Fertilizing Garden Soils

From Cornell Cooperative Extension, Chemung County

More gardening information at www.gardening.cornell.edu

Soil Nutrients

Twenty nutrients have been identified which plants require for proper growth and function. Of these 20 nutrients, air and water supply carbon, oxygen, & hydrogen.

The remaining 17 nutrients come from the soil. Among the soil nutrients, nitrogen, phosphorus, and potassium are the most important. These three nutrients are required in relatively large amounts and are referred to as macronutrients. Calcium, sulfur and magnesium also fall into this category.

The remaining 11 nutrients are only needed in tiny amounts and are referred to as micronutrients. A lack of any of the 20 essential plant nutrients may limit plant growth and development. It is the gardener's job to insure that her garden soil contains all soil nutrients in the right quantities and in forms available for plant absorption. This is accomplished through the judicious application of fertilizers and proper management of soil structure.

Soil Testing

The first step to creating a fertile garden soil is to determine current nutrient levels. This is done through a soil test. While home soil testing kits are available, the most reliable way to test your soil is to send a sample to your state soil laboratory. Here are a few instructions for collecting a soil sample:

1. Make a 6" deep hole with a spade.
2. Cut a ½" to 1" slice of soil from the back of the hole. Be sure the slice is 6" in length and of even thickness.
3. Place this sample in a clean bucket.
4. Repeat five or six times at different spots in your garden (10-15 per acre).
5. Thoroughly mix samples in bucket.
6. After mixing, remove 2 cups of soil and mail to State testing laboratory.

In order to receive recommendations on soil test results, State laboratories need site and crop information. Information sheets along with mailing bags are available from your local Extension office. Test results will usually give macronutrient and pH analysis. Soil should be tested every four to five years.

Soil pH

The first step after soil test results are received is to amend the soil pH. Soil pH is a measure of how acidic or alkaline the soil is. A pH value of 7 indicates a neutral soil. A pH below 7 is an acid or "sour" soil while a pH above 7 means an alkaline or "sweet" soil. Soil pH greatly influences the availability of nutrients in the soil. Most garden soils should be slightly acidic with a pH between 6 and 7.

Soil pH is amended by applying either lime or sulfur. Lime raises a soil's pH while sulfur lowers it. It is best to apply lime or sulfur 3-4 months prior to planting crops. For maximum effectiveness, the amendment should be mixed into the upper 6" of soil after surface application.

The quantity of lime or sulfur needed to attain a proper pH will depend on your soil's

texture and current pH. Use the charts below to help determine proper amounts.

Lbs. of Lime/100 ft^2 to raise pH to 6.5

Soil pH	Soil Texture: Sand	Loam	Clay
4.5	12.6	25.3	34.8
5.0	10.6	21.1	29.0
5.5	4.2	8.4	11.6
6.0	1.7	3.3	4.5

Lbs of Sulfur/100 ft^2 to lower pH to 6.5

Soil pH	Soil Texture: Sand	Loam	Clay
7.0	.5	1.0	1.4
7.5	1.0	2.0	2.7
8.0	1.7	3.4	4.7
8.5	3.0	5.0	6.0

After amending the pH, the next step is to establish a basic soil fertility level by applying a fertilizer according to the soil test results. This first application is usually heavy and will not be needed every year. Once a basic fertility level is achieved, it is maintained by using light annual fertilizer applications, applying seasonal side dressings, and maintaining high organic matter levels.

Fertilizers

Light fertilizer applications are needed on an annual basis to maintain the basic fertility level. These maintenance applications serve to replace the nutrients removed in the form of vegetables, flowers, and crop residue the preceding year. There are many different types of fertilizers that can be applied. These can be divided into two categories, chemical and organic.

Chemical fertilizers are the most common type of fertilizer used. They consist of various inorganic salts that dissolve easily in water and are quickly available for plant use. For this reason, they should always be applied in the springtime, just before the crop is planted. They need not be worked deeply into the soil, the upper 3-5 inches will do.

Chemical fertilizers usually come as a dry, granular powder along with a guaranteed nutrient analysis. This analysis lists the percentages of the three most important plant nutrients, nitrogen, phosphorus, and potassium, in that order. For example, a fertilizer that is labeled 10-10-10 contains 10%nitrogen, 10% phosphoric acid, and 10% potash. Some chemical fertilizers also contain other macro- and micronutrients and should list their percentages on the bag as well. Maintenance application of a 10-10-10 or 5-10-5 chemical fertilizer is usually 1-2 lbs. per 100 square feet.

Organic fertilizers are derived from natural sources such as plant and animal residues or rock dust. Organic fertilizers tend to have a lower, more variable nutrient analysis than chemical fertilizers. They also tend to release their nutrients more slowly, over a longer time period. For these reasons, it is often hard to know the nutrient value of a given organic fertilizer. The table below gives some general guidelines of nutrient percentage and availability for select organic fertilizers.

Guide to the Nutrient Value of Organic Materials

Material	% N	% P	% K	Availability
Bone Meal	1	11	0	Slow
Compost	1.5	0.5	1	Slow
Dried Blood	12	1.5	0.5	Rapid
Fish Meal	10	4	0	Slow
Kelp	1	0.5	9	Rapid
Manure-Fresh				
Cow	0.25	0.15	0.25	Medium
Horse	0.3	0.15	0.5	Medium
Sheep	0.6	0.33	0.75	Medium
Swine	0.3	0.3	0.3	Medium
Poultry	2	2	1	Rapid
Milorganite	5	2-5	2	Medium
Peat & muck	1.5	0.25	.5	Slow
Rock Phosphate	0	25	0	Slow
Urea	45	0	0	Rapid
Wood Ashes	0	1-2	3-7	Rapid

Due to their low nutrient analysis, organic fertilizers need to be applied in greater quantities than chemical fertilizers. While chemical fertilizers should be applied in the

spring, most organic fertilizers are best applied in the fall so they have time to decompose and release their nutrients.

Side Dress with Nitrogen

Vegetables and flowers vary in the amounts of nitrogen they need. Usually vegetable crops require most of their nitrogen after they have made considerable growth or have begun to fruit. Too much nitrogen before this time will delay maturity and reduce flowering and yields.

Most of the nitrogen your plants use comes from three sources: The breakdown of organic matter, the yearly maintenance application of fertilizer, and nitrogen side dressings. Until the plant starts fruiting or makes considerable growth, it will receive enough nitrogen from the first two sources.

But afterward, the demand of the plant for nitrogen often exceeds that supplied by the first two, and a nitrogen side dressing is needed. Because vegetable crops vary so greatly in both the amount of nitrogen required and the time of application, the chart at the end of this factsheet was developed for handy reference. Fertilizer requirements for annual flowers do not vary as much, and a single treatment may be made for an entire season.

Care must be taken when applying dry fertilizer around growing plants. The inorganic salts in a chemical fertilizer can burn leaves and roots if they come into direct contact with them. Apply fertilizer 2-4 inches away from the base of the plant and rake lightly into the soil. Water the area after application.

One alternative to applying a dry fertilizer is to use a fertilizer solution. A liquid fertilizer can be applied directly on and around plants without leaf or foot injury and it does not have to be raked and watered in.

A fertilizer solution is made by dissolving 1-¼ ounces of a readily soluble, 15-15-15 fertilizer in 2 ½ gallons of water. (If directions are given on the fertilizer container, follow them instead). Water soil with fertilizer solution at a rate of 1 quart per square foot of soil area. Two liquid waterings are equivalent to one dry application.

Maintaining Organic Matter

So far, we have been primarily concerned with the chemical aspects of garden soils. Just as important are the physical properties of your soil: the soil type and the amount of organic matter. While soil type is hard to change, you can control the amount of organic matter.

Organic matter improves soil structure. It increases water drainage in clay soils while increasing water absorption in sandy ones. Organic matter improves soil aeration, reduces nutrient leaching, and increases microbial activity. Sandy soils should contain 2%-3% percent organic matter; clay soils need 4%-5%.

Annual applications of organic matter are required to reach these levels and maintain them. You can add organic matter to the soil in the form of compost, animal manure, mulches, and cover crops. For the small garden, peat moss is also an excellent source.

Every home should have a compost pile. While there are many forms a compost pile can take, the goal of all compost piles is to turn organic waste into nutrient rich humus. This humus can be tilled into the soil or used as mulch on top of the soil. For more information on composting consult your local extension office.

Animal manure is an excellent source of both nutrients and organic matter. Animal bedding also falls into this category. Animal manure should be well rotted and applied in the fall. One disadvantage to using manure is that it often contains weed seeds. It may also harbor potential human pathogens like *E.coli* and salmonella. For that reason, only aged manure should be applied at least 120 days before harvest. Manure should not be applied as a sidedressing.

Cover crops, or green manures, are legume or small grain crops that are specifically grown to add organic matter to the soil. These crops are plowed under *while still in the green stage*. The green plant tissue quickly decomposes, adding organic material directly into the soil. Your local extension office can give you more information on cover cropping.

Organic mulches are applied around growing crops to suppress weeds and

conserve soil moisture. Over time, mulches gradually decompose into the soil adding organic matter. Mulches are especially good for encouraging earthworm activity in the upper layers of the soil. Earthworms help aerate the soil and their castings provide nutrient rich humus. Some common mulch materials are grass clippings, leaves, hay or straw, peat moss, and shredded paper.

Adding dry, woody plant material such as straw, pine needles, sawdust, or shredded bark directly to the garden soil should be avoided. These materials will draw nitrogen out of the surrounding soil during their decomposition. These materials should first be composted or else used as mulch to allow partial decomposition before they are incorporated into the soil.

Conclusion

Plants depend on the nutrients in the soil to grow and flourish. Maintaining a fertile soil is one of the most important duties of the home gardener. Soil should be tested periodically to determine pH and nutrient content. This information is used to establish a basic soil fertility level. Once this basic level is established, soil fertility is maintained by annual fertilizer application, seasonal side dressing, and organic matter maintenance.

A light fertilizer application at the start of the growing season helps maintain minimum soil nutrient levels. Side dressing during the growing season provides plants with the nutrients they need at critical points in their life cycle. Finally, to maintain soil structure and microbial health, organic matter should be applied at least once a year. Following these maintenance principles will ensure healthy plants and good yields for years to come.

Compiled by Eric de Long
Chemung Co. 11.01, rev. 3.04 S. Reiners

References

Anonymous. *Natural Fertilizers*. Cornell Cooperative Extension of Rockland County fact sheet. 1995.

Anonymous. *Nutrient Management*. National Association of Conservation Districts, Backyard Conservation fact sheet. 1998.

Anonymous. *Soil Preparation With Lime*. Source unknown.

Anonymous. Cornell Cooperative Extension of Columbia County fact sheet.

Eames-Sheavly, Marcia, Robert Kozlowski, and Joan Gruttadaurio, eds. *A Guide to the Nutrient Value of Organic Materials*. Cornell Cooperative Extension fact sheet.

Gaus, Art, Vic Lambeth, and Ray Rothenberger. *Steps In Fertilizing Garden Soil*. United States Department of Agriculture fact sheet 4-5-2. 1978.

Gruttadaurio, Joan, ed. *Soil Preparation and Fertilizer for the Home Flower & Vegetable Garden*. Cornell Cooperative Extension of Washington County fact sheet.

Gutierrez, Dorianne, ed. *Soil Building*. Troy, NY: Capital District Community Gardens.

Utzinger, James D., William B. Brooks, and E.C. Wittmeyer, eds. *Improving Soils For Vegetable Gardening*. Cornell Cooperative Extension of Albany County fact sheet. 1991.

RECOMMENDED NITROGEN SIDE DRESSINGS

Crop	Amount of Side Dressing (Lbs of Ammonium Nitrate* per 100-foot row)	Times of Application
Tomato	1	1) 1 to 2 weeks before first tomato ripens 2) 2 weeks after picking first ripe tomato 3) 1 month later
Cucumber, Cantaloupe	1	1) 1 week after blossoming begins 2) 3 weeks later
Sweet Corn	1	1) When plants are 8”-10” tall 2) 1 week after tassles appear
Asparagus	2	Before growth begins in spring
Potato	1 ½	After tuber formation starts
Peas & Beans	1	After heavy bloom and set of pods
Peppers, Eggplants	1	After first fruit sets
Cabbage, Cauliflower, Broccoli	1	3 weeks after field transplanting
Spinach, kale, mustard & turnip greens	1	When plants are about one-third grown
Onions (mature)	1	1 to 2 weeks after bulb formation begins
Sweet potatoes, watermelons, carrots, beets, turnips, lettuce	None	Excessive amounts of nitrogen will reduce yields of lower quality or both.
Annual Flowers	1	4 to 6 weeks after planting

*Ammonium Nitrate analysis is 33-0-0. Other forms of nitrogen may be used on an equivalent basis.