K-STATE Kansas State University Research and Extension

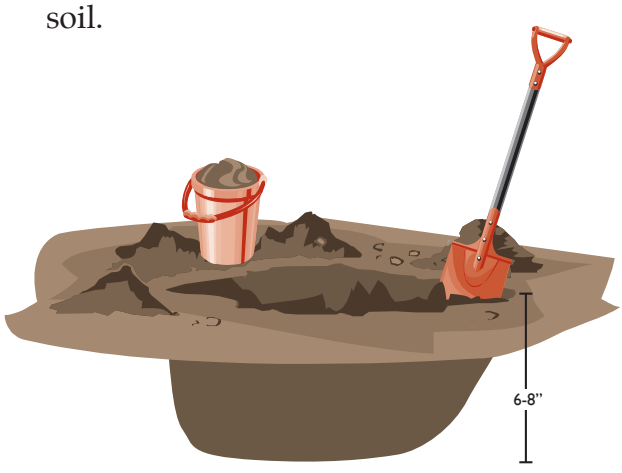
Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Fertilizing Gardens in Kansas

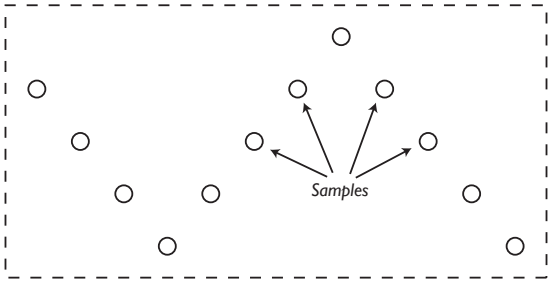
The Soil Test

The soil test provides a starting place for a soil improvement program for the home gardener. Unless you know the problems in your garden soil, you are only guessing when you apply fertilizer. Check with your local K-State Research and Extension office for soil testing information.

Use a soil probe, spade or shovel to sample the soil profile to a depth of 6 to 8 inches. It is important to obtain a representative sample of the soil in the root zone rather than only the surface soil.



Slice for sample: 6 to 8 inches deep by 1 to 1½ inches wide.



Take several subsamples (at least 10) around the garden area, then combine these in a clean bucket or pail. This gives a representative sample of the entire garden area.

From the bucket or pail, select about a pint of soil. Special soil sample containers are available from your local K-State Research and Extension office or fertilizer supplier. Or you may use a clean milk carton, ice cream container or similar package. Plastic bags work well also. Make sure the container is clean and labeled with your name, address, and information on the garden crops grown. If you send more than one sample, label each plainly.

Your local office will send the sample to the Kansas State University soil

testing laboratory and make recommendations on the amounts of fertilizer to use on your garden area. Rely on K-State Research and Extension for information and advice about your gardening problems.

Fertilizers

The nutrient elements required by plants can be supplied by organic or commercial fertilizers. All plants require 17 nutrient elements for growth. Fourteen of these come from the soil. When organic fertilizers are used, they must break down to release fertilizer elements to inorganic ions in the soil that plants can use.

It makes no difference whether the fertilizer is organic or chemical as long as essential nutrients are there. In addition to providing nutrients, organic fertilizers improve the physical condition of the soil. However, organic materials must be used in large quantities compared to commercial fertilizers, which are more concentrated.

Organic Fertilizers

Organic matter is vital. When incorporated into the soil, decaying organic residue serves several useful functions:

- Loosens tight clay soils to provide better drainage.
- Provides for better soil aeration which is necessary for good root growth.
- Increases the water-holding capacity of all soils. This is especially helpful on sandy soils.
- Makes soil easier to till and more easily penetrated by plant roots.
- Supplies nutrients for plant growth.

Cover Crops

Plowing under a cover crop will provide organic residue to give the useful benefits listed above. These crops are generally seeded in the fall and turned under with a plow or heavy garden tiller in the early spring. Seed the cover crop in mid-September. This cover protects the garden from erosion during winter months. Turn

Approximate Composition of Some Organic Fertilizers

Material	Nitrogen (N)	Phosphorus (P)	Potassium (K)
		Percent	
Bat Guano	3	10	1
Blood Meal	12	1	1
Alfalfa Meal	5	1	2
Cottonseed Meal	5	2	1
Feather Meal	12	0	0
Coffee Grounds	2	0.5	1
Cow Manure, Fresh	0.5	0.1	0.4
Cow Manure, Dried	2	1	1
Poultry Mature, Dried	3	3	1
Feedlot Manure, Dried	2	1	1
Bone Meal	2	14	0
Worm Castings	1	2	1
Wood Ashes*	0	1	5

Other commercial or processed fertilizers may be available. Consult label for variation in nutrient content by brands/sources. Organic materials should be incorporated into the soil and allowed to decompose if full fertilizer value is to be available.
* Do not use wood ashes unless your soil is low in pH.

the cover crop under when it is 6 to 8 inches tall in the spring, or earlier if you plant an early spring garden. Per 1,000 square feet of garden space, use:

annual ryegrass ..... 1–2 lbs
rye..... 3–4 lbs
wheat..... 3–4 lbs

Composting

Compost is composed largely of decaying plant materials. It can be made by piling any type of plant material such as leaves, cornstalks, weeds, straw, sawdust, waste hay, garden trash or other waste material into a pit, pile, or enclosed bin. The addition of small amounts of commercial fertilizers and garden soil to each bushel of material will speed the decaying process and increase the fertilization value. Keep the pile damp and turn or stir it occasionally. Use the compost from last summer and fall on next spring's garden at the rate of 1 to 2 bushels per 100 square feet. This would equal a ¼- to ⅓-inch layer spread over the surface of the soil.

Other Organic Fertilizers

Stable manures — Use 1 to 2 bushels per 100 square feet. This would equal a ¼ to ⅓ inch layer spread over the surface of the soil. This type of manure includes both fresh and dried cow or horse manure.

Poultry and sheep manure — These are more concentrated forms of manure and should be used more sparingly. The recommended rate is ½ bushel per 100 square feet.

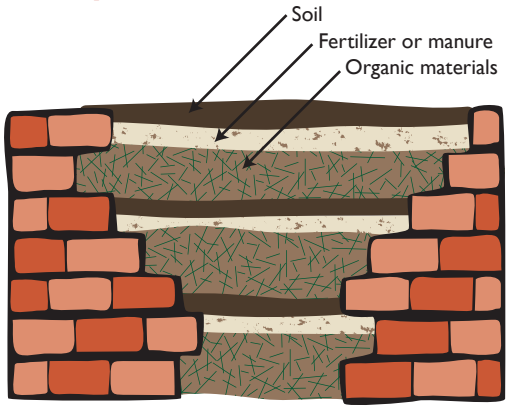
Rotted sawdust, shredded leaves, cornstalks and other plant residue — These materials should be composted six months to a year before being used. Use 3 to 4 bushels per 100 square feet or about ½-inch layer spread over the surface.

Feedlot manure — This concentrated manure should be used sparingly, ½ bushel per 100 square feet. Excessive use of this manure may build up salt contents in the soil.

Note: Organic fertilizers should be mixed into the soil before planting.

A wire container used to accumulate yard waste, which will slowly decompose over time. Not everyone builds a perfect compost pile.

Compost Pile



Materials are layered when making a compost pile. When the pile cools, turn (mix) the pile.

Chemical Fertilizers

The Analysis — Plants require 17 essential nutrients for growth with the nutrients most frequently lacking for growth being nitrogen, phosphorus, and potassium.

N (Nitrogen) — This nutrient element provides dark green color in plants. It promotes rapid vegetative

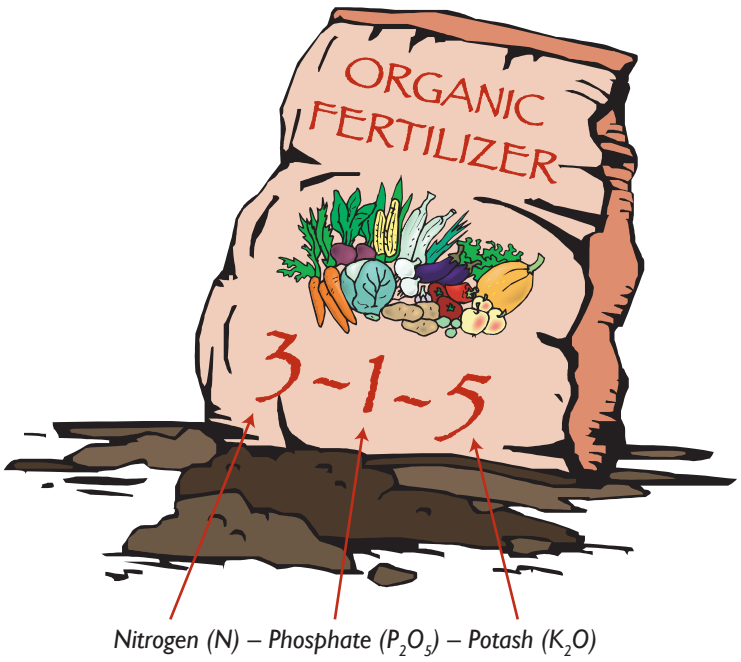
growth. Plants deficient in nitrogen have erect stems, pale or yellow foliage showing first on older leaves, and smaller-than-normal leaves.

P (Phosphorus) — This nutrient promotes early root formation, gives plants a rapid, vigorous start and hastens blooming and maturity. Plants deficient in this element have shortened stems and the leaves often develop a purplish color.

K (Potassium) — Potassium or potash hastens ripening of fruit. Plant disease resistance as well as general plant health depends on this element. It is important, also, in developing plump, full seeds. Plants deficient in this element have graying or browning on the outer edges of the older leaves.

The content of N, P and K is specified on bags of chemical fertilizers. The analysis or grade refers to the percent of nitrogen, phosphate and potash (in that order) the bag contains. Thus a 10-10-10 fertilizer contains 10 percent nitrogen (N), 10 percent phosphate (P_2O_5) and 10 percent potash (K_20).

To calculate the amount of fertilizer needed for an area, consider the recommendation for the particular nutrient needed and the fertilizer analysis.



Levels of major plant nutrients are printed on fertilizer bags.

If you need to add 1 pound of N per 1,000 square feet, and you have a 10-10-10 fertilizer (which contains 10 percent N) you will have to add 10 pounds of this material per 1,000 square feet to achieve the needed amount of N.

The Ratio — Sometimes the term, ratio, is used when referring to fertilizer analysis. The ratio is the relationship of the contents of N, P and K to each other. For example, a 1-1-1 ratio means there are equal proportions of N, P_2O_5 and K_2O such as 10-10-10 analysis. However, a 2-1-1 ratio means there is twice as much N as P_2O_5 and K_2O such as is true for 10-5-5. The ratio does not indicate the content of the elements but only their relationship to each other.

Other Nutrients — In addition to N, P and K there are 14 other elements that plants require, 11 of which come from the soil. It is not usually necessary to add these elements since they are often present in sufficient quantities in Kansas soils. However, on occasion it may be necessary to add one or more of these secondary and micronutrients. One of the most common of these micronutrient elements found lacking is iron in high pH soils commonly found in western Kansas. The symptom of iron deficiency is a pale yellow color that develops in the new growth of the plants. This can be corrected by a foliar application of iron or by reducing the soil pH. There also may be need for sulfur or zinc on very sandy soils or garden areas with topsoil recently removed.

Methods of Application

Broadcast — Most fertilizers are applied by distributing the material uniformly over the surface of the soil. This is generally done before plowing

Fertilizer Analysis

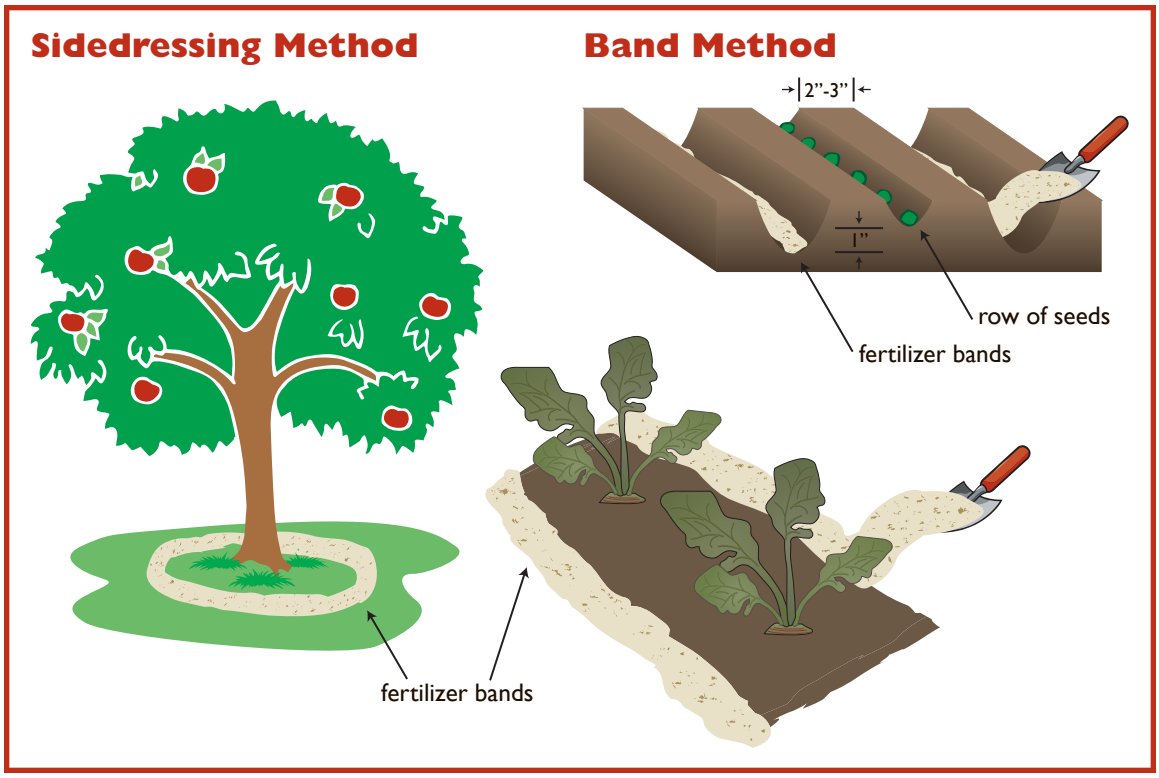
	Fertilizer Sources	Analysis
Nitrogen sources	Ammonium sulfate	20.5-0-0
	Nitrate of soda	15-0-0
	Nitrate of potash	13-0-44
	Urea	46-0-0
Phosphorus souces	Monoammonium phosphate	11-52-0
	Diammonium phosphate	18-46-0
Potassium sources	Potassium chloride	0-0-60
Sulfur sources	Elemental sulfur	98+% sulfur
	Copper sulfate	20% sulfur
	Ammonium sulfate	24% sulfur
Iron sources	Iron chelate	6%, 10% or 12% iron for foliar or soil application.
Other commercial sources of iron may be available. Consult the label for iron content.		
Zinc sources	Zinc sulfate	36% zinc
	Zinc chelates	variable
Other commercial sources of zinc may be available. Consult the label for zinc content.		
Magnesium sources	Epsom salts ($MgSO_4$)	10.4% magnesium
Some types of limestone (Dolomitic) will also be sources of magnesium.		
Boron sources	Borax	11.3% boron
Other commercial boron sources may be available. Consult the label for boron content.		

or tilling so the nutrients can be incorporated into the soil. This allows the plant roots to have easy access to the fertilizer materials. Soil incorporation of plant nutrients before planting is particularly important for deep-rooted perennial plants such as asparagus, rhubarb, tree fruits, and grapes.

The application can be made with a small fertilizer spreader, calibrated to deliver a quantity of fertilizer on a given area. It is also possible to distribute the fertilizer by hand but it is usually more difficult to achieve uniform coverage. Incorporation is more important for phosphorus and potassium because of low mobility in soils compared to nitrogen.

Band — For some crops it may be desirable to apply the fertilizer in a band or narrow stream near the row of vegetable seeds or plants or under the branch area of a fruit tree. It is generally advisable to place the fertilizer a few inches to the side and an inch or so below the seeds in the row. Applying fertilizer, especially N, P, K, in direct contact with the seeds may result in damage to the seeds or greatly reduce stands.

Sidedressing — "Sidedressing" is an application of fertilizer at the side of the plant row sometime during the growing season. For application of nitrogen, particularly in sandy soils, it is generally best to add part of the required N at the beginning of the season and the remaining N as a sidedressing part of the way through the season. Nitrogen in particular is well



adapted to this method of application because it is subject to leaching or being washed into the soil.

Starter Fertilizer

Starter fertilizers are used to provide nutrients to young plants in order to get them off to a rapid, vigorous start. These materials are usually rich in phosphorous and applied as a liquid solution for transplants. Liquids or dry fertilizers rich in phosphorus can also be used as a band placement near seeded crops.

Commercially available starters are available for this purpose from your local garden supply dealer. However, you can make a starter solution from your ordinary garden fertilizer by adding 2 tablespoons of phosphorus-rich fertilizer to a gallon of water. After allowing this to dissolve for several hours with occasional stirring, the liquid solution will contain enough of the fertilizer elements to serve as a starter fertilizer. Use about 1 cup of this solution around each plant at transplanting time.

Foliar Feeding

In emergency situations it may be possible to add certain nutrients by application to the foliage when nutrient deficiency symptoms develop. Every attempt should be made to add the necessary nutrients to the soil before symptoms develop because foliar application of nutrients should only be used as an experimental or emergency treatment. Unless the soil conditions causing the symptoms are corrected, they will appear again soon.

Better coverage of the foliage can be obtained by using a commercial wetting agent or a few drops of detergent in the solution. Apply the sprays in early morning or late afternoon, on a cloudy day or soon after a rain. Mixing of these elements with one another or with a pest control spray may cause mixing problems. **Do not attempt to mix foliar nutrients with pest control sprays.**

Fertilizing Fruit Plants

Fruit and nut plants usually grow and produce quite well under a fairly

wide range of soil conditions. Their requirements for and response or lack of response to applied nutrients may be quite different from that of vegetable plants.

Excessive use of fertilizers may be detrimental to fruit plants. Too much nitrogen may delay fruit maturity, retard red color development of the fruit and reduce plant hardiness to low temperatures. Also, excess quantities of some elements may result in the deficiency of others.

Some characteristics of healthy fruit and nut plants include large, green leaves characteristic for the kind of tree, fruits set on and developing normally, and a relatively smooth bark on the trees. Older trees may naturally have some scaliness on the trunks.

Signs that plants are low in nutrition include leaves that are small, yellow or other abnormal color; poor annual branch growth; small, highly colored fruit; reduced fruit set; and excessive winter injury to wood.

Nitrogen is the most important nutrient for growing tree fruits and grapes and usually the first element to cause poor tree and fruit growth.

The addition of organic residues/compost to soils before and after planting generally is beneficial to plants. This material helps hold moisture and supplies nutrients.

The ideal time to determine fertility levels and add needed elements where fruit is to be grown is before planting. A soil test will show the levels of the required elements in the soil. After perennial plants are planted, it is considerably more difficult to place the needed nutrients in the root area, except for nitrogen which would move downward with moisture.

Controlling Soil pH

The pH of the soil is a measure of the acidity or alkalinity of a garden soil. The standard measurement for soil acidity is called the pH or soil reaction. Most plants grow best in a soil that is neither too acid nor too alkaline. Because of the parent rock materials, previous fertilizer use, cropping sequence or other factors, the pH of the soil may differ from the desirable range.

Some Useful Measures

1 acre = 43,560 square feet

100 lbs/acre = approximately 2 lbs/1000 square feet

2 tablespoons (level) = 1 ounce

8 ounces = 1 cup

2 cups = 1 pint

1 pint (2 cups) = 1 pound of most dried fertilizer materials

Fertilizer for Foliar Feeding (Use only in an emergency)

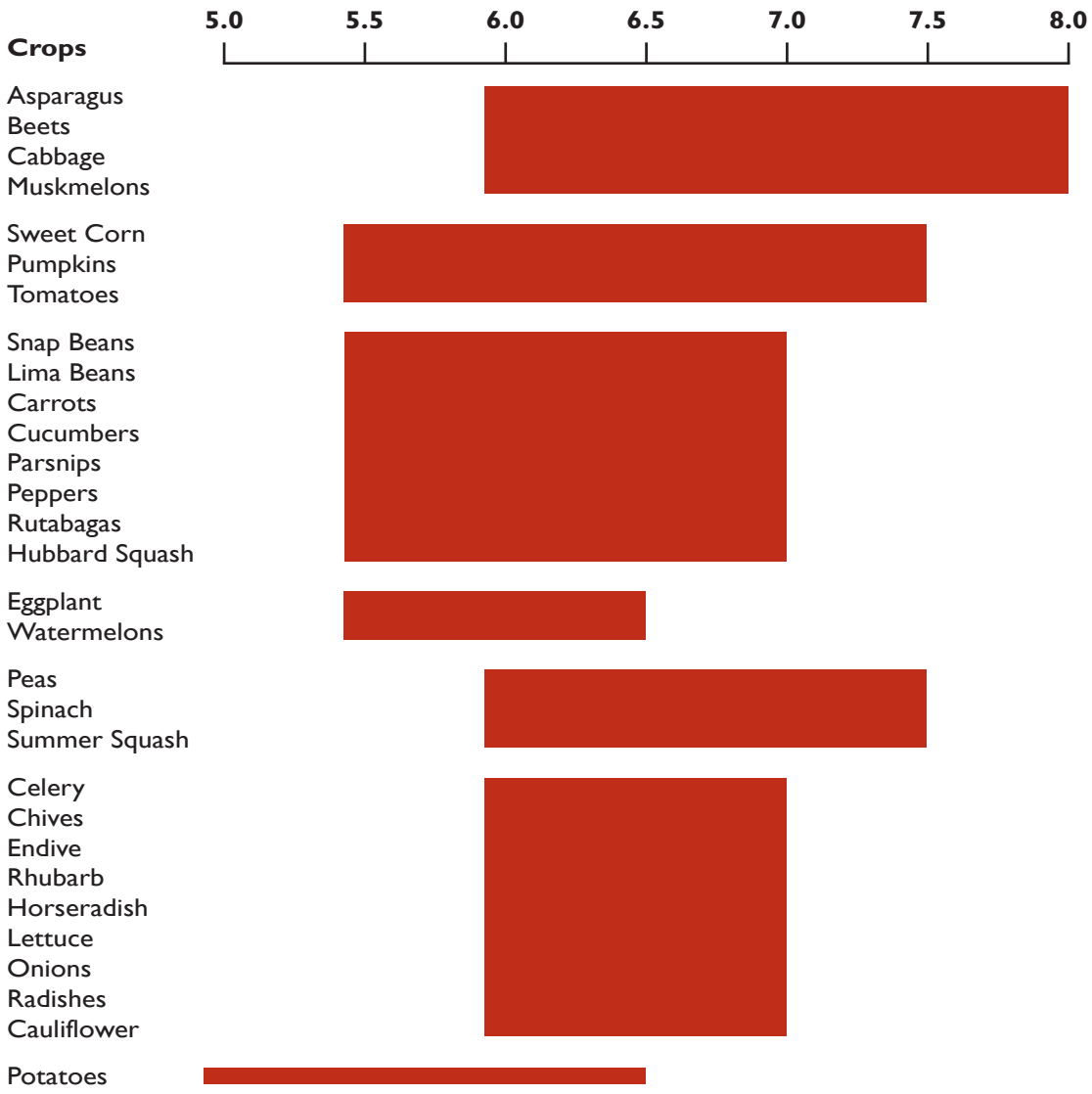
Element	Material	Oz./3 gal. water per 1,000 sq ft	Remarks
Iron	Iron Chelate	Follow package directions	Iron deficiency found when pH is above 6.8. Use iron chelate containing EDDHA if pH is above 7.2.
	Iron Sulfate	0.5 oz.	
Magnesium	Magnesium Sulfate	4–5 oz.	Use more than one application
Nitrogen	Urea	2–3 6–7 9–10	Most crops Potatoes Carrots, parsley and onions
Calcium	Calcium Chloride	2	Direct at the growing point
Manganese	Manganese Sulfate	1–2	

One part of the soil test is measurement of the soil pH and, if acid, recommendation of amount of lime to reduce soil acidity. Sulfur may be used on alkaline soils to reduce the pH to the desired level.

Some eastern Kansas gardens may have problems with soils becoming too acid, while the soils in western Kansas will tend to be alkaline.

Your local K-State Research and Extension agent can recommend the desired amount of lime or other material needed to correct the soil pH based on soil test results. See page 12 for a list of liming materials. Often, correcting soil pH can be as important as adding fertilizer materials to improve plant growth. Do not neglect this significant part of the soil test.

Optimum pH Range for Vegetable Crops



Information from "Liming Vegetable Crops," University of Illinois Cooperative Extension Service.

Materials to Add to Correct Soil pH

Lime (to increase pH)

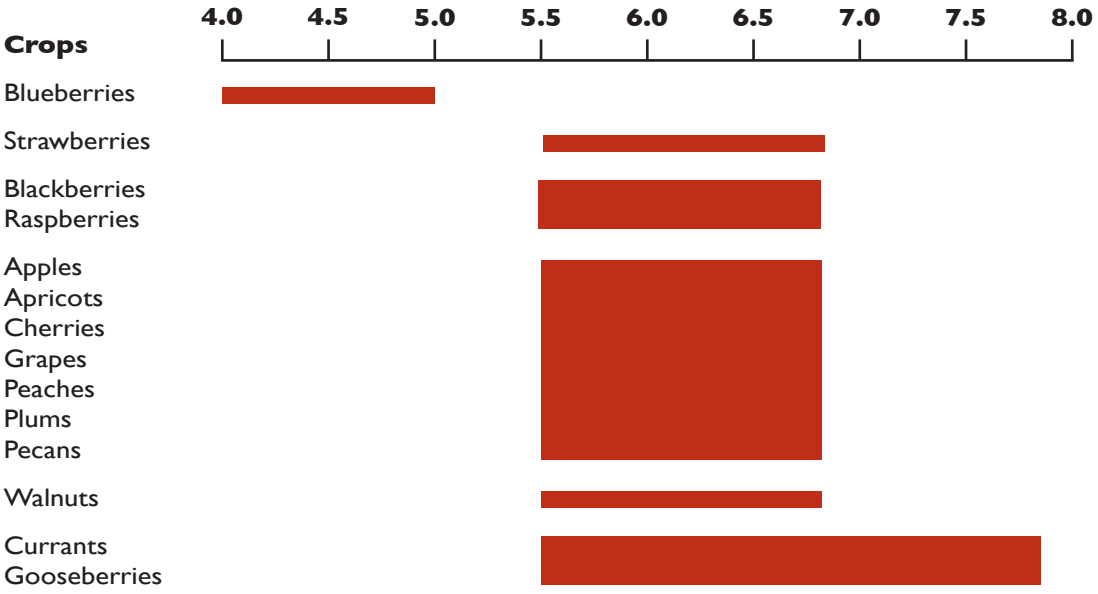
pH level from soil test (increase to 6.5)	Pounds ground limestone/100 sq ft		
	Sandy Soil	Loam Soil	Clay Soil
4.0	11	16	23
4.5	9	13	19
5	7	10	15
5.5	6	7	10
6	3	4	5

Sulfur (to lower pH)

pH level from soil test (decrease to 7.0)	Pounds sulfur (95%)/100 sq ft		
	Sandy Soil	Loam Soil	Clay Soil
7.5	1.5	2	3
8	3	4	5
8.5	5	6	7
9	8	8	8

Add all materials to soil and incorporate to a depth of 6 inches with soil tillage when no crops are growing in the garden area. Note: Specific recommendations by your local agent may vary from these amounts based on local conditions and knowledge of specific soil factors. Use local recommendations instead of this table if available.

Optimum pH Range for Fruit and Nut Crops



Deciding How Much Fertilizer to Apply

Soil test results determine whether to apply low, medium, or high rates of nitrogen, phosphorus, and potassium. See table at right. Suggested amounts of each can be found in the tables below.

Recommendations for Fertilizer Additions Based on K-State Soil Test Results

	Soil test interpretation
Nitrogen* (Available nitrogen from lawn and garden soil test)	0–25 ppm – low 25–50 ppm – medium 50–80 ppm – high
Phosphorus* (P from soil test results)	0–25 ppm – low 25–100 ppm – medium 100+ ppm – high
Potassium* (K from soil test results)	0–125 ppm – low 125–250 ppm – medium 250+ ppm – high
pH	See the following tables for materials and amounts to correct pH.

*If you do not have soil test results, follow recommendations for a medium application level.

Suggested Fertilizer Rates for Fruit and Nut Crops

Crop	When to apply	N			P_2O_5			K_2O		
		High	Med	Low	High	Med	Low	High	Med	Low
Strawberries (New planting)	*Before planting:* Broadcast over entire area during site preparation and incorporate before setting plants.	Pounds to apply per 1,000 sq ft								
		0	1	1.5	0	1	1.5	0	1	1.5
Strawberries (After harvest)	*After harvest:* Broadcast over row area immediately after harvest and in mid-August. Remove excess fertilizer from plants with water, broom or similar method.	Pounds to apply per 1,000 sq ft								
		0	1.5	3	0	1.5	3	0	1.5	3
Bush Fruits Blackberries, Currants, Raspberries, Gooseberries	Apply in early spring before growth begins. Broadcast or band around individual plants.	Ounces to apply per plant								
		0	0.75	1.25	0	1	1.75	0	1	1.75
Grapes	Apply in 4-foot diameter circle or 6- to 8-inch band around each vine; apply in early spring before growth begins.	Ounces to apply per vine								
		0	1	1.5	0	1	1.75	0	1	2
Apples and Pears	Band or broadcast in late winter under drip area of tree; keep at least a foot from trunk of mature trees.	Ounces to apply per tree								
		0	2*	3*	0	2	3	0	2	3
Apricots, Cherries, Peaches, Plums	Same as apples and pears.	Ounces to apply per tree								
		0	2*	3*	0	2	3	0	2	3
Pecans, Walnuts	Same as apples and pears.	Ounces to apply per tree								
		0	3*	4*	0	2	3	0	2	3

* Nitrogen rates listed are per tree for each year of tree age up to a maximum of 1 pound per tree for dwarf apples and other tree fruits, 2 pounds for mature standard size apple trees and 4 pounds for mature nut trees. If grass sod is growing under the trees, double the rate of nitrogen or apply in a 2- to 3-inch band.

Suggested Fertilizer Rates for Vegetable Crops

Crop	When to apply	Pounds to apply per 1,000 sq ft								
		N			P_2O_5			K_2O		
		High	Med	Low	High	Med	Low	High	Med	Low
Legumes Dry Beans, Snap Beans, Lima Beans, Peas	Before or at planting	0	0.75	1	0	1	1.5	0	1	1.5
	Notes: Use lower nitrogen on all crops if manure or other organic residues were used. Only peas are sidedressed. Apply 2 to 3 weeks after emergence (except in dry weather).									
Leafy Green Vegetables Lettuce, Endive, Mustard, Spinach, Collards, Kale	Broadcast before planting and incorporate	0	1	1.5	0	1	1.5	0	0.5	0.75
	Notes: These crops respond to nitrogen fertilizers. Only collards and kale are sidedressed. Apply when plants reach ⅓ size.									
Vine Crops Cantaloupes (or Muskmelons), Cucumbers, Watermelons, Squash, Pumpkins	Broadcast before planting and incorporate	0	0.25	0.33	0	0.5–0.75	1.5	0	.75	1.5
	At planting (band)	0	0.5	0.75	0	0.5	1	0	0.5	1
	Notes: Reduce N if manure or other organic residue is used. Fertilizer should be broadcast and incorporated before planting for cantaloupes and cucumbers. Watermelons, squash and pumpkins should have fertilizer banded at planting. Pumpkins: Sidedress when vines begin to run.									
Perennial Vegetable Crops Asparagus, Rhubarb	On new plantings	0	1	1.5	0	2	2	0	1	1.5
	On established plantings	0	0.5	0.75	0	1	1.5	0	0.5	0.75
	Notes: Incorporate organic residue/compost in new plantings. Use more potash than listed for soils that are very sandy. Established plantings should be fertilized in before spears appear in the spring. Rhubarb should be sidedressed in June and asparagus should be sidedressed when harvest ends.									
Root Crops Carrots, Radish, Beets, Turnips, Rutabagas, Onions, Potatoes	Before or at planting	0	0.5	1	0	1	2	0	1.5	2.5
	Notes: Only onions and potatoes are sidedressed. Sidedress onions 2 to 3 weeks after plants emerge. Sidedress potatoes when plants are 6 to 8 inches tall.									
Root Crops Sweetpotatoes	Broadcast before planting or below the ridges	0	0.25	0.5	0	.5	1	0	0.75	1.5
	Notes: Use a starter solution at transplanting. Sidedress in July.									
Transplanted Crops Tomatoes, Peppers, Eggplant	At planting broadcast	0	0.5	1	0	1.5	3	0	1.5	3
	Notes: Use a starter solution at transplanting. Sidedress when first fruits are small (walnut size).									
Crucifers Cabbage, Broccoli, Cauliflower	Broadcast before planting	0	0.5	1	0	0.75	1.5	0	0.75	1.5
	Notes: Sidedress 1 to 2 weeks after planting and again 2 weeks before harvest.									
Sweet Corn	In bands at planting time	0	0.5	1	0	0.75	1.5	0	0.5	1
	Notes: Sidedress when corn is 8 to 12 inches tall. Double the normal rate. On sandy soils, a second sidedressing may be beneficial.									

Sidedressing is done by applying fertilizer near the plants and watering in. Use a high nitrogen fertilizer such as a 27-3-3, 30-3-4, 29-5-4 or something similar at the rate of 1 pound (1 cup) per 100 feet of row. Many of these fertilizers are lawn fertilizers but will work well as long as they contain no weed killers or weed preventers. If using nitrate of soda (16-0-0), double the rate.

Types of Liming Materials

Material	Chemical composition	Neutralizing equivalent*
Crushed limestone	Calcium carbonate ($CaCO_3$)	100
Dolomite	Calcium-magnesium carbonate ($CaCO_3$—$MgCO_3$)	108
Burned or lump lime	Calcium oxide (CaO)	150–175
Hydrated or slake lime	Calcium hydroxide ($Ca(OH)_2$)	120–135

*Neutralizing equivalent based on calcium carbonate being 100 percent and the material very finely ground.

Get the Most Out of Your Fertilizer

1. Select soil well adapted to crop growth because fertilizer will prove more profitable on good soil than on poor soil. A well-adapted soil is well drained, deep and free from rocks or other debris. It should be fairly level, especially for vegetables.
2. Get a soil test. Do not guess about soil fertility or other soil problems. Find out exactly what your soil needs.
3. Add organic matter where practical. It can provide additional benefits other than merely providing soil nutrients.
4. Control weeds and use sound cultural practices.
5. Select only the best plants and seeds.

Revised by Ward Upham, M.S., Extension Associate, Horticulture, Forestry, and Recreation Resources

Adapted from *Fertilizing Gardens in Kansas* by Charles W. Marr, Frank D. Morrison, David A. Whitney, January 1998.

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