**H1325** (Revised June 2021)

# *Evaluating, Preparing and Amending* Lawn and Garden Soil

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**One of the biggest steps to establishing and growing turf, vegetables, ornamentals or flowers successfully is understanding the soil that provides their physical support and supplies them with water and nutrients.**

Sometimes, the original soil will serve as an excellent growth medium, while other soils may need to be amended or even replaced with more adequate topsoil. This publication will help serve as a guide to evaluating soils and suggest amendments that will improve the success of lawn and garden plantings.

Soil evaluation should be conducted physically and chemically. Physical characteristics affect the ability of roots to explore the soil for water and nutrients, and the capacity of the soil to hold water as a reserve for plants between rains or irrigation. They also affect how easily water moves through the soil, preventing ponding.

While not a physical characteristic, the topography of the soil surface also will be an influence on water movement into the soil.

## Physical Characteristic Terminology

**Aeration** – the process of using equipment to extract soil cores or to pierce the soil to allow more oxygen to enter the soil and carbon dioxide to exit, thereby enhancing root health

**Bulk density** – the weight of dry soil per unit of volume. Well-aerated soil has a relatively low bulk density; compacted soil has a high bulk density.

**Permeability** – the ability to allow water to move freely through soil

**Porosity** – the percent of soil volume devoted to pore space. Compacted soils have lower pore space and higher bulk density.

**Texture** – the percent of sand, silt and clay that makes up the mineral portion of soil. Texture can be estimated by feeling for sand grains between your fingers and by the ability to produce a clay ribbon between your thumb and index finger **(Figure 1, Page 2)**. If necessary, texture can be measured accurately with a soil evaluation.

**Fine textures** – soil with more clay than sand or silt

**Medium textures** – soil with no dominance of sand, silt or clay

**Coarse textures** – soil with more sand than silt or clay

**Water-holding capacity** – the amount of water a soil can hold. Soil can hold two types: water that is loosely held and available to plants and water that is tightly held by soil particles and is unavailable for plant use. A silt loam has the most plant-available water but clay soil holds the most total water. Medium-textured soil holds more plant-available water than coarse-textured soil.

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**Figure 1.**

**Determining clay content in soil via the ribbon test. The ribbon length indicates the soil is fine-textured.**

Photo by Esther McGinnis

Soils in nature develop in layers, called horizons **(Figure 2)**. The sum of horizons from top to bottom is called the soil profile.

**Figure 2.**

**A slice of soil showing the various layers or horizons that have been formed through time.**

The uppermost layer of soil in most of North Dakota developed under prairie grasses and forbs, and tends to be dark colored due to the resulting organic matter accumulation. This layer is the most productive in the soil.

The organic matter and biological activity in the zone help soil particles clump together into aggregates.

These aggregates tend to resist compaction and contribute greatly to permeability, favorable bulk density and porosity. The surface layer, rich in organic matter, also is a storehouse of slow-release nutrients that are helpful for plant growth.

The underlying layers are not as productive as the surface layer due to lower organic matter content. Sometimes the subsurface layers have been altered with an accumulation of soluble salts and carbonates.

These accumulations generally are not desirable and may limit the cultivation of some types of plants.

With ornamentals, having a subsoil chemical analysis before selecting adapted species for planting is particularly important. Subsoils cannot be improved easily.

# Soil Evaluation

Soil evaluation should begin with physical observations. Physical problems or limitations are most difficult to remedy, so knowing if the soil has any restrictions on use is important to determine.

# Aeration

## Evidence

Look for an abundance of fine, white roots under previous plant growth. Well-aggregated soils with bright yellow subsoil are indicators of well-aerated subsoils. Poorly aerated soils may have a musty smell from fungal growth or be dark, drab gray or olive.

## Remedies

In general, poor aeration is caused by high clay content, compaction and/or natural depressional landscape positions. Take care to not overwater. Choose a better landscape position for garden plants or consider a raised bed.

### Lawns

Mechanical core aerators can be used to alleviate compaction. Natural shrinking and swelling of clay will fill in the cavities made by the coring machine, forming smaller aggregates.

### Gardens

Do not amend clay soils with sand. The addition of sand to a predominantly clay soil will create a soil structure similar to cement. Organic matter such as compost, peat moss or composted manure are better amendments. The organic matter serves to separate the soil particles and the biological activity it promotes results in better aggregation of soil particles and separation of clays, making them more resistant to compaction.

# Chemical Evaluation

A soil test is the best way to evaluate nutrient needs in plants, regardless of whether you plan to use an organic or chemical approach to nutrition. Home test kits provide general guidelines.

North Dakota recommendations are based on locally calibrated laboratory tests to get more reliable and repeatable results. Sending a soil sample to local labs across the state or to NDSU's soil testing lab on campus in Fargo will assure more accurate results with more reliable recommendations.

Collect soil samples from three to six spots in the area to be tested. The depth of each sample for lawns and vegetable gardens should be 6 inches and can be collected using a trowel, shovel or soil probe. If sampling for the purpose of planting a tree or shrub, collect to a depth of 12 inches. When coring below 6 inches, call the One-Call 800 number in your area to avoid contacting or cutting utility cables. If these obstacles are in the intended garden area, consider another site for the garden.

Do not include organic matter such as turf, the thatch layer or leaves with the soil sample. Break up clumps and mix the three to six samples using a clean bucket and send in 1 pint of soil following the lab's instructions for submitting samples.

Soil testing bags for the NDSU soil testing lab are available from your local Extension agent. Alternatively, a quart sandwich bag can be used.

A separate set of samples should be collected for each location to be tested: backyard, front yard, vegetable garden, etc. **For more detailed instructions, consult NDSU Extension's video titled "How to Take a Soil Sample in Your Garden"** *(https://tinyurl.com/vxvb9j62)*.

## Lawns

Request a standard turfgrass test, which includes pH, soluble salts (EC), nitrogen (N), phosphorus (P), potassium (K) and organic matter content. While these three nutrients (N, P and K) are considered primary for good turfgrass growth, they are only three of the 13 mineral elements found in the soil that are necessary for plant growth.

Nitrogen is the key element in turfgrass growth, and the level of soil nitrogen can vary depending on the quality of the turf desired.

Minimally maintained lawns should receive a single application of fertilizer in the fall at a rate of 0.75 to 1 pound of actual N per 1,000 square feet; high-quality lawns should receive two to three applications of fertilizer, including applications in mid-May, early July and September.

The form nitrogen comes in is important; WSN (water-soluble nitrogen) quickly stimulates grass growth, causes increased mowing frequency and is short-lived.

When selecting fertilizer, look for at least one-third of the nitrogen source to come from WIN (water-insoluble nitrogen) sources for longer-lasting effect and not as high a mowing frequency.

The other two elements on the fertilizer bag, phosphorus and potassium, usually are not an issue in most home lawn situations. If a soil test indicates a serious deficiency of these two elements, recommendations will include specific formulations.

Existing lawns seldom will be deficient in P or K if the homeowner follows any kind of fertilization program and returns the grass clippings to the lawn most of the time. For new lawns, incorporating any needed P or K into the topsoil following lab recommendations is advisable before seeding or installing sod.

# How to Read a Fertilizer Bag

All fertilizers registered for sale are required to be analyzed for their plant nutrient content and display the results on the bag: for example, 30-5-10. In this instance, the numbers refer to the amount of nitrogen, phosphorus pentoxide and potassium oxide, but simply are expressed as N, P and K.

A 35-pound bag of fertilizer with this analysis would have 30% N (10.5 pounds of N), and 5% and 10% of the other two materials, respectively. Often the single element of nitrogen is sold as Ureaform, with an analysis of 46% nitrogen, and would show up on the bag as 46-0-0.

In North Dakota, the soil often is quite alkaline (high pH), resulting in the tie-up of a particular element, iron (Fe). When the usual fertilization practices don't green up the lawn to full potential, the problem may be an iron deficiency, characterized by a yellowing (chlorosis) of the turf.

In that case, look for a fourth number on the bag following potassium to indicate iron content, generally 3% to 5%, and usually combined with sulfur (S) as iron sulfate.

Although Earth has more than 100 elements, only 14 mineral nutrients are required universally for plants to grow and produce fruit or seed. They are listed below with their chemical symbols:

nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), manganese (Mn), boron (B), molybdenum (Mo), iron (Fe), chloride (Cl), nickel (Ni).

# Organic Gardens

A soil sample should be used to guide amendments. Generally, organic gardening practices with the heavy use of plant and animal waste from composting are not in need of any drastic additions. The soil nutrient levels are usually in good balance for optimal plant growth.

Crop rotation and cover crops are common practices with organic gardeners. As the growing season comes to an end, sow an oat or cereal rye crop when the seasonal vegetables have been removed to help build the soil and mitigate the common home gardener habit of planting the same vegetables in the same spot each year.

# Compaction

Compaction reduces soil porosity, which means air and water have more trouble penetrating and moving through the soil. Air movement and root penetration are restricted in compacted soils. Roots move readily in larger pores but may not have enough strength to part soil particles between smaller pores.

## Evidence

Water runs off rather than moving into the soil. Water may pond rather than infiltrate into the soil.
Roots tend to be restricted to the top few inches. In lawns, rooting is mostly in the top couple of inches. Roots may grow sideways rather than down.

## Remedies

### Lawns

Mechanical core aerators result in better aggregation and aeration. Limit traffic when soil is wet.

### Gardens

Add 3 inches of peat moss or compost and till into the soil. Avoid overtilling the soil in the future. Alternatively, a cover crop can be grown and tilled into the soil.

# High Soil Sodium

Spots in the yard or garden where water ponds may indicate areas of sodium accumulation. Soils dry hard and, when watered, water tends to pond very quickly. Sodium prevents soil particles from aggregating, instead forming large monoliths with soil particles so tightly bound that roots can explore only the surface. Plants growing in these areas require frequent watering and grow poorly, if at all.

## Evidence

You'll see areas of poor plant growth, ponding and soils that are hard to till. Often the surface of the soil has a white crust, and a soil test of the top 6 inches shows high levels of sodium present.

## Remedies

Better drainage is required for any amendment to be effective. A soil test can provide an SAR, or sodium absorption ratio, showing the relative balance of sodium to the desirable cations of calcium and magnesium.

The higher the SAR reading, the greater amount of soluble calcium amendments you'll need to replace sodium on soil clays and flush them away with rainfall or high-quality (low-sodium) irrigation water. Amounts required may range from 20 to 200 pounds per 1,000 square feet of gypsum. The amendments will need to be tilled in to the depth of the sodium problem.

Several rooting depths of water may be required to leach out the sodium. If the soil has limited drainage and the irrigation water is high in sodium salt, the probability of positive results using this technique is slim.

Growing grasses that are tolerant to drought, considering moving the garden or building raised beds that have better drainage and contain soil that is not degraded by excess sodium would be better.

# Layering

Plants develop better in deep, homogenous soil layers that are similar in texture. A few inches of good topsoil over some not-so-good soil will result in plant roots growing mostly in just the good soil. This restricts the amount of soil used for water and nutrient uptake, which will require more frequent watering and fertilization.

## Evaluation

Soil core samples indicate soil textural changes in the common rooting zone. The rooting zone for lawns is about 6 inches. Most garden plants need about 18 inches.

## Remedies

### Lawns

Before seeding, make sure that the topsoil is at least 6 inches deep; deeper is better. If you have an existing lawn with layers, periodic core aeration may homogenize the layers.

### Gardens

Amendments need to be incorporated into the soil and not just the surface.

Raised beds need to be as uniform as possible to the entire depth. If raised beds are shallower than 18 inches, incorporating the original soil – if not contaminated with salts or undesirable materials – into the added soil material for raising will increase effective rooting.

# Salts

Salty soils are a natural, but undesirable, result of relatively young soils. They are high in nutrient content, have poor drainage and are often in a semiarid climate **(Figure 3)**. Some plants have a higher salt tolerance than others. Most garden plants and many desirable lawn grasses have a low tolerance for salt.

When the water table is high (the water table is a fluctuating zone under the soil where the soil is saturated

**Figure 3. Salt-affected soil.**

**In a soil such as this, growth of most horticultural plants would be very poor, if at all.**

(Photo courtesy of Naeem Kalwar, Langdon Research Extension Center)

with groundwater for a long period of time), salts are brought to the surface by capillary action. The water is pulled toward the soil surface and evaporates, leaving the salts behind.

During times of continuous dry weather, any rainfall received tends to drive the salts deeper. In wetter periods, salty areas expand as water tables move closer to the soil surface.

## Evaluation

A sign of salty soils is white, chalky material at the soil surface. Plants growing in or near these areas may be stunted or dull, have scorched-looking leaves or leaf margins and require more frequent watering. Soil tests indicate EC (electrical conductivity) is greater than 0.5 millimho per centimeter (or decisiemen/meter).

## Remedies

No amendment that "neutralizes" salty soil is available. Salts are present due to poor drainage and high water tables. Adding any amendment usually increases salt levels.

Test irrigation water for salts. If salt levels are high for your soil, a leaching irrigation after the season (for example, turfgrass, 6 inches; vegetables and flowers, 12 to 18 inches; trees and shrubs, 18 to 24 inches) might be needed to sustain productivity.

### Lawns

If tiling is an option, you might consider it, especially in golf courses and natural athletic fields. Having an adequate outlet is often a problem and is a reason tiling is not used more often.

Before tiling, make sure that sodium will not be a problem if the salts are drained out of the soil. Usually salts only affect a certain area of a lawn. These areas might be better off seeded to a salt-tolerant grass (NDSU Extension publication H1824, "Interpreting the NDSU Soil Test Analysis for Managing Turfgrass").

### Gardens

Consider moving the garden to a less salty spot if possible. If this is undesirable, consider a substantially raised bed at least 18 inches or taller. Fill the bed with new, low-salt soil and avoid incorporating the original soil into the bed.

# Soil Cracking

Soil cracking is common in dry soils with high clay content. These cracks accelerate the drying of subsoil and limit soil water-holding capacity during hot summer months.

## Remedies

### Lawns

Use more frequent but less intense waterings; maintain good grass coverage.

### Gardens

Add organic amendments, especially unmilled peat moss, to improve aggregation. Do not overwater, but do not allow the soil to become overly dry.

# Soil Crusting

Crusts may form following a hard rain or intensive irrigation on bare soil. Crusts are most harmful when establishing a lawn from seed or when a small-seeded crop, such as lettuce or carrots, has just been seeded into the garden.

## Evidence

You can observe a hard surface layer after a heavy rainfall or when the soil dries.

## Remedies

### Lawns

Use a mulch to slow soil drying. Irrigate with smaller, less intense droplets. Gypsum may help reduce crusting in some soils.

### Gardens

If you noticed soil cracking in previous gardening years, amend soil with unmilled peat moss. A gypsum application may be helpful in some soils. Apply gypsum at rates of about 45 to 90 pounds per 1,000 square feet. Applications are recommended in the fall after crop removal to allow the chemical reactions to begin taking place. Gypsum generally is not as beneficial as organic amendments.

## Soil Temperature

Around a home, soil temperatures can vary as much as 10 degrees at any given time. The north side of a house shades the soil for as much as two spring months more than the south side.

A thermometer can guide a gardener toward plants more adapted to cooler or warmer soil environments.

If the daytime temperature is too hot for some plants, mulching the soil after emergence or planting will help reduce soil temperature fluctuations and produce a cooler soil on average.

If soils are too cool, warming them is difficult. However, you can select plants that tolerate or require cooler temperatures and shade to thrive.

## Texture

Take a small amount of soil in your palm and wet it slightly. Roll it into a small ball in your palm. Next, try to make a flat ribbon between your thumb and your first two fingers **(Figure 1)**. Push the soil into your fingers with your thumb.

If you can make something that looks like a ribbon about one-quarter inch thick, the soil is at least medium-textured and may be fine-textured. If the ribbon breaks off readily before it reaches ¾ inch in length, the soil is medium-textured.

If you can make a ribbon longer than that, the soil is fine-textured. If the soil doesn't make a good ribbon and you can feel the sand grains easily, it is coarse-textured.

## Thatch

Thatch is a surface layer of undecomposed organic material in established lawns that can be good for the turfgrass if it is ½ inch or less in thickness. If it is more than ½ inch thick, it becomes restrictive to water, air and nutrient movement into the root zone.

Excess thatch can develop hydrophobic properties that repel water. It also can harbor insects and diseases, and because of the restrictions of air and water movement, it limits rooting.

### Evaluation

You'll notice excessive cushioning when walking on the turf. Sod appears loose due to a lack of rooting. The response to fertilizer, water and pesticide applications is poor.

Using a knife or soil probe, cut into the sod and measure thickness; any thatch that is deeper than ½ inch will cause problems.

### Remedies

Thatch can be controlled through regular core aeration; power-raking; adjusting cultural practices, including fertilization, mowing and pesticide use; and selecting nonaggressive turf cultivars. It is not caused by clippings being returned to the surface when mowing.

## Undesirable Minerals

In certain parts of North Dakota, primarily along the northern tier of counties, the shale bedrock that underlies most of the state is fairly close to the surface. In these areas, glaciation mixed the shale more abundantly in the soil. These shales often contain relatively high levels of cadmium, selenium and arsenic.

If in the course of tillage, small pieces of gray, flat rock (shale) are evident in the soil, the chances are greater than normal that higher levels of these undesirable minerals will find their way into leafy green garden plants.

These elements tend to accumulate in green, leafy vegetables, particularly broccoli, cauliflower, Brussels sprouts, kale and Swiss chard. They are much less concentrated in grain and fruit crops such as sweet corn and tomatoes.

If you are in a region prone to high levels of undesirable minerals, growing leafy crops in raised beds with imported soil would reduce exposure to these minerals.

## Water-holding Capacity

The water-holding capacity is the amount of plant-available water possible if the soil is wetted to a point called field capacity – approximately one-third of atmosphere suction. This is almost totally dependent on soil texture, but the amount of aggregation and organic matter extends a soil's capacity, while sodium decreases it.

- **Coarse-textured soils –** *1 inch per foot in depth*
- **Medium-textured soils –** *about 1½ to 2 inches per foot in depth*
- **Fine-textured soils –** *2½ inches per foot in depth*

## Checklist for Soil Evaluation – Garden Soil

Site location _____

Date _____ Plant species _____

| | | |
|---|---|---|
| **Texture** | | **Water-holding capacity** |
| Coarse | ☐ | 1 inch/foot |
| Medium | ☐ | 2 inches/foot |
| Fine | ☐ | 2½ inches/foot |
| **Aeration** | | **Remedy** |
| Excellent | ☐ | None |
| Good | ☐ | Add organic matter |
| Poor | ☐ | Add organic matter |
| **Compaction** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Add organic matter; plant cover crop |
| **Soil cracking** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Avoid deep soil drying |
| **Crusting** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Add organic matter, low-intensity irrigation |
| **Layering** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Thorough mixing of soil |
| **Salts** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Improve drainage, raised bed, move garden |
| **Sodium** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Improve drainage, apply gypsum if drainage and deep tillage is possible. Move garden; investigate water source |
| **Undesirable minerals** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Raised bed, bring in alternative soil, avoid leafy and Cole family plants |
| **Soil test evaluation** | | **Remedy** |
| Needs N | ☐ | Follow soil testing lab recommendations |
| Needs P | ☐ | Follow soil testing lab recommendations |
| Needs K | ☐ | Follow soil testing lab recommendations |
| Acid pH | ☐ | Apply lime to achieve desired pH – about 6 pounds/400 SF |
| pH > 7 | ☐ | Plant adapted species, incorporate sphagnum peat |
| Organic matter <3% | ☐ | Add compost and/or peat moss and mix thoroughly |
| Soil EC > 0.5 | ☐ | Improve drainage; build raised beds; plant salt-tolerant plants or move garden to lower-salt area |

## Checklist for Soil Evaluation – Lawns

Site location _____

Date _____ Turfgrass species _____

| | | |
|---|---|---|
| **Texture** | | **Water-holding Capacity** |
| Coarse | ☐ | 1 inch/foot |
| Medium | ☐ | 2 inches/foot |
| Fine | ☐ | 2½ inches/foot |
| **Aeration** | | **Remedy** |
| Excellent | ☐ | None |
| Good | ☐ | None |
| Poor | ☐ | Mechanical core aeration |
| **Compaction** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Mechanical core aeration |
| **Soil cracking** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | More frequent but lower irrigation rates |
| **Crusting** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Mulch new seedlings (straw, virgin wood fibers) |
| **Layering** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Start lawn with at least 6 inches of good topsoil; annual core aeration may be used for existing lawns |
| **Salts** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Improve drainage, seed tolerant grass species |
| **Sodium** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Improve drainage; apply gypsum if drainage and deep tillage is possible; seed drought-tolerant grasses; investigate or seek new water source |
| **Thatch** | | **Remedy** |
| No | ☐ | None |
| Yes | ☐ | Power raking, core aeration; adjust cultural practices |
| **Soil test evaluation** | | **Remedy** |
| Needs N | ☐ | For normal lawns, clippings returned to turfgrass – 1 pound N/1,000 square feet – September<br>Exceptional lawns, clippings removed – 2 to 3 pounds total per season, distributed mid-May, early July and mid-September |
| Needs P | ☐ | 4 to 5 pounds $P_2O_5$ per 1,000 square feet<br>Do not exceed N recommendations |
| Needs K | ☐ | 4 to 5 pounds $K_2O$ per 1,000 square feet<br>Do not exceed N recommendations |
| pH > 7 | ☐ | Plant adapted species |
| Soil EC > 0.5 | ☐ | Improve drainage; plant adapted cultivars |

## Consult the NDSU Soil Testing Lab's website for more information on taking and submitting a soil sample for testing:

*www.ndsu.edu/snrs/services/soil_testing_lab/*

## For more information on understanding soil issues that affect turfgrass:

Zuk, A. and E. McGinnis. 2017. Interpreting the NDSU Soil Test Analysis for Managing Turfgrass. NDSU Extension publication H1824.

*www.ag.ndsu.edu/publications/lawns-gardens-trees/interpreting-the-ndsu-soil-test-analysis-for-managing-turfgrass*

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1.5M-3-07; 1M-4-09; 500-7-11; 1M-3-13; 500-3-14; 200-3-16; web-1-19; web-5-21