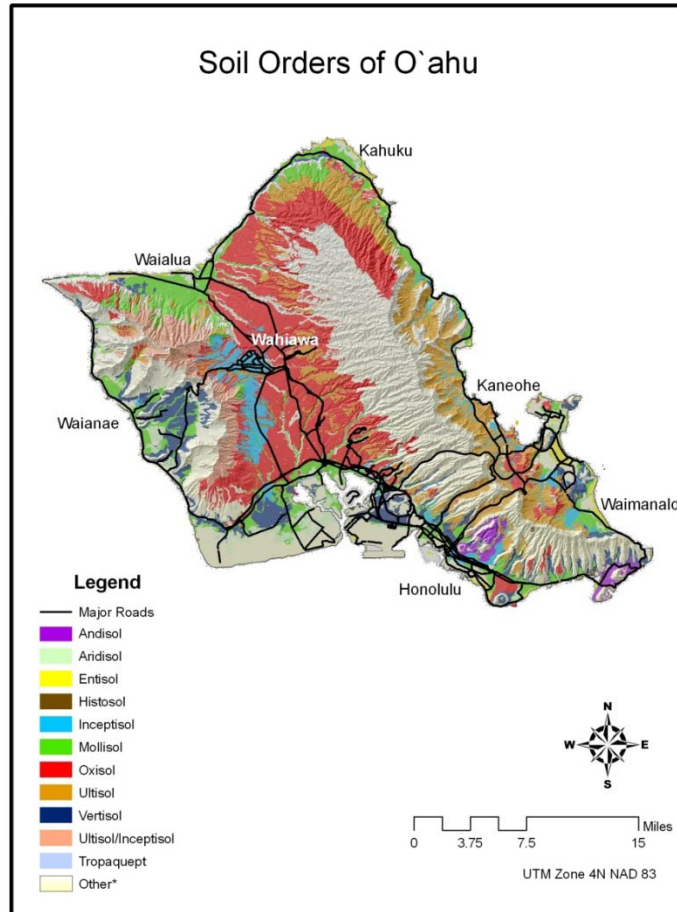
Get to Know Your Garden Soil



All Gardening (and Soil) is Local!



CTAHR + NRCS Research



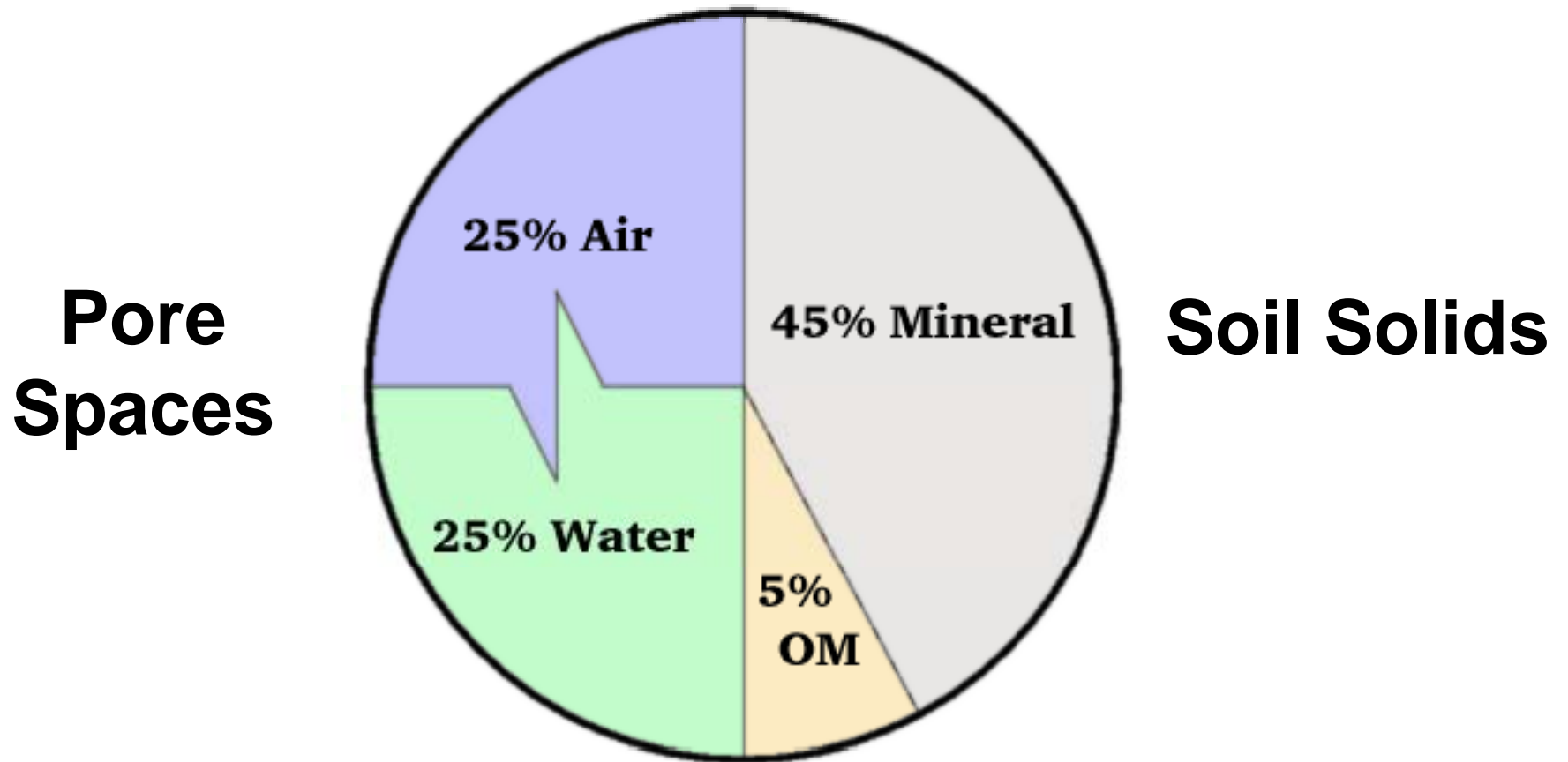
*Beaches, coral, fill land, marsh land, and rocky land



Provides Broad & Specific Soil Data



Optimal Soil Composition by Volume

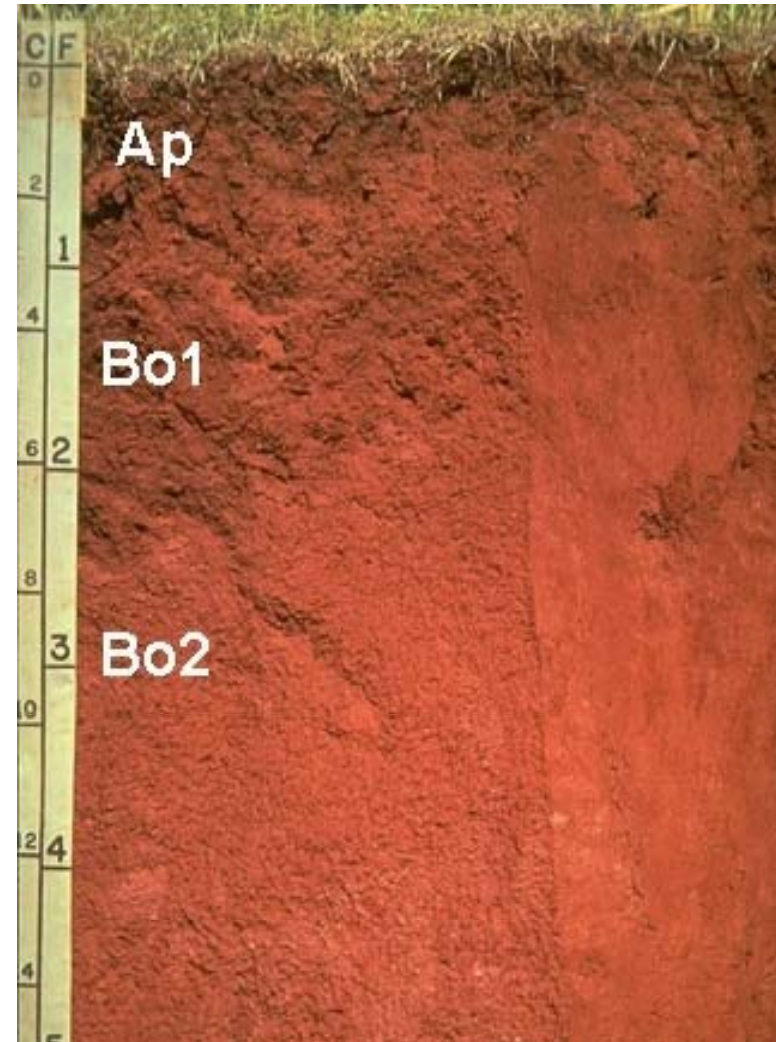
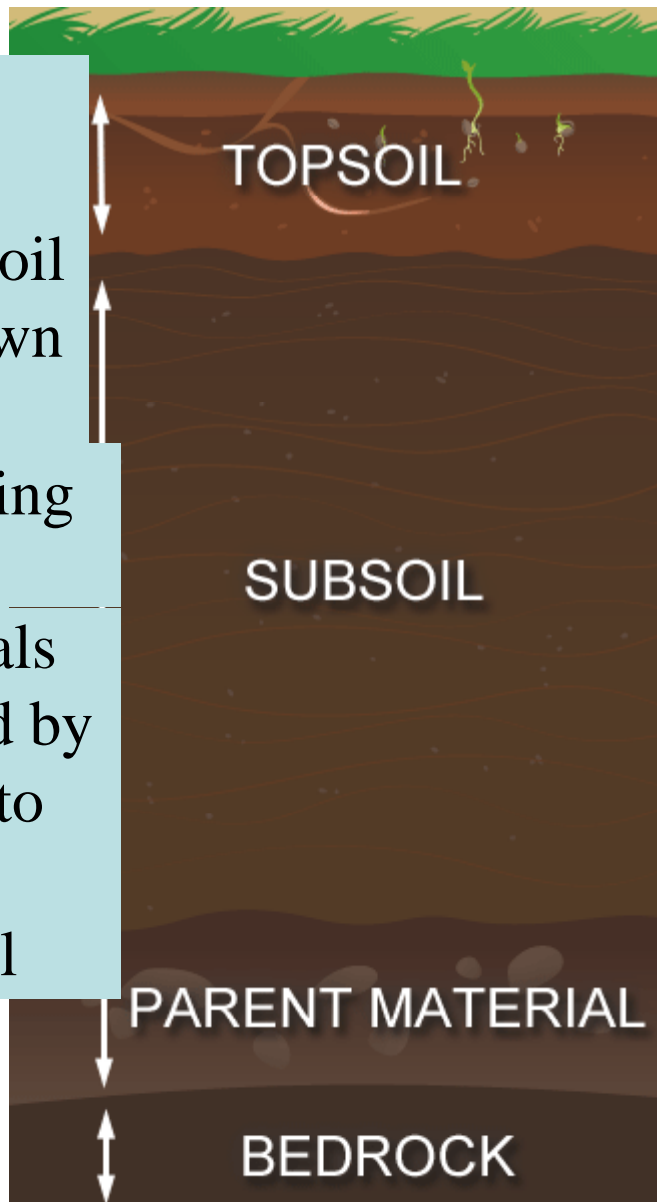


Soil = Pore Spaces + Soil Solids



Organic Material gives topsoil a rich brown color

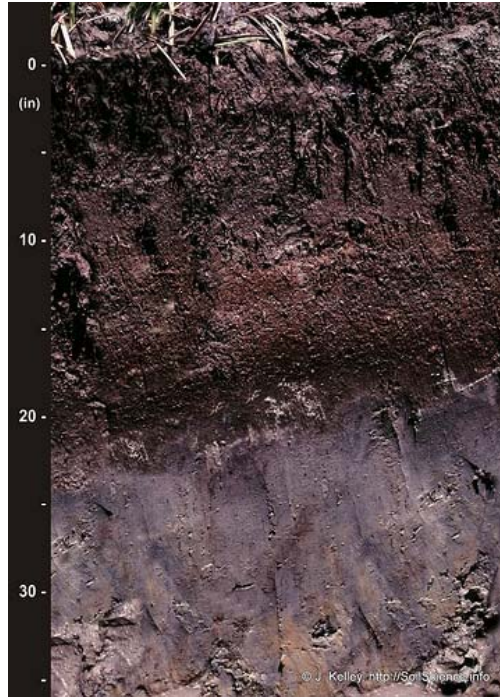
Leaching takes minerals carried by water to the subsoil



Where is your most Fertile Soil Layer?



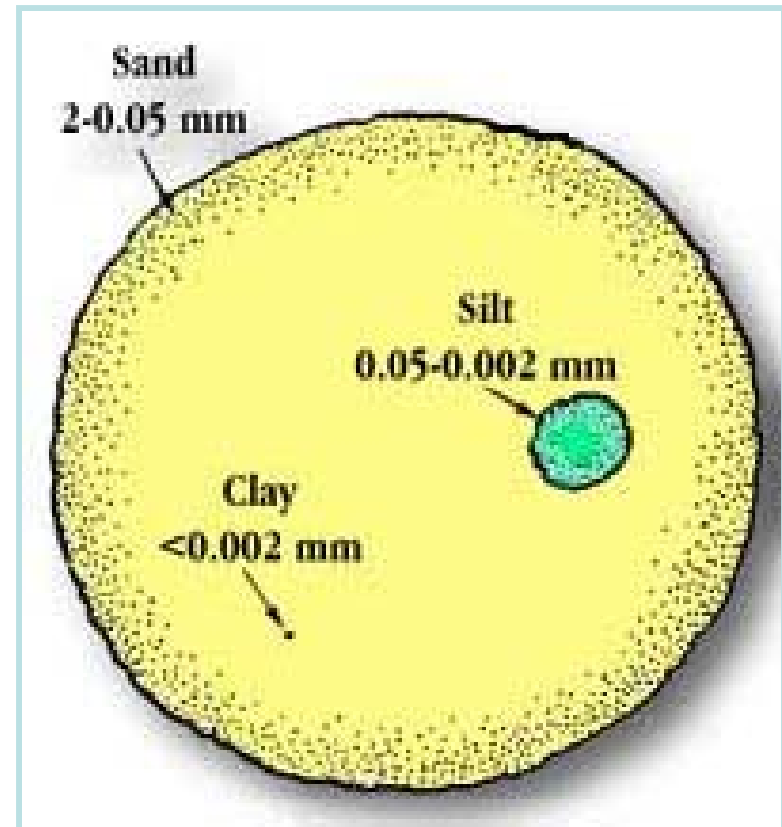
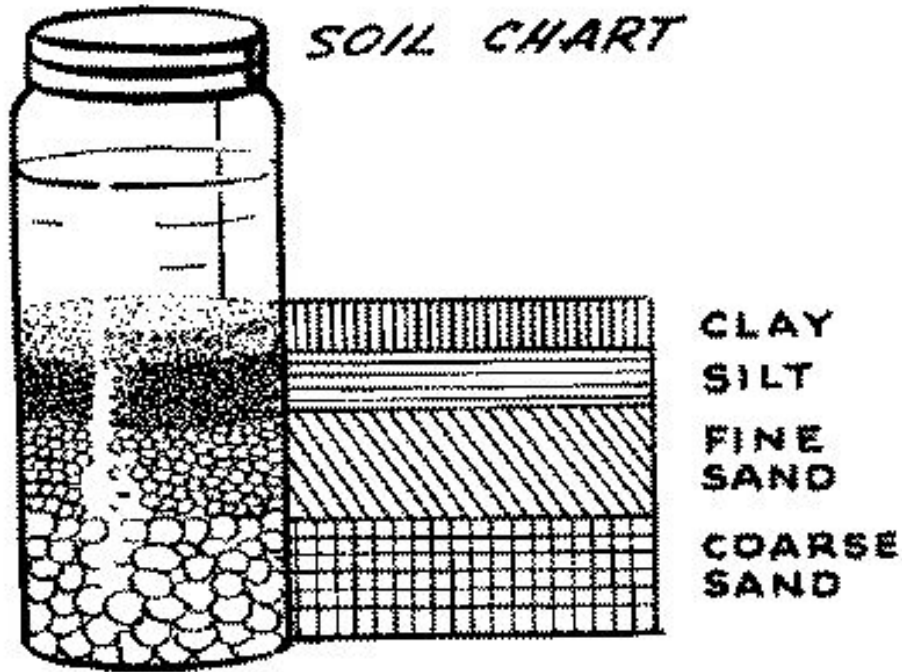
Soil Color



Indicates: Organic Matter, Drainage, Aeration



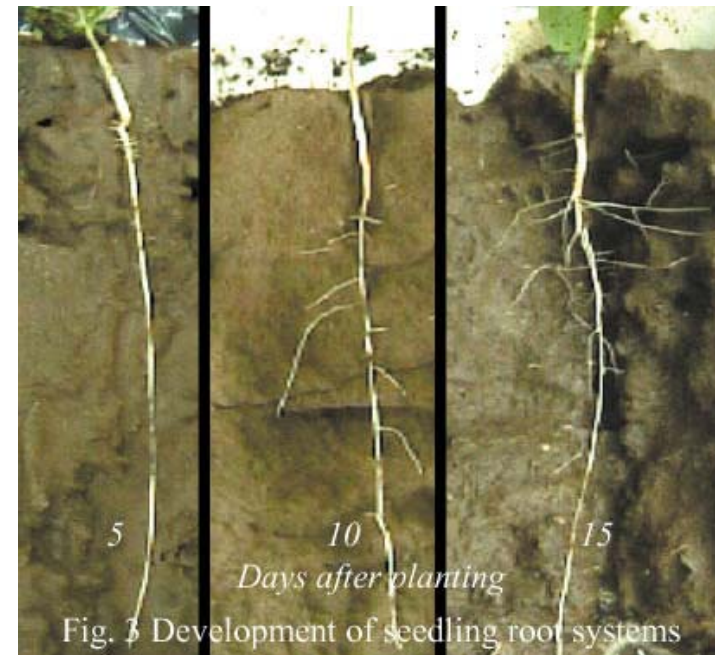
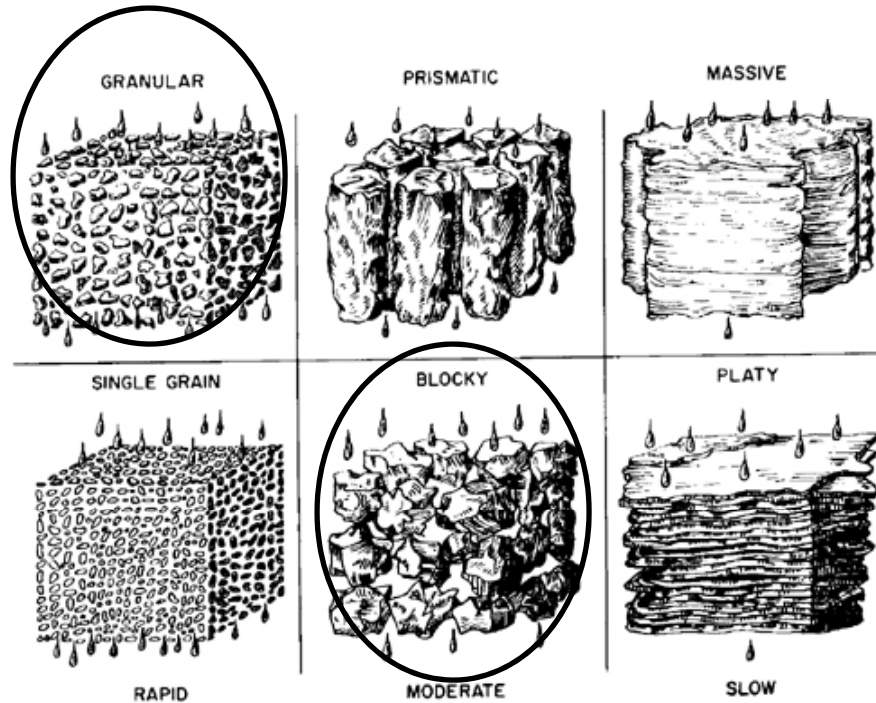
Soil Texture: Sandy, Silty, Clayey, Loamy



How Easy/Hard is it to Dig?



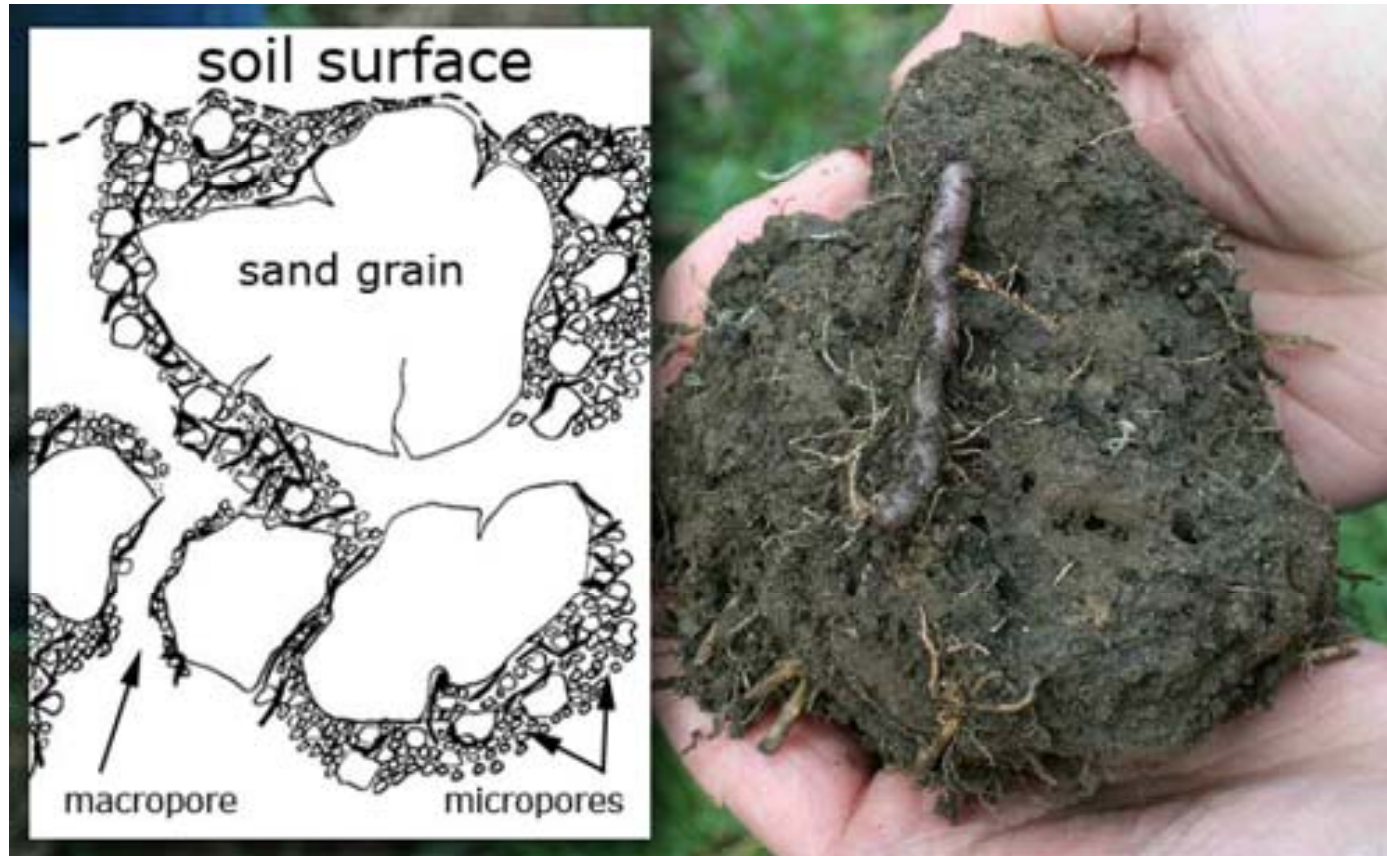
Soil Structure



How often do I need to water?



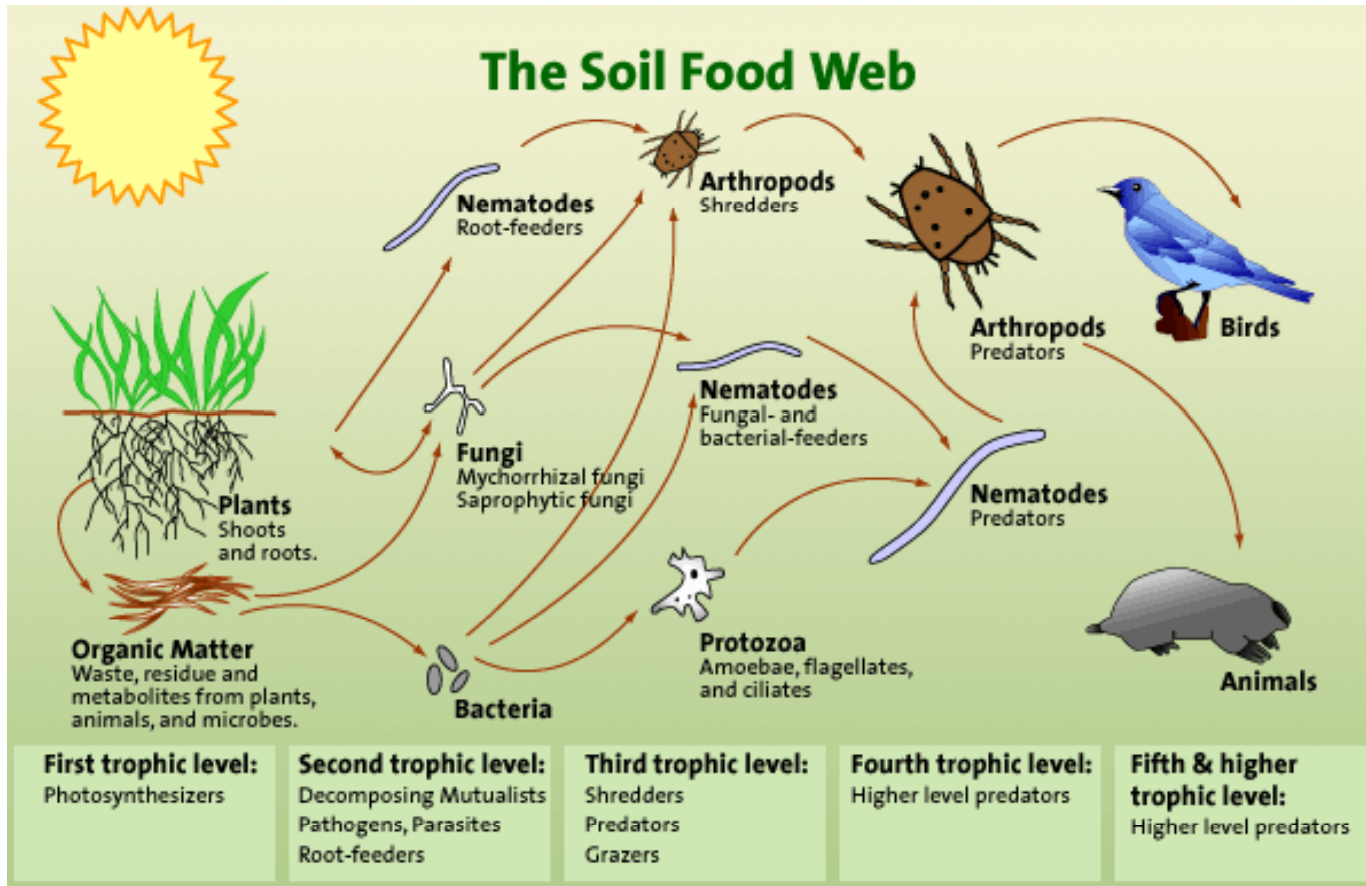
Soil Texture + Structure



Influences Life in Soil



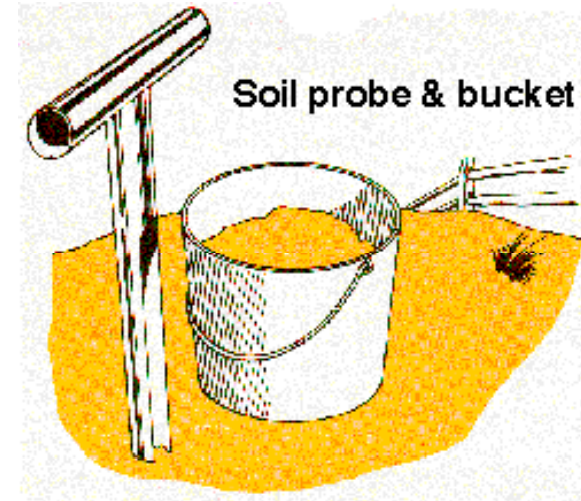
Soil Biology



Feed the Soil Food Web = Feed the Plant



Soil Chemistry



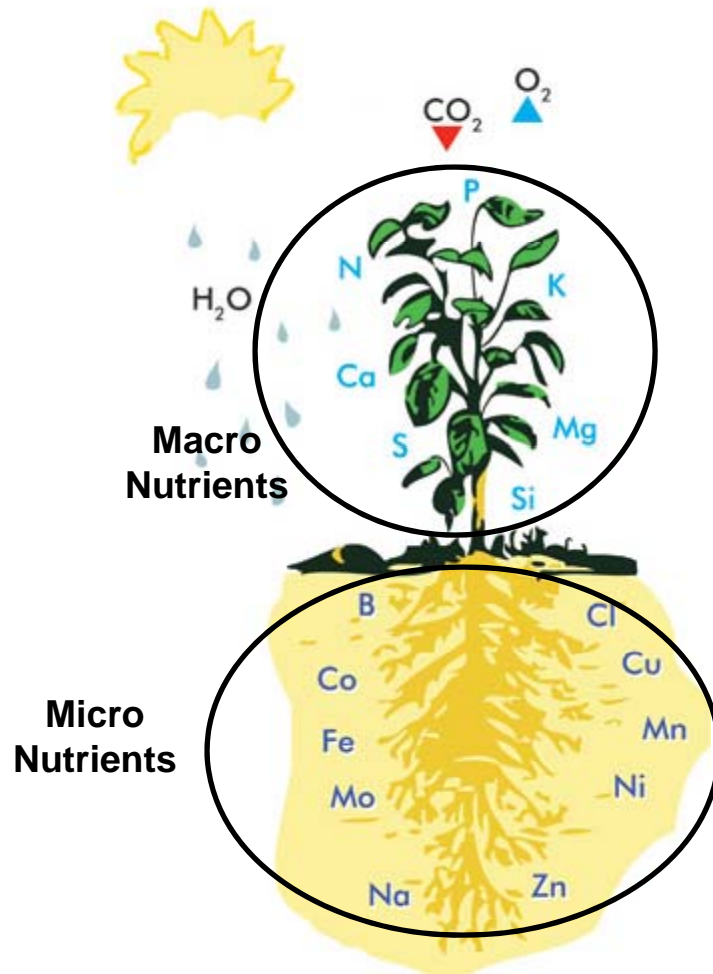
Don't Guess, Soil Test !

- To find out if there are unseen problems
- To find out if you should add or not add nutrients
- To find out what kind of nutrients you should use
- To find out how much nutrients you should apply

Basic Soil Analysis = Soil pH + nutrient levels + fertilizer recommendations



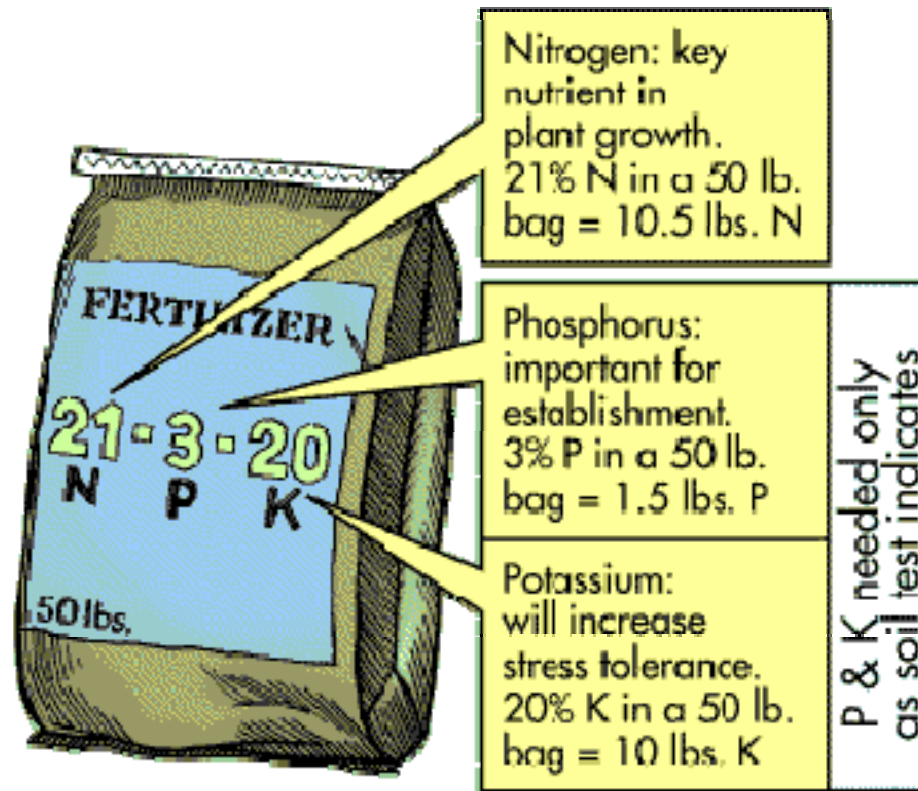
Plant Nutrients



Soil Supplies 13 Essential Plant Nutrients



Fertilizers



How to Read a Fertilizer Bag



Incorporating Fertilizers

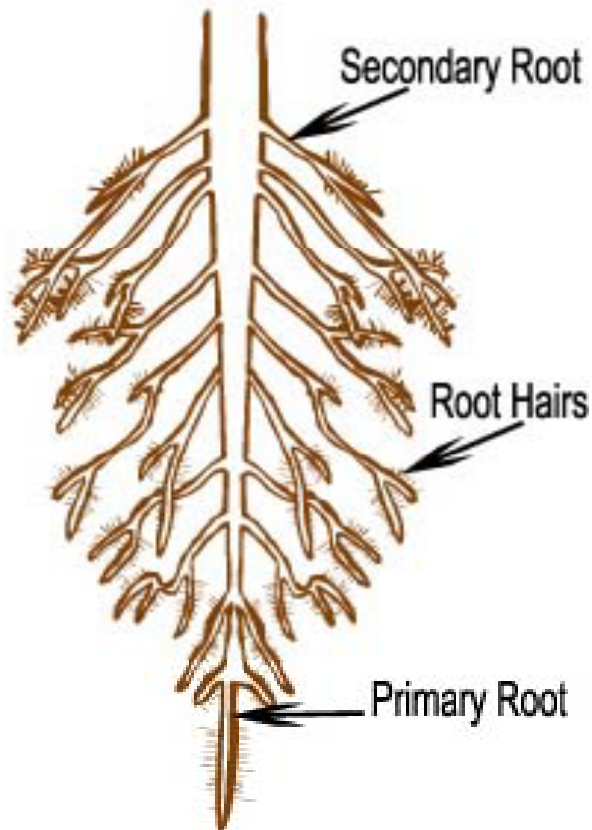


Mix into top few inches of soil



Mass Flow, Root Interception, Diffusion,

PRIMARY AND SECONDARY ROOTS

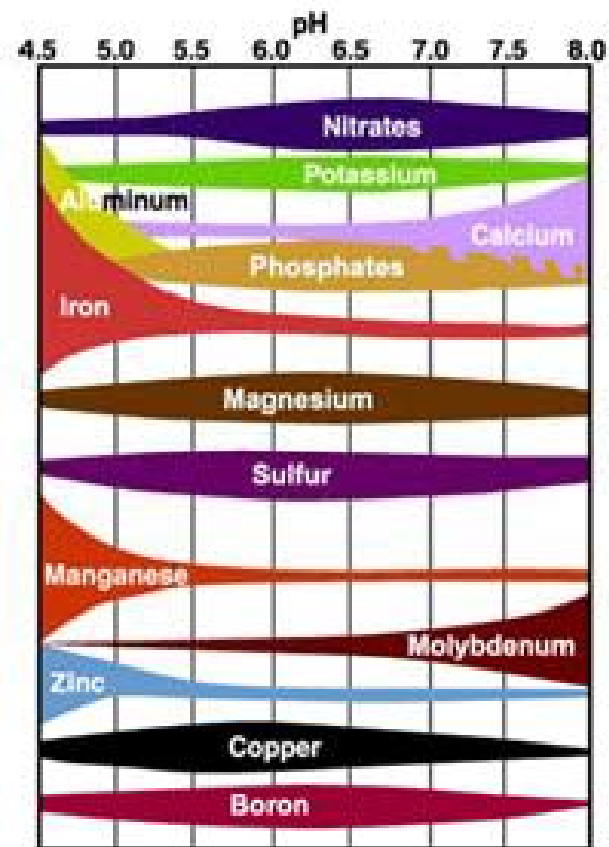
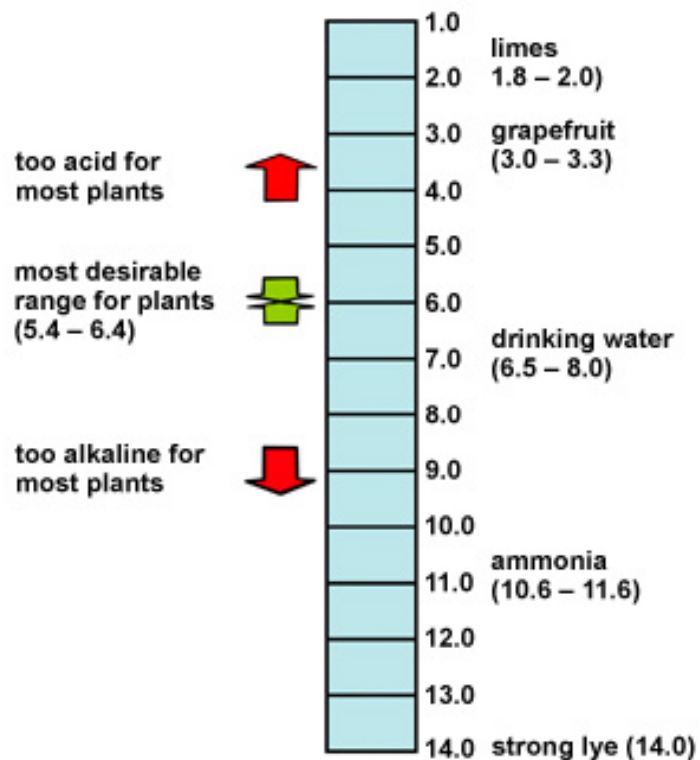


Nutrient (sample plant)	Root Interception % of plant needs	Mass Flow % of plant needs	Diffusion % of plant needs
N	1	99	0
P	2	4	94
K	2	20	78
Ca	120	440	0
Mg	27	280	0
S	4	94	2

Nutrient Uptake



Soil pH



How acid or alkaline?

Availability of Plant Nutrients



Correcting Soil pH



Use Lime If Soil is too
Acidic (<5.4 pH)

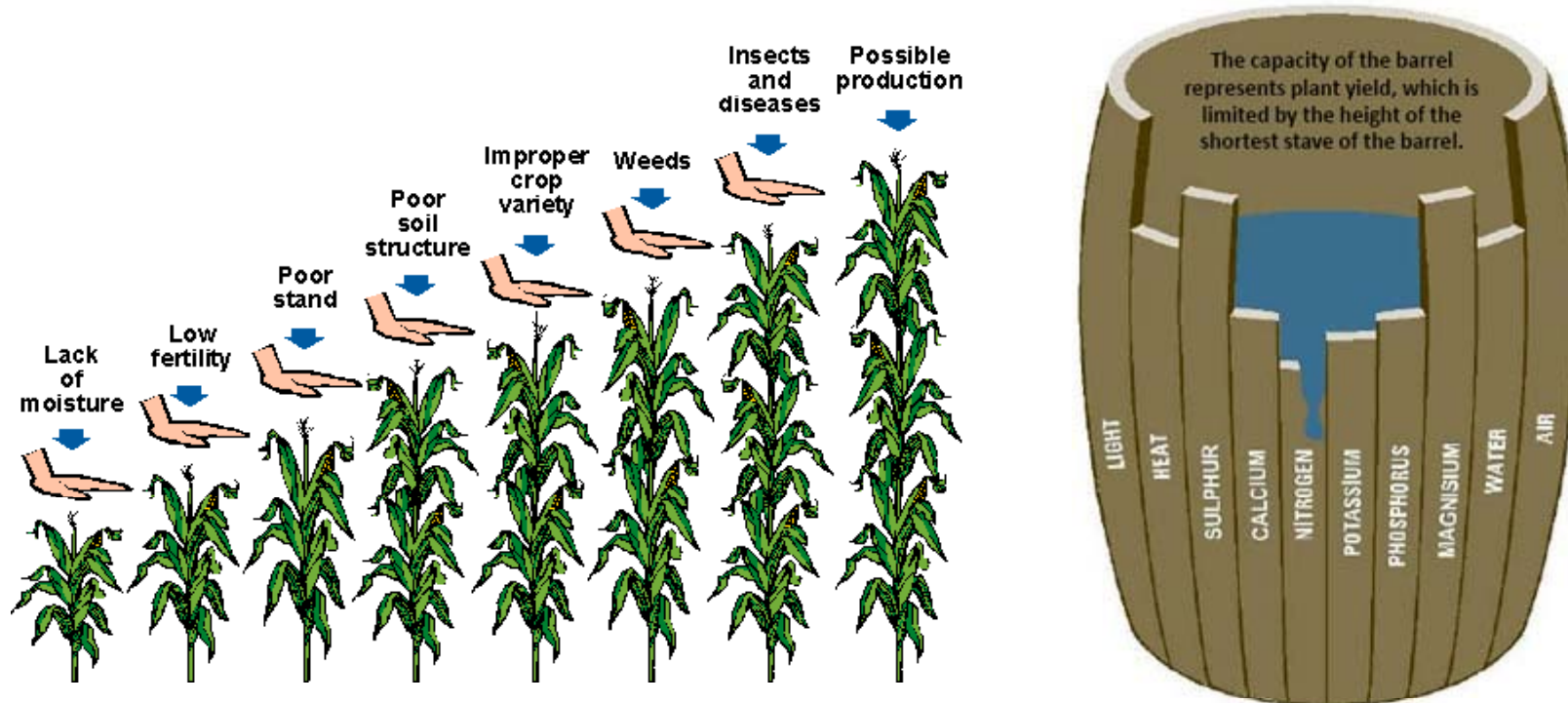


Use Sulfur, If Soil is too
Alkaline

**Best Choice = Choose plants that match
existing soil pH!**



Other Factors to Consider For Optimal Plant Growth



Soil Interaction Plays an Important Role



Healthy Garden Soil

1. Smell it:

- Earthy smell means high biological activity

2. Look at it: Color

- Dark brown soil, high organic matter

Look at it: Structure

- Root passages, good tilth



3. Feel it: Texture

- Cookie crumbs (friable), forms aggregates



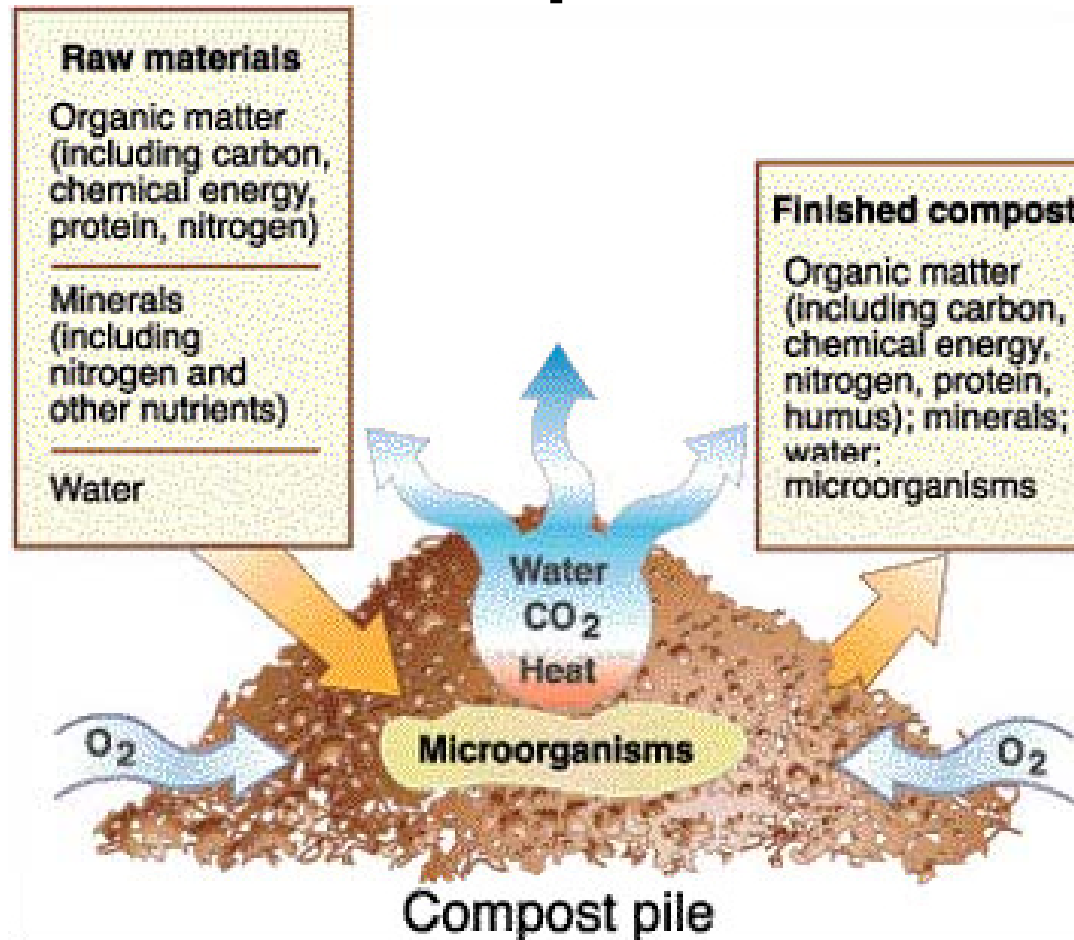
Improving your Soil



**Soil Amendments/Conditioners:
Composts, Composted Manures,
Green Manures**



Composts



**Organic Material = Food for Soil Organisms,
Provides better Soil Structure**



Composting Material

browns
CARBON

- brown bags
- dried landscape waste
- fall leaves
- sawdust
- straw
- wood chips

greens
NITROGEN

- alfalfa meal
- coffee grinds
- crushed eggshell
- hair
- fresh landscape waste
- fruits & vegetables
- tea bags

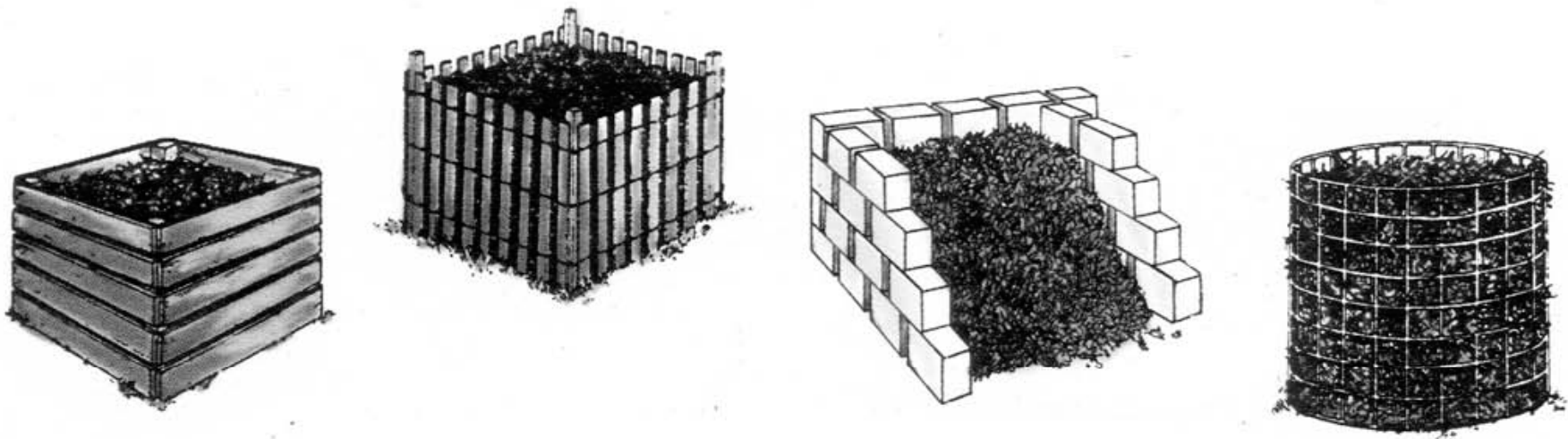
no nos

- fish bones
- meat dairy
- diseased plants
- poop from people & meat eating animals

2/3 (25 Parts) Browns + 1/3 (1 Part) Greens



Composting Bins



Think:

Water, Air, Browns, Greens, and Turning!



Quality Compost

- ✓ Dark brown
- ✓ Soil-like in texture and consistency
- ✓ Parent material not visible
- ✓ Rich, soil-like odor
- ✓ Moist enough to hold together



Composted Manures: Worms, Steer, Chicken



Apply as a Top Dressing or Mix Into Soil



Green Manures



**Tropic Sun Sunn Hemp, Cowpea, Buckwheat,
Lana Vetch, Sudan Grass, Oats**



Mulch



**Retains soil moisture, prevents weeds
and provides continuous food source
for Soil Food Web**



Container Gardening “Soils”



Soiless Potting Mix



Potting Soil

Soiless Potting Mix: Vegetables/ornamental plants

Potting Soil: Succulents



Suggested Online References

Soil Inspiration

- www.people.ku.edu/~azung/my_friend_soil_Jenny.pdf (Hans Jenny)
- www.hulu.com/watch/191666/dirt-the-movie (Dirt The Movie)
- www.soils.wisc.edu/~barak/fdh (F.D. Hole)

Soil Education/Lesson Plans

- www.doctordirt.org
- <http://soils.usda.gov/education/>

Hawaii Soils

- www.ctahr.hawaii.edu/oc/freepubs/pdf/SCM-20.pdf
- www.ctahr.hawaii.edu/oc/freepubs/pdf/soils_poster_3.pdf

Soil Survey

- www.websoilsurvey.nrcs.usda.gov/app/HomePage.htm
- http://soils.usda.gov/survey/online_surveys/hawaii/#islands1972



Suggested Online References

General Composting

- <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/HG-41.pdf> (Backyard)

Vermicomposting

- <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/HG-45.pdf> (Small Scale)
- <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/HG-46.pdf> (Worms)

Composted Animal Manures

- <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/AWM-1.pdf>

Cover Crops/Green Manures

- <http://www2.ctahr.hawaii.edu/sustainag/Database.asp>



Suggested Book References

- **Teaming with Microbes** by Jeff Lowenfels and Wayne Lewis
- **Dirt: The Estatic Skin of the Earth** by William Bryant Logan
- **The Gardener's Guide to Better Soil** by Gene Logsdon
- **Rodale's Chemical-Free Yard & Garden** by Anna Carr, Miranda Smith, Linda A. Gilkeson, Joseph Smillie, Bill Wolf
- **Let it Rot!** By Stu Campbell
- **The Rodale Book of Composting** by Grace Gershuny and Deborah L. Martin
- **Worms Eat My Garbage** by Mary Apelhof





Questions?



Let's Go Outside For Demos!



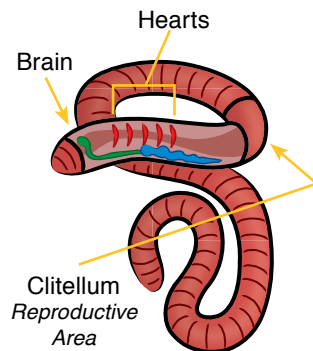
Double Dig, Raised Bed, Soil Sampling





ABOUT COMPOSTING WORMS

- Composting worms recycle “waste” into a fantastic natural fertilizer for plants!
- Composting worms are different from the earthworms that you find in the soil. Composting worms may be purchased from an in-state retailer or shared among friends. It is illegal to import composting worms from out-of-state.
- Wet your hands when handling worms; they breathe through their skin and must be kept moist. Worms have five hearts and no eyes or bones! Handle them very gently.
- Composting worms are photophobic and like to live in a dark, damp environment.



CREATING YOUR WORM BIN

- Worm bins may be purchased or they can be made from recycled materials. Wood or plastic bins (even old drawers) make great worm bins. Drill holes in the bottom for drainage and in the sides for airflow. Holes will be big enough for worms to fit through, but your worms will stay put if they are happy! If they leave it means something is wrong with their environment.
- Never place your bin where it will be directly exposed to the sun.
- Like a compost pile, worm bins need the right balance of carbon (bedding), nitrogen (food scraps), air, and water.
- Worm bedding can be made from shredded newspaper, office paper, cloth, or coir (shredded coconut husk fiber). More than one type of bedding may be mixed together. Bedding should always be shredded, fluffed, and thoroughly soaked before being placed in the bin. The bedding layer should be no more than 1-2” thick. Do not compact the bedding. Bedding provides shelter and a balanced diet for the bin ecosystem, retains moisture, discourages fruit flies, and creates structure for air flow.
- Place a dish under your bin to collect drips. Be sure that the bin is elevated and does not sit in the liquid. This liquid, called “leachate,” can be diluted (approximately 1 part leachate to 10 parts water) and used on plants and trees or in compost piles. Avoid the use of leachate on the edible parts of food plants as it may contain undesirable bacteria.
- Ants are an undesirable visitor to worm bins. Your bin may not be moist enough if they are present. Moisten your bin contents and consider creating a water barrier around the bin legs to discourage ants.

EXAMPLES OF DIFFERENT WORM BINS STYLES



Tiered Worm Bin



Large Plastic Bin

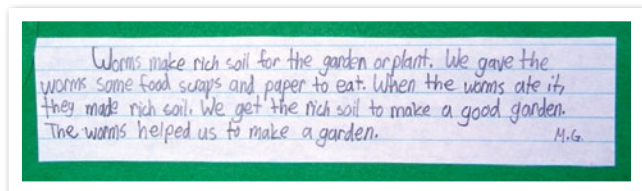


Pipeline Bin System
 (minimum 15 pounds of food waste per week)

How to... Create a Vermicomposting System

FEEDING YOUR WORMS

- Always place a layer of moist bedding over the food scraps to keep fruit flies and odors away.
- Food scraps that are chopped into smaller pieces will make for quicker composting. Avoid “blenderizing” food scraps because the slurry can lock out oxygen and cause a stink.
- Do not add meat, dairy, and fats/oils to your worm bin as they may putrefy and stink.
- Do not add papaya seeds to your bin; they will sterilize your worms and the colony will die.
- Coffee grounds, citrus peels, breads, and grains are OK to add in small quantities.
- Crushed eggshells help to balance the pH of your worm bin; rinse and crush them well before adding.
- Do not overfeed your worms! Add food only when the worms are mostly finished with the previous food batch. If your worm bin smells bad then you are probably overfeeding!



Students creating bedding materials for small-scale worm bins.

HARVESTING AND USING VERMICAST

- “Finished” vermicast that is ready to be harvested does not contain any food scraps and should have a pleasant smell or no smell.
- Vertical harvesting method: Harvest as needed any finished vermicast that has built up in the bottom of your worm bin.
- Horizontal harvesting method: Allow the worms to migrate away from the finished vermicast (over time) by placing fresh food scraps and bedding adjacent to the vermicast.
- Finished vermicast must be hand sorted in order to separate your composting worms from the vermicast. This is a great job for kids! Place the vermicast (with worms) on a flat plastic surface or in a shallow bin and provide empty bins for the separating of worms from finished vermicast.
- Use your vermicast to provide nutrition once a month to potted plants and gardens. You may mix it directly into soil, or dissolve it in water and water the soil with the mixture. “Worm tea” is made by mixing vermicast and water and aerating it (for example with an aquarium pump) for 24 hours to brew and grow beneficial microorganisms. Further research is recommended before making worm tea.



Harvesting vermicast



A science experiment demonstrating the effects of vermicast on plant growth.

COMPOSTING is an excellent way to recycle biodegradable resources while creating a valuable soil amendment and key component of your garden program - for free! When added to the garden soil, finished, "living" compost improves soil drainage

and water retention and adds nutrients and essential living organisms to the garden. Finished compost is an excellent source of organic matter, which must be regularly added to your garden soil as plants grow and are harvested and removed.

COMPOST MATERIALS

- Bin materials (wooden palettes, discarded bicycle inner tubes)
- Sign-making materials (scraps of wood, paint, drill for rope holes, rope or other non-permanent means of attaching to bins - signs will need to move as active pile rotates)
- Hand clippers/pruners and loppers (for processing materials)
- Garden gloves and closed toe shoes
- Water key and access to a hose that reaches the bins
- Compost thermometer (order online)

CHOOSING A COMPOST SITE

- A shady area is best, so compost piles can stay moist even in dry areas.
- The site must have access to a water source (a hose will be used for regular watering).
- It is ideal to have at least three separate bins that are labeled with signs:
 1. "Active Pile" - only add "processed" (clipped) materials.
 2. "Storage Pile" - for storing "unprocessed" materials.
 3. "Resting Pile" - do not add anything; allow to break down for 2 to 3 months.



COMPOST BIN CONSTRUCTION

- Compost piles should be a minimum size of 3'x3'x3'.
- Creating compost inside a bin can help to keep the process neat. However it is not essential to have a bin as piles can also be "freestanding".
- Bins can be constructed easily at very little cost:
 1. Collect wooden palettes (free) of equal size (3 compost bins = 7 palettes total).
 2. Form bins by standing palettes upright and forming 3-sided cubes.
 3. Tie palettes together at the corners with discarded bicycle tire inner tubes (free).
 4. Notes: In areas with feral pigs, you will need an extra palette for each bin to cover the front side of the bin. Palettes may be painted prior to bin assembly and may last longer this way.

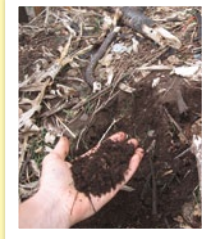
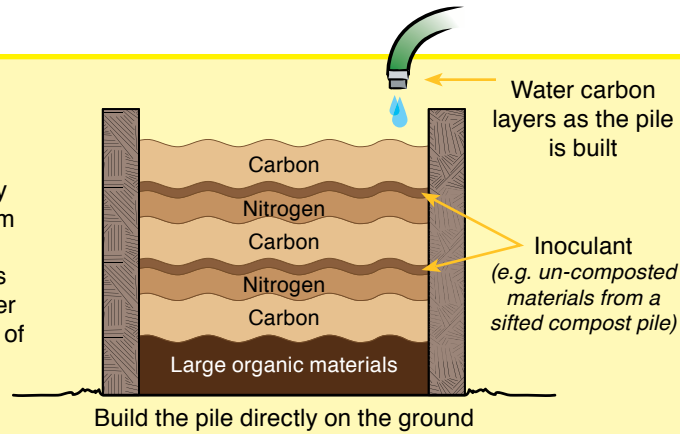
COMPOST MAINTENANCE

- Invite custodians to collect and bring school yard wastes to the compost area. Bags of "unprocessed" yard materials can be left in the "Storage Pile" bin.
- At least one class and teacher (or club) must be dedicated to weekly maintenance of the compost bins and compost area, including:
 - Processing (clipping and assembly) of materials into a compost pile in the "active" bin.
 - Watering the active and resting compost piles thoroughly: piles must be kept moist, but not soaking.
 - Keeping the composting area neat and clean.
 - Optional turning of compost piles: Turning helps the pile break down faster. If desired, use a pitchfork to turn the pile into an empty bin. If the compost materials appear dry, water them as they are turned.
 - Optional temperature monitoring: Use a special compost thermometer to regularly monitor the temperature of the pile in order to ensure proper decomposition. Weed seeds and pathogens are inactivated and beneficial microbes thrive at temperatures between 55 - 70 degrees Celsius. When the temperature begins to drop, turn the pile and add water and nitrogen/carbon materials as needed.

How to... Create Aerobic Compost

WHAT TO COMPOST

Create a compost pile by layering “browns” (carbon) and “greens” (nitrogen) and watering thoroughly as the pile is built. The very bottom layer of the compost pile should consist of larger materials such as branches and palm fronds, in order to facilitate air flow. Below is a list of what to add and what not to add to your compost piles.



Greens + Browns +
Air + Water + Life =
Aerobic Compost!

YES

Nitrogen-rich materials (“Greens”)

- Fresh grass clippings
- Fruit and vegetable scraps (keep toward center of pile and always cover with a layer of carbon material)
- Kitchen scraps like coffee grounds, egg shells, leftover bread, rice, etc.
- Fresh, leafy garden trimmings
- Burned and crushed shells and bones (for calcium)
- Seaweed/invasive algae

Carbon sources (“Browns”)

- Chipped trees (wood chips)
- Dry leaves, dry grass clippings
- Twigs, small branches (chopped)
- Sawdust (from untreated wood)
- Stems of fibrous grasses
- Palm fronds (chopped or shredded)
- Newspaper or office paper (shredded)

NO

May contribute pests (weeds, plant diseases) when inadequately composted

- Weedy, persistent plants
- Diseased plants

Human health hazard

- Dog or cat feces, used kitty litter
- Magazines (heavy metal inks)

May attract flies, rats, animals

- Oils
- Dairy products
- Meat or bones of animals, poultry, fish
- Processed food products

Are not biodegradable

- Metals, glass
- Rubber, plastics

COMPOST PILE TROUBLESHOOTING

Symptoms	Likely problems	Solutions
Offensive odor	Insufficient aeration	Turn and “loosen” pile
Ammonia odor	Too much nitrogen	Add carbon-source materials
Pile doesn't heat up	Insufficient nitrogen	Add nitrogen-rich materials
	Pile too wet	Turn, add dry carbon sources, protect from rain
	Pile too dry	Turn, sprinkle with water
	Pile too small	Add more materials
Pile attracts flies, animals	Inappropriate materials	Don't use meats, oils; remove attracting materials or rotate them to center of pile and cover pile with carbon-source materials

A COMPOST SIFTER is a large and sturdy framed screen used to harvest finished compost from your compost bin for use in your gardens.

Note: Exact measurements may vary according to your materials. Be sure to take measurements as you go and adjust cuts and dimensions if necessary.

MATERIALS FOR ONE COMPOST SIFTER

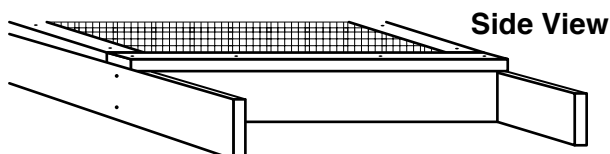
- 12' of 1x4 wood
- 9' of 1x2 wood
- 30" of hardware cloth (for the screen): 24" wide, 1/2" mesh, 19 gauge (one 10' roll makes four sifters when cut roll into 30" lengths)

TOOLS

- Tape measure
- Saw (hand saw, jig saw, or circular saw)
- Hammer and nails
- Drill and screws (optional)
- Staple gun and staples
- Wire cutters
- Sandpaper
- Paint and brushes (optional)

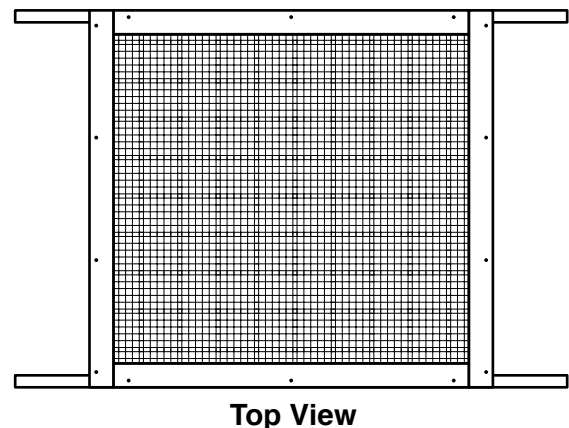
DIRECTIONS

1. Cut boards using saw:
 - 1x4 piece: Two 4' long pieces and two 22.5" long pieces
 - 1x2 piece: Two 27" long pieces and two 24" long pieces
2. Cut hardware cloth using wire cutters: 24" wide x 30" long
3. Nail/screw the 1x4 boards together in a rectangle shape with handles (see diagram)
4. Optional: Paint and decorate the wooden frame and 1x2 pieces
5. Staple screen to the rectangular frame
6. Nail the 1x2 cover boards over the screen and staples
7. Sand any rough edges
8. Hammer down or cut any protruding screen points
9. Now you are ready to sift your finished compost and add it to your garden soil!



HOW TO USE YOUR COMPOST SIFTER

1. Place the compost sifter over a wheelbarrow. Have two people work together to use the compost sifter; each person will hold onto the two handles on the short sides of the sifter.
2. Shovel the compost onto the screen and move the compost sifter back and forth horizontally over the wheelbarrow. Large pieces of un-composted material will be separated from the finished compost, which will collect in the wheelbarrow below.
3. Add the large un-composted pieces to an active compost pile so they will inoculate the new pile with beneficial microorganisms and continue to decompose.
4. Continue the process until the desired amount of compost has been harvested.
5. Use your screened, finished compost to amend your garden beds before planting or periodically as plants grow. The finished compost may also be used as potting soil for seeds and transplants.





Backyard Composting

Recycling a Natural Product

To protect the *āina*, many people practice the three Rs of conservation. They *recycle* aluminum cans, paper, and glass. They *reuse* paper as scratch pads and line garbage pails with plastic grocery bags. Some *reduce* their use of energy and materials through energy conservation and careful maintenance to make things last.

Apply the three Rs to yard trimmings and leftover food, and you have composting—an economical way to reduce solid waste, reuse organic materials, and recycle nutrients as a soil conditioner. Composting is about being good caretakers of our environment.

It's in the bag

In order to estimate how much you threw out last week, gather one day's garbage from your household. Weigh on a bathroom scale or estimate by comparing to a known weight, like a 20-pound sack of rice. Multiply by seven, and you have the amount of garbage produced by your household each week.

Look at what's in your garbage. Any recyclable plastic or aluminum containers or old newspapers? Take these to be recycled. See any food stuff – banana peels, fuzzy leftovers, coffee grounds – or yard trimmings? These materials are easy to compost. When you remove the recyclables, 20 pounds of garbage is often reduced to as little as 5 pounds.

Imitating nature

Composting is a process by which organic materials (such as branches, leaves, and fruits) biologically decompose under controlled conditions.

More simply, compost is the result of humans imitating nature's disposal system.

When vegetation dies or falls off trees in forests and fields, insects, worms, and bacteria eat it. They leave behind small loose particles called humus. Humus binds soil particles together into larger aggregates, or grains, that allow water and air to enter the soil more easily. Humus also contains important nutrients in forms plants can easily use for healthy growth and reproduction.

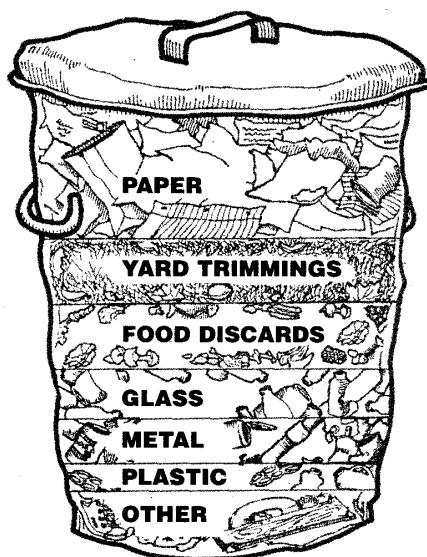
Mixed with soil, compost improves the soil's tilth. That is, it makes the soil looser, or lighter, which makes water, oxygen, carbon dioxide, and minerals more available to plants. Compost improves root penetration and makes the soil easier to work. Compost conserves water by helping the soil retain it better.

Because it is made from decomposed organic material from many sources, compost contains many of the nutrients plants require (although not always enough to sustain intense commercial production). Compost has

even been known to reduce the incidence of certain soil-borne diseases that have devastating effects on plant health and productivity, perhaps because the beneficial soil microbes added in compost outcompete the pathogenic organisms.

How it works

A balance of five essential ingredients is the key to rapid, trouble-free composting. If you maintain a pile with the correct balances of moisture, air, and carbon and nitrogen contents of the raw materials, then decomposing organisms—insects, worms, bacteria, and fungi—will do the rest.



Often, over half of home wastes are compostable.

HG-41, continuing the CTAHR General Home Garden Series, was first published as Instant Information Series 21, October, 1996.

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Water is required by all living things, including decomposers. The compost pile should be moist, but not too wet. A bad odor may indicate that excess moisture is inhibiting decomposition.

Oxygen is essential to most decomposers. Oxygen cannot circulate well if the pile is too tight, too big, or too wet. If the pile is soaked with water, most decomposers die and composting is taken over by a few “specialists” that can live without air. Anaerobic decomposition—detected by its swampy odor—is slow and inefficient.

Carbon is abundant in most organic materials and is broken down by decomposers to create food-energy. However, other nutrients are needed for carbon to be readily eaten. Wood and paper are examples of materials that are high in carbon but may be deficient in other nutrients and thus slow to decompose.

Nitrogen is required by decomposers in relatively large quantities. It is a major ingredient in protein, a basic building block of life. Without sufficient nitrogen in your compost pile to assist digestion of carbon-rich materials, decomposition goes very slowly. Green leaves and grass clippings are examples of nitrogen-rich materials.

Decomposing organisms produce heat by their activity. This heat in turn energizes them, and the whole process goes faster. Heat also helps kill disease organisms and weed seeds. The speed of composting varies, but at some point the center of the pile should feel hot or very warm to the touch. More mass (a bigger heap), more water, more air, or more nitrogen may be needed to get the process going.

A well managed pile can produce compost in about two or three months.

Getting started

A proper surface is important. Compost is easier to turn when piled on concrete or another hard surface, but worms and other beneficial organisms from the soil will have a harder time reaching the pile. Level ground is also a good surface.

The dimensions of the pile, as a rule of thumb, should be at least 3 feet high by 3 ft wide by 3 ft long to maintain sufficient heat in its interior. If the pile is too large, air has trouble getting to the center. Maximum recommended size is 5 ft high by 5 ft wide, with no limit to the length.

The appropriate location for a compost pile is a shady area protected from wind (to prevent it from drying out). Protect the pile from heavy rain by covering it with a

plastic sheet, or make it under a roof. Build it where it can't be flooded.

Have a protected area to store finished compost if it isn't going to be used immediately. Avoid mixing undecomposed materials with finished compost.

Choose a composting method

Set-ups for a compost pile range from simple to elaborate.

Basic compost heap—Simply pile and mix the compost materials on the ground. Cover the pile when it rains to prevent it from getting too wet or losing nutrients to leaching. Turn the heap regularly (every week or two). Building the pile over a layer of scrap plastic pipes drilled with holes allows for air penetration from below and reduces the need for turning.

Compost pit—Pits are ideal for composting materials consisting mostly of food scraps. Dig a hole in the ground, add the materials, mix with soil in the hole, and refill the hole with at least 8 inches of soil. Fallow areas of your garden are good places for compost pits.

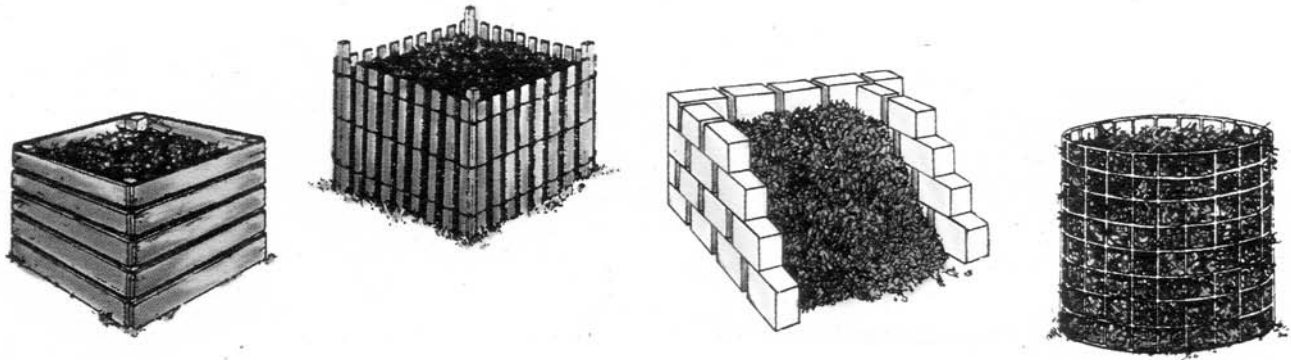
Holding units—Bins help to contain the compost heap, keep it out of sight, and can make it easier to turn. They can be made of concrete blocks, wire mesh, or wood (although wood may lead to termite problems). If the bin is a movable type, it can be lifted from the pile and placed next to it when it is time for turning; just shovel the heap back into the empty bin. Old garbage cans can be used as holding units if they have enough large holes to allow air to circulate and holes in the bottom to allow water to drain.

Turning units—Some commercial composting units feature rotating barrels that make mixing the pile easier and reduce the use of shovels or forks for turning. Another way to make turning easier is to build two or three adjacent holding units. The first is filled with the new pile. When the pile is turned, it is shifted into the next bin. By the third turning, the pile is usually on its last month of decomposition.

What to compost

Organisms that decompose organic materials to form compost depend on a “diet” of carbon and nitrogen. Fresh, green materials are rich in nitrogen, and so are animal manures. Just as plants need nitrogen to grow, decomposers need nitrogen to fuel the decomposition process. Grass clippings are rich in nitrogen, and wood chips are a carbon source. The key to making a compost

Some examples of compost enclosures



pile is to combine nitrogen-rich materials with carbon sources in the right proportions, with the right amount of moisture, and adequate aeration.

Building a compost pile

This simple recipe for making a compost pile should produce ready-to-use compost in a few months.

1. Accumulate enough materials for a pile at least 2 x 2 x 2 ft; or even better, to make a 3-ft cube.
2. Shred or chop the materials to 1–2 inches in size to expose more surface area for faster decomposition.
3. Start the pile with a 4–6 inch thick base of carbon-source materials (dead leaves, wood chips, shredded paper, etc.). Moisten. Add a 2–3 inch layer of nitrogen-rich materials. Food scraps may make up part of this layer. Continue to alternate and mix layers of nitrogen-rich materials with carbon sources, adding water as needed. The pile should be about 3–4 ft high or, if in a bin, not more than 4–5 ft high. Close the bin or cover

the pile with a plastic sheet.

4. Inoculate a new pile, if desired, by sprinkling a small amount of topsoil or compost between layers. Some composters believe this speeds the process by “seeding” the new pile with decomposing organisms.
5. Monitor moisture content; test by feeling a handful of compost and squeezing it as you would a sponge. It should feel moist without yielding more than a few drops of liquid. If the pile is too wet, turn it to allow air in and improve drainage. If the pile is too dry, water it and turn it.
6. Periodically check the temperature in the pile’s interior. A compost thermometer is helpful, but you can estimate the temperature by touch. It should peak between 120° and 160°F (hot to the touch). When the temperature begins to drop, turn the pile and rotate materials from the outer and top parts of the pile toward the base and middle; move the more composted middle part to the outer part of the pile. For easy turning, use a garden fork to shift the compost to a second bin; the mate-

Materials OK to use

Nitrogen-rich materials

Grass clippings
 Seaweed and aquatic plants (washed to remove salt)
 Fruit and vegetable trimmings
 Kitchen scraps like coffee grounds, egg shells, leftover bread, rice, etc.
 Fresh, leafy garden trimmings

Carbon sources

Chipped trees
 Twigs, small branches from trees and shrubs (chopped)
 Sawdust (from untreated wood)
 Stems of fibrous grasses
 Palm fronds (chopped or shredded)
 Newspaper or white paper (shredded)

Undesireable materials

May contribute pests (weeds, plant diseases) when inadequately composted

Weedy, persistent plants
 Diseased plants

Human health hazard

Dog or cat feces, used kitty litter

May attract flies, rats, animals

Oils
 Dairy products
 Meat or bones of animals, poultry, fish

Are not biodegradable

Metals, glass
 Rubber, plastics

rial at the top will now be at the bottom. In the process, you are aerating the pile, and you can add water if the pile seems to be dry.

7. Continue to monitor the temperature in the pile. It should heat up again. After the temperature peaks, turn the pile once more. You may note that white molds decrease over time, insect populations will change, and beneficial worms become abundant as the compost matures.

8. The process is completed when the pile does not generate any more heat. When the pile is cool and the compost has aged for another four weeks, it should be finished. The pile should be much smaller than its original size, and the original materials should no longer be recognizable. The compost should be dark, loose (crumbly), and without any strong or unpleasant odor.

9. Use the compost to mix into the soil or to make compost tea to use for watering crops, seedlings, and starts. Spread compost on your lawn and under shrubs, flowering plants, vegetables, and trees.

Helpful hints

- Chop or shred leaves, twigs, and other materials to speed composting. Smaller pieces of organic material “cook” faster than larger pieces because more of the material surface is exposed.
- A compost pile needs the right mix of materials to decompose quickly. When building the pile, try to have at least one part nitrogen-rich materials for every two to three parts carbon sources. You may need to experiment with different materials and proportions to develop enough heat for rapid decomposition.
- If there is not enough nitrogen-rich material, sprinkle

small amounts of commercial nitrogen fertilizer between layers. (Note: these fertilizers are concentrated; use sparingly.)

- Balance moisture and aeration to develop heat; too much of either results in a “cold,” inactive pile. The hotter the pile, the faster the composting process. Temperature of an actively composting pile normally range from 120 to 150°F. Higher temperatures (140–160°F) kill harmful pathogens, insects, and weed seeds. Avoid turning the pile too often, because the heat is lost whenever the pile is turned. Turn it immediately, however, if an odor develops; the smell should fade away.

Alternatives to composting

You can reuse organic materials in your yard in other ways. People practice “passive” composting when they pile up organic materials but don’t turn the pile. Without turning, the pile will be “cooler” and much slower to decompose. The materials break down eventually, and compost can be removed from the bottom of the pile. This method may not kill weed seeds and plant pathogens, and the pile may attract insect and animal pests.

To fertilize your lawn, leave nitrogen-rich grass clippings in place after mowing. Mow “high”—clippings should be less than one-third of the grass blade—and mow so as to spread the clippings evenly across the lawn.

Mulching is similar to composting but requires less effort. Chipped or shredded organic materials such as lawn clippings, leaves, pine needles, shrubs, and trees can be spread on the soil surface around your plants. Mulch controls weeds, keeps moisture in the soil, and reduces soil erosion.

Compost Pile Troubleshooting

<i>Symptoms</i>	<i>Likely problems</i>	<i>Solutions</i>
Offensive odor	Insufficient aeration	Turn and “loosen” pile
Ammonia odor	Too much nitrogen	Add carbon-source materials
Pile doesn’t heat up	Insufficient nitrogen	Add nitrogen-rich materials
	Pile too wet	Turn, add dry carbon sources, protect from rain
	Pile too dry	Turn, sprinkle with water
	Pile too small	Add more materials
Pile attracts flies, animals	Inappropriate materials	Don’t use meats, oils; remove attracting materials or rotate them to center of pile and cover pile with carbon-source materials.



Testing Your Soil: Why and How to Take a Soil-Test Sample

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Why to have a soil tested

- Does my soil have problems?
- Does my crop need fertilizer?
- What kind of fertilizer should I use?
- How much should I apply?

A soil analysis can help farmers and gardeners answer these questions. A *basic soil analysis* provides information on two important soil characteristics:

- **Soil pH** is a measurement on a scale from acid (low pH) to alkaline (high pH). Most soils are on the acid side of the pH spectrum. Good soils for crop production are often moderately acid, but some soils in Hawaii are acidic to the extent that crops grow poorly. Soil tests indicate pH problems and allow recommendations for correcting them.
- **Available nutrient levels** in the soil indicate how good crop growth will be. Testing for phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) helps determine the need for liming material and the appropriate fertilizer formulations and amounts for the crop to be grown.

In addition to the basic information on pH and levels of major nutrients, *specialized soil analyses* can help to investigate other factors that may limit crop growth:

- **Soil salinity** can build up in coastal areas and in soils irrigated with brackish water or to which too much fertilizer has been applied.
- **Nitrogen (N)** is required in large quantities by most crops, and adding N is a basic part of most fertilizer programs. In special circumstances, N can be analyzed as total N, ammoniacal N (NH₄-N), or nitrate N (NO₃-N), but this is not usually done because N does not remain in the root zone for very long.

- **Organic carbon (C)** analysis, like N analysis, is useful only in special circumstances. Most soils benefit from additions of organic matter.
- **Aluminum (Al)** in soils can be toxic to plants if pH is low and the Al is too available to them. Knowing the soil's pH and classification is the first step in predicting Al problems, and tests for "extractable" Al can then be done if necessary.
- **Micronutrient** levels in the soil may be analyzed when crop symptoms suggest problems. Micronutrients often measured include boron (B), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn).
- **Heavy metals** that might indicate contamination include cadmium (Cd), chromium (Cr), lead (Pb), selenium (Se), and vanadium (Va).
- **Particle size distribution** measurement determines the proportions of sand, silt, and clay particles.

These specialized soil tests usually are not called for unless crop growth problems have been observed or there are other reasons to suspect that they are needed.

Taking a good soil sample

Soil tests are done on a sample that is only a tiny fraction of a field or garden plot. Soil treatment recommendations assume that data from the analysis of that tiny fraction represent the entire area to be treated. Therefore, care must be taken to ensure that the soil sample truly represents the field or plot.

If differences can be seen in the soil from various parts of the overall area to be sampled, each distinct sub-area should be sampled separately. Differences in soil color or texture are obvious reasons for taking separate samples. Other reasons include differences in land slope, soil drainage, crop management history (different soil

amendments or fertilizers), variations currently observed in crop growth, or variations in the natural vegetation.

Each soil sample analyzed should be a combination of 5–10 subsamples taken from the soil area of interest. The subsamples should each be about the same amount of soil, and they should be mixed together thoroughly as they are collected. The final sample taken from this mixture is called a composite sample.

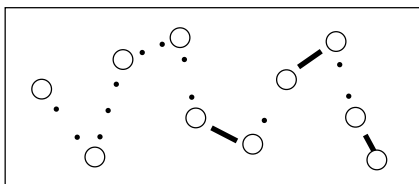
How large an area to sample? For home gardens, one sample that is representative of the garden plot is usually sufficient. For orchards or farms, even if no distinctly different soil types are noticeable, large areas should be subdivided into sample areas of 2–5 acres and sampled separately.

What equipment do I need?

- **map** the area sampled if you are taking more than one sample. Mark each sampled area on the map with a label that you will also write on the sample bag.
- **spade** or shovel (for specialized soil tests, tools should preferably be made of steel, because tools made of brass, bronze, or galvanized metal may contaminate samples with copper or zinc)
- **plastic bucket** or large plastic bag for collecting and mixing subsamples
- **plastic bag** to contain about 2 cups (1 pint) of the final, composite soil sample (thin plastic bags that can “breathe,” such as sandwich bags, are better than thick plastic bags for storing soil; brown paper bags can contaminate samples to be tested for boron)
- **waterproof marker** to label the plastic bag to identify the sample.

Collecting the soil sample

For each distinct soil area you are sampling, take 5–10 subsamples and mix them together to obtain the final sample. Take the subsamples by selecting spots in a pattern that ensures a balanced representation of the whole area sampled. Don’t sample spots that look atypical of the area being sampled.



Collect soil samples in a zig-zag pattern

Use clean tools to sample soil, a clean container to mix it, and clean bags to store it. Small amounts of contaminants, especially fertilizer or lime, can distort the analysis results.

How deep to sample?

- Sample the top 4 inches for lawns, turf, established pasture, and “no-till” fields.
- Sample the top 8 inches for conventionally tilled fields and garden plots.
- Sample the top 8 inches plus a separate sample for the 8–24 inch zone for tree crops.

The sampling method

1. Clear surface litter and plant growth from the sample spot. Dig a hole about as wide as your spade and as deep as the layer you are sampling.
2. With the spade tip placed one inch outside the edge of the hole, cut down to remove a slice of one side of the hole wall.
3. Keeping that slice on the blade of the spade, use a trowel, knife, or machete to cut away the sides of the slice, leaving a center section about 1 inch wide. This 1 x 1 inch vertical section of the soil is your subsample.
4. Place the subsamples in the plastic container, mix them together well, and remove about 2 cups (1 pint) of this mixture. This is your composite sample, to send to the laboratory for analysis. (If nitrate analysis is being requested, keep the sample on ice and submit it promptly.)

Getting the sample analyzed

The Agricultural Diagnostic Service Center (ADSC) of the College of Tropical Agriculture and Human Resources (CTAHR) at the University of Hawaii at Manoa provides residents of Hawaii with a reasonably priced soil and plant-tissue testing service. Samples for analysis by ADSC can be taken to county offices of the CTAHR Cooperative Extension Service (CES), or they can be delivered or mailed directly to ADSC at 1910 East-West Road, Room 134, Honolulu, HI 96822.

Soil samples sent to ADSC should be accompanied by the ADSC soil information form (p. 4). Complete information helps ADSC provide more accurate recommendations. Helpful information about your soil sample includes

- an estimation of the soil texture, either “heavy” (which applies to many of Hawaii’s soils), “light” (soils de-

rived from volcanic ash on the Big Island), or ‘a‘ā (irregular pieces of lava)

- a description of the plot or field (slope, presence of rocks, drainage problems)
- the kind of plants presently growing at the site (natural vegetation or crops)
- whatever is known about past use of the site or management of the soil
- the crop or crops to be grown.

An analysis fee schedule and extra copies of the soil sample information form can be obtained from the ADSC or at CES county offices, or they can be found on the Web at <http://www.ctahr.hawaii.edu/adsc>.

Plan to submit soil samples well in advance of when you wish to prepare your soil to plant. It may take several weeks before the laboratory results become available. If liming is recommended for your soil, the effects of the amendment will not be realized for a month or more after incorporating the lime.

Soil analysis results from the ADSC will be sent to you in the mail. The test values will be given, as well as an interpretation of them. For example, available nutrient levels will be rated as very low, low, sufficient, high,

very high, or extremely high. Based on these interpretations and on the nutritional requirements of the crop you wish to grow, the form will also provide specific recommendations for soil amendments and fertilizer formulations, as well as the amounts of these to apply.

The analysis results form also asks for feedback on how your crop grew after you followed ADSC fertilizer recommendations. This information helps ADSC to fine-tune future recommendations.

The bottom line

Applying too much or the wrong kinds of fertilizer can harm your crop and be a costly waste of money. Perhaps more important, it can affect our coastal waters and drinking water by washing into streams or leaching into the groundwater.

Failing to correct soil problems or apply enough of the right types of fertilizer to your crops can result in poor yields and wasted effort.

The CTAHR Agricultural Diagnostic Service Center is dedicated to helping you make the right decisions about amending and fertilizing your soil. We hope that our recommendations will enable you to make your soil more productive while protecting Hawaii’s environment.



Soil Sample Information Form

Name _____
first, middle initial, last

Mailing address _____

City _____ State _____ Zip code _____

Phone _____ Fax _____ E-mail _____

Sample description Identification label: 1. _____ 4. _____

(The sample identification label should be written on the sample container. This form may be used for up to six samples. When information is given below, be sure to clearly note by number [1–6] the sample that is being referred to. If this cannot be clearly done, use separate forms.)

2. _____ 5. _____

3. _____ 6. _____

Sample type: soil potting media compost Size of area sampled: _____ square ft or _____ acres

This sample is: accompanied by plant tissue sample/s [provide tissue sample ID label: _____]
 a follow-up sample, related to a sample previously analyzed
[provide sample ID label from previous analysis report: _____]

Soil series or mapping unit: _____

(This information can be obtained from the Soil Survey of the State of Hawaii, available at local libraries)

Describe the location, conditions, and any problems

(If more space is needed, use the back of this form)

Apparent soil density: heavy light 'a'ā lava

Can you till in fertilizer 4–6 inches if necessary? yes no

Soil management history: type or formulation quantity applied how often applied date of last application

lime _____

manure _____

fertilizer _____

other _____

Plant/s to be grown

Vegetable crop:

- lettuce cabbage
 onion watermelon
 tomato bean

other _____

Orchard crop:

- coffee macadamia nut
 papaya guava
 avocado banana

other _____

Field crop:

- wetland taro dryland taro
 corn soybean

other _____

Mixed garden planting

Turfgrass

Container plant/s (specify)

Pasture: improved pasture natural rangeland intensive grazing

Forage: grass legume (specify plant/s)

Other crop category (specify plant/s)

Special reporting instructions:

Only nutrient levels and adequacy diagnosis are needed (no fertilizer recommendation needed).

Other instructions:

ADSC use only	Job Control no. _____	Date received _____ month/day/year
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