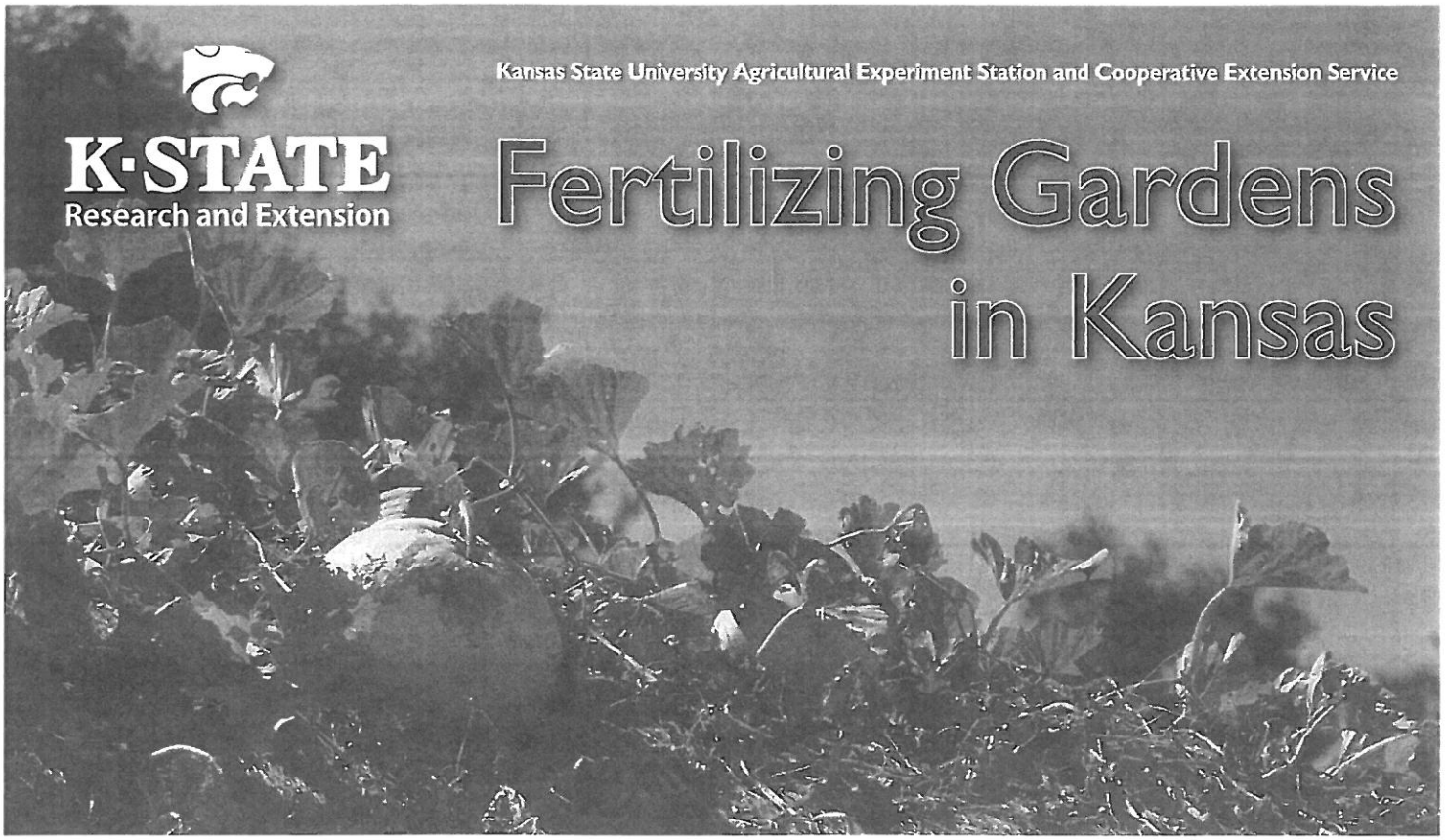
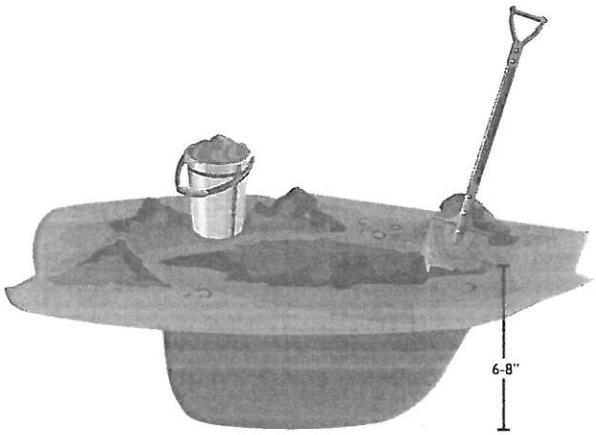
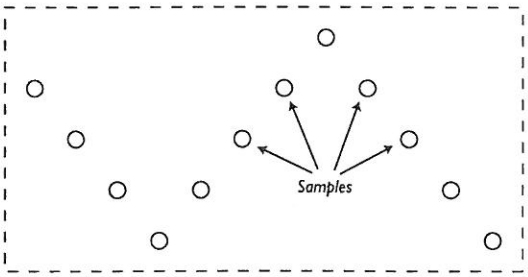


The Soil Test

Any effort to improve garden soil should begin with a soil test. Unless you know your soil's composition, you are only guessing when you apply fertilizer. Use a spade, shovel, or soil probe to sample the soil profile 6 to 8 inches deep. Your sample should represent the soil in the root zone as well as at the surface. Take at least 10 subsamples from around the garden and combine them in a clean bucket or pail.



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



Select about a pint of this soil and place it in a container labeled with your name, address, and crops grown. You can pick up a soil sample container from your local K-State Research and Extension office or fertilizer supplier. Or you can use a plastic bag, clean milk carton, ice cream container, or similar package.

If sending more than one sample, plainly label each one. Your local office will send the samples to the K-State soil-testing laboratory and make fertilizer recommendations based on results.

Fertilizers

All plants require 17 nutrient elements for growth, and 14 of these come from the soil. These nutrients can be supplied with organic materials or commercial fertilizers. It makes no difference whether you use an organic or chemical fertilizer as long as it contains essential nutrients. Organic materials improve the physical condition of the soil but must be used in larger quantities than commercial fertilizers, which are more concentrated. Organic fertilizers must be broken down to release nutrient elements in a form plants can use.

Organic Fertilizers

Incorporating organic materials into the soil 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 soil's water-holding capacity, which is particularly helpful on sandy soils.
- Makes soil easier to till and for plant roots to penetrate.
- 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 the cover crop under when it is 6 to 8 inches tall in the spring, or earlier if preparing for 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

Approximate Composition of Some Organic Fertilizers

Material	Nitrogen (N)	Phosphorus (P)	Potassium (K)
		Percentage	
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 the 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.

Composting

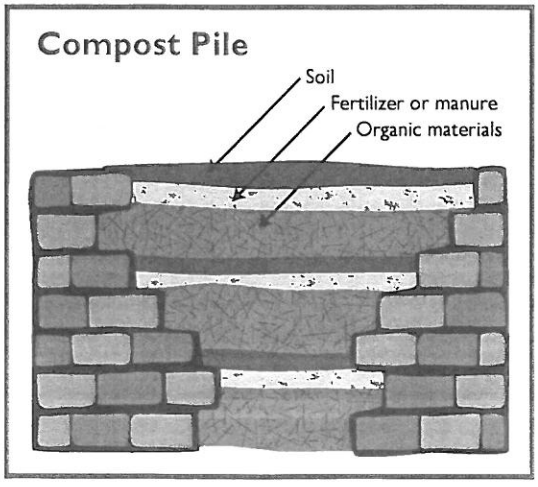
Compost consists largely of decaying plant materials. It can be made by piling any type of plant material such as leaves, cornstalks, weeds, straw, sawdust, waste hay, garden trash, or other waste material into a pit, pile, or enclosed bin. The pile should be a minimum of 3 feet in diameter to make good compost. Adding small amounts of commercial fertilizers and garden soil to each bushel of material speeds the decomposition process and increases fertilization value. Keep the pile damp and turn or stir it occasionally.

Compost from the summer and fall can be used on the garden the following spring. Apply at the rate of 1 to 2 bushels per 100 square feet, which equals a ¼- to ⅓-inch layer spread over the soil surface.

Other Organic Fertilizers

Stable manures — These include both fresh and dried cow or horse manure. Use 1 to 2 bushels per 100 square feet, which equals a ¼- to ½-inch layer spread over the surface of garden soil.

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



Layering of compost pile materials. When the pile cools, turn (mix) to supply oxygen required for decomposition.

Instead of building a compost pile, you can accumulate yard waste in a wire container and let it decompose naturally over time.

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

Feedlot manure — This concentrated manure should be used sparingly, about ½ bushel per 100 square feet. Excessive use may increase salt content of the soil.

All organic fertilizers should be mixed into the soil before planting.

Chemical Fertilizers

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

N (Nitrogen) — This nutrient element gives plants their dark green color and promotes rapid vegetative growth. Signs of nitrogen deficiency include erect stems, pale or yellow foliage appearing first on older leaves, and leaves that are abnormally small.

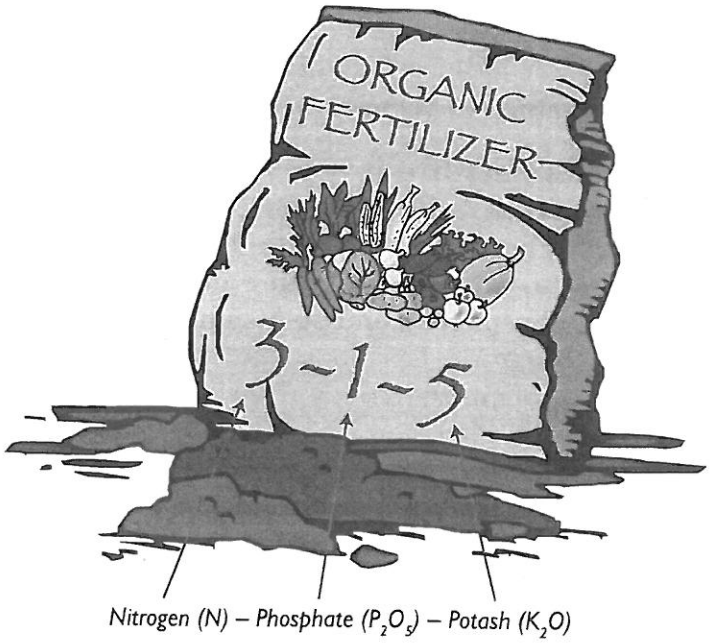
P (Phosphorus) — This nutrient promotes early root formation, gives

plants a rapid, vigorous start, and hastens blooming and maturity. Plants deficient in this element have shortened stems. Leaves often develop a purplish color.

K (Potassium) — Potassium or potash hastens fruit ripening, promotes disease resistance, and general plant health. Potassium is important for developing plump, full seeds. Graying or browning on the outer edges of older leaves may indicate a deficiency.

Bags of chemical fertilizers specify the amount of nitrogen, phosphate, and potash the product contains, in that order. A 10-10-10 fertilizer, for example, contains 10 percent nitrogen (N), 10 percent phosphate (P_2O_5), and 10 percent potash (K_2O).

To calculate the amount of fertilizer for an area, consider the recommendation for the particular nutrient required and the fertilizer analysis. If the recommendation is 1 pound of N per 1,000 square feet and you have a 10-10-10 fertilizer containing 10 percent N, you would need to add 10 pounds of this material per 1,000 square feet to provide the proper amount of nitrogen.



Levels of major plant nutrients are printed on fertilizer bags.

The ratio — The term ratio may be used in reference to fertilizer analysis. The ratio is the relationship of the contents of N, P and K to each other. A 1-1-1 ratio indicates equal proportions of N, P_2O_5 and K_2O as in a 10-10-10 analysis. A 2-1-1 ratio means there is twice as much N as P_2O_5 and K_2O as in 10-5-5. The ratio does not indicate the content of the elements, but rather their relationship to each other.

Other nutrients — In addition to N, P and K, plants require 14 other elements, 11 of which come from the soil. It usually is not necessary to add these elements because they are often present in sufficient quantities in Kansas soils. On occasion, it may be necessary to add one or more secondary and micronutrients. Iron is one micronutrient element often unvailable in high pH soils in western Kansas.

Pale yellow color that develops in new plant growth may indicate iron deficiency. This can be corrected with a foliar application of iron or by reducing soil pH. Very sandy soils or garden areas where topsoil has been recently removed may need sulfur or zinc.

Application Methods

Broadcast — Most fertilizers are applied uniformly over the soil surface. Generally, this is done before plowing or tilling so nutrients can be incorporated, providing plant roots with easy access to fertilizer materials. Incorporating plant nutrients into soil before planting is particularly important for deep-rooted perennial plants such as asparagus, rhubarb, tree fruits, and grapes.

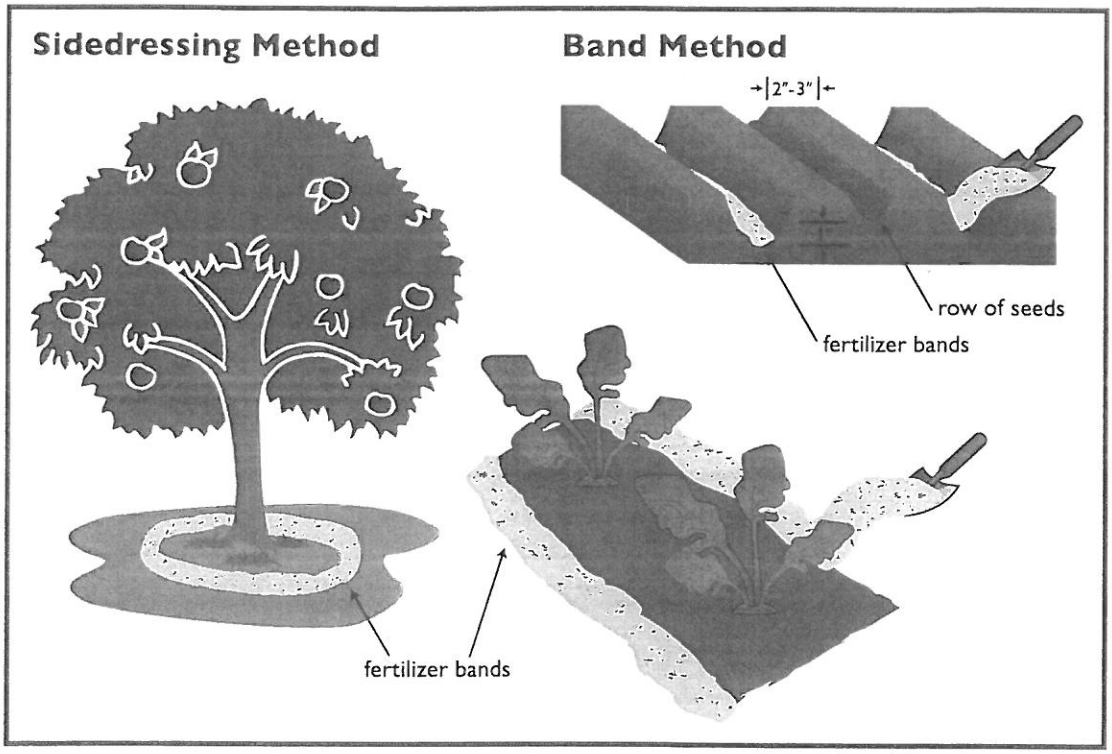
Fertilizer Analysis

	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 sources	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) also provide magnesium.		
Boron sources	Borax	11.3% boron
Other commercial boron sources may be available. Consult the label for boron content.		

The application can be made with a small fertilizer spreader, which has been calibrated to deliver a quantity of fertilizer on a given area. Fertilizer can be distributed by hand, but with this method, it is more difficult to achieve uniform coverage. It is more important to incorporate phosphorus and potassium into the soil because of their 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, placing it 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 damage the seeds or greatly reduce stands.

Sidedressing — This term refers to the application of fertilizer at the side of the plant row during the growing season. For application of nitrogen, particularly in sandy soils, it is best to add part of the required N at the beginning of the season and the remaining N as a sidedressing part way through the season. Nitrogen is given to leaching or being washed into the soil and is particularly well-suited to this application method.



Starter Fertilizers

Starter fertilizers provide young plants with nutrients for a rapid, vigorous start. These materials are usually rich in phosphorus and applied to transplants in a liquid solution. Phosphorus-rich liquids or dry fertilizers can be placed in a band near seeded crops.

You can buy starter fertilizer from the local garden supply dealer or make your own. Do this by adding 2 tablespoons of phosphorus-rich garden fertilizer to a gallon of water. After letting this dissolve for several hours with occasional stirring, the solution should contain enough fertilizer elements to work as a starter. Use about 1 cup of the fertilizer solution around each plant at transplanting time.

Foliar Feeding

When deficiency symptoms develop, certain nutrients can be applied to the foliage. Make every effort to add required nutrients to the soil before symptoms develop, reserving foliar applications for emergencies or experimental treatments. Symptoms will reappear unless soil conditions causing the problem are corrected.

You can obtain better coverage of the foliage by using a commercial wetting agent or a few drops of detergent in the solution. Apply sprays early morning or late afternoon, on a cloudy day, or soon after a rain. **Do not combine foliar nutrients with pest control sprays, which may not mix.**

Fertilizing Fruit Plants

Fruit and nut plants grow and produce quite well under a fairly wide range of soil conditions. Requirements and responses to nutrient applications may be quite different from those of vegetable plants.

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

Characteristics of healthy fruit and nut plants include large, green leaves normal for the type of tree, fruit set on and developing normally, and relatively smooth bark on the trees. Older trees may naturally have some scaliness on the trunk. Signs of low nutrition include small, yellow, or abnormally colored leaves, poor branch growth, small, highly colored fruit, reduced fruit set, and excessive winter wood injury. Nitrogen is the most important element for tree fruits and grapes and usually the first to cause poor tree and fruit growth.

Adding organic residues or compost to soils before and after planting holds moisture and supplies nutrients. The ideal time to evaluate fertility levels and add nutrients to sites where fruit is grown is before planting. A soil test shows existing levels of required elements. After planting it becomes much more difficult to place required nutrients into the root area, except for nitrogen, which moves down into the soil with moisture.

Controlling Soil pH

The pH 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. Soil pH may differ from the desirable range because of parent rock materials, previous fertilizer use, cropping sequence, or other factors.

Useful Measures

1 acre = 43,560 square feet

100 lbs/acre = approximately 2 lbs/1,000 square feet

2 tablespoons (level) = 1 ounce

8 ounces = 1 cup

2 cups = 1 pint

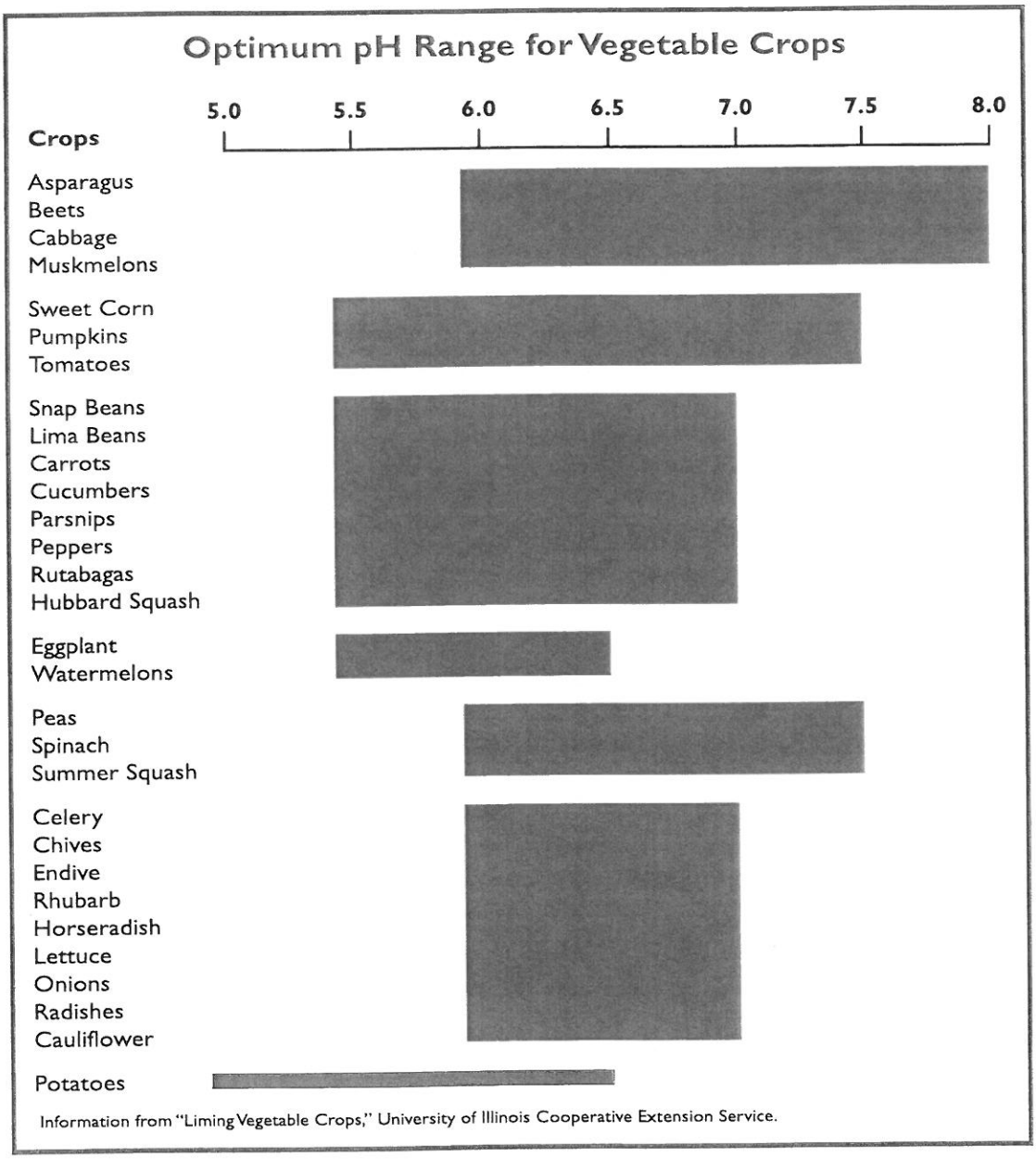
1 pint (2 cups) = 1 pound of most dried fertilizer materials

Fertilizer for Foliar Feeding (Emergency Use Only)

Element	Material	Ounces per 3 gallons 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 pH measurement, and, if acidic, the recommended 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 soils in western Kansas tend to be alkaline.

Your local K-State Research and Extension agent can determine the amount of lime or other material needed to correct the soil pH based on soil test results. A list of liming materials can be found on page 12. Correcting soil pH is often as important for improving plant growth as adding fertilizer. Do not neglect this part of the soil test.



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

Materials to Add to Correct Soil pH

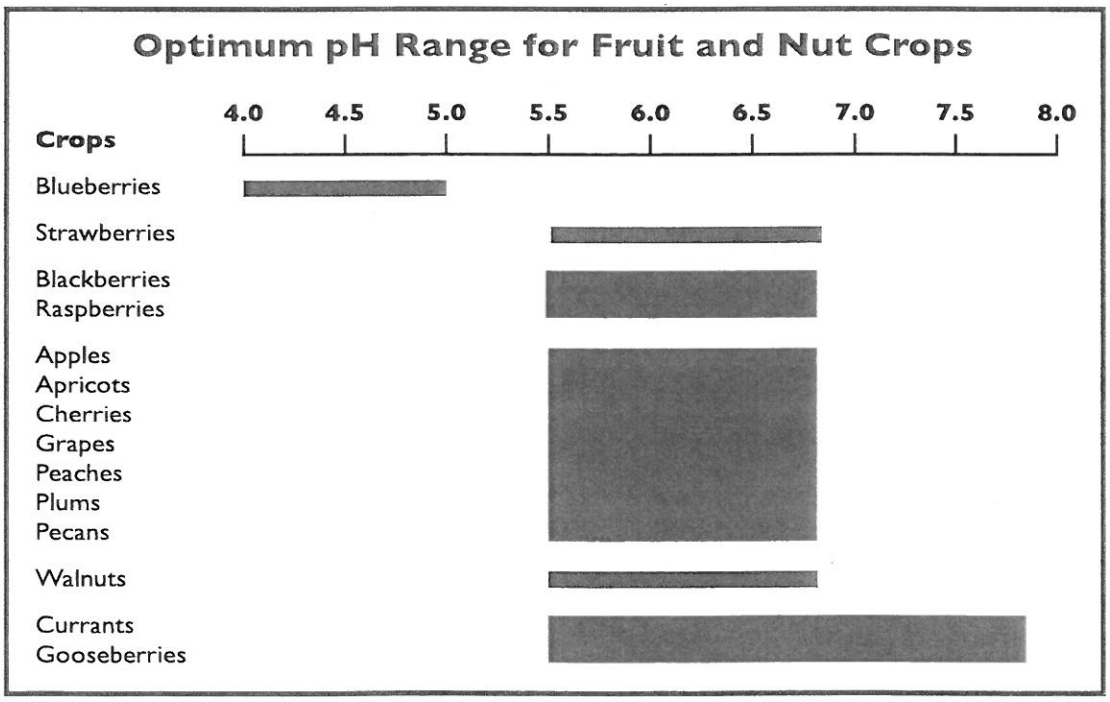
Lime (to increase pH)

pH level from soil test (increase to 6.5)	Pounds of 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 reduce pH)

pH level from soil test (decrease to 6.5)	Pounds of 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. Till soil 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. If available, use local recommendations instead of this table.



How can I tell how much fertilizer to apply?

Soil test results (right) indicate whether to apply low, medium, or high rates of nitrogen, phosphorus, and potassium. The table below shows the suggested amounts of each.

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 Application 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 per 1,000 square feet**								
		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 per 1,000 square feet**								
		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 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 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 per tree**								
		0	2*	3*	0	2	3	0	2	3
Apricots, Cherries, Peaches, Plums	Same as apples and pears.	Ounces per tree**								
		0	2*	3*	0	2	3	0	2	3
Pecans, Walnuts	Same as apples and pears.	Ounces per tree**								
		0	3*	4*	0	2	3	0	2	3

*Nitrogen rates listed are per tree for each year of age, with a maximum of 1 lb per tree for dwarf apples and other tree fruits, 2 lbs for mature standard-sized apple trees, and 4 lbs for mature nut trees. If there is grass under the trees, double the nitrogen rate or apply fertilizer in a 2- to 3-inch band. **To determine how much fertilizer to apply, divide the number from the chart by the fertilizer analysis. For example, if the soil test calls for a medium amount of nitrogen for grapes and you're using a 10-5-8 fertilizer, you would divide 1 (from the chart) by 0.10 (the first number in the fertilizer analysis) to calculate ounces per vine. In this case, you would need to apply 10 ounces of fertilizer per vine (1/0.10).

Suggested Fertilizer Rates for Vegetable Crops

Crop	When to apply	Pounds per 1,000 square feet								
		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
	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
	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
	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
	Incorporate organic residue/compost in new plantings. Use more potash than listed for soils that are very sandy. Established plantings should be fertilized 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
	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
	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
	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
	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
	Sidedress when corn is 8 to 12 inches tall. Double the normal rate. On sandy soils, a second sidedressing may be beneficial.									

Sidedress by applying fertilizer near the plants and watering it 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 do not contain any weed killers or weed preventers. Double the rate if using nitrate of soda (16-0-0).

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.

How to Get the Most Out of Your Fertilizer

1. Select soil well adapted to crop growth. 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 benefits other than merely providing soil nutrients.
4. Control weeds and use sound cultural practices.
5. Select only the best plants and seeds.

Ward Upham, Horticulturist

Revised from original by Charles W. Marr, Frank D. Morrison, and David A. Whitney

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