

# Soil Health for Optimum Plant Growth



**Extension**

Sullivan County Office  
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## Soil Health for Optimum Plant Growth

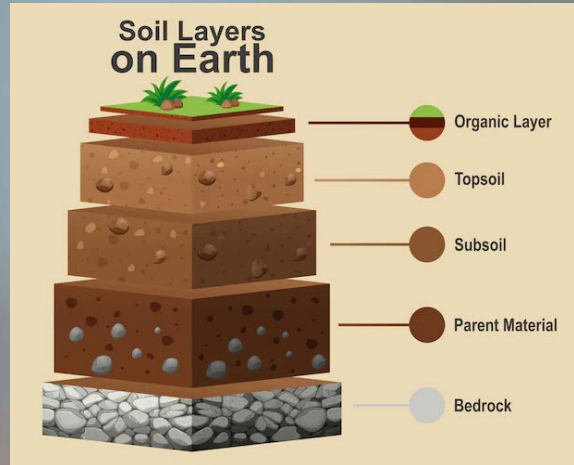
Soils perform many functions that are important to all of us:

- Filters and cleans our water
- Acts as a medium for plant growth and habitat for organisms
- Stores water and regulates water flow
- Recycles nutrients and organic materials
- Helps to regulate the Earth's climate
- Is an engineering/structural medium



Most of us don't think about soil on a daily basis but soil performs many functions that are important to all of us and we are really connected to the soil in many ways.

## Soil Layers



Soil exists in layers on the earth as shown here. **Organic layer:** dead plants and animal material; **Topsoil:** rich in humus (decomposed organic matter), soft and porous, microorganisms; **Subsoil:** less porous, deeper, minerals; **Parent material:** weathered broken rock, layers above come from here; **Bedrock:** unweathered parent rock.

## Soil Texture



- Soil texture is determined by the relative amounts of sand, silt and clay particles.
- Texture determines, in large part, how the soil feels and behaves.

Soil texture is determined by the relative amounts of sand, silt and clay. It's determined by the parent material (rocks from which the soil formed). Climate and slope also impact texture. Sand particles are the largest. Silt particles are next in size, followed by clay particles that are 1,000 times smaller than sand particles. The texture of the soil determines how the soil behaves. If your soil is heavy in sand, making it quite porous, or heavy in clay, making it wet then you may need to augment your soil to try to get it to a better ratio of sand, silt and clay, for best plant growth.

If you're a hands-on gardener, you can use the "feel method" to determine your soil texture. Just grab a small amount of moistened soil and rub it between your fingers. If it feels gritty, you've got sandy soil; if it's smooth, it's silty; and if it's sticky, it's clayey.

## Soil Texture

**Loam** describes the ideal soil composition for most garden plants.



Loam describes the ideal soil composition for most garden plants—the ideal combination of sand, silt and clay (about 40% sand, 40% silt and 20% clay). Adding organic material attracts beneficial organisms that makes the loam even higher quality. Loam holds nutrients and has a texture that retains water long enough for plant roots to access it, yet it drains well.

## Soil Texture

### Organic matter:

- Soil organic matter is the fraction of the soil that consists of plant or animal tissue in various stages of decomposition.
- Sources of organic materials include:
  - Crop residues
  - Animal manure
  - Compost
  - Cover crops
  - Perennial grasses and legumes



Soil organic matter is the portion of the soil that consists of plant or animal tissue in various stages of decomposition.

Most of our productive agricultural soils have between 3 and 6% organic matter. Over time, the application and incorporation of organic materials can result in an increase in soil organic matter levels.

## Benefits of Organic Matter



Soil properties change with increased organic matter:

- Surface structure becomes more stable and less prone to crusting and erosion.
- Water infiltration increases and runoff decreases.
- Soil organic matter holds 10 to 1,000 times more water and nutrients than the same amount of soil minerals.
- Beneficial soil organisms become more numerous and active with higher organic matter levels.
- Improved air quality, water quality, and agricultural productivity

The benefits of organic matter are many. Soil properties can be changed with the addition of organic materials.

## Soil Series

Soils are classified into categories, or series, based on certain characteristics, such as texture, grain size, etc. The main purpose of soil classification is to provide a common basis for the exchange of knowledge and experience regarding soil.

**Agricultural Evaluation Worksheet**  
Sullivan County, New Hampshire

Date of Download: 12/24/2000

| Map Unit Symbol | Map Unit Name                                       | Parent Soil Class                | Map Unit Acres | Parent Soil Acres | Parent Soil Acres % |
|-----------------|---|----------------------------------|----------------|-------------------|---------------------|
| Agt1            | AGAWAM VERY FINE SANDY LOAM, 6 TO 8 PERCENT SLOPES  | All areas are prime farmland     | 100            | 610               | 0.16                |
| Ha              | HADLEY SILT LOAM, FREQUENTLY FLOODED                | All areas are prime farmland     | 100            | 175               | 0.23                |
| Hb              | HADLEY SILT LOAM, OCCASIONALLY FLOODED              | All areas are prime farmland     | 100            | 112               | 0.26                |
| Hc1             | HADLEY VERY FINE SANDY LOAM, 0 TO 3 PERCENT SLOPES  | All areas are prime farmland     | 100            | 589               | 22.22               |
| Of              | OSWEGO FINE SANDY LOAM                              | All areas are prime farmland     | 100            | 736               | 89.63               |
| Agt2            | AGAWAM VERY FINE SANDY LOAM, 3 TO 8 PERCENT SLOPES  | All areas are prime farmland     | 87.5           | 730               | 17.63               |
| Hd1             | HADLEY VERY FINE SANDY LOAM, 3 TO 8 PERCENT SLOPES  | Farmland of statewide importance | 87.5           | 1,540             | 23.05               |
| UW1             | UNIONVILLE VARIANT SILT LOAM, 3 TO 8 PERCENT SLOPES | Farmland of statewide importance | 87.5           | 620               | 69.43               |
| Hd2             | HEMLOCKTON SILT LOAM, 3 TO 8 PERCENT SLOPES         | All areas are prime farmland     | 85             | 1,995             | 79.05               |
| OH              | OTTOPESS SILT LOAM, 3 TO 8 PERCENT SLOPES           | All areas are prime farmland     | 82             | 470               | 24.25               |
| Md              | MARION LOAM, 3 TO 8 PERCENT SLOPES                  | All areas are prime farmland     | 80.5           | 4,500             | 130.75              |
| Md1             | MONMOUTH FINE SANDY LOAM, 3 TO 8 PERCENT SLOPES     | All areas are prime farmland     | 80.5           | 1,245             | 14.62               |
| NW              | NORWICH FINE SANDY LOAM, 0 TO 3 PERCENT SLOPES      | All areas are prime farmland     | 80             | 465               | 148.80              |
| Sd1             | SIOUX SILT LOAM, 3 TO 8 PERCENT SLOPES              | All areas are prime farmland     | 80             | 400               | 102.85              |
| Sd2             | SIOUX SILT LOAM, 3 TO 8 PERCENT SLOPES              | Farmland of statewide importance | 80.5           | 385               | 126.70              |
| Wb              | WINDSOR SILT LOAM                                   | All areas are prime farmland     | 80             | 300               | 189.70              |
| Pw              | POULING FINE SANDY LOAM                             | Farmland of statewide importance | 81.5           | 1,830             | 129.65              |
| Rb              | REUBEN LOAM   | Farmland of local importance     | 81             | 2,050             | 205.40              |
| Sd2c            | SHERBROOKTON SILT LOAM, 8 TO 15 PERCENT SLOPES      | Farmland of statewide importance | 77             | 2,280             | 232.35              |
| Sum             | SULLIVAN COUNTY TOTAL                               |                                  | 84             | 2420              | 100.00              |

Soils have been surveyed, described, named and mapped all across the country by the Natural Resources Conservation Service, a branch of USDA. Here you can see an example of soil information just for Sullivan County, NH. There are many more soils than this, but this little section just gives you a sense of the different names, how they are described and prime use. I just want you to be aware that this system exists. This is how soil scientists refer to soils all across the country.

SPI is a calculation that results in a rating from 0-100 of soil's capability to produce crops.



## Soil Data

USDA NRCS Web Soil Survey  
Web Soil Survey - Home ([usda.gov](https://websoilsurvey.sc.egov.usda.gov/))

The screenshot displays the USDA NRCS Web Soil Survey interface. The left sidebar contains several sections: 'Area of Interest' with options to import from Shapefile or Zipped Shapefile; 'Quick Navigation' with fields for address, state, and county; and 'Soil Survey Area' with dropdowns for state (New Hampshire) and county (Sullivan). Below these is a table of soil survey data.

| Name                           | Area                                | Data   | Version |
|--------------------------------|-------------------------------------|--|---------|
| Sullivan County, New Hampshire | NHD19 Tabular and Spatial, complete | Survey Area: Version 29, Aug 22, 2023<br>Tabular: Version 27, Aug 22, 2023<br>Spatial: Version 6, Sep 15, 2019 |         |

The main map area shows a satellite view of Sullivan County, New Hampshire, with a red boundary highlighting a specific area of interest. The map includes a scale bar and a 'View Extent' dropdown set to 'Contiguous U.S.'.

If you are interested in learning more about soils in your area, the Natural Resources Conservation Services of the US Dept. of Ag (NRCS) offers a website that allows you to put in your own location and identifies the soils.

## Soil Fertility



All crops require a well-balanced supply of the major plant nutrients: nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), and calcium (Ca).

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A "complete" fertilizer, whether from organic or inorganic sources, contains various amounts of the first three elements, nitrogen, phosphorus, and potassium. The elemental symbols for these nutrients are N, P, K.

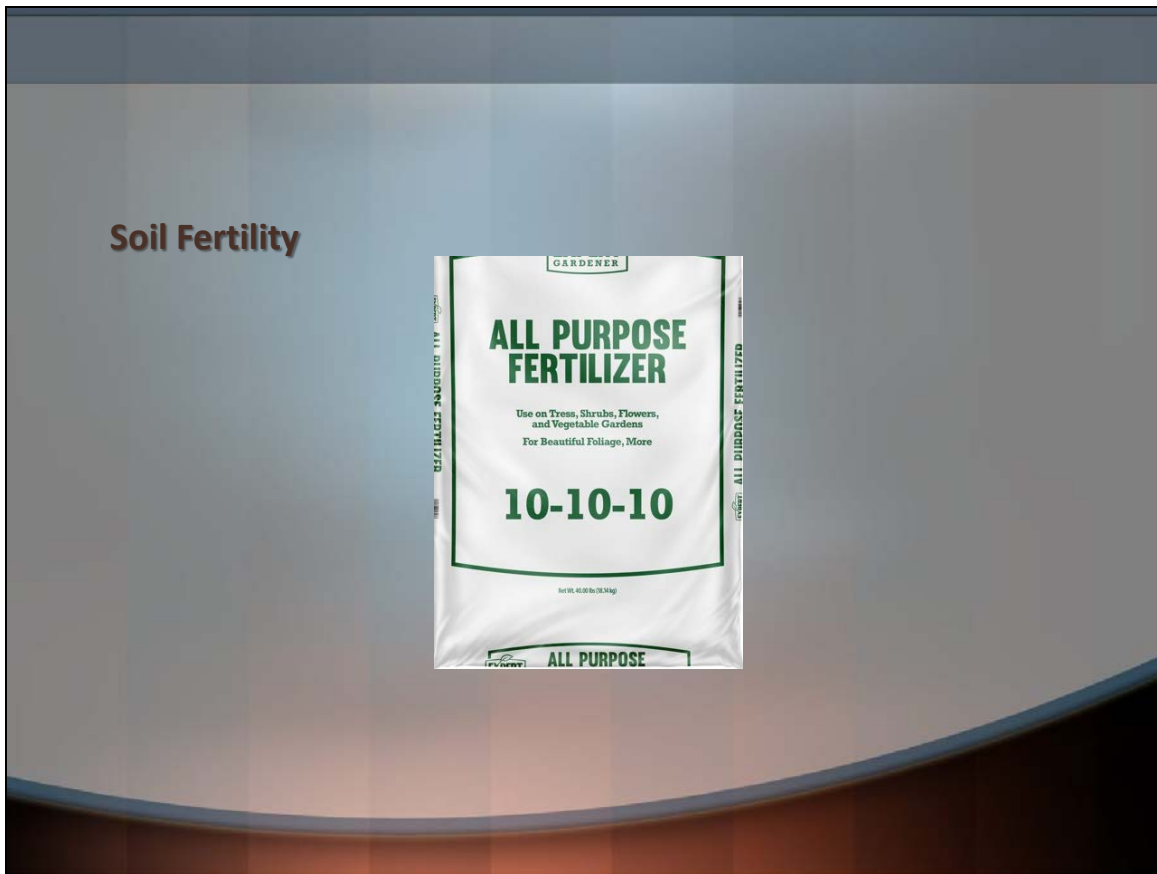
## Soil Fertility

By law, the label on the fertilizer package must indicate the amount of nitrogen, phosphorus, and potassium in the product, in that order. **N P**

**K**



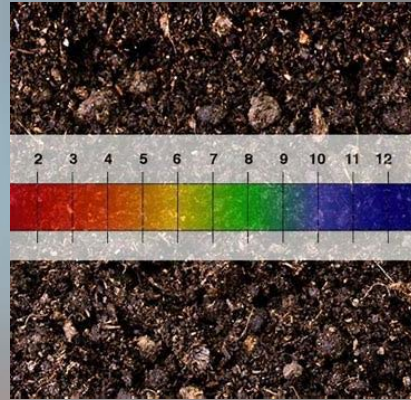
If you are looking at a fertilizer bag the numbers will always refer to N, P, and K in that order. Nitrogen promotes plant growth; phosphorus promotes flowering and fruiting, and Potassium promotes hardiness.



The numbers on a fertilizer bag indicates the fertilizer grade and represents the ratio of N, P and K in the product– it's the weight percentage of each nutrient in the package. So in this example, 10% N, 10% P and 10% K. The remaining materials in the bag are some micronutrients and inert materials that serve as carriers for the nutrients. You'll find lots of different grades of fertilizers, and you can also get products with just nitrogen, or just phosphorus, etc.

## Soil Fertility

- pH is an abbreviation for "power of hydrogen"
- pH scale ranges from 1-14
- Nutrients are available to most plants when the soil pH is 6.0 to 6.7.
- Acid loving plants



pH of the soil is another important consideration for successful gardening. pH is an abbreviation for "power of hydrogen" and is a measure of acidity. The pH scale ranges from 1-14 where 1 is very acidic and 14 is very alkaline. 7 is neutral. Plant nutrient availability directly relates to soil pH. Nutrients present in the soil are available to most plants when the soil pH is 6.0 to 6.7.

There are certain acid loving plants that utilize nutrients at lower pH levels. Examples include blueberries, rhododendrons, azaleas. You can find pH requirements for most plants online. It might be helpful to research the pH requirements of plants before selecting them for your garden.

However, you can adjust your soil pH. To raise the pH of an acidic soil, limestone is typically added. It has a pH of 7. To make an alkaline soil more acidic, sulfur is typically added. Bacteria in the soil convert the sulfur to sulfuric acid, which lowers the pH. Sulfuric acid pH ranges from 1-2.

## Soil Fertility



Adding lime to correct an acidic soil:

- Apply lime based on soil test results
- Incorporate lime into the soil
- Start to see effects in about 4 weeks but can take 6-12 months for lime to completely dissolve

Most of us will likely be attempting to raise the soil pH from acidic to the range desired by most plants. Lime is the material typically used to raise an acid pH. To determine how much lime, it's best to have a soil test completed for the site. Quantities of lime will be recommended based on the soil type, current pH, types of plants to be grown and size of the area.

When applying lime to a typical garden site, if you can till the ground first then apply the recommended lime evenly over the area then rake into the soil to at least a couple inches, this is ideal. You can start to see the impact of the lime on the pH within a few weeks, but the pH won't reach the full level until the lime is fully dissolved and that can take a year or more, depending on soil type. So if you need to adjust an acid pH, it's best to get the lime on the soil as soon as possible; fall for a spring planting is a great idea. That way the lime can have 6-8 months to change the pH. The form of lime you're using can impact how long it takes to break down.

## Soil Fertility

### Soil Testing

- A basic soil test usually measures phosphorus, potassium, soil pH and organic matter.
- Take the soil sample well before planting, so there is time to prepare the site. For the most accurate results, use the services of a commercial soil testing lab rather than a soil testing kit.



In addition to pH, a soil test will measure phosphorus, potassium, and organic matter. Nitrogen recommendations are based on crop needs with the assumption that very little available N remains in the soil at the end of the growing season and will need to be replenished. Recommendations given reflect the amount of nitrogen needed for one growing season for the specified crop.

Taking the test in the fall for the following production year is ideal. It takes a little time for pH to adjust after lime is added. Fertilizer is added at planting time so the nutrients are available in the root zone for the plants. If you apply fertilizer too soon, as in the fall, some nutrients may be leached away from the plants, wasting the application.

Adding needed lime in the spring is better than not adding at all. You'll see some benefit, you probably won't see full benefit until the next growing season.



## Compost

When organic material decays and breaks down the results material is called compost.

Materials that can be composted:

- Plant debris
- Food waste
- Animal manure
- Grass clippings
- Leaves
- Wood chips
- Paper



Adding composting can be a beneficial practice for the home garden, as well. Composting is the process of decomposition of organic materials. This breakdown is accomplished by microorganisms, mainly bacteria, that consume the materials.

Compost adds organic material to the soil which improves soil texture. Compost is rich in nutrients and can be added to soil as a nutrient source, replacing some fertilizer needs. You can purchase compost or make your own. To make compost, the key is the right balance of green or nitrogen rich material and brown or high carbon materials. Brown and green materials in a ratio of about 30:1 are layered in a pile or bin. The pile should be moist, but not saturated and the microorganisms (which are everywhere) begin feeding.

It takes 6 months to 2 years to finish the compost, depending on the size of the materials in the pile. The smaller the surface area the faster the breakdown. Internal temperature of the compost pile must reach 90-140 degrees F for microorganisms to work their best. Green materials: grass clippings, vegetable scraps, plant debris. Brown materials: Leaves, straw, wood chips. Size of the pile can impact internal temp and rate of compost formation—bigger piles may be faster due to more insulation of the core. Limit animal manure to cattle, horse, etc. (herbivores). Pet manure is not a good idea because of the potential for parasites that are likely not killed at temperatures reached in typical home compost scenario.



## How to take a Soil Test

**Soil Testing Form – Home Grounds & Garden**

**Instructions:**

- Soil sampling instructions, test descriptions and crop codes are on page 2.
- Please print legibly.
- Please give each sample a unique name.
- Make checks payable to "UNH Cooperative Extension."
- Please allow **3 WEEKS** for test results.

**Mail Samples to:**  
 UNH Cooperative Extension  
 Soil Testing Service  
 Barton Hall Room 8206  
 34 Sage Way  
 Durham, NH 03824  
**Questions?** Call 603-862-3200  
 Email: soil.testing@unh.edu  
 Visit: extension.unh.edu/diagnostics

Name: \_\_\_\_\_ Business/Farm: \_\_\_\_\_ County: \_\_\_\_\_  
 Address: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_ Zip Code: \_\_\_\_\_  
 Email: \_\_\_\_\_ Phone: \_\_\_\_\_ FAX: \_\_\_\_\_

Receive Test Results by (choose one): Email  Mail  FAX  Payment Type: Cash  Check

| UNH# (if #<br>(leave blank) | Sample Name<br>*Please provide initials and date<br>& time of sample collection. | Crop Codes* | Standard<br>Test<br>\$10 | pH<br>ONLY<br>\$8 | %<br>Organic<br>Matter<br>ONLY<br>\$4 | Texture<br>Class<br>\$9 | Heavy<br>Metal<br>Package<br>\$10 | TOTAL<br>Sample<br>Cost: |
|-----------------------------|--|-------------|--------------------------|-------------------|---------------------------------------|-------------------------|-----------------------------------|--------------------------|
|                             |  |             |                          |                   |                                       |                         |                                   |                          |
|                             |  |             |                          |                   |                                       |                         |                                   |                          |
|                             |  |             |                          |                   |                                       |                         |                                   |                          |

### Collect samples according to the instructions on the form:

- Dig to a depth of 6 inches for home garden
- Collect samples from 6-8 locations around the garden site
- Combine samples together and take one sample from the combined soil to submit to the lab

A soil test is the best way to get a clear picture of what's going on in your site and determine what you need to add to make the site the best possible growing conditions for your crops. UNH offers a soil testing service and there are also private labs that offer soil testing. When collecting samples to submit to the soil lab, follow the instructions for the specific crop you are growing. For a garden dig 6 inches. For trees and shrubs dig 6-8 inches and for lawn, dig 3-4 inches. Collect samples from 6-8 locations around the garden area (or more samples from a large area like an orchard) and combine these together and take one sample to submit to the lab. Submit samples for different uses separately. For example, submit a sample for your garden separately from a sample for your lawn. Be as descriptive as you can regarding your garden plans as this helps to make more precise recommendations.

## Soil Test Results

| Test Data                 |               |         |                 |
|---------------------------|---------------|---------|-----------------|
| pH - Soil                 | 6.60          |         | Optimum Range   |
| Calcium, Mehlich 3 (Ca)   | 976.60 (ppm)  | O       | 800 - 1200      |
| Magnesium, Mehlich 3 (Mg) | 82.00 (ppm)   | O       | 60 - 120        |
| Potassium, Mehlich 3 (K)  | 84.00 (ppm)   | L       | 170 - 280       |
| Phosphorus, Mehlich 3 (P) | 105.00 (ppm)  | H       | 30 - 50         |
| Lead, Mehlich 3 (Pb)      | 10.35 (ppm)   | VI      |                 |
| Org. Matter, LOI-360 (OM) | 3.84 (%)      |         |                 |
| <b>Optimum Range Key:</b> |               |         |                 |
|                           | VI - Very Low | L - Low | O - Optimal     |
|                           |               |         | H - High        |
|                           |               |         | VII - Very High |

### Recommendations

**Vegetable Garden** (Target pH Range: 6.0 - 6.5)

**Lime:** No Lime or Sulfur required at this time.

|  | Nutrient Recommendations |            |           |
|--|--------------------------|------------|-----------|
|  | Nitrogen                 | Phosphorus | Potassium |
| Nutrients Required (per 1,000 sq. ft.)             | 3 lbs                    | 0 lbs      | 4 lbs     |
| <b>Credits:</b>                                    |                          |            |           |
| from organic matter                                | 0 lbs                    | -          | -         |
| <b>Apply the equivalent of</b> (per 1,000 sq. ft.) | 3 lbs                    | 0 lbs      | 4 lbs     |

#### Conventional Fertilizer Recommendations

We recommend that you uniformly broadcast 13.8 lbs per 1,000 sq. ft. of 10-0-10 plus 5 lbs per 1,000 sq. ft. of 0-0-22.

A second application of fertilizer (12 lbs per 1,000 sq. ft. of 10-0-10) 3-4 weeks after planting or transplanting should be side dressed or applied by banding six inches from the growing plants and if possible, lightly incorporated into the soil.

This will result in a total application of 25.8 lbs per 1,000 sq. ft. of 10-0-10 plus 5 lbs per 1,000 sq. ft. of 0-0-22.

**OR**

#### Organic Fertilizer Recommendations

An equivalent organic source for 3 lbs of Nitrogen is 50 lbs of soybean meal, OR 23 lbs of dried blood.

An equivalent organic source for 4 lbs of Potassium is 18 lbs of sul-po-mag (0-0-22).

Composted manure is an excellent source of all three nutrients, but should not be used as the sole source on a long term basis.

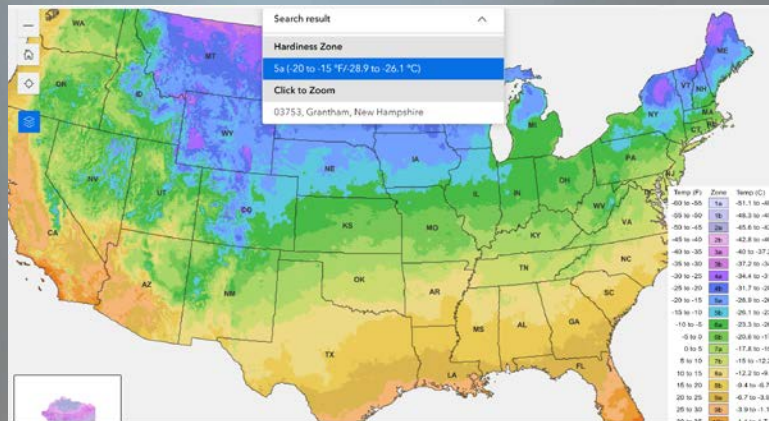
Manure will provide approximately 1 lb of Nitrogen for every 800 lbs applied per 1000 sq. ft. Manures and composts are excellent sources of nutrients, but should not be used as the sole source on a long term basis. Please see the fact sheet Using manure and composts in the home garden.

#### General Comments

Specific fertilizer analyses are recommended for the purpose of simplicity. No endorsement of products is intended nor discrimination against similar products not mentioned.

After the sample has been analyzed the results will tell you pH and current ranges of key nutrients, as well as organic matter level. You will have recommendations provided to you to get these to the desired levels of these items for your crop. Using this as a guide you can prepare your site for planting your crops.

## USDA Plant Hardiness Zones



An important related component to successful gardening is to be aware of your hardiness zone. USDA has created a plant hardiness zone map showing typical ranges for winter temperatures across the country. The lower the zone number the colder the winter temperature in the zone. Plants in turn are rated for their ability to tolerate specific temperature ranges.

USDA just released an updated hardiness zone map in 2023. NH used to be within hardiness zones 3-5. The new map shows our range creeping into Zone 6 in the southern part of the state. This is probably more important for perennial plants like trees, shrubs, fruit plants, etc. When you are shopping for plants in a garden center you will often see that plants are described as hardy to a specific zone and this is what they are referring to. Grantham would fall mostly into Zone 5.

## Site Selection



### Choose a site with:

- Appropriate soil type and drainage for what you intend to grow
- For convenience, locate your garden near a source of water.
- Avoid trees for potential root interference as well as potential shade issues
- Be aware of microclimates. Microclimates are small areas in the landscape with slight variations on the weather due to topography, elevation, slope, etc.

And finally, a last little bit on site selection, keep these points in mind as you choose a site for planting:

**Microclimates:** An example is a dip in your property where the low lying area is susceptible to frost. Plants growing up hill may be fine, while plants in the low area may be damaged from frost.

An entire property that is located in a spot that is protected by hills, or trees or buildings can overcome freezing temperatures that damage crops on another property just down the road. Example of King Blossom Farm in May 2023.

# Questions?



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# Asian Jumping Worms



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Moving on to Asian Jumping Worms.

## Asian Jumping Worms



- Invasive worm that was introduced to North America from Asia likely in the 18<sup>th</sup> or 19<sup>th</sup> century
- Widespread in North America
- Potential to dramatically change soil structure

Jumping worms are an invasive earthworm that were introduced to North America from Asia, likely as early as the 1800's and coming in on horticulture products. This photo shows a jumping worm on the right and a common earthworm night crawler on the left and you can see they are very similar in appearance. Jumping worm adults have a smooth milky-white collar (clitellum) close to the head end (14-16 segments away), and goes all the way around the body. Nightcrawlers have a raised pink-red collar that does not go completely around the body and is located more central along the worm's body.



## Asian Jumping Worms



### Jumping worm (*Amyntas agrestis*)

- Thrash and twitch
- Shiny, slightly iridescent, and grey-brown
- Milky-white ring (clitellum)
- Mostly dry

Photo credit: Purdue Plant and Pest Diagnostic Laboratory



### Common earthworm (*Lumbricus terrestris*)

- Wiggle gently
- Dull red-brown
- Red-ish ring (clitellum)
- Slimy

Photo credit: Joseph Berger, Bugwood.org

These photos from Purdue University show the clitellum a little more clearly as well as some other distinguishing characteristics.



## Jumping Worms

- Jumping worms hatch from eggs laid in the fall, which are in protected cocoons.
- Jumping worm eggs hatch in April/May

Jumping worms hatch from eggs laid in the fall, which are in protected cocoons about the size of poppy seeds. These cocoons are very small and difficult to see with the naked eye. Jumping worm eggs hatch in April/May and will continue to grow from 1-8 inches long until the soil freezes and kills the adults. The eggs and cocoons will overwinter in the soil to hatch in the spring. It's thought that worms can lay several sets of eggs during the growing season before freezing.

## Concerns

Compared to earthworms, Jumping worms:

- Reproduce more quickly
- Are more aggressive
- Eat more and breakdown plant debris faster
- Can exist in larger density



While earthworms aerate the soil and enrich it with their excrement, Asian jumping worms eat organic matter so quickly, it doesn't have time to break down to be beneficial to the soil and plants. Unlike the helpful earthworm castings that feed our garden plants, the castings of jumping worms seem to keep nutrients bound up and can easily get washed away, depleting the soil. Their castings provide poor structure and support for plants.

## Jumping Worm Concerns



Jumping worms are also a problem in forest land. They can clear forest leaf litter in just a couple of months. (photo in PA in June on left and August)

## Jumping Worm Concerns



The entire life cycle of the jumping worm happens in the top layer of soil so it's quite easy to accidentally move them to uninfested areas. Both eggs and worms can be moved in contaminated soil, plant roots, wood mulch and compost. Be diligent in your garden activities.

## Jumping Worm Concerns

- Be diligent and watch for worms and remove them
- Scan plants and clean/bare root the plants
- Before introducing mulch, topsoil or compost, inspect for worms
- Don't share plants, mulch or compost from your property if you have jumping worms
- Clean garden boots, gear
- Check property periodically—mustard test
- Research has shown that neither worms or cocoons can survive temperatures of 104 degrees F for more than 3 days



There is not yet a “magic bullet” control for jumping worms, but research continues. Until then, prevention is key. If you determine that you have a small population, you can hand pick the worms, bag them and put them in the trash. According to the University of Wisconsin drenching the garden area with a mixture of dried mustard and water can help as a control and as a way to scout for presence—the recipe is a 1/3 cup of dried mustard in a gallon of water. This mixture apparently irritates the worms and causes them to come to the surface where you can remove them. If you have a large area this is probably not practical.

They are here and until we have effective controls monitoring and preventative practice are the best we have.

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**Thank you!**

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