

SOIL & WATER MANAGEMENT FOR HOME GARDENERS

Soils vary greatly: some are ideal garden soils; others may have physical and/or chemical limitations-too shallow, too sandy, too stony, too clayey, too steep, too salty, or with too high a content of elements toxic to plant growth. While all these factors make soils difficult to manage, almost all soils can be successfully managed if the gardener knows the properties of the soil and the needs of the plants. The successful gardener soon learns how to manage the soil and which plants will do well in it.

The functions of a soil in relation to plant growth are to provide:

- mechanical support for the plant;
- a reservoir of water and air for plant roots;
- a source and reservoir of plant nutrients.

Managing soil and water to obtain the best plant growth means maintaining or improving these factors by fertilization, irrigation, drainage, tillage, and by improving the soil structure.

It is not possible to give all the recommendations required to fit all conditions. However, the following information and guidelines may help you find your gardening and yard work a source of enjoyment and relaxation instead of unrewarding hard work and frustration.

FERTILIZATION

There are 16 elements that are known to be required for plant growth and development. They are given below.

Source		
Air and water	Soil	
carbon	nitrogen	magnesium
hydrogen	phosphorus	manganese
oxygen	potassium	molybdenum
	sulfur	copper
	zinc	calcium
	iron	chlorine
	boron	

Plants obtain the first three elements from air and water; they get the remaining 13 elements in the inorganic form from the soil. Some plants, known as legumes-e.g., beans and peas-are capable, with the help of certain micro-organisms, of obtaining the nitrogen they need from the air. Other plants must obtain their nitrogen from the soil.

Soils are rarely fertile enough to supply all the nutrients required for the best growth of plants. However, it is equally as rare for a soil to be deficient in several of the mineral nutrients that plants need. In California, soils contain most of the elements known to be essential to plants, so you only need to add the ones that are deficient in your particular soil. (See page 3.)

In general, gardeners have a tendency to either under- or over- fertilize. Too little fertilization results in poor plant growth and appearance. Too much fertilization, regardless of the source, is unnecessarily expensive and may cause plant injury and unwanted changes in the environment. Use the rates suggested in tables 1 and 2 as general guides to good fertilization.

Types of fertilizers

Manure, when used correctly, can be a good garden fertilizer. It helps improve the soil structure and supplies the plants with many nutrients. However, manures may also contain undesirable weed seeds and relatively high amounts of salts. Use them cautiously if weeds or salts could create a problem.

Manures vary greatly in their nutrient content, depending on the type of manure and how it has been handled. As the percentage of nutrients in the manure increases from the lower to the higher value indicated in table 1, apply less material than the amount suggested.

Chicken manure is by far the most concentrated and can serve as the only garden fertilizer. Dairy manure is much less concentrated and usually has less nitrogen readily available to the plants. If you use dairy manure, it may be necessary to add some commercial nitrogen fertilizers. Steer manure from animals fattened on concentrated feeds is higher in nutrients than dairy manure. If it has been handled to prevent nitrogen losses, you can usually use it as the sole source of nitrogen.

If you use either dairy or steer manure on a yearly basis, decrease the amount applied each year. For example: apply the suggested amount (table 1) the first year; apply 70 percent of the suggested amount the second year; apply 60 percent the third year; and apply approximately 50 percent every year thereafter.

The best way to apply manure is to mix it into the soil well in advance—at least 1 month—of preparing the seed beds for planting. This allows time for the manure to partially rot or decompose and for the excess mineral salts to be leached out of the root zone before you plant the crop.

In most gardens where organic matter can be obtained from crop residues or grass clippings, you can use commercial fertilizers without manures.

Commercial fertilizers vary in the plant nutrients they contain. Some fertilizers may contain a single nutrient material, such as ammonium nitrate, or double nutrient compounds, such as ammonium phosphates, or the fertilizer may be a mix containing nitrogen, phosphorus, and potassium. By law, the content of the fertilizer, expressed as a percentage of each plant nutrient supplied, must be given on the bag.

Under this labeling method, the first number shown is the percentage of nitrogen (N); the second is the percentage of phosphorus (P), expressed as P_2O_5 ; and the third is the percentage of potassium (K), expressed as K_2O . Thus, 100 pounds of a 12-12-12 fertilizer contains 12 pounds each of N, P_2O_5 , and K_2O . If a micronutrient has been added to the fertilizer, then this must also be listed, along with its percentage, on the bag. However, the first three numbers always refer to N, P_2O_5 , and K_2O .

When applying either commercial fertilizers (inorganic) or manures (organic), use good judgment, based on local experience, to supply the right plant nutrients in the right amounts. Many successful gardeners use a combination of inorganic and organic fertilizers. However, regardless of which fertilizers you apply, use them efficiently to reduce cost. Prevent plant injury, and to prevent unwanted changes in the environment.

Nutrients most commonly needed

Nitrogen is naturally low in almost all California soils, and additional nitrogen is needed for optimum growth of plants. In many lawns and gardens, nitrogen may be the only nutrient needed. Legumes can usually obtain their nitrogen needs from the air if the seed has been inoculated with the proper micro-organisms.

Phosphorus may be low in some California soils, particularly in highly weathered soils, which are often reddish and have hardpan or claypan layers in the subsoil. Other soils may be low due to long-term cropping. Soil analysis can help diagnose a soil deficient in phosphorus.

Potassium is usually not needed because most California soils naturally contain this element. Once again, however, soil analysis can help diagnose a soil deficient in this nutrient.

Sulfur deficiencies are not widespread but may occur in some soils where rainfall is high and water supplies containing little or no sulfur are used for irrigation. Some highly weathered soils may need sulfur. Soil tests are difficult to interpret but may be helpful.

Zinc deficiency of certain garden crops, such as sweet corn, may occur in some areas, especially where the surface soil has been removed during building and leveling operations. Soil analysis may be helpful in diagnosing a deficiency. Fertilizers that contain zinc include zinc sulfate, zinc oxide, zinc ammonium nitrate, and zinc chelate. Apply these fertilizers according to the directions on the package.

Iron deficiency is common when acid-loving plants are grown on soils that contain lime (calcium-magnesium carbonate). It is usually possible to correct an iron deficiency by acidification of the soil and/or by the use of iron fertilizers, such as iron chelate and iron sulfate. Apply according to the directions on the package.

To apply commercial fertilizers-

- Broadcast and mix into the soil before planting, or broadcast over established lawns.(See table 1 for suggested rates.)
- Band applications of a phosphate or phosphate-containing fertilizer at planting time are especially effective when phosphorus is needed. Apply the band of fertilizer 2 to 3 inches to one side and slightly below the seed at planting time. (See table 2 for suggested rates.)
- Sidedressing with nitrogen fertilizer is especially effective for young plants, since the nitrogen is easily moved into the root zone by subsequent irrigations. (See table 2 for suggested rates.)

The rates of nutrient application suggested in table 2 are lower than those in table 1 because of the placement of the fertilizer next to the plants. However, it may be necessary to use both band applications of phosphorus and sidedressing of nitrogen to meet the plants' nutrient requirements. When you sidedress and how frequently depend on the length of the growing season of the plants. Do not sidedress with nitrogen more than three to four times and do not apply nitrogen after the plants have begun to mature.

Volume measurements of manure and fertilizers-

- One cubic foot of air-dry manure weighs about 25 pounds.
- One pint of an average commercial fertilizer weighs 0.7 to 1.1 pounds. Weigh 1 pint of your fertilizer and then you can use volume measurement.

Suggested Fertilization Rates

Table 1 shows the approximate nutrient content of manures, the analysis of a few representative fertilizers, and suggested yearly rates of application per 1,000 square feet of garden area. (The rates given are for materials used singly. If combinations of two or more materials are used, reduce the rates accordingly.)

TABLE 1.

Type of Manure or fertilizer	Percentage ¹				Suggested Amounts of Material (pounds)
	Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)		
chicken manure, dry	2 to 4.5	4.6 to 6.0	1.2 to 2.4		125
steer manure, dry	1 to 2.5	0.9 to 1.6	2.4 to 3.6		450
dairy manure, dry	0.6 to 2.1	0.7 to 1.1	2.4 to 3.6	600	
calcium nitrate (15.5-0-0)	15.5	0	0		16 to 25
ammonium sulfate (21-0-0)	21	0	0		12 to 19
ammonium nitrate (33.5-0-0)	33.5	0	0		7 to 12
urea (46-0-0)	46	0	0		5 to 9
19-9-0	19	9	0		13 to 21
16-20-0	16	20	0		16 to 25
12-12-12	12	12	12		20 to 35

¹P₂O₅ actually contains only 44 percent phosphorus, and K₂O contains only 83 percent potassium. The percentages given for the oxide may be converted to percentages of the element by multiplication: P₂O₅ X 0.44=P; K₂O X 0.83=K.

Table 2 gives suggested amounts of a few representative commercial fertilizers per 100 feet of row when rows are spaced 1, 2, or 3 feet apart. (The number of measuring cups given is approximate, based on the density of the fertilizer.) The amount of material applied by a combination of broadcast and sidedress should not exceed the total amount for the material shown in Table 1.

TABLE 2.

Type of Fertilizer	Row Spacings ¹					
	1 Foot		2 Feet		3 Feet	
	pounds	cups	pounds	cups	pounds	cups
calcium nitrate (15.5-0-0)	1.0	1.4	2.0	2.8	3.0	4.2
ammonium sulfate (21-0-0)	0.75	1.5	1.5	3.0	2.25	4.5
ammonium nitrate (33.5-0-0)	0.45	1.0	0.9	2.0	1.35	3.0
urea (46-0-0)	0.35	1.0	0.7	2.0	1.05	3.0
superphosphate (0-21-0)	0.5	1.0	1.0	2.0	1.50	3.0
treble superphosphate (0-45-0)	0.25	0.5	0.5	1.0	0.75	1.5
19-9-0	0.80	1.5	1.6	3.0	2.40	4.5
16-20-0	0.95	2.0	1.9	4.0	2.85	6.0
12-12-12	1.25	2.5	2.5	5.0	3.75	7.5

¹materials to be applied by sidedressing per 100 feet of row length for the row spacings indicated

IRRIGATION

The texture and the structure of a soil determine the amount of available water the soil will hold at any one irrigation. This water-holding capacity cannot be changed appreciably by normal additions of organic matter or other materials, although it is possible to increase it by adding massive amounts of organic matter. So-called soil mixes, which contain 25 to 50 percent organic matter, and peat soils have very high water-holding capacities.

Guide to Irrigation Frequency and Amount

The available water-holding capacity of a soil depends primarily on the soil texture. Table 3 gives the approximate water-holding capacity of various soil types. The values are given in inches of water per foot of soil depth and gallons of water per cubic foot of soil.

TABLE 3.

Soil Types	Approximate Water-Holding Capacity	
	Inches per foot of soil depth	Gallons per cubic foot of soil
sandy	0.8	0.5
loam	1.6	1.0
clay		1.5

The soil depth from which a plant normally extracts water depends on the rooting depth of the plant. The depth of rooting varies with the type of plant. As a general guide, however, the main root zones of plants are as follows:

- lawn grasses and leafy vegetables - top 1 foot;
- corn, tomatoes, and small shrubs - top 1 or 2 feet;
- small trees and large shrubs - top 2 or 3 feet.

The amount of water a plant uses in 1 day depends on the air temperature and the wind velocity. Table 4 is a general guide to average daily water use.

TABLE 4.

Irrigation Season ¹	Location in California	
	Hot interior valleys (inch)	Coastal valleys (inch)
summer	0.25 to 0.35	0.15 to 0.2
spring or fall	0.1 to 0.2	0.1 to 0.15

¹water use is slightly higher during dry, windy periods or when temperatures are abnormally high.

For example, during the summer a grass lawn growing on a loam soil in an interior valley would use approximately 0.3 inch of water per day. (See table 4.) Since the top foot of a loam soil holds about 1.6 inches of water (table 3), the plants would deplete most of the available water from the main root zone in about 5 days. Thus, an irrigation would be required every 4 or 5 days.

If you have a sprinkler that applies about 0.5 inch of water per hour and no runoff occurs, a 3-hour irrigation would be required. In the spring and fall, the amount of water required per irrigation would be the same, but the number of days between irrigations would be almost twice as long. With deep-rooted trees and shrubs, you could wait two or three times as long between irrigations, but you would need to apply two to three times as much water per irrigation.

You can also use plant symptoms as a guide to irrigation. When short of water, many plants show a dark bluish-green color, or wilting, or both. The symptoms first appear during the hottest part of the day. When either of these symptoms appears, it is time to irrigate.

Another method to determine when to irrigate is to use a shovel or soil tube to check the soil-water content at the 6-inch depth. With a sandy soil, squeeze the soil in your hand; if the ball crumbles easily, it is too dry. With a clay soil, try to roll it into a thread; if this is difficult to do, it indicates that the soil is becoming depleted of water. As you gain experience with the feel of the soil and by observing plant symptoms, it will help you time your irrigations.

Provide enough water at each irrigation to replenish the water used by the plants. This means that you should fill the soil reservoir for the plants to use over a period of time. It is best to give a thorough soaking, then not irrigate again until necessary.

Do not irrigate frequently with small amounts of water. This results in excessive evaporation without deep wetting in the root zone and may result in excessive build-up of salts. Sprinkling by hand is usually a waste of time because not enough water is applied. Frequent applications of water may also encourage root rots and other diseases.

How to Apply Water

You can apply water in furrows, basins, or by standard garden or lawn sprinklers. If you use sprinklers, the application rate should be low enough so that the water soaks into the soil immediately, without runoff. If runoff occurs, stop irrigating for an hour or two; then continue irrigating until enough water has been applied.

A good rule: **irrigate thoroughly but not frequently.**

DRAINAGE

Good drainage is needed to give the plant roots adequate air in the soil and to help prevent diseases, such as root rots. It is usually difficult or unnecessary to do anything about drainage in the home garden except to plant on raised beds. Using raised beds is especially good in winter gardens because the water from excessive rainfall then drains away from the plants.

If salinity is a problem, you can leach or wash the excess salts down through the soil by irrigating with large amounts of water. If it is necessary to leach, do it before planting, or during the dormant season with perennial plants.

TILLAGE

Tillage stirs the soil and is useful for mixing in manures, fertilizers, composts, clippings, or other crop residues. It also temporarily loosens the soil and helps control weeds that compete with crops for moisture and plant nutrients.

Frequent stirring or cultivation does not improve the soil, since soil loosened by cultivation usually returns to its original condition after one or two irrigations. It is usually unnecessary to spade or turn the soil more than once a season, even though rains or irrigations have beaten it down.

Cultivation does not save water, except by killing weeds that compete with crops for both water and nutrients. However, if you apply mulching material to the surface of a soil after a cultivation, it often improves the rate of water infiltration and helps conserve soil moisture by preventing surface evaporation.

Do not till your garden soil unless you are accomplishing some useful purpose, such as turning under organic matter, controlling weeds, making irrigation furrows, or loosening a small amount of soil for planting seed. Some gardeners maintain the beds and irrigation furrows for several years and till only a narrow strip on top of the beds to plant seeds. To avoid packing the garden soil, provide paths for walking and other traffic.

IMPROVEMENT OF SOIL STRUCTURE

Maintaining or improving the soil structure is one of the most important phases of soil management in the garden. It requires consistent and timely use of all good soil management practices. Cultivate or till your soil only when it has a medium moisture content and the soil crumbles easily. If you stir the soil when it is too wet, it will puddle or pack. If you work it when it is too dry, it will form into large clods or powdery dust.

Add organic matter to help maintain or improve the structure of most garden soils, especially clay or adobe soils. Crop residues or grass clippings from a well fertilized garden and lawn area provide a good and readily available source of organic matter.

Manures and composts are also valuable sources of organic matter. (See table 1 for suggested application rates.) You can also use carbonaceous organic materials that decay slowly - peat moss, sawdust, rice hulls, shredded bark, and straw - either as a surface mulch or mixed into the surface soil. Since these materials are low in nitrogen, it is advisable to add a chemical nitrogen fertilizer to the growing plants. Apply approximately 1 pound of nitrogen (5 pounds of ammonium sulfate) for each 100 pounds of carbonaceous organic material used.

You cannot permanently build up large amounts of organic matter in the soil because it will soon decompose and disappear. However, occasional additions of organic matter, either as plant residues or manures, ensure a continuous supply of energy for soil organisms. As the soil organisms decompose the organic matter, they help maintain good soil structure and also change the organic matter into inorganic nutrients that can be used by the growing plants. It is through the process of decomposition - the release of compounds into the soil environment that cement small soil particles together - that soil structure is improved.

OTHER GARDENING PROBLEMS

The successful gardener must also watch for problems, such as plant diseases, insects, weeds, rodents, nematodes, and others. You can obtain information on how to control these pests from your local garden store and/or from the University of California Cooperative Extension farm advisor in your county.