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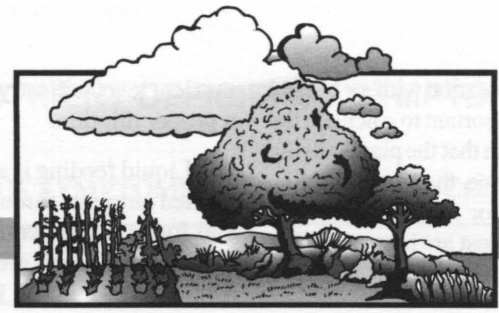

Fertilizing the Garden

*Diane Relf and Alan McDaniel**

The amount of fertilizer to apply to a garden depends on the natural fertility of the soil, the amount of organic matter present, the type of fertilizer used, and the crop being grown. The best way to determine fertilizer needs is to have the soil tested. Soil testing is available through your local Extension agent, through private labs, and with soil test kits which can be purchased from garden shops and catalogs.

Vegetables fall into three main categories according to their fertilizer requirements, heavy feeders, medium feeders, and light feeders. It may be advantageous to group crops in the garden according to their fertilizer requirements to make application easier.

MAJOR ELEMENTS

Fertilizers are identified by their analysis, such as 5-10-10 or 10-10-10. The numbers refer to the percentage of nitrogen, phosphorus, and potash, respectively, in the fertilizer. In 100 pounds of 5-10-10 there are 5 pounds total nitrogen (N), 10 pounds available phosphorus ($P_2 0$), and 10 pounds soluble potash ($K_2 O_5$). A fertilizer of high analysis, such as 10-10-10, is more expensive per 100 pounds than a fertilizer of low analysis, such as 6-8-8, but less of the high analysis fertilizer is used per 1000 square feet of garden, and it is often the best buy. Both synthetic and commercial organic fertilizers must display these numbers; synthetic fertilizers are usually (but not always) higher in nutrients by weight.

In general, synthetic fertilizers act more quickly than organic types, though some organic materials release their nutrients quite rapidly. It isn't possible, therefore, to make a blanket statement about the long-term effects of fertilizers, except that organic materials, such as manures and plant waste, do usually help improve the soil structure while adding nutrients, while chemical fertilizers do not affect soil structure.

General-purpose synthetic fertilizers have the advantage of being readily available to the gardener and relatively inexpensive. The availability of organic fertilizers depends on your area, surrounding farms, businesses and industries, your own garden's size and accumulation of plant wastes, and your resourcefulness. Good compost can supply a substantial percentage of the nutrients you need and can be made from easily gathered materials, such as leaves and grass clippings. Commercial organic fertilizers are more difficult to find unless you have an organically oriented farm/garden nearby. Most garden centers carry small bags of dried blood, bone meal, and cottonseed meal, but at a prohibitive price for all but the very small garden. Some farm supply stores sell 50-pound bags of cottonseed meal which is also used as an animal feed, otherwise, it is difficult to find these materials for sale in bulk. Probably, the best way to get organic fertilizing materials is to scrounge them wherever possible. Manures from farms; mill wastes; seaweed gathered from the ocean; wastes from processing, such as spent hops; and grocery-store produce wastes are a few examples of available materials.

TRACE ELEMENTS

In addition to nitrogen, phosphorus, and potassium, plants must have trace, or minor, elements for good growth. These are needed in very small quantities, and most soils already contain sufficient supplies. With good soil-building practices (see VCE Publication 426-326, *Composting*, and VCE Publication 426-313, *Soil Preparation*), trace elements do not generally present a problem to the home gardener. See the chart entitled Nutrient Deficiency Symptoms for a description of problems caused by minor element shortages.

Synthetic fertilizers are relatively pure chemicals, and most do not carry the trace elements normally present in organic fertilizers. Therefore, addition of trace elements through purchased or other organic materials, such as manure, compost, green manures, and mulching, is recommended.

APPLYING FERTILIZERS

Dry Fertilizers and Manures

In the fall or in the spring before working the soil, measure out the correct amount of fertilizer and spread it evenly over the ground. You can toss it from a pail by hand or use a spreader. Thoroughly mix dry fertilizers into the upper 6 inches of soil. Be sure to wear gloves to protect your skin from irritating chemicals. Always follow the directions on the label for rate of application of all fertilizers and add the correct amounts. Too much fertilizer will harm plants and pollute the environment, especially through runoff into water systems. It is also a waste of money.

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Organic materials may be used in combination with, or instead of, chemical fertilizers. In any case, it is important to calculate the total available nutrients in order to be certain that the plant is being supplied with adequate nutrient levels. See the chart entitled, Comparison of Materials as Fertilizers, for more information. Slow-acting fertilizers, manures, and compost are best applied in the fall to give them some time to start breaking down.

Liquid Fertilizers and Foliar Feeding

Fertilizer solutions are often used to water-in transplants, providing a readily available supply of nutrients for fast root growth and plant establishment. Liquid fertilizers may also be applied to plant foliage where the nutrients are absorbed directly through the leaf surface. This foliar feeding provides nutrients to the plant very quickly.

There are several choices of fertilizers for liquid application. Commercial soluble fertilizers, either as transplant starter or house plant formulations, are readily available and easy to use. (Granular fertilizers are not satisfactory because the phosphorus is not soluble.) Fish emulsion and liquid kelp (a seaweed) are good commercial organic sources. Follow label directions for each of these. Many gardeners produce manure tea by suspending a cloth bag containing fresh manure in a covered bucket of water for several days. The resulting solution will look like weak tea but has a high content of available nutrients. It should not be applied full-strength. Because the nutrient level will vary, experimentation is needed to determine a proper dilution.

Liquid feeding is appropriate for container plants to supply needed nutrients throughout the growing season. The commercial forms are generally cost-prohibitive for continued use in the garden where a greater soil volume is available to the plant roots. Instead, liquid feeding is more often a one-time procedure, either as a transplant starter or as a foliar feeding to correct a deficiency in a major or trace element. If a foliar feeding is desired, follow directions carefully. Using too much fertilizer, especially the synthetic forms, can quickly burn the foliage.

FERTILIZERS AND pH

The degree of acidity or alkalinity of the soil, as measured by pH, is an important factor in the availability of soil nutrients to plants. At pH extremes, some nutrients become partially or completely locked up in the soil and cannot be used by plants even though they are still present. For example, in a soil with a pH near 8.0, copper, zinc, iron, and manganese all become unavailable. At 4.5 or below, plants cannot get nitrates, magnesium, or phosphates. Other elements may become so readily available that they are toxic to plants, as happens with aluminum at very low pH. Most vegetables do best between pH 5.9 and 7.0. On more acid soils, lime is often added to increase the pH to a desirable level. However, the addition of lime does not eliminate the need to add fertilizer.

RELATIVE NUTRIENT REQUIREMENTS FOR VEGETABLES

HEAVY FEEDERS	MEDIUM FEEDERS	LIGHT FEEDERS
Broccoli	Beans	Okra	Peas
Cabbage	Beet	Peanut	
Cauliflower	Carrot	Pepper	
Celery	Chard, Swiss	Radish	
Corn, Sweet	Cucumber	Spinach	
Lettuce	Eggplant	Sunflower	
Onions	Greens	Turnip	
Potatoes, Irish	Melons		
Potatoes, Sweet			
Pumpkins			
Tomatoes			

VEGETABLE TOLERANCE TO SOIL ACIDITY

SLIGHTLY TOLERANT (pH 6.0 TO 6.8)	MODERATELY TOLERANT (pH 5.5 TO 6.8)		VERY TOLERANT (pH 5.0 TO 6.8)
Asparagus	Bean	Pumpkin	Potato, Irish
Beet	Bean, Lima	Radish	Potato, Sweet
Broccoli	Brussels Sprouts	Rutabaga	Watermelon
Cabbage	Carrots	Soybean	
Cauliflower	Collards	Squash	
Chard, Swiss	Corn	Sunflower	
Chinese Cabbage	Cucumber	Tomato	
Lettuce	Eggplant	Turnip	
Muskmelon	Garlic		
New Zealand Spinach	Kale		
Okra	Kohlrabi		
Onion	Parsley		
Peanut	Pea, English		
Spinach	Pepper		

NUTRIENT DEFICIENCY SYMPTOMS

ELEMENTS	DEFICIENCY SYMPTOMS	COMMENTS
Major Elements		
Nitrogen (N)	Stunted, yellowing from bottom up and leaf tip back to petiole; reduced size; slow, stunted growth.	Heavy application may cause leaf burn; excess promotes luxuriant growth, but inhibits flowering. Easily leached from soil.
Phosphorus (P)	Stunted, short internodes; purple or dark green foliage; old leaves die back; flowers and fruit poor; slow growth; delayed maturity.	Phosphorus is poorly available at high and low pH, in dry or cold soils, and in high-organic container soils. Apply according to soil test.
Potassium (K)	Older leaves scorched on margin; weak stem; fruit shrivelled, uneven ripening.	Fairly easily leached. Fertilize according to soil test.
Trace Elements		
Boron (B)	Tip of growing plant dies; bud becomes light green; roots are brown in center; fruit is corky; flowers do not form.	Some Virginia soils are low in boron. Managed best by organic matter additions.
Calcium (Ca)	Young leaves turn yellow then brown; growing tip bends; weak stem; short dark roots; causes blossom end rot of tomato.	Properly limed soils usually supply adequate calcium.
Copper (Cu)	Leaves appear bleached, elongated; new growth dies back.	Seldom a problem in organically improved soil.
Iron (Fe)	Young leaves are yellow between veins first, top to bottom; veins, margins, and tips stay green.	Usually due to pH problems. May use iron sulfate or chelated iron.
Magnesium (Mg)	Leaves are thin, lose color from between veins from bottom of plant up; tend to curve upward.	Use dolomitic lime according to soil test. May use epsom salt solution.
Manganese (Mn)	Tissue between veins turns white; leaves have dead spots; plant is dwarfed.	Seldom a problem in organically improved soil.
Molybdenum (Mo)	Plant is very stunted; pale and distorted leaves.	Seldom a problem in organically improved soil.
Sulphur (S)	Lower leaves yellow; stem and root small in diameter; stems hard and brittle.	Seldom a problem in organically improved soil.
Zinc (Zn)	Terminal leaves are small; bud formation is poor; leaves have dead areas.	Seldom a problem in organically improved soil.

Adapted from: Pierce, J. H., Greenhouse Growhow, Plants Alive, Seattle, WA, 1977.

COMPARISON OF MATERIALS AS FERTILIZERS[1]

FERTILIZER	% N	% P	% K	TONS/ ACRE FOR 60 LBS. N	AVAILABILITY	ACIDITY
Inorganic example	5.00	10.00	10.00	0.60	quick	acid
Fresh Manures (2)						
Cow	.55	.15	.50	5.00	moderate	varies
Hen	1.10	.90	.50	2.70	moderate	depending
Hog	.55	.30	.45	5.50	moderate	on
Horse	.65	.25	.50	4.60	moderate	bedding;
Sheep	1.00	.75	.40	3.00	moderate	generally
Steer (feed lot)	.60	.35	.55	5.00	moderate	alkaline
Rabbit	2.40	1.40	.60	—	moderate	
Organic and Rock Fertilizers (3)						
Fish meal	10.0	4.00	—	0.30	slow	acid
Sewage sludge (4)	2.0-6.0	1.0-2.5	0.0-0.4	1.5-0.5	slow	acid
Dried blood	12.00	1.50	0.80	0.20	mod. slow	acid
Soybean meal	7.00	1.20	1.50	0.40	slow	sl. acid
Animal tankage	9.00	10.00	15.50	0.30	slow	acid
Garbage tankage	2.50	1.50	1.50	1.20	very slow	alkaline
Tobacco stems	1.50	0.50	5.00	2.00	slow	alkaline
Seaweed	1.00	—	4.0-10.0	3.00	slow	—
Bone meal, raw(5)	3.50	22.00	—	0.90	slow	alkaline
Wood ashes	—	2.00	4.0-10.0	—	quick	v. alkaline
Cottonseed meal	6.00	2.50	1.50	0.50	slow	acid
Horn&Hoof meal	12.00	2.00	—	0.25	—	alkaline
Milorganite (4)	6.00	2.50	—	0.50	—	—
Peat and muck	1.5-3.0	0.2-0.5	0.5-1.0	2.0-1.0	very slow	acid
Ground rock phosphate	—	33.00	—	—	very slow	alkaline
Colloidal phosphate	—	18.00	—	—	moderate	alkaline
Greensand	—	1.00	6.00	—	very slow	—
Comfrey leaves	0.74	0.24	1.19	—	—	—
Fish emulsion (4)	4.00	4.00	1.00	—	—	—
Compost Pile Ingredients						
Corn stalks/leaves	.30	.13	.33			
Crabgrass, green	.66	.19	.71			
Oak leaves	.80	.35	.15			
Pine needles	.46	.12	.03			
Feathers	15.30	—	—			
Coffee grounds	2.08	.32	.28			
Eggs, rotten	2.25	.40	.15			
Tea leaves	4.15	.62	.40			
Maple leaves	.52	.11	.75			
Apple leaves	1.00	.15	.35			

(1) Percentages vary with different batches of the same substances, depending on animal feeds, season of year, stage of harvest, method of preparation, and other factors. These are general figures to be used only as a guide.

(2) Allow time for breakdown after tilling in to prevent burning of crops.

(3) Percentages on dry weight basis(except fish emulsion).

(4) Milorganite and Nutragreen are examples of bagged, heat-treated biosolids meeting the "exceptional quality" standards that can be used in home gardens.

(5) Processed bone meal may contain little or no N.

Fertilizer per	1000 sq. ft.	100 sq. ft.	bushel
if using 5-10-10	40 lbs.	4 lbs.	2 oz. or 4 Tbsp.
if using 10-10-10	20 lbs.	2 lbs.	1 oz. or 2 Tbsp.