Soil Science Basics

Presented February 9, 2022 by Darien Payne, Master Gardener

1. Disclaimer: We are gardeners and volunteers! Please be patient with our tech skills.

2. Title Slide: 1. What is soil? 2. Soil and Plant Communities 3. Gardening for Healthy Soil
A short introduction to Darien

3. Our Resources come from WSU publications and other respected academic sources, enlivened by our own gardening experiences.

4. Soil: The Source of Terrestrial Life *Can we learn to garden in alignment with nature's cycles?*
Earth cycles and recycles all, nothing is wasted. Air, water, rock, life: they meet and transform in the soil.

5. Soil Forming Factors as they affect Puget Sound soils

Parent material (underlying rock—here glacial deposits and volcanic ash & mud flows),
Climate (temperature & precipitation): rain, wet cool winters, warm dry summers. Rain cools and compacts the soil, leaches soluble minerals. Rainy climates tend to have lower pH, acidic soils. *Microclimates matter too.*
Topography affects the gravitational distribution of water & wind sediment flows, through erosion and deposition. Slopes loose soil, lower elevation flat areas gain soil. *Gravity rules!*
Life: Terrestrial life and soil are co-creators.
Time: Puget Sound area has geologically young soils, 15,000 years since glaciers retreated; more time generally means more developed soil layers and deeper topsoil, absent erosive forces.

6. Healthy Soil is created when the three properties of soil are in balance.
(*More on healthy soil later in presentation)*

7. Physical: *Soil Texture* is mostly influenced by parent material and geological history, and refers to the sizes of mineral/rock particles in the soil. Puget Sound's varied terrain and many microclimates have given us a variety of soil textures.
Soil texture: we get what we get. Difficult to change soil texture by adding clay or sand, you could end up with concrete.

8. Chemical: In the 20th C., agriculture and horticulture science focused attention on soil chemistry, the mineral nutrients in the soil.

Nutrient stores and flows—the elements & compounds. Plants roots exchange hydrogen ions for other mineral ions dissolved in water (soil solution). The mineral nutrients are called ions, compounds of water soluble minerals. Positively charged minerals are CATIONS, and negatively charged minerals are ANIONS. Most of the plant essential nutrients are positively charged cations, but not all.

9. Chemical: pH of soil determines which minerals are available to plants. Lower numbers are more acidic, higher numbers are alkaline, 7 is neutral. Optimum range for most vegetables is slightly acidic.

10. **Biological**: *Organic Matter* is the living, the dead, the very dead & the very hidden. About 58% or dry organic matter is CARBON. Of soil OM, only 5% of it is alive. 33–50% is in stable, long lasting OM, *humus* or humic substances. Humus can be very resistant to decay, long lasting. Healthy soils have a continual supply of fresh OM.

11. **Questions?**

12. **Part 2: Plant and Soil Communities:** Photosynthesis: It starts with the sun! Plants use energy from the sun to convert CO2 from the atmosphere into sugars, carbohydrates, cellulose, lignin, also proteins. Cellulose and lignin are structural support for the plant. Carbon is fuel for plant metabolism. Plants offer, or exude (leak, discharge), 10 to 30% or more of the sugars they create into the soil. Most of the soil life is concentrated around plant roots, the *rhizosphere*.

13. **The Carbon Cycle:** Carbon is an essential plant nutrient supplied by the atmosphere. Atmospheric Carbon dioxide (CO2) is taken in by plants and transformed into a variety of compounds, using the energy provided by the sun. Plant carbon compounds are the basis of the earth's food chain. Carbon is cycled from flora (plant) to fauna (animal) and fungi.

14. **The Nitrogen Cycle:** Nitrogen is another essential plant nutrient supplied by the atmosphere. Atmospheric nitrogen, N2, is a very stable molecule. In nature, only lightning and specialized nitrogen fixing soil bacteria can break that stable bond and turn N2 into plant available nitrogen. In the soil, nitrogen is mutable, changing continually from one form to another. Plants cannot use N directly from air, but depend on *nitrifying* soil bacteria to convert N2 to soluble ammonium and nitrates, plant available forms of N. Nitrogen is stored in soil organisms, (*immobilized)* until excreted as waste *(mineralized*).

    N is essential for photosynthesis, DNA synthesis, and proteins. Excess soil N is *denitrified* or converted back to a gas, atmospheric form, by denitrifying bacteria.

    Excess N is easily leached from soil, and is a toxic pollutant of ground water. Excess N also can enter the atmosphere as nitrous oxide, N2O, a potent greenhouse gas.

15. **The Soil Food Web:** *Producers* are the photo-synthesizers (plants). They are the basis for life. *Consumers* are the rest of the fauna and fungi, getting their energy from consuming plants or other organisms that have consumed plants.

16. **Bacteria and Actinomycetes** Tiniest and most abundant members of the soil community, they have many functions in soil. Upper left photo, small rod-shapes bacteria on a root hairs: *Rhizosphere!*

    Lower two on left, N fixing mutualist bacteria on soy host plant. The nodules contain the bacteria. Bacteria are in the soil, and "infect" the plant root.

    On the right, Nematodes and protozoa are predators & herbivores. Protozoa eat bacteria. Nematodes vary in what they eat. Their mouth parts identify what they consume. Bacterial feeders have these elaborate mouth parts. These are "secondary consumers." These larger members of the micro biome offer *micro manures,* minerals in plant available form.

17. **FUNGI** are soil builders and nutrient miners. *Mycorrhizal* fungi are important in plant uptake of minerals, especially phosphorus, which they mine from rock particles and offer to plants. Mycorrhiza also scavenge and share other nutrients with plants, including nitrogen.

    Most of our food/vegetable crops have *endomycorrhizal* associations, with notable exceptions being the beet and cabbage families.

18. **FUNGI** *Ectomycorrhizal* fungi: about 2000 plant species, mostly woody trees/shrubs, conifers partner with this type of mycorrhizal fungi. They do not enter into the plant cell but go in between the cell membranes, and form a protective mantle around the root.

19. **Arthropods** have a variety of functions in the soil food web. All of them are nutrient banks and nutrient cyclers, storing minerals in their bodies, excreting excess nutrients in plant available form.

20. **Earthworms:** Decomposers, shredders, nutrient cyclers. They are architects and engineers of the soil: creators of pore space. Pore space allows water infiltration, brings oxygen deeper into the soil, creates root (and organism) pathways, crevices for other creatures. Earthworm castings concentrate nutrients, in plant available form. All earthworms in Puget Sound area are invasive European species, as the native species were wiped out by glaciers eons ago. Although beneficial for agricultural soil, they are destructive in native forest soils.

21. **Aggregates:** It is the life in the soil that turns the mineral particles (texture) into soil *aggregates.* Aggregates define the structure of the soil. Healthy soil is crumbly, cottage cheese-like, with small and larger aggregates. Aggregates create pore space, which is not only space for air and water, but also habitat for micro- and meso- soil life.

22. **Questions?**

23. **Part 3: Gardening for Healthy Soil:** *Healthy soil is "the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans"*

    Good soil tilth • Sufficient depth • Good water storage and good drainage • Sufficient supply, but not excess of nutrients • Small population of plant pathogens and insect pests • Large population of beneficial organisms • Low weed pressure • Free of chemicals and toxins that may harm the crop • Resistant to degradation • Resilience when unfavorable conditions occur

24. **Know What You Have:** Soil tests are a SNAPSHOT of your soil quality and chemical composition, not the complete picture. What I've found most useful in them: *OM percent, pH, CEC*, excess or deficiency of nutrients.

    What standard soil tests can't tell you: what kinds of soil organisms are there, accurate N levels, toxic metals or chemicals. OM percent is a kind of proxy for soil organisms, and an estimate of available N. Soils with excess of phosphorus, more than 70ppm, are detrimental to mycorrhizal fungi.

    King CD offers 5 free soil tests in a lifetime for every address in the county.
    http://kingcd.org/programs/better-soils/healthy-soil/

25. **Fertilizing Your Soil**: Get your soil tested and bring your test to Growing Groceries class #4, April 6th, with Gia Parsons **"Understanding Your Soil Test and Amending Your Soil"**

    Less is more!

    Synthetic fertilizers are very soluble, quick acting, and prone to leaching. They do not feed the soil life and require a lot of fossil fuel energy in their manufacture and transport. Synthetic N tends to increase soil acidity. Synthetic N production is one of agriculture's largest source of global warming gases & pollution.

    Organic fertilizers are often a waste product from a plant or animal product. Organic fertilizers are generally slower acting, but provide a longer lasting source of nutrients.

    If it seems your soil is very low in organic matter, add one to three inches of compost.

MANURE Add only aged (at least 120 days) or composted manure, as an alternative to other compost. If you've added manure for multiple years, your soil may accumulate excessive phosphorus and/or potassium. *Have your soil tested!*

NITROGEN Add an organic nitrogen fertilizer sparingly, and when it can be taken up by soil life and plants, generally as the soil warms in spring. Too much nitrogen can leach from the soil, becoming a pollutant. Your soil OM contribute nitrogen too, so don't over apply fertilizer! Don't count on compost as a significant source of N. In garden systems that are too well fertilized, plants can loose their ability to partner with their symbiotic microbial partners.

26. What about purchased soil and potting soil?

Top soil generally is a mix of sand and compost, it might include some native loam. In our region the compost may be made from yard waste, manure, or wood waste. Purchased top soil does not have the aggregate stability or microbial life of many native soils. It will take time for the gardener to nurture soil biology.

Potting soil: purchase the best quality you can afford. Look for ingredients listed on the bag, avoid those made with peat moss as it is not a renewable resource. Our regional mixes are most likely made from wood products, compost, manure or worm castings, and possibly lime (calcium carbonate) as a pH balancer. The potting soil may or may not be sterile, without living organisms. Potting soils generally are formulated to provide season long nutrition for plants. If they are not OMRI certified they may contain conventional fertilizers.

27. Benefits of Cover Crops: Cover crops are planted primarily to feed and protect your soil.

Keep soil covered as much of year as possible. • Maximize living roots in the soil profile. *Remember those living roots feed soil life with their exudates.* Optimum: Multi-species cover crops.

28. Winter Cover Crops capture excess nutrients after summer crops, protect soil from winter rains, and provide continued carbon (fuel) for soil organisms, building soil organic matter.

Diversity is insurance. If one or more species fails, there are others that will survive. Diversity above means diversity below ground, you will be feeding diverse species of soil biota.

Brassicas do not form mycorrhizal relationships, but can have a bio-fumigant effect on the soil.

Legumes fix N so are essential in bringing more N to your soil.

29. Summer Cover Crops: Many of the same species that are planted for winter cover crops will work in our climate for summer cover crops too. Summer cover crops can be quick growing fillers between spring crops and late summer or fall crops. Fast growing and flowering: buckwheat, phacelia, cilantro, radishes. Fast growing flowering plants provide nectar and pollen for beneficial insects (pollinators, predators, and parasites).

Buckwheat is notable for its quick growth, flowers loved by beneficial insects, and its ability to scavenge phosphorus.

Legumes are nitrogen contributors. Crimson clover can be planted from spring to early fall.

Brassicas can help reduce soil fungal pathogens, especially mustards and arugula.

30. Managing Cover Crops: timing is key, over seeding helps ensure good cover, hiding/protecting from birds and mice helps too.

"Cover Crops for Home Gardens West of the Cascades"
http://pubs.cahnrs.wsu.edu/publications/pubs/fs111e/

Fall/winter cover crops are best planted by or before mid September. Earlier plantings provide more biomass, but smaller younger plants can survive a severe frost more easily. Rye, Triticale, and fava beans can be planted the latest, into October. They may not show much growth until spring, but they should survive winter and grow well in spring.

Interplanting even earlier, in July, between young corn, squash, under pole beans, and at the base of tomatoes can give fall cover crops a head start before taller plants slow their growth with shade. This can work well with clovers and oats.

Harvesting Cover Crops: Leave the roots in the soil! Dry matter should only be used as mulch or carbon for your home compost, do not dig it into soil. To capture most N, cut legumes when they are flowering.

31. **Minimize Soil Disturbance:** *Allow your soil community to flourish! Aggregates are habitat for your soil community* • Reduce tilling or spading soil • Deep forking or digging every few years instead of annually • Shallow cultivation, top few inches only • Shallow furrows for seeds • Add compost on top • Reduce/ eliminate chemical biocides and fertilizers • Use IPM methods • Use non-toxic bait stations for slugs. *It takes effort to change our habits.*

32. **Feed and Protect Your Soil**

    Maximize Biodiversity & Continuous Living Roots

    Minimize Disturbance & Maximize Cover

33. **Questions?**