

# **Groundwork Rhode Island Soil Health Guide**

The Nutrient Cycle, Compost Application, and Caring for Cultivated Soil

*From the April 2021 workshop series*



## **Part I: The Nutrient Cycle**

A sufficient balance of nutrients in soil is one of the most important factors determining plant health and growth. Since nutrients are uptaken by plants, they need to be replaced by amending the soil or building a healthier garden system that can replenish nutrients itself. Without critical nutrients, plants may become stunted, have low yields, or have a weak structure.

- Nutrients are synergistic. For example, potassium helps plants absorb nitrogen. If you don't have enough potassium, your plants may be nitrogen deficient, even if there is plenty of nitrogen in the soil.
- Macronutrients are required in larger amounts than micronutrients, but both are required for the optimum growth of your plants.

<b>Optimum Ranges for Nutrients in Garden Soil, parts per million (ppm)</b>			
<b>Macronutrients</b>		<b>Micronutrients</b>	
Phosphorus (P)	4–14	Boron (B)	0.1–0.5
Potassium (K)	100–160	Manganese (Mn)	1.1–6.3
Calcium (C)	1000–1500	Zinc (Zn)	1.0–7.6
Magnesium (Mg)	50–120	Copper (Cu)	0.3–0.6
Sulfur (S)	>10	Iron (Fe)	2.7–9.4

**Figure 1.** *UMass Extension.* If your soil samples have test results that fall within these optimum ranges, it can be accepted that most crops will have the nutrients they need to grow successfully.

### **The Dangers of Chemical Fertilizer**

Over-application of nitrogen and phosphorus can be problematic when rain washes these chemicals into our local waterways and eventually Narragansett Bay. Nitrogen is more of an issue in the ocean and phosphorus is more of an issue in freshwater. Since the bay is brackish, a combination of fresh and saltwater, the runoff of both nutrients must be minimized. It is generally recommended to apply compost or fertilizer in relation to the phosphorus needs of the soil, rather than nitrogen, since the phosphorus threshold is usually lower.

- Too much phosphorus in soil can also result in chlorosis, a condition in which plants produce insufficient chlorophyll (needed for photosynthesis), resulting in pale or yellow leaves. Too much nitrogen can “burn” plants and kill them.
- Environmental harm is much more likely to occur with chemical fertilizers than with compost application. Compost increases the water-holding capacity of soil, decreasing the potential for runoff from heavy rainstorms; it also has a great capacity to hold onto nutrients, unlike many fertilizers. The diverse array of nutrients in compost synergistically work together to help soil and plants become more efficient in nutrient uptake itself!

## Product Comparison

*We are not making recommendations on the fertilizers in the following table. Fertilizer use should be tailored to the needs of soil and plants in specific situations. Our intent is merely to provide a way to compare nitrogen, phosphorus, and potassium (N-P-K) ratios for some commonly used soil amendments.*

Product	Primary Use	N-P-K
Earth Care Farm Compost	Rich in macro- and micronutrients. Made with food scraps. Used for remediating soil & yearly soil maintenance.	34-93-49
Casella Compost	Low-nutrient compost, made with yard debris; may need to supplement with additional nutrients.	12-2-5
Bone Meal	Very high phosphorus—be careful!	4-12-0
Blood Meal	A nitrogen additive. May attract animals.	12-0-0
Dried Chicken Manure	Higher in nitrogen than other manures. You can purchase “dried chicken manure” or compost it yourself. Do not apply fresh!	5-2-1
Fish emulsion	High in nitrogen. You can make it at home! Must be diluted: 1 tbsp to 1 gal water	5-1-1
Urea (pee!)	Must be significantly diluted! Can cause damage to vulnerable plant parts; research appropriate uses.	46:0:0
Fresh Coffee Grounds	Slightly acidic; rinsing helps remove acidity. Do not place near tomatoes.	104-16-14
Eggshell	Takes at least a year for calcium to become plant-available.	60-20-7
Kelp	Not a great source of N-P-K, but used for micronutrients and growth hormones.	1-0-4
Scott’s Turf Builder	Chemical fertilizer for lawn maintenance.	30-0-4
Scott’s Starter	Chemical fertilizer for starting a new lawn.	24-25-4
Miracle-Gro Shake n’ Feed	Chemical fertilizer for vegetable/flower garden maintenance.	36-12-24

**Figure 2.** Average N-P-K ratios for various fertilizers and soil amendments. Actual values may vary.

## Where to get compost in RI?

*Prices may vary year-to-year.*

### **Earth Care Farm** - Charlestown, RI.

Made from food scraps and yard debris.

\$75/cubic yd loose; \$7.99/half-cubic ft.

*Currently sold out; will have more later this spring.*

401-364-9930 | Email [info@earthcarefarm.com](mailto:info@earthcarefarm.com)

### **Harvest Cycle** - Providence, RI

Made from food scraps and yard debris

\$60/cubic yd loose (\$40 for low-income individuals and nonprofit organizations); \$2/gallon.

*Currently sold out; will have more later this spring.*

Email [compost@groundworkri.org](mailto:compost@groundworkri.org)

### **Smithfield Peat** - Smithfield, RI

Made from yard debris.

\$45/yd for 6–11 yards; less for 11+ yards.

*Does not deliver less than 6 yards.*

(401) 231-1111

### **Earth Products, Inc.** - Warwick, RI

Made from yard debris.

Around \$40/cubic yard; pickup or pay for delivery.

401-732-2270 | Email [sales@earthproductsri.com](mailto:sales@earthproductsri.com)

### **Casella (at RIRRC)** - Johnston, RI

Made from yard debris.

Around \$30/ cubic yard; pickup or pay for delivery.

Compost can also be purchased at hardware and garden stores. Vermont Compost is very popular and can usually be purchased bagged, by the cubic foot, at retail stores such as Cluck!, Adler's, Mount Pleasant Hardware, Home Depot, and Lowes.

**Or, make it yourself!** Make sure to do some research on proper ratios of “greens” to “browns” (nitrogen to carbon), proper aeration, and management, and make sure to cure your compost for several months after it no longer resembles food or smells bad and has cooled down.

### **Know your compost!**

Most compost sellers can provide a lab analysis for their compost. Compost should be fully cooled and cured for several months before application. If compost is still hot, it can rob oxygen from your plants as the carbon and nitrogen continue to break down, or the volatile nitrogen can kill them. To test whether or not compost is finished, leave it in a pile for a week before applying to make sure it doesn't heat up. Lastly, stable (finished) compost should not change pH of soil.

## **Part II: Testing and Preparing Soil for the First Time**

### **Test Your Soil!**

**URI** conducts a free soil testing service that determines pH levels and texture, and provides basic information and recommendations.

If you are looking for a deeper understanding of your soil, complete soil analysis is available through the **University of Connecticut Soil Lab** and the **University of Massachusetts Soil & Plant Nutrient Testing Laboratory** for a fee. We suggest testing soil every few years, and especially when growing in new garden spaces.

The UConn Soil Nutrient Analysis is \$12, with many additional options ranging from \$4–12. The UMass Routine Soil Analysis is \$20, with additional options for \$6 each.

These tests determine:

1. Nutrient levels and fertilizer recommendations
2. Elevated lead levels or other toxic heavy metals
3. Proper soil amendments to avoid pollution of local waterways

Both include:

- Soil pH, Macronutrients, Micronutrients, Heavy Metals, Cation Exchange Capacity, Test Interpretations, and Recommendations for your chosen crops

Optional Tests:

- Organic Matter Content, Soluble Salts, and Nitrates

Cation Exchange Capacity (CEC) is an important factor for soil and plant health. You can think of it as the soil's ability to retain and supply nutrients, and how available those nutrients are to a plant. The plant needs to do less work when the nutrients are more available, which prevents it from becoming stressed. That saved energy can then go into producing healthier, better tasting fruit, leaves, and flowers!

Since a soil's CEC comes from the clay and organic matter content, soil texture and color can be used to give a general estimate of the CEC. A higher clay and organic matter content means a higher CEC.

- For example: Light colored sands (think dry beach sand), which are very low in clay and organic matter, have a very low CEC; dark-colored loams (think rich farm soil), which have much larger amounts of clay and organic matter, have a higher CEC.

Testing for the Organic Matter Content of your soil is important for other reasons, too. Organic matter reduces soil erosion, improves water retention, and sequesters carbon dioxide! Most plants do best in soils with organic matter contents between 4 and 8 percent.

## UMass Routine Soil Analysis Example

<b>Results</b>					
<i>Analysis</i>	<i>Value Found</i>	<i>Optimum Range</i>	<i>Analysis</i>	<i>Value Found</i>	<i>Optimum Range</i>
Soil pH (1:1, H <sub>2</sub> O)	7.4		Cation Exch. Capacity, meq/100g	35.7	
Modified Morgan extractable, ppm			Exch. Acidity, meq/100g	0.0	
<i>Macronutrients</i>			<b>Base Saturation, %</b>		
Phosphorus (P)	137.9	4-14	Calcium Base Saturation	89	50-80
Potassium (K)	180	100-160	Magnesium Base Saturation	10	10-30
Calcium (Ca)	6332	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	442	50-120	<b>Scoop Density, g/cc</b>	0.97	
Sulfur (S)	61.5	>10	<b>Optional tests</b>		
<i>Micronutrients</i> *			Soil Organic Matter (LOI), %	10.2	
Boron (B)	1.3	0.1-0.5			
Manganese (Mn)	8.0	1.1-6.3			
Zinc (Zn)	7.2	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	6.7	2.7-9.4			
Aluminum (Al)	15	<75			
Lead (Pb)	2.4	<22			

\* Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.

### Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
<b>Phosphorus (P):</b>				
<b>Potassium (K):</b>				
<b>Calcium (Ca):</b>				
<b>Magnesium (Mg):</b>				

Phosphorus is excessive.

### Recommendations for Home Vegetable Garden

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P <sub>2</sub> O <sub>5</sub>	Potassium, K <sub>2</sub> O
0	.25 - .3	0	0

#### Comments:

\*To supply Nitrogen, apply EITHER 2 - 2.5 lbs. Dried Blood (12-0-0) OR 0.6 - 0.7 lbs. Urea (45-0-0) per 100 square feet.

Application should be split between early spring and mid-June.

\*Soil test values for phosphorus and potassium are above optimum. Only a source of nitrogen is necessary this year.

-For instructions on converting nutrient recommendations to fertilizer applications in home gardens and landscapes, see Reference "Step-by-Step Fertilizer Guide for Home Grounds and Gardening" (listed below).

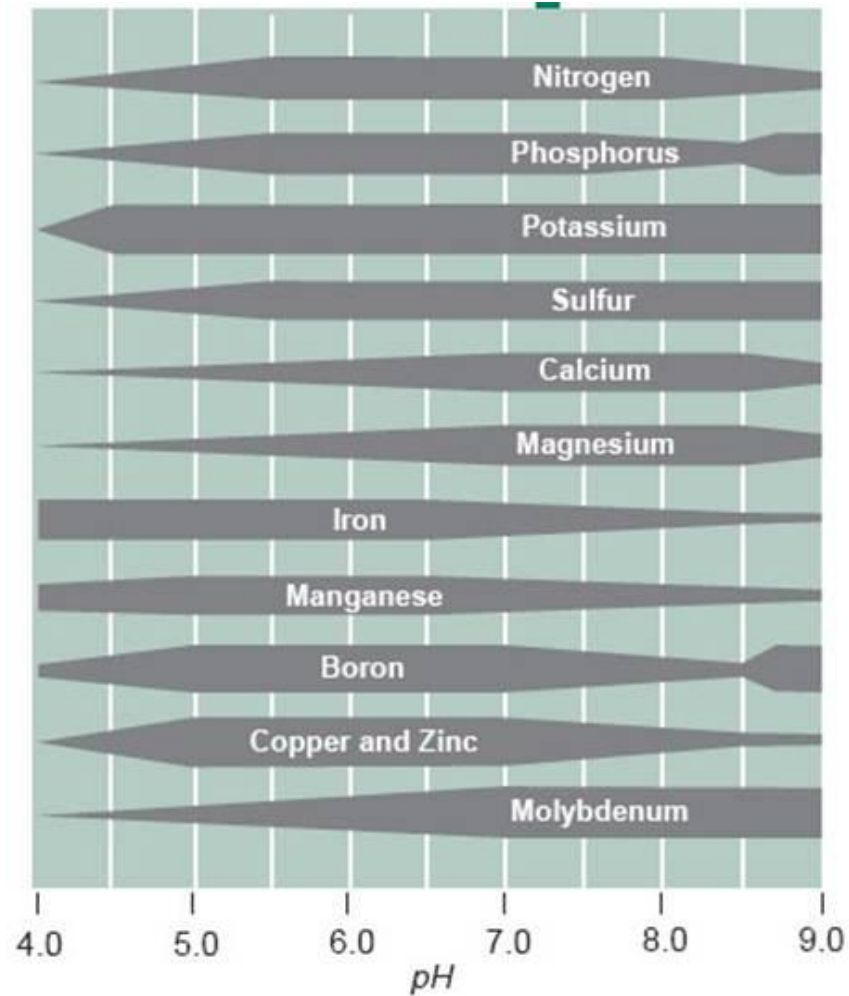
-Avoid over-fertilization. In addition to threatening water quality, excessive nutrient applications can compromise plant health and contribute to insect and disease problems. For details, see Reference "Corrective Measures and Management of Over-Fertilized Soils" (listed below).

-When pH is greater than 6.8, Cation Exchange Capacity (CEC) tends to be overestimated.

-The lead level in this soil is less than 22 ppm, which falls below the listed optimum level. However, many variables affect this result, and safety thresholds vary by location and soil use. There is still a potential risk of lead exposure for soils used for growing food or as play areas for children. Our Total Sorbed Metals test provides an accurate measurement of soil lead. For more information about lead levels in soil, see the fact sheet entitled "Soil Lead: Testing, Interpretation, & Recommendations," listed under General References at the end of this report. ATTN: The Total Sorbed Metals Test is currently unavailable. We apologize for any inconvenience.

## The Importance of pH

The figure below shows how soil pH affects nutrient availability for plants. Generally, the most important nutrients are less available to plants when the soil is more acidic.



**Figure 3.** *The University of Hawai'i at Mānoa.* The effect of soil pH on the availability of essential plant elements. Greater nutrient availability is indicated by thickened lines, whereas narrow lines indicate a decrease in availability.

You can see how having the proper soil pH can help with nutrient absorption. At the very least, knowing your soil's pH will give an overview of what is happening in its ecosystem.

Soil test results often include a recommendation to apply lime in order to reach the ideal pH (between 6.0 and 7.0 for growing most plants). That is because lime is alkaline and will neutralize acidic soils, and most soils in Rhode Island are somewhat acidic.

## Compost as a Soil Conditioner

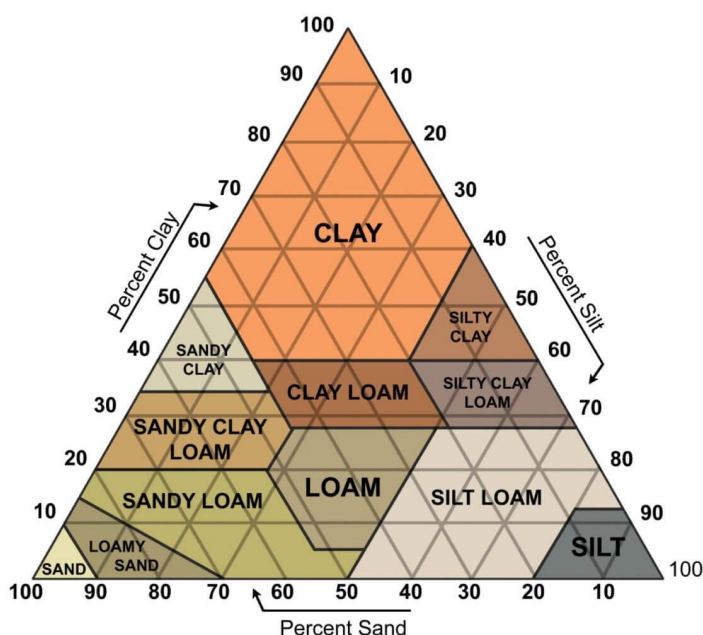
Compost primarily improves plant health by improving soil health, through altering physical and biological soil properties and increasing the organic matter content. Fertilizers, on the other hand, improve plant productivity by directly supplying significant amounts of nutrients that are available for the plant to use. Compost conditions soil more than it fertilizes it, and so should not be considered a substitute for fertilizing practices. That being said, we advise against using chemical fertilizers and recommend using alternative fertilizing practices.

Because compost is a slow-release source of nitrogen, it should not be applied at rates high enough to meet immediate nitrogen requirements for your plants. This will result in excess phosphorus and potassium, which as we discussed in Part 1, can lead to major issues for both your plants and the environment at large.

Using compost as a soil conditioner, your plants and soil will gradually become healthier and more productive over time! It is an additive and regenerative process.

## Scenario A: Remediating In-Ground Soil for Gardening

When remediating soil for the first time, it is especially important to get it tested, for heavy metals at the very minimum. We recommend getting the routine soil test and optional organic matter content test. However, if price is a burden, free tests for heavy metals are available through the Green and Healthy Homes Initiative, and URI offers free pH and soil texture testing. Soil organic matter can be inferred to a certain extent from soil texture.



Much of the soil in the urban growing areas of Providence falls in the category of “sandy loam.” The organic matter of this soil is typically between 0.5% and 4% organic matter. Organic matter content decreases at lower depths. For example, the top 6 inches of soil might have 2% whereas 1 foot below might have less than 1%.

Organic matter is incorporated into soil aggregates and provides habitat and food for microbes and insects, which in turn provide nutrients for your plants!

Figure 4. SoilSensor.com, based on the NRCS soil textural triangle.



## To Till or Not To Till?

Tillage is the preparation of soil by some form of agitation, such as digging, turning, and mixing. With compost application, we typically recommend using a no-till method. Although, if your soil test comes back with 0–4% organic matter, you may want to apply a larger amount of compost and till it into the existing soil. If the soil organic matter is above 4%, intensive tillage should be avoided in order to preserve bacterial and fungal networks in the soil.

Mixing various depths of soil will impact soil organic matter levels negatively, having an inverse effect even when mixing in something like compost that has higher levels of organic matter. During tillage, the rich topsoil gets mixed up with those deeper layers, which have a much lower organic matter content. This would dilute all of the organic matter you were starting with, taking it away from the very important root zone. And with such a high degree of disturbance and damage to the soil, it would take years for organic matter to accumulate once again.

In the case of very low organic matter, the benefits of fully mixing in compost potentially outweigh the loss of bacterial and fungal networks in the soil. In this situation, the main consideration is how much compost you can afford to buy! Based on how low the organic matter percentage is, you may want to add up to a 1:1 ratio of compost to existing soil and till down to between 6 inches and 1 foot.

Multiply the length x width of the area to be remediated x 0.5 or 1 ft (depending on tillage depth)

The resulting number will be the cubic feet of compost you need to purchase. You can find cubic feet to cubic yard conversion calculators online, if needed.

## Notes on Adding Compost

- In general, most soil in Rhode Island is sandy with good drainage, and can accommodate plenty of compost without losing drainage capacity. If for some reason your soil drains poorly already (i.e. you notice it becomes swampy for a few days after rain), you may want to be careful with adding compost, as the high water-holding capacity can exacerbate these conditions. Still, low organic matter generally correlates to low water-holding capacity; there may be other issues causing poor drainage, such as compaction or loss of topsoil. Adding compost and using the appropriate method of tilling can help in these areas too!
- Adding compost to soil is part of a long-term strategy for remediating land. Keep in mind that only between 10-25% of the nitrogen in compost will be available to plants in the first year, and this amount will increase over time. Phosphorus and potassium generally become available more quickly.
- Consider planting nitrogen fixers as a cover crop: clover, vetch, alfalfa, peas, and beans work well. Once they die, their decomposition releases the stored nitrogen into the soil.

## Scenario B: New Raised Bed

If the ground soil is lead-contaminated (in Providence, it's best to assume it is, unless you have had it tested) or if you or others using the garden cannot bend down to cultivate an in-ground garden, you may want to build a raised bed.

**Size:** Make sure your raised bed is at least 10–12 inches tall (taller is even better!), so that plant roots have room to grow. Also, make sure it is not too wide to reach the center from both sides.

**Placement:** Working with raised beds is very different from working with pre-existing soil, especially if they are placed on an impervious surface that has no drainage or contact with soil. Essentially, you are creating a habitat from scratch; you can think of these like very large potted plants! If possible, placing raised beds on soil is ideal because there will be some contact between the wider soil food web and the soil in the bed. If you must place the bed on pavement, permeable pavers are preferable in order to improve drainage.

**Building the soil:** In a raised bed, you want to be even more careful about what compost or fertilizer you are adding. Since the bed is a closed system (or almost closed, if the bottom is open to soil), your chances of creating nutrient imbalances increase. If you can find topsoil for sale, that is the best! You can mix topsoil and compost in a 2:1 ratio. Many people add peat moss, vermiculite or “soil-less potting mix” for a total ratio of 6 parts topsoil to 3 parts compost to 1 part potting mix. If you do not want to purchase mined/imported materials, you can leave out the potting mix. Make sure the compost you are using is finished (doesn't heat up) and comes from a reliable source. You may also mix loam and compost in a 1:1 ratio.

- In raised beds placed on impermeable surfaces, be careful with the amount of compost you add because of its high water-holding capacity. You may end up with a swampy soup if it rains! Start with a more conservative ratio of compost to soil, observe the soil after it rains, and add more later.

## Part III: Maintaining Existing Cultivated Soil

### Keeping Your Soil Alive

Always keep your soil covered when you are not cultivating it. This can mean planting cover crops (especially nitrogen fixers!) or covering it with mulch in the winter. Some growers like to use a chop-and-drop method at the end of the growing season: chopping up all the uncultivated plant material into smaller pieces and leaving it atop the soil. Most of it will break down over the colder months while insulating the soil, keeping microbial activity higher for longer! Avoid using especially woody materials and diseased plants.

## Crop Rotation

If you grow the same annuals every year, try growing them in different spots, especially spots where the plants grown the year before were very different (i.e. flowers vs. veggies vs. herbs). Different types of plants uptake nutrients in different amounts, so crop rotation gives the soil some time to recover whatever was uptaken in high amounts the year before.

## Yearly Compost Application

Again, we recommend top-dressing compost rather than tilling it in, as to not disturb or damage the soil's structure and microbial networks. 1–2 inches is generally good. You can also use this formula to determine how many cubic yards of compost you need:

Specific area to cover (length x width in sq ft) x amount of compost to apply (depth in inches) x 0.0031 = cu yds of compost needed ( **\_\_ ft<sup>2</sup> x \_\_ inches of compost x 0.0031 = \_\_ yd<sup>3</sup>** )

- If you apply compost over the top of mulch, the nitrogen in the compost will be used to break down the carbon in the mulch and will not be available to your plants. So in the spring, pull back your mulch and apply 1–2 inches of compost beneath, directly on top of the soil. The combination of soil organisms and water will draw all the benefits of the compost down into the soil. You can then reapply mulch to further improve water retention and prevent weeds from growing.
- You may want to apply compost in the fall rather than (or in addition to) the spring, to give the nutrients in the compost more time to be absorbed by the soil.
- Young annuals and seedlings are very delicate and may be adversely affected by compost. Try to put the compost on the soil a week or more before adding seedlings and keep a margin of a few inches around plants for soil stability.

## Heavy Feeders

Certain plants, known as “heavy feeders,” require more mineral nutrients than others. Examples include tomatoes, corn, and squash; meeting the optimal nutrient levels will lead to improved plant structure and production, increasing your yield! Some growers like to apply additional compost in the areas that are used for heavy feeders to ensure their nutrient requirements are met. One way of doing this is to apply the compost as a shallow top-dress on the soil surrounding your plant throughout its growing season, but no more than once a month. This method should be used only with established plants, since young plants or seedlings are more vulnerable and may be damaged by an excess of nutrients.

## Natural Pest Control

Diversifying your crops will make them less likely to attract pests, since specific critters like specific plants and will be attracted to large numbers of the plants they like. Some plants have properties that deter pests. Many gardeners have found success using the following plants as natural pest deterrents:

Plant	Pests that the plant deters
Basil	Flies, mosquitoes
Borage	Tomato hornworms, cabbage worms
Catnip	Flea beetles, aphids, squash bugs, ants, and weevils
Chives	Japanese beetles, carrot rust flies
Dill	Spider mites, squash bugs, and aphids
Garlic	Carrot flies, cabbage worms, slugs, root maggots, aphids
Lavender	Fleas, moths
Marigolds	Nematodes, rabbits, aphids, mosquitoes
Mint	Ants, fleas, moths, beetles, aphids
Nasturtiums	Woolly aphids, whiteflies, squash bugs, cucumber beetles
Petunias	Asparagus beetle, leafhoppers, aphids, tomato worms
Rosemary	Cabbage loopers, snails, slugs, and Mexican bean beetles
Thyme	Cabbage loopers

**Figure 5.** *Missouri Botanical Garden, other online articles.*

We recommend reading guides for companion planting to learn more about diversifying your garden and maintaining a balance of all its inhabitants.

## Understanding Your Personal Scenario

All of these scenarios have a vast amount of variables, so we cannot give an absolutely right or best method to follow. This guide is based on our own knowledge and research, but we encourage you to do your own research and learn about your particular soil. Ask other growers about methods they have used and whether or not they have been successful! Get your soil tested and build a deeper understanding of what is happening in it! Trust generational and ancestral knowledge, and your instincts, when there are seemingly no answers to be found!