Managing the Growing Environment for Herbaceous Plant Soils

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Flower Beds Don’t Just Happen
The Basic Ingredient is the Soil
Soil Is Like the Garden Gnome
Where Can You Find It?
Is This My Soil?
Is This My Soil?
Is This My Soil?
What is topsoil?
The “stuff” on top?
“I can’t describe it, but I know it when I see it”
The *A horizon* in a soil profile
What is a soil profile?
Topsoil-subsoil characteristics

“Topsoil”
- high organic matter
- low salts
- high nutrients

“Subsoil”
- low organic matter
- high clay and/or lime
- high salts
- high pH
Natural forest soil profiles
Cache County forest soils

Litter layer - O horizon

A horizon ("topsoil")

B or E horizons
Forest vs. landscape soils
Forest Litter Layers and Mulches

Litter layers
- Insulate
- Nutrient source
- Reduce competition
- Water conservation
- Aeration
- Other?

• Mulches
- Insulate
- Nutrient source
- Reduce weeds
- Water conservation
- Aeration
- Other?
The main points:

Topsoil is available in limited supply

In most cases, subsoil is not a satisfactory replacement for true topsoil

Seek out true topsoils for landscapes
“An ounce of prevention is worth a pound of cure”
Topsoil quality guidelines

Key chemical and physical properties:
- soluble salts
- pH
- texture
- organic matter
- Sodium Adsorption Ratio (SAR)
Soil salinity
Soil salinity = soluble salts in soil

Salts inhibit plant growth
Salts cause “chemical drought” - equivalent to induced water stress
Visual diagnosis: salt crusting/salt burn
Soil salinity = soluble salts in soil

Soil test diagnosis:

- Electrical conductivity (EC) is the measure of soil salinity.
  - EC > 2 deciSiemens/meter is a saline soil for horticulture uses
  - EC > 4 deciSiemens/meter is saline for ag.
Sources of salts

Residual salts in new development areas

Irrigation waters
- natural sources?
- water softeners?

Deicing salts (road throw and sidewalk)

Over-application of fertilizers and/or manures and composts
Solutions to salt problems

Control the source
- History, water, fertilizer, manure runoff, other?

Select salt tolerant vegetation
- Salt prone areas
- Salt prone landscapes

Clean up the problem
- Remove salts by leaching with water
### Salinity and plant adaptation

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Leaching salts with water

Ensure that soil has good internal drainage. Water must move through the soil to carry salts out

- Add organic matter
- Deep tillage/ripping

Apply water over 1-2 days

- 6 inches of water to cut EC by 50%
- 12 inches of water to cut EC by 80%
- 24 inches of water to cut EC by 90%
Soluble salts

Electrical conductivity of the solution extracted from soil

Guidelines:
- Ideal: < 2 dS/m or mmho/cm
- Acceptable: < 4 dS/m or mmho/cm
- Unacceptable: > 4 dS/m or mmho/cm
Flower tolerance to soil salinity

Very few studies on tolerance to soil salinity. Most studies on tolerance to salinity on foliage (salt spray).

“Ideal: topsoils are okay for most flowers.”
Treatment of salinity problem

Select tolerant species and varieties
Increase drainage through soil
Leach soil with clean water to wash salts lower into profile, or out of profile
Soil pH
Soil pH

Soil pH: the degree of acidity or alkalinity of soil

The pH scale:

2  4  6  8  10  12

acidic ← Neutral (7.0) → alkaline
pH (alkalinity)

The degree of acidity or alkalinity (basic nature) of soil

Guidelines:

- Ideal: between 5.5 and 7.5
- Acceptable: between 5.0 and 8.2
- Unacceptable: below 5.0 or above 8.2
Acidic Loving Azaleas, Rhododendron, Magnolias
Alkaline Loving Alfalfa, Salt Cedar and Halogeton
Soil pH and nutrient availability

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</table>
Treatment of high pH problem

Select tolerant species and varieties
Try amending soil with acidic organic matter or elemental sulfur
Good luck
Jordan River Temple
Jordan River Temple
Changed pH from 8.2 to 7.5 in 25 years in the flower beds
Major pH problem: iron chlorosis
Soil texture
Soil texture

The percentage (by weight) of sand-, silt-, and clay-sized particles in soil

Guidelines:

– Acceptable percentages:
  • less than 30% clay, and
  • less than 70% sand, and
  • less than 70% silt
Soil texture classes

Class guidelines:

- Ideal: loam, silt loam
- Acceptable: sandy clay loam, sandy loam, clay loam and silty clay loam
- Unacceptable: clay, sandy clay, silty clay, silt, sand, loamy sand
Soil texture

The relative proportion (percent) of sand, silt and clay in soil

Refers to individual or primary soil particles left after structure is removed
The effect of particle size

Sand particles

Clay particles

Air flow
Determining soil texture

• By feel
• Soil test
• Using the jar method
  – Fill a 1 quart jar ¼ full of soil
  – Fill the jar up to ¾ full of water
  – Shake very well to suspend soil
  – Place on a flat surface and allow soil to settle
Qualitative indicators of topsoil quality

- Visual appearance
- Feel when wet and dry
Visual appearance

• **Do you see salt crystals on the surface?**
  – high salinity problem

• **Is soil white or light in color?**
  – low organic matter
  – high lime
  – high salt
Feel

• Wet:
  – sticky? too much clay
  – gritty? too much sand
  – generally, does it feel right?

• Dry:
  – too hard to crush? low organic matter or high clay
Treatment of texture problem

• Select species tolerant of:
  – drought if soil is coarse ("sandy")
  – poor drainage if soil is fine ("clayey" or "silty")

• Few treatments for wrong soil texture
  – add large quantities of organic matter
Organic Matter
Organic matter

- The percent organic matter in a soil (by weight)
- Guidelines:
  - Ideal: greater than or equal to 2%
  - Acceptable: greater than or equal to 0.5%
  - Unacceptable: less than 0.5%
The effect of organic matter

Silty clay texture class

0% organic matter  5% organic matter
Correcting low organic matter

• Add high quality organic matter
  – composts
  – sawdust
  – wood chips
  – bark
  – rice hulls
  – grain straw
Soil Depth
Oregon forest soil profiles
Soil Structure
Soil Structure is One of the Few Aspects of Your Soil Condition You Can Change
Soil structure

- The combination of sand, silt and clay (with organic matter) into secondary particles called aggregates
Structured or not?
Amending soils with organic matter

• Benefits
  – improves drainage of high clay soils
  – improves water-holding capacity of sandy soils
  – reduces compaction
  – provides nutrients to plants
  – improves soil “tilth” (ease of tillage, working with a soil)
  – lowers soil pH
How much should I add?

- How much is already there?
  - Native Utah soils ~ 0.25 to 2.0%
  - Ideal soils 5-10%
- Are you satisfied with the current condition of your soil?
- Don’t Learn to live with it!
- You must add organic matter to maintain soil conditions
Ways to add/preserve organic matter

- **Grow plants**
  - plants put organic matter back into soil in the form of roots and leaf litter
- **Mulch around perennials** - organisms will incorporate the organic matter for you
- **Add extra organic matter to flower gardens and other annual planting areas**
Sources of organic matter

- **Wood residues**
  - chips/sawdust/bark materials persist but need extra nitrogen to prevent tie-up (1 lb of nitrogen per 100 lbs of material)
Sources of organic matter

- Grass or leafy green residues
  – can’t go wrong with these
Sources of organic matter

- Composts and animal manure
  - good sources of organic matter and nutrients
  - watch for salts and weed seeds
  - Biosolids
Add Leaves
How much OM should I add

- **Single application**
  - 1 (one) inch per year for normal applications in annual areas
  - 2-3 inches of low salt material if you are in dire need of organic matter (a new site needs significant improvement)

- 1 inch of material = 3 cubic yards spread over a 1000 square foot area
Advanced techniques

- Double digging (increases depth of organic matter incorporation)
  - Excavate 6 inches of topsoil
  - Add organic matter to the depression
  - Incorporate organic matter in the depression
  - Replace the topsoil
  - Add organic matter to the replaced soil and incorporate
Soil Compaction Impacts on Flower Beds
Compaction Problems for Plants
Outline

• Causes of soil compaction
• The impact on landscapes
• The root of the problem
• Prevention
• Treatment
Causes of soil compaction
Causes of compaction

• Compression of soils by:
  – vehicle traffic
  – foot traffic
  – water (sprinklers)

• Passive vibrational forces (street, mass transit traffic, construction equipment)
The impact on flower beds
The impact on flower beds

• Vegetation declines
  – Visual impacts
  – Economic impacts

• Water runoff and erosion - urban nonpoint source pollution

• Common problem in every high use flower beds and most home landscapes
The root of the problem
The root of the problem

- Reduced aeration
  - plant smothered due to lack of oxygen in the root zone
- Reduced water-holding capacity of soils
  - water stress
- Physical impedance to root growth
The ideal soil (% by volume)

- Minerals: 45%
- Water: 25%
- Air: 25%
- Organic matter: 5%
- Pore space: 50%
The compacted soil

- 75% Minerals
- 10% Water
- 10% Air
- 5% Organic matter
- 20% pore space
How much is too much?

- Plant growth is severely restricted when air space <10% of total soil volume
  - highly compacted soil
  - over watered, moderately compacted soil
Prevention
Preventing compaction

• Restricting traffic
  – signs
  – fencing

  – landscape design opportunities
    • sidewalks
    • shrubs
    • walls
Preventing compaction

• **Treatments**
  – grates
  – Brick
  – Stay out of Beds
Preventing compaction

• Compaction-resistant soils
  – sandy materials - sandy loam/loamy sand textures, fine sands resist compaction
  – high organic matter induces the formation of soil structure
Treating compaction
Treating compaction

- Dynamite? - early 1940s technique
- Add organic matter
- Ripping - deep compaction
- Roto-tilling - shallow compaction
- Aeration/aerating - shallow compaction
  - hollow tine implements are best
Deep ripping or subsoiling

- Recommended for construction sites before establishing landscape
Mulching

• Surface mulch for trees and trails

• Vertical mulch for trees:
  – Vertical holes 3-4 inches in diameter
  – Backfill with coarse gravel or wood chips
  – Provides outlet for water flow from root zone; improves deep watering and aeration
Jetting

• Injecting water or air under high pressure to fracture soil
  – Hydrojet injects water
  – Terrajet injects air
• Mixed results with these units, but may be only option
Soil drainage
Poor drainage problem

- Consider installing a subsurface drainage system (tile drain)
Poor drainage problem

- Add organic matter
- Consider drainage ditches
- Compaction?
- Consider raised beds
- Precise water management
Poor Drainage = Dead Plants
Excessive drainage problem

- Very sandy soil
- Consider sunken beds
- Add extra organic matter
- Precise water management
The “Average” Utah Soil
Soil trends and variation in Utah
Let’s begin with a quote

• There is more soil variability along a mile transect in Utah than there is across the entire state of Iowa
  -(paraphrased) author unknown
Utah soils are variable

- Texture
- pH
- Salinity (soluble salt levels)
- Organic matter contents
- Nutrient levels
- Other – structure/compaction, foreign materials...
Why is there so much variability?

- **History, geology, and geomorphology**
  - Ancient Lake Bonneville
  - Complex geologic features (mountains, basins...)
- **Climate**
  - Arid climate = lack of vegetation (low organic matter levels) and low leaching (salt accumulations)
Ancient Lake Bonneville

- Existed 32,000 to 14,000 years ago
- Covered 20,000 square miles of Utah, NV, ID
Lake Bonneville influence

• Lacustrine (lake) sediments are typically fine textured soils high in silt and clay
• Fine-textured soils cover the majority of the areas covered by Lake Bonneville
Lake Bonneville influence

- Coarse-textured soils are found in stream/river outwash plains and at the foot of mountain slopes (bench areas) where coarse materials were deposited
Recall Lake Bonneville

Focus on Salt Lake County

USDA Soil Survey map
Salt Lake County Soil Survey

Salt Lake City

Poorly drained (fine-textured) soils

Well-drained (coarse-textured) soils
The influence of an arid climate

- Thousands of years of low rainfall means:
  - low native plant growth (low soil organic matter levels)
  - inadequate leaching of soluble salts (saline soils)
  - lime accumulation (calcareous soils)
  - alkaline (high pH soils)
  - sodic (sodium-dominated soils)
Summary: Utah soils today

• The product of a long history of soil genesis
• Complex landforms and geology = complex soil patterns
• Some soils still influenced by Great Salt Lake and other saline water sources (water tables, etc.)
• Difficult to generalize about Utah soils
Trends in Utah Soils
Utah State University data

- Analytical Laboratory data from 1999 (Dr. Jan Kotuby-Amacher)
- Taken from 1697 samples submitted to the lab
- “Frequency distribution” plots for texture, salinity, and pH (as examples) – parameters that are difficult to change
A frequency distribution

Number of samples

Sand  Loamy sand  Sandy loam  Loam  Silt loam  Clay loam  Silty clay loam  Silty clay  Clay
Soil texture

Excessive Drainage

Poor Drainage

Number of samples

Sand
Loamy sand
Sandy loam
Loam
Silt loam
Clay loam
Silty clay loam
Silty clay
Clay
Soil pH

Number of samples

- < 6
- 6 to 7
- 7 to 8
- 8 to 9
- > 9

Few problems Big problems

< 6 to 7 to 8 > 8 to 9
Soil pH refined

Number of samples

- 7.0 to 7.1
- 7.2 to 7.3
- 7.4 to 7.5
- 7.6 to 7.7
- 7.8 to 7.9
- 8.0 to 8.1
- 8.2 to 8.3
- 8.4 to 8.5
- 8.6 to 8.7
- 8.8 to 8.9
Soil salinity (ECe)

Salinity (ECe in dS/m)

No problem  Increasing problems

0 to 2  2 to 4  4 to 8  > 8

Number of samples
Other parameters

- Nutrients, organic matter, etc. are also variable
- However, these are easier to influence over shorter time scales (fertilizer and soil amendment additions can alter soil nutrient and organic matter levels in days)
The “average” Utah soil?

- Intermediate texture class (sandy loam, loam, or silt loam)
- Alkaline (pH = 7.8 to 8.0)
- Non-saline (EC < 2 dS/m)
A word about averages

• Averages are okay as long as you remember that the soil at any given location may differ from the average

• The range in soil properties may be more important than the average
  – The frequency distributions given earlier tell us Utah soils are highly variable
What do you do?

• Soil testing is essential if you know little or nothing about the properties of the soil on a site – it’s cheap information and insurance

• Rely on previous experience with a site

• Look up general properties in the USDA Soil Survey
The USDA Soil Surveys

- Available at:
  - local libraries
  - local county extension offices
  - local NRCS offices
Vitamins and Minerals for Plants
General classes of products

- Mineral supplements and fertilizers
- Biostimulators
- Vitamins
- Seaweed extract, yeast extract
First, the ‘hype’
Why does this deserve attention?

- Thousands of products are currently on the market, and more are appearing daily.
- Some products make wild claims.
- Some products are expensive.
- Some products have clever labels.
- Some products work and some don’t.
Thousands of products!!!

Maxicrop Seaweed Extract
- reduces stresses
- encourages strong plant development
- increases plant health, quality and productivity
Some of the wild(er) claims

- “...puts oxygen into soil.”
- “...can be used as a plant, livestock, or human mineral supplement.”
- “...increases overall plant size while reducing water and nutrient requirements.”
- “...replaces all other fertilizer needs.” (but only contains 3 essential nutrients)
Price

- Wide variation, from $10 per gallon to $750 per gallon.
Clever labels

- “...contains all 16 essential plant nutrients in a natural, organic form.”
- “...contains hormones that have been shown to promote root and shoot growth, and flowering.”
- “...contains trace amounts of ...”
- “...enhances plant growth...”
A clever label?

• Nature’s Wonder
• CV-DHMO

1. Contains large quantities of 2 essential elements required by plants, smaller quantities of the remaining 14 essential elements, and trace levels of other elements shown to be beneficial for some plants;
A clever label?

- Nature’s Wonder
- CV-DHMO
  - 2. Can be used as a solvent and carrier for other fertilizer salts, as well as vitamins and hormones;
  - 3. Is compatible with virtually all herbicides and insecticides;
A clever label?

- **Nature’s Wonder**
- **CV-DHMO**
  - 4. Relieves temperature stress;
  - 5. Stimulates plant growth;
  - 6. Colorless and odorless; no MSDS or special handling required.
A clever label?

- Nature’s Wonder
- CV-DHMO
  - Directions for use:
    - 1. Apply CV-DHMO in concentrated form at the rate of one gallon per plant. Reapply every 5 to 7 days.
A clever label?

- Nature’s Wonder
- CV-DHMO

- Supporting research:
  - Compared to controls (no CV-DHMO), Utah State University research trials have shown that CV-DHMO may increase plant growth 200% or more.

- Warning: Do not exceed the recommended dosage.
A clever label?

Nature’s Wonder

CV-DHMO

= Cache Valley Dihydrogen Monoxide

= Cache Valley Water
Now, the research
Scientific evidence to support product claims?

• Limitations:
  – Each product is a little/lot different.
  – Products do not list specific ingredients.
  – Products have ingredients with unknown properties or effects.
  – Products have beneficial ingredients at very low concentrations.
Minerals and fertilizers

- Demonstrated, recognized beneficial effects of 13 essential elements supplied by mineral supplements and fertilizers:
  - Nitrogen
  - Phosphorus
  - Potassium
  - Calcium
  - Magnesium
  - Sulfur
  - Iron
  - Zinc
  - Copper
  - Manganese
  - Chlorine
  - Molybdenum
  - Boron
Ib. Minerals and Fertilizers

- Contains 11 essential elements (-Ca, Mg).
Ic. Other mineral sources

• **Organic products:**
  – generally contain a broad spectrum of essential elements, but at a high cost per pound;
  – proven beneficial if applied at realistic rates.
Ic. Other mineral sources

- **Ground rock products:**
  - contain some essential elements but little or no nitrogen;
  - limited research supports benefits.
- **Seaweed extracts:**
  - Contain some essential elements, some excess sodium
Id. Minerals and fertilizers

• Considerations
  – What is needed - soil test? historic needs?
  – What is in the product?
  – Are the elements in an available form?
  – What does the product cost?
IIa. “Biostimulators”

- Mainly products containing natural and artificial hormones (growth regulators):
  - Auxins (cell elongation and root initiation)
    - indoleacetic acid (IAA)
    - indolebutyric acid (IBA)
    - naphthaleneacetic acid (NAA)
IIa. “Biostimulators”

- Mainly products containing natural and artificial hormones (growth regulators):
  - Cytokinins (elongation and bud growth)
  - Giberellins (cell division and organ formation)
IIb. “Biostimulators”

- **Hormones**
  - Substantial research supports the effects of hormones on plants.
  - Hormones are effective at micromolar concentrations.
  - Overapplication or hormones will often have opposite effect - stunting, defoliation, premature fruit drop.
### IIc. “Biostimulators”
**Research - mixed results:**

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<td>Agron. J. 82; 901-</td>
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<td>Hortsci. 26:254-</td>
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<td>Carl Whitcomb</td>
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<td>no shoot; +root</td>
<td>K. Karnok, GA</td>
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IIId. “Biostimulators”

• Why the inconsistent results?
  – Carl Whitcomb:
    • 1. Hormone concentrations in many products are too low to be effective.
    • 2. Hormones applied to soil are consumed by microorganisms.
  – Keith Karnok:
    • 1. Under normal growth conditions, turf produces adequate levels of hormones.
    • 2. Hormones work under stress conditions.
IIIa. Vitamins

- **Select functions in plants:**
  - B₁ (thiamine) - Kreb’s cycle (metabolism)
  - B₆ - (pyridoxine) - metabolism
  - Vitamin D - IAA-like, root initiation

- **Manufactured within the plant.**

- **Standard component in tissue culture media.**
IIIb. Vitamins

- Research?
  - Research shows that vitamins (B and D) are absorbed in limited quantities by plants growing in solution culture.
  - Little or no research on the growth effects of added vitamins on plants.
  - Salisbury and Ross, Plant Physiology:
  - No evidence to support claims that exogenous supplies of various B vitamins promote plant growth or root formation.
IIIc. Vitamins

- Why the inconsistent results?
  - When applied to soil, vitamins may be used or consumed by microorganisms.

= FOOD!

![Pyridoxine](image)
IVa. Other products

- **Yeast extracts** - a source of B vitamins.
- **Seaweed extracts** - a source of minerals and cytokinins.
  - + responses in turf and forage grasses.
  - - response in tomato (salinity issue?).
  - no response in barley.
Summary

- **Minerals and fertilizers** - considerable research support.
- **Biostimulants** - some research support.
- **Vitamins** - little research support.
Recommendations

• Avoid products that make claims beyond common sense.
• Read the label - what’s really in there?
• Stick with proven products.
• Test materials on small areas yourself.
• Don’t rely on testimonials; request university research trial results.
Questions?