Nutrient Requirements of Garden Plants
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G. M. Kessler, Department of Horticulture
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Nutrient Requirements Of Garden Plants

By G. M. Kessler
Associate Professor Emeritus
Department of Horticulture

To perform well in the garden, plants require the right amounts of clean air, sunlight, water and certain mineral nutrients in the soil. This publication indicates what mineral nutrients plants require and how best to apply fertilizers when the available nutrients in the soil are below optimum for garden crops.

What Makes a Plant Grow?

Carbon dioxide and water

To grow normally, a plant needs carbon dioxide which it usually absorbs from the air through its leaves. It also needs water, which is usually absorbed by the roots and transported to the leaf and all other plant parts. Then, in the presence of the plant's green pigment (chlorophyll) and adequate warmth, the energy from sunlight splits the water molecule, releasing hydrogen, which combines with carbon dioxide to form sugar. From sugar, the plant is able to synthesize starch, other important carbohydrates, fats and other complex substances necessary for natural plant growth and reproduction. This process, called *photosynthesis*, takes place largely in the leaves but sometimes also in young green stems, green flower parts and even immature green fruits.

Mineral elements

A plant must also produce proteins, since these are vital components of all living cells and tissues. It accomplishes this by combining carbohydrates with nitrogen absorbed from the soil dissolved in water.

To grow and develop normally, the plant also requires phosphorus, potassium, iron, magnesium and other elements from the soil. Some of these — nitrogen, phosphorus and potassium — are needed in quantity. Others, often called trace elements, are used in much smaller amounts. A deficiency of these is often associated with excessively high or low soil pH[1]. However, regardless of amount, all are needed for normal plant growth and development. Fertilizers contain mineral elements and can be applied to the soil or directly to plants to improve their performance.

[1]*pH is a measure of soil acidity.*

Nitrogen is the nutrient most likely to be lacking in the soil, mainly because it is easily leached out (washed out of the soil by rain and irrigation water) and because decay organisms feed on it. Very rapid-growing, short-season garden plants such as lettuce have higher nitrogen requirements than crops like tomato or potato. Under average soil conditions, nitrogen fertilizer alone is sufficient for adequate growth, flowering and fruiting of trees, shrubs and woody vines. However, the soft-stemmed vegetables and flowers ordinarily require a mixed fertilizer containing potassium and phosphorus as well as nitrogen.

Kinds of fertilizers

Organic fertilizers are complex chemical substances containing carbon. Generally, they are naturally occurring, and are derived from living things, such as barnyard manures. However, a few organic fertilizers are synthetic — urea, for example.

Inorganic fertilizers are chemically simpler substances than the organic, and are usually obtained from nonliving sources. They are noncarbonaceous chemicals except for the simple carbonates like calcium carbonate (limestone). Although most of them are synthetic, such as ammonium sulfate, some, like rock phosphate, occur naturally.

Organic fertilizers

Nutrient content — Bulky organic materials generally contain a very small amount of nutrients on a percentage basis as shown in this table:

	Nitrogen %	Phosphorus %	Potassium %
Fresh cattle manure	0.55	0.15	0.45
Grain straw	0.60	0.20	1.10
Sawdust	0.20	0.10	0.20

Processed concentrates are usually higher in plant nutrients than the more bulky materials:

Dried cattle manure	2.0	1.8	2.2
Bone meal	4.0	23.0	0.0
Cottonseed meal	6.0	2.5	1.5

Availability to plants — Most organic fertilizers are slowly available to plants. Before organic nutrients can be absorbed by plants, they first have to be broken down to an inorganic state. This has some advantage for perennial crops[2], in that one application, repeated annually, is adequate over a long period. However, rapidly growing annual vegetables such as lettuce require a high level of available nutrients, which most organic fertilizers cannot deliver quickly enough.

Impact on soil structure — Organic matter improves the structure of the soil — ability to hold nutrients, water and air — and is generally more useful for these purposes than as a source of nutrients. This is especially true with the very low-nitrogen organic materials which require a supplement of inorganic nitrogen to avoid reduced plant growth due to competition from nitrogen-consuming decay organisms in the soil.

Cost — Organic fertilizers are not cheap if applied in amounts adequate for good plant growth and yield, unless you have a free source. They can be considerably more expensive than inorganic fertilizers when applying equivalent amounts of available plant nutrients.

Time of application is usually early spring or late fall. Fall-applied organic fertilizers will be available to plants earlier the following season than those applied in spring.

How much to use varies with the nutrient content of the particular material, especially its nitrogen content. The age of the material is also a factor. When organic fertilizers decay and are rained upon, they lose nutrients. Five hundred to 1,000 pounds of horse manure and 250 to 500 pounds of poultry manure have been suggested for 1,000 square feet of garden.

Inorganic fertilizers

Availability — In general, inorganic fertilizers are more quickly available to plants than are organic fertilizers. This makes them especially useful with short-season vegetable crops such as lettuce, and whenever a quick response is desirable.

Analysis of a fertilizer material, expressed with a formula or series of numbers such as 5-20-20, is always printed on the labels of commercial fertilizer containers. Each number indicates the percentage content of the three major available nutrients found in most commercial fertilizers. The first number is nitrogen, the second is phosphorus[3] and the third, potassium[3]. A hundred pounds of fertilizer with the above analysis contains 5% available nitrogen, 20% available phosphorus, and 20% available potassium. The remainder of the 100 pounds consists mostly of filler and a material which prevents caking.

[2]Perennial crops are plants that live on for more than 2 years. Apple, strawberry, asparagus and chrysanthemum are perennial.

[3]Available phosphorus and potassium in fertilizer formulas are expressed as combinations with oxygen, as P_2O_5 and K_2O respectively.

The higher-analysis fertilizers, containing 30% or more of active ingredients, are usually more economical, although the cost of the 100 pounds may be higher than that of a lower-analysis fertilizer. However, there is more danger of burning plants in the garden with high-analysis fertilizers (by applying too much) than with low-analysis kinds.

Forms of fertilizers

Granulated dry fertilizer is the most commonly available. It is fairly cheap, and relatively easy to spread.

Pelleted fertilizer consists of granules which are coated so that they are rather uniform in shape. It is the easiest to handle and spread, but fairly expensive.

Slow-release fertilizers may be synthetic, granular organic fertilizer which have to be broken down to inorganic state in the soil before they become available to plants; or they are granules coated with a substance which slows down the release of the nutrients. These kinds of fertilizer are also somewhat expensive.

Powdered fertilizer is not uniform in particle size and mostly small. It is difficult to spread evenly, cakes easily and may burn the leaves to which it tends to adhere. It is usually the cheapest per unit weight.

Concentrate solids are highly soluble materials that are dissolved in water and applied as liquid. It is important that this form be diluted as directed so as to avoid burning the plant. They become available quickly, resulting in quick plant response. Because they contain mostly available nutrients (very high analysis), the cost per unit of available nutrients is relatively low.

Concentrate liquids are diluted with water before being applied to the soil. They have many of the same advantages as concentrated solids.

Starter solution is a diluted solution made with concentrated fertilizers which are usually high in phosphorus, such as 10-55-10. Phosphorus seems to be associated with root development. Such solutions can be used successfully when transplanting vegetables and flowers, but generally have not proved especially effective with woody transplants.

There are many kinds of inorganic fertilizers. Most gardeners will use mixed fertilizer containing at least the three major nutrients as previously described.

When shopping for mixed fertilizers, select one which gives you the most nitrogen for your money, because nitrogen is the most expensive ingredient. However, when fertilizing woody plants in midwestern and northeastern states, apply only nitrogen, unless you are sure that the soil is deficient in other nutrients.

There are times when you will want to apply fertilizers which contain single fertilizer nutrients. A few commonly used ones are:

Ammonium nitrate (33% nitrogen) tends to absorb

water from the air and cake if not kept in an air tight container. Do not use it for blueberry and other plants that require acid soil.

Sodium nitrate (16% nitrogen).

Ammonium sulfate (21% nitrogen) is a preferred source of nitrogen for plants that require acid soils.

Muriate of potash (50% potassium).

Phosphate rock (55 to 78% P_2O_5) is a natural fertilizer that releases its phosphorus very slowly.

Superphosphate (14 to 20% P_2O_5) is the most commonly used form of phosphorus.

Limestone (56% lime) is used mainly to raise pH of acid soils; but is also useful as a source of calcium when this nutrient is low in the soil It is a slow-release natural material.

Hydrated lime (60 to 80% lime) is used for the same reason as limestone but is more quickly available.

Aluminum sulfate is used mainly to acidify soil for acid-loving plants like blueberry and rhododendron.

Trace elements

Chelates are synthetic organic substances containing an essential trace element such as iron, zinc, manganese or copper. They seem to be absorbed by plants from the soil more readily than the inorganic salts of these elements when the soil pH is too high or too low.

Borax (11.3% boron).

Epsom salt (10% magnesium) is a highly soluble source of magnesium.

Manganese sulfate (33% manganese) is the usual source of manganese.

Application Methods and Placement

Surface Feeding (simplest and cheapest):

Broadcasting — This refers to the spreading of dry fertilizers uniformly over an area of established lawn, strawberry rows or beds, or an asparagus patch. Leaves should be dry to avoid burning. After broadcasting on strawberries, brush the fertilizer from the leaves to avoid burning them. Broadcasted fertilizers are most effective when applied just before a rain, or watered in during dry periods.

Topdressing — This is hand application of dry fertilizers in a ring around the plant, big or small. To accommodate the needs of larger plants having more extensive root systems, the width and diameter of the ring should be in proportion to the size of the plant. For example, the ring applied around a tomato plant a month after transplanting into the garden would be about 2 or 3 inches wide, and the inside diameter of the ring would be about 4 inches. If you were top dressing a good-sized shrub, the ring might be about 2 feet wide, the inside diameter about 3 or 4 feet and the outer diameter of the ring should extend somewhat beyond the spread of the top, since feeding roots extend that far.

Sidedressing — This is much like topdressing but the fertilizer is applied in a continuous strip along the side of a row of vegetables or flowers in the garden.

Distributors — These mechanical devices spread dry fertilizers on the soil surface more evenly than one can do by hand. The fertilizer is either scattered widely or dropped, depending on the device. It is vital to adjust the distributor for the correct rate of distribution to avoid either over- or under-fertilizing.

Liquid feeding — This method involves applying liquid fertilizers through water hose attachments or simply with an ordinary sprinkling can. It is a quick and easy way of getting the job done.

Foliar feeding

When applied as a spray, water solutions of certain highly soluble compounds of nitrogen, phosphorus, potassium and a number of the trace elements are readily absorbed through the leaves of some plants and contribute to their growth. Plants respond most to foliar feeding when the levels of nutrients being applied are low both in the plant and the soil.

Since absorption and plant response are quick, foliar feeding is often effective as an emergency measure. It is not practical as a replacement for soil fertilization, but can be helpful as a supplement.

Foliar feeding is a very effective method for applying trace elements when deficiency symptoms for one of them are evident; however, proper dilutions must be made to avoid leaf injury. Ammonium phosphate, calcium nitrate, urea and zinc chelates are examples of fertilizer compounds that have been successfully used in foliar sprays. For more information, see Extension Bulletin E-449 (Leaf Analysis for Fertilizer Requirements of Michigan Fruit Crops), E-852 (Fertilizers for Fruit Crops) and RR 398 (Nutrient Trends in Michigan Fruit Planting).

Subsurface feeding

Broadcasting by spreading dry fertilizer on the surface will provide a subsurface nutrient source if it is done before planting and the fertilizer is worked into the soil.

Banding involves the application of fertilizer in a narrow band when seeding vegetables or flowers in garden rows. The band should be about 2 inches away from the seed row and about 1 inch deeper than the seed to avoid

burning the emerging roots of the young plants. This method requires the use of a mechanical device which deposits both the seed and fertilizer.

Root plug feeding is used for trees in the lawn. Narrow holes are dug with a soil auger about 18 inches deep and about the same distance apart under the trees, covering an area similar to that covered when topdressing. Dry fertilizer is mixed with soil and placed in the holes. It is time consuming.

Lance feeding is similar to root plugs except that water and fertilizer are forced into the holes at the same time through a special tube connected to a garden hose. Such fertilizer becomes rapidly available to the tree. Like root plug feeding, it is time consuming.

How Much Fertilizer to Use and When

Age and size of plants

Younger plants are vigorous and must be adequately fed; yet their total needs are less than those of older, larger plants. Old trees and shrubs and woody vines often need extra nutrients to stimulate new growth, flowering and fruiting.

Kind of Plant

Vegetables and flowers — Before planting, rototill about 20 pounds of 5-20-20 fertilizer or its equivalent per 1,000 square feet of soil; or plow (or spade) under half of the fertilizer to place it deep, and then disc (or rake) in the other half near the surface. Supplement this with 2 pounds of a high nitrogen side- or top-dressing at least one month after transplanting, or later in the case of seeded plants — possibly 6 weeks after planting.

Trees and shrubs — No fertilizer is needed the first year, unless the soil is very low in nutrients. Early spring or late fall applications are recommended of either a nitrogen fertilizer or high-nitrogen, mixed fertilizer of 20% nitrogen or higher at the rate of about 10 pounds per 100 feet of shrub hedgerow, or about 1/2 pound per medium-sized shrub. Trees require 1/4 pound of ammonium nitrate (or equivalent) per inch of trunk diameter (at waist height) up to about 6 to 8 pounds per mature tree. Too much nitrogen, or summer application of nitrogen, may induce late growth, which is susceptible to cold damage in late fall or early winter.

[4]*Fill is soil often containing various sorts of debris. Contractors use it to fill low spots on a building site.*

[5]*Directions for taking a soil sample can be obtained from county Extension offices and can be found also in Extension Bulletin E-498 (Sampling Soils for Fertilizer and Lime Recommendations). Send samples for testing to the Soil Testing Laboratory, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824.*

Soil fertility

Recommended rates of application are all subject to modification, depending on current soil fertility. Lower rates are appropriate on more fertile soils, higher rates on infertile soils. Very sandy or very clayey soils are likely to fall in the latter category.

Fill[4] consisting of subsoil is usually low in fertility, and often physically poor for good root growth. *It is therefore important that every home construction contract should clearly state that debris-loaded fill is not to be used, and that at least 4 inches of top soil must be replaced on the construction site wherever it was removed.*

Indicators of fertilizer needs

Soil tests — Quick tests to determine major fertilizer needs of shallow-rooted plants, such as annual vegetables and flowers, can be determined with reasonable accuracy by using soil-testing kits. More accurate analyses can be made by sending soil samples to the MSU Soil Testing Laboratory for quantitative, more accurate determinations[5]. Soil tests are not too helpful with deep-rooted woody plants because soil sampling tends to be shallow, and they do not detect nutrients available to such plants deep in the soil.

Tissue tests — Tissue tests can be more accurate than soil tests, since they reflect what nutrients are actually absorbed by a plant. Quick tests for nitrogen, phosphorus and potassium in samples of tissue of herbaceous plants like lettuce and tomato can easily be made with special kits; however, these tests are not reliable with woody plants. Very accurate quantitative tissue tests for woody or herbaceous plants might be too costly for the gardener[6]. Reports from such tests often include fertilizer recommendations as well as nutrient content.

Plant performance — The growth and yield of plants are reliable indicators of fertilizer needs, if interpreted correctly. Poor growth and yields are often due to lack of soil nutrients; however, poor soil aeration, injury to roots caused by diseases, rodents or insects, or winter injury of perennials may also cause poor plant performance. If these can be detected early, there may still be time to correct the problems. Yield data at the end of the season cannot help for the current season, but can be a help with perennials for the following year.

Deficiency symptoms — Specific discoloration patterns or dead areas of the leaves are sometimes good indicators of fertilizer needs. Here, too, be sure to eliminate other possible causes of the symptom. Nitrogen deficiency usually shows as a yellowing of the leaf. Potassium deficiency is often expressed as a marginal discoloration, curling and burning of the leaf. Other deficiencies have their own special leaf symptoms.

[6]*Quantitative tissue tests are made through the MSU Department of Horticulture.*

Soil pH

Soil pH is a measure of ***soil acidity.*** We are concerned with soil pH because of its influence on availability of plant nutrients in the soil and their uptake by plants. Many plants perform best when the soil pH is about 6.5, slightly acid (pH 7 being neutral). However, a wide range of plants do quite well between pH 7.0 and 7.5 (slightly alkaline).

There is a small group, including blueberries and rhododendrons, that require soil pH of 4.5 to 5.5, and are unable to absorb sufficient iron from the soil at a higher pH. Very simple, easy-to-use, inexpensive soil pH testing kits are available.

Correcting too low pH — The common materials used for this purpose are hydrated lime and ground limestone. Three to five pounds of ground limestone per 100 square feet in spring or fall, worked into soil, should correct a pH of 5.5 to 6.0. The lower rate is suitable for sandy soils, the higher rate for heavier soils.

Lime not only corrects pH, but also provides plants with the essential nutrient, calcium. However, applying limestone regularly without testing the soil for pH can lead to an unbalance of soil nutrients and plant deficiencies, caused by an excess of calcium.

Correcting too-high pH — Chemicals generally used are sulfur (cheapest), aluminum sulfate and iron sulfate. Ammonium sulfate provides nitrogen as well as an acidifying effect on soil. One-fourth to 1/2 pound of sulfer per 100 square feet, or 2.5 to 5 pounds of aluminum sulfate should correct the pH adequately. The lower rate is sufficient if the initial pH is 6, and the higher rate, if the pH is 7.

Summary

Garden and landscape plants will not perform well year after year unless additional nutrients are applied in the proper manner. Organic fertilizers like barnyard manure can be very helpful as long as you recognize that you need large amounts because of their relatively low nutrient content.

The most commonly used garden fertilizers are dry, synthetic materials containing either nitrogen, phosphorus, or potassium compounds, or a mixture of these.

Nitrogen is the most expensive component and the one most likely to be lacking in the soil.

Some fertilizers can be effectively applied as a foliar spray to certain plants in emergency situations to satisfy part of their need. However, in general, garden plants should be fed by applying dry, granular fertilizers to the soil.

The amount of fertilizer used in the garden depends on the kind of plant, its size age and stage of development, and the fertility of the soil.

Vegetables and flowers should be first fertilized with an application to the soil before planting, and once more later in the season when the plants are well developed. Established trees and shrubs in a Michigan type climate should be fertilized in early spring or late fall when the leaves are changing color.

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Table 1. Fertilization Schedule for Garden Plants in Michigan ★

	Time	Analysis†	Rate and method‡
Flowers			
All kinds	BP	5-10-5	2 lb./100 sq. ft. BW
Annuals	E Sp + S (twice 6 wks apart)	5-10-5	2 lb./100 sq. ft. SD
Perennials	E Sp + S (twice 6 wks apart)	5-10-5	2 lb./100 sq. ft. SD
Hardy spring bulbs	S (after bloom)	5-10-5	2 lb./100 sq. ft. SD
Tender bulbs	S (when plants are about 6" high)	5-10-5	2 lb./100 sq. ft. SD
Vegetables and Herbs			
All kinds	BP	5-10-10	20 lb./1000 sq. ft. BW
	1 mo. after seeding	5-10-10	1-5 cups/50 ft. of row. SD. Rate is varied
	1 mo. after transplanting	5-10-5	with crop and evidence of need.
Perennials	E Sp and as needed during growing season	5-10-10	3 cups/50 ft. row SD
Fruits and Nuts§			
Fruit and nut trees	E Sp or F	33-0-0	1/4 lb./yr of plant age to maximum of 2 1/2 lbs. SD. May be split between Sp and F. SD
Brambles	E Sp	33-0-0	3 lb./100 ft. row. SD
Blueberry	E Sp, and again 6 wks later	20-0-0 (ammonium sulfate)	2 oz./plant SD, increasing 2 oz. each year to maximum of 3/4 lb./plant
Grape	E Sp	33-0-0	2 oz./plant, SD, increasing 2 oz. each year to maximum of 1/2 lb.
Strawberry (June bearing)	BP	5-10-10	1 lb./100 sq. ft. BW
	1 mo. AP or Aug.	5-10-10	2 lb./100 sq. ft. TD
	after harvest	5-10-10	2 lb./100 sq. ft. TD
Woody ornamentals ★‡#			
Large evergreen trees	E Sp or F	33-0-0	18 lbs./1000 sq. ft. B
Large shade trees	E Sp or F	33-0-0	18 lbs./1000 sq. ft. RP# or B
	E Sp or F (every 3-5 yrs.)	10-6-4	60 lbs./1000 sq. ft. RP# or B
Small tree and shrub species	E Sp or F	10-6-4	8 lbs./1000 sq. ft. B
Roses	E Sp, and S (if needed)	5-10-5	2TB/plant or 3 lb./100 sq. ft. TD
Vines	E Sp or F	10-6-4	8 lbs./1000 sq. ft. B
Ground covers	E Sp or F	33-0-0 (pelleted)	3 lbs./100 sq. ft. TD

ABBREVIATIONS

BP — before planting
E Sp — early spring, before or soon after growth begins
S — summer
F — fall
BW — broadcast and work into soil
SD — sidedress
TD — topdress
B broadcast
RP — Root plugs

★Organic matter in soil enhances the effects of fertilizers on garden plants by improving the physical structure and biological condition. Maintain a good level by regularly working manure or dead plant material into garden soil before planting, or by using mulches of plant materials to control weeds.

Soil pH: The degree of soil acidity, as measured by pH, has a very important effect on availability of soil nutrients to plants. Most garden plants respond best to a pH of about 6.5, although many are tolerant to either somewhat higher (less acid or lower (more acid pH. In Michigan, soil pH is more likely to be too acid than too alkaline. An average soil requires about 70 pounds of limestone/1,000 square feet to raise its pH one unit.

Certain acid-loving plants such as blueberries and azaleas grow well only if pH is 4.0 to 5.5 To bring pH down, work sulfur or aluminum sulfate into the soil.

†Analysis figures represent percentages of nitrogen, phosphoric acids, and potash (in that order) in commercial fertilizers. The analyses are merely examples of common dry material and in most cases can be substituted at rates adjusted to be equivalent on the basis of nitrogen content. If highly soluble fertilizers are used as substitutes and applied diluted in water, use a total amount of nitrogen equivalent to that recommended. Do not exceed the maximum recommended on the label for any one application of these highly soluble materials.

‡Rates suggested are for average soils and should be increased for poor soils and decreased or none at all applied on fertile soils.

§Never fertilize woody plants in Michigan later than July 15, to avoid stimulating late growth which would be susceptible to winter injury. Fall applications should be made when leaves begin to fall. Rates shown are for mature woody plants and should be less for younger plants. Adjust rates also on basis of how well plants are performing.

#Root plugging is recommended under shade trees in the lawn for applying high levels of nitrogen to avoid burning the lawn grasses. An alternative is to split the amounts in two and broadcast twice with a two-week interval between the first and second application. Be sure that the first application has been washed into the soil with rain or a thorough irrigation. Otherwise, burning could still occur.