Home & Garden
Pest Management Guide
For British Columbia

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Chapter 7
Soil Management and Composting

Soil Management and Composting

> *"Feed the soil not the plant." The goal of managing a garden soil should be to ensure that the soil is healthy.*

Healthy, vigorous roots make healthy, vigorous plants. Many plant health problems are the result of poor root growth. A suitable soil for growing healthy roots and plants must be fertile and have a good structure or "tilth" which permits air and water movement around the roots and good root penetration and growth.

Soil texture, or the relative amounts of sand, silt and clay in the soil, imparts most of the physical characteristics of the soil. Soil structure, or the arrangement of the lumps within the soil, provide a visual key to soil tilth. A "light" soil with a high percentage of sand or gravel may allow water and nutrients to drain or "leach" out too quickly for most plants. A sandy soil will also tend to have smaller lumps or be single grained. A "heavy" soil with a high percentage of clay will tend to become waterlogged and will not allow enough air to get to the roots. Clay soils tend to have harder lumpy tilth. A soil that is compacted or hardened will not allow roots to penetrate and grow well. A "loamy" soil is generally a soil with a mixture of sand, silt and clay particles which, combined with organic matter, create a friable or well aggregated and crumbly structure.

A fertile soil is one which contains all of the essential nutrients (minerals) needed by the plants for growth. These nutrients must be available in sufficient quantities and in a form that can be taken up by plant roots.

Availability of nutrients to plants depends on how healthy the soil is - good soil tilth will lead to better nutrient supply. To maintain good soil fertility and tilth, organic matter and fertilizer nutrients should be added regularly. The pH of the soil, which measures how acid it is, will affect nutrient uptake as will the salt content of the soil.(see "Lime and Soil pH", below).

Organic Matter

Organic matter is primarily added to soil to improve its physical structure. Depending on the source and degree of decomposition of the organic matter it may also supply nutrients. Organic matter breaks down in the soil to form humus. Organic matter can improve air and water movement in a clayey soil and makes it easier to work. Organic matter also improves the water and nutrient-holding capacity of sandy soils. Organic matter should be applied regularly to vegetable gardens, woody ornamentals, and flower beds.

Organic matter suitable for gardens comes from a ranges of sources including yard and garden waste (leaves or grass clippings), animal manures, composts, peat moss, seaweed, and wood products (sawdust, shavings or bark mulch). Peat moss is useful as a soil conditioner, but supplies almost no nutrients. The ability of organic matter to supply nutrients depends on its source, particles size and degree of decomposition. If wood products such as sawdust are used, extra nitrogen may have to be applied if dry fertilizer is used. For every layer of sawdust 5 cm deep, add an extra 65 grams of 46-0-0 urea fertilizer, 190 grams of 16-20-0

(ammonium-phosphate-sulfate) per 9 square meters (100 square feet), or equivalent amount of nitrogen in addition to whatever amount of nitrogen is needed by the crop. Applications of liquid fertilizer should not be affected by the sawdust and do not need to be increased.

Manures and composts are among the best materials to add because they add organic matter to soil, often improving aeration, drainage, nutrient-holding capacity, and biological activity and other soil properties. However, nutrient levels vary among different composts and most composts do not supply nutrients in the same ratios that are needed by plants. If composts are made from a significant amount of manure, nutrient levels tend to be higher compared to other composts such as yard trimmings compost. Heavy applications of compost may supply high levels of soluble salts, which can be damaging to plant roots. If composts derived from animal manures are going to be used in raised beds, containers or planters, the volume of compost should be less than one third of the total volume of 'soil' in the container. Weed seeds can be introduced into the garden by adding immature compost or material that has not fully composted, regardless of whether it contains manure.

Composting

Composting is very beneficial to the garden and the environment. If plant material is properly composted at the right temperature, most insects, diseases and weed seeds may be destroyed. Home composting may not destroy all of these if proper temperature and moisture is not maintained. If weed seeds or certain pests or diseases are present, it is advisable to dispose of crop refuse in a landfill where it will be quickly buried, rather than composting it. Homeowners usually add ingredients in small quantities; therefore the compost doesn't usually get very hot. This is referred to as "cold composting". It doesn't kill everything, but produces good compost. Properly composted material should look dark and spongy, and have a fibrous, moist texture.

Compost Preparation

Compost is produced by the decay of vegetative (plant) matter. Compost is a soil conditioner, a source of organic matter available to all gardeners. Choosing a compost site carefully is very important. Partial shade is ideal, to avoid summer drying and also provide some solar heat to onset composting action. To prevent too much moisture loss, choose a site that is protected from drying winds. Locate your composting site in a spot that is wheelbarrow accessible to make it easier to move compost volumes in and out.

Compost is made by alternating layers of "green and brown" material. Examples of green materials include kitchen waste, grass clippings, and fruit and vegetables. Examples of brown material include leaves, newsprint, and shredded paper. Do not add meat, bones, or dairy products which can attract animals and vermin. Adding a light dusting of soil every few layers will assist the earthworms in breaking down organic material. Store vegetative matter until enough is accumulated to make a pile. Chop up large, coarse pieces before added them to the pile. Materials used in building compost piles should be moist, but not waterlogged. For example, a large pile of wet grass clippings will not compost as well as a pile made of layers of different materials varying in moisture content and texture. Turn or aerate the compost pile frequently (every

few weeks or more often) to introduce oxygen into the pile. Some plastic compost bins are not suited to "turning". Compost aerating tools (Wingdiggers) or a sharp stake, can help accomplish this task. A properly constructed compost pile will not emit offensive odours, but will produce a lot of heat.

If compost is made inside a covered bin or box, heat will be retained. A cover is recommended in the coastal area to encourage heating, prevent loss of moisture in the summer and reduce leaching by the winter rains. This results in faster decomposition and kills most insect pests. In the dry areas of the Interior, a cover is not so essential and it is more important to add water periodically during dry weather. The box should have holes or gaps in the sides and bottom to allow air to enter.

The ideal is to have three receptacles: one for storage of incoming vegetative materials, one for the working pile, and one for the finished product. Most homeowners only have space for one compost bin. This is why the plastic covered bins have a door at the bottom, so finished compost can be moved out, while new material is added to the top. It is also possible to remove the front of a wooden box and slide the box to a new location before re-attaching the front so that it can be refilled. This eliminates the cost of building three boxes. Screening is not necessary unless a finer product is required for lawns or containers. Non-decomposed, coarse materials can go back to the working pile for further decomposition.

Some plant material should not be composted. This includes plant parts containing certain insects and diseases, such as root maggots or clubroot of crucifers; mature weeds and plants from the flower garden with ripened seeds; and lawn clippings that have been recently treated with weed killer. Avoid highly resinous wood and leaf prunings from conifer plants such as junipers, pine, spruce and arborvitae. The resins protect these materials from decomposition and extend the time needed for composting in comparison with other plant materials. This type of plant material should be buried, taken to a landfill, burned (where permitted), or placed in plastic garbage bags and set out with the household garbage for disposal (where permitted).

Compost piles built in the spring should be ready for use in the fall. Those constructed in the fall may be ready by spring or early summer of the following year. In regions with heavy winter rains, if the compost box has no permanent cover, use a plastic sheet during the winter to permit faster decomposition and reduce leaching of nutrients. Excess water will cause piles to become “anaerobic” from lack of oxygen and decomposition will stop.

Composting Pest Problems

Rats may look at a compost bin as an ideal site to nest in. Try to keep compost moist and regularly turned to make a compost pile unattractive. Rats may be looking for food in the pile so be sure to bury food scraps. Consider building an enclosed bin for kitchen waste and have an open bin for grass clippings and garden waste. Never add meats, greasy foods or dairy products to a compost bin. Always make sure bin lid is secured. If rats are burrowing underneath the compost, stand the bin on ¼ inch mesh wire. If rats are gnawing into a plastic bin, try reinforcing the sides, top and bottom with ¼ inch mesh wire.

Fruit flies can become a problem if food is left exposed, or if there is too much food in the bin. Always bury food, do not overload the bin, and consider covering the surface of the bin with a plastic sheet, old carpet or sacking. Freezing food prior to composting may also help. If this problem persists, move the bin to a location where the flies will not be so bothersome.

Unpleasant odour can result from improper nitrogen/carbon layering, not enough air, too much moisture or too many acidic foods such as citrus peels. Ensure proper aeration by checking if holes are clear, or drill more holes. If there is not enough air in the compost, aerate. Cut back on acidic food, and consider adding dolomitic lime. Adding course, dry materials such as straw can help.

If raccoons become a problem, do not put food of any kind in open compost piles; instead, use a securely covered compost structure or a commercially available raccoon-proof composter to prevent attracting raccoons. A covered worm box is another alternative. If burying food scraps, cover them with at least 8 inches of soil and don't leave any garbage above ground in the area—including the stinky shovel. Placing a wire mesh barrier that is held in place with a heavy object over the in-ground compost will prevent problems.

Compost Tea: A Growing Concern

The term "Compost Tea" describes the watery solution obtained by soaking compost in water in the presence of nutrients such as molasses, kelp, and rock dust. The term "Compost Tea" is sometimes used to include the following products:

- Compost leachate - leachate from the compost pile
- Compost extract - soaking compost in water
- Manure tea - soaking manure in water
- Herbal tea - soaking fresh green plant material in water
- Liquid manure - fermented plant and marine animal material

Compost teas are sometimes used as liquid fertilizers or to suppress plant diseases.

Compost Teas and Food Safety

Compost teas that are improperly prepared may contain pathogens, such as *Salmonella* and *E. coli* 0157:H7. Gardeners using compost tea must be certain that the compost tea does not contaminate food plants with organisms that can cause human illness. Since the microbial composition of a home made compost tea can not be controlled, it is risky to use compost teas, and they are not necessarily effective for managing plant diseases.

If using compost teas, apply only to the soil as a weak fertilizer. Do not apply to plant foliage or fruit that will be eaten.

Lime and Soil pH

Many soils, particularly those on the Coast, are subject to leaching from heavy rainfall, resulting in an acidic (low pH) or "sour" soil that can limit plant growth. A few plants, such as camellias, rhododendrons, azaleas, Fraser firs, mountain laurels and blueberries prefer acidic soils. For others, applications of lime may be needed to neutralize soil acidity (raise the pH) and, to a lesser degree, to supply calcium. If dolomite lime is used, magnesium, which is often deficient in coastal soils, will also be supplied.

Many regions of the province, particularly those in the Interior, have naturally occurring high pH (alkaline) soils. These soils should **not** be limed, unless the pH has been decreased (artificially) below optimal levels for the crop. The pH of alkaline soils can be lowered through the use of small amounts of finely ground sulfur fertilizers. Over time, the addition of certain nitrogen fertilizers will also acidify soil. Many alkaline soils tend to have higher salt contents. Additions of organic matter will also aid in buffering high pH and higher salt contents. Salts may need to be leached from the soil. If calcium is required in high pH soils, apply gypsum (calcium sulphate) which provides calcium without raising the pH.

The need for lime and how much to apply is best determined by a soil test. A relative pH level can be obtained by using a quick test or pH probe (purchased from a garden centre) which may be sufficient for the home garden. Soil testing laboratories can provide a more accurate measure of pH, along with a complementary measure (e.g., buffer pH) that is needed to provide a lime recommendation.

The two best liming materials for use in the home garden are ground limestone (calcium carbonate - $CaCO_3$) and dolomite lime (calcium/magnesium carbonate - $CaCO_3 \cdot MgCO_3$). Properly applied, either of these materials will gradually increase soil pH, making the soil more alkaline, and will hold this pH level for a few years. Lime is slow to react with soil so it should be mixed into the soil or applied in fall so that winter moisture can move it into the soil. Avoid adding sources of nitrogen (e.g., some composts, ammonium-based fertilizer) at the same time as liming, since the lime and nitrogen will react together to result in nitrogen losses into the air.

Calcium hydroxide, $Ca(OH)_2$, also known as hydrated lime, is not recommended for home gardens. It can burn roots or other plant parts on contact, therefore it should be used only on ground being prepared for seeding and/or planting. Excess calcium hydroxide may make the soil too alkaline and reduce the availability of some nutrients. It also breaks down organic matter in the soil. It should never be used on lawns as it encourages certain diseases of turf.

Raising the soil pH is best done by thoroughly incorporating lime into the top 15-30 cm of soil the year before planting. Thereafter, top-dressing established plantings with lime will help to maintain the pH at more neutral levels. Ideally, lime should be worked into soil well before planting. If necessary, lime may be applied at planting time along with fertilizer, but work the lime in thoroughly and follow planting with a thorough watering or irrigation. For most coastal soils, an application of lime every 3 to 4 years will maintain the soil pH at a level suitable for most plant growth.

In coastal vegetable gardens, finely ground limestone or dolomite should be applied every 2 or 3 years at the rate of 20 kg/100 m^2 and incorporated while digging or rotovating. This is best done in the fall or early spring, at least a month before planting. Do not apply lime where potatoes are to be grown, as high soil pH promotes scab disease.

In coastal flower and shrub beds, apply 20 kg/100 m^2 of ground limestone or dolomite lime and incorporate before planting. After initial establishment, lime may need to be applied to perennial beds as a top-dressing every few years at 5-10 kg/100 m^2.

For lawns, 25 kg/100 m^2 of ground limestone or dolomite can be incorporated into the topsoil before seeding or sodding. Fall liming is recommended to allow winter rains to move the lime into the soil. Thereafter, 12-25 kg/100 m^2 may be applied to the lawn surface every 2 to 3 years as a top-dressing to maintain pH and reduce the growth of moss. Note: Liming lawns encourages the growth of some broad-leaved plants such as white clover.

Fertilizers

Soils must supply multiple mineral elements for plants to grow properly. If any one essential element is deficient, plant growth will suffer. Elements required by plants in the largest amounts are nitrogen (N), phosphorus (P), and potassium (K). Nitrogen is usually the most limiting, especially in high rainfall areas such as coastal B.C. Nitrogen, P and K are called “major” or “macronutrients” and are represented by the three numbers on a fertilizer label (e.g., 46-0-0 indicates a fertilizer is 46% nitrogen by weight). The other minerals are needed in smaller amounts and are called “minor” or “micronutrients”. Most soils contain sufficient amounts of micronutrients, but sometimes they may be deficient or even in excess, which can damage plants.

Manures and Composts

Manure is both an organic matter source as well as a nutrient source. Animal manures and composts may provide enough major plant nutrients for a garden. Because of its high nutrient content, compost derived from manure, fish meal or biosolids should be used as a fertilizer. High rates of manure use should be avoided as this can lead to leaching or runoff loss of nutrients.

If large quantities of manure are available, other fertilizers may not be required. However, animal manures can vary in their ability to supply nutrients depending on their origin, age, and the method of storage. When storing manure, cover it with plastic to prevent leaching. If sufficient quantities of manure are not available, use whatever organic material is available and supplement this with commercial fertilizers if necessary.

Application rates for fresh manure should be equivalent to approximately 2 centimeters in depth or 50 kg per 10 m^2. A notable exception is poultry manure that has not been composted. This material has a much higher nitrogen content than cattle or horse manure and should be applied at closer to 5 kg per 10 m^2, or it should be composted with other materials before being applied.

Caution: Fresh animal manure may contain potentially harmful organisms. To avoid risk of infection from pathogens, manure should be composted for at least one year prior to use or it should be incorporated into the soil for use with long season crops such as corn or late potatoes. Do not use fresh manure on short season crops such as radishes or leaf lettuce.

Approximate Composition of Fresh Manure* (%)				
Manure	Moisture	Nitrogen	Phosphate	Potash
Chicken	55	2.7	2.5	1.1
Cattle	80	0.5	0.3	0.8
Hog	75	0.5	0.2	0.4
Horse	60	0.3	0.2	0.3
Spent Mushroom Compost	65	0.6	0.2	0.8
Sheep	65	0.9	0.8	0.9
* Nutrient content of manure will vary widely depending on the type and amount of bedding used, the age of the manure and the storage method.				

Composition of Dried & Bagged Manure

Many types of bagged manure are sold in garden centres. These products have only 10-20% moisture and are 2 to 8 times more concentrated in terms of nutrient content than fresh manure. Like compost, manure should make up less than 15% of the total volume of soils used in containers or raised beds due to the higher nutrient concentration and potential for manure to contain salts.

Commercial Fertilizers

Commercial fertilizers may be derived from organic or inorganic materials.

Organic Fertilizers:

Organically-derived chemical fertilizers become available to plants slowly. These types of fertilizers must undergo various reactions in the soil in order to supply nutrients in the form absorbed by plants. Because organic fertilizers become available slowly, fertilizer or salt burn of plants is less likely than when using highly concentrated mineral fertilizers, but can still occur if too much is applied to young, tender plants and roots. Read the label carefully and apply as directed.

Examples of organically-derived fertilizers include fish fertilizers and blood meal (nitrogen suppliers), bone meal (phosphorus supplier), greensand, wood ashes, and seaweed (potassium suppliers).

Slow-Release Fertilizers:

Several types of coated, slow-release fertilizer pellets are used in ornamental nurseries. The slow release is created by coating or mixing the fertilizer pellets with sulfur or some form of polymer resin. They can be recognized as small white, yellow or grey round pellets on or in container plants purchased at garden centres. Although they are “slow-release” products, over-application next to stems can cause burn of plants at the soil line. In the home landscape, another type of season-long, slow-release fertilizer for woody ornamentals is in the form of a small stake which is driven into the ground near a shrub or woody perennial.

Chemical Fertilizers:

Chemically-synthesized fertilizers are relatively inexpensive and readily available. They are prepared in a form that is readily absorbed by plant roots. Most fertilizers for home gardens are mixtures of urea (46-0-0); di-ammonium phosphate $(NH_4)_2HPO_4$, (18-46-0); and muriate of potash (KCl, 0-0-60). Balanced fertilizers for use by home gardeners are made by mixing these fertilizers in varying proportions.

Composition of Fertilizers:

All packages of commercial fertilizers, whether organic or chemically-synthesized, have 3 numbers on the bag or box. These numbers indicate the percentage by weight of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) in the blend. Note that P_2O_5 and K_2O are simply units of phosphorus and potassium, not the actual forms of nutrients that plants take up.

For Example:

- 4-10-10 = 4% nitrogen, 10% phosphate, 10% potassium
- 6-8-6 = 6% nitrogen, 8% phosphate, 6% potassium
- 46-0-0 = 46% nitrogen, 0% phosphate, 0% potassium

When deciding how much fertilizer to apply, the composition of the blend must be taken into account.

For Example:
A 10 kg bag of 46-0-0 contains almost as much nitrogen as a 75 kg bag of 6-8-6. There are 4.6 kg of nitrogen in one 10 kg bag of 46-0-0 (46% nitrogen x 10 kg = 4.6 kg).
A 75 kg bag of 6-8-6, (or 7.5 X 10 kg bags) contains 4.5 kg of nitrogen (6% nitrogen x 75 kg = 4.5 kg).

What Fertilizer to Use and How Much?

Fertilizer requirements for crop phosphorus and potassium requirements are best determined by a soil test before planting. Nitrogen requirements depend mainly on the crop type and less so on soil tests. Soil nutrient levels can be determined by using a quick test kit (purchased from a garden centre). Soil testing laboratories can provide a more accurate measure of soil nutrient levels and needs (refer to your local garden centre for suggestions for a testing lab).

Generally, fertilizers that are relatively high in nitrogen are used in the spring to promote vegetative growth, for example, leafy vegetables, lawns, young trees and shrubs. These should not be applied in late summer to perennial or woody plants which need to "harden off" before winter. Fertilizers relatively high in phosphorus and potassium are used to promote production of flowers, fruits, or roots.

The following rates are recommended as general guidelines. Other fertilizers of higher analysis but similar ratios can be substituted at lower rates, for example, instead of using 15 kg of 4-10-10, you can use 7 kg of 8-24-24. Do not use excessive rates or crop damage in the form of fertilizer burn may result and nutrients will be lost to the environment by runoff or leaching. If manures or composts are also used, apply lower rates of fertilizer. Do not apply concentrated fertilizer to leaves or close to the roots or stems of plants. Never put fertilizer in the seed furrow in close contact with the seeds or in the transplant hole in contact with the roots, as this may burn new seedlings.

Fertilizing Vegetables

Broadcast one of the following fertilizer formulations over the garden and incorporate into the top 15 to 20 cm of soil just before planting.

Fertilizer	Fertilizer Rate kg/100 m^2
Coastal Gardens:	
4-10-10	12-15
6-8-6	12-15
Interior Gardens:	
16-20-0	4-5

For leafy vegetables, carrots and corn, apply a side-dressing of one of the following nitrogen fertilizer formulations after the plants are well established.

Fertilizer	Fertilizer Rate kg/100 m^2
Calcium Nitrate 15.5-0-0	4
21-0-0	3
46-0-0	1

Calcium nitrate (15.5-0-0) is one of the best products to use in coastal home gardens because it also provides 20% calcium; does not lower soil pH; is least likely to burn plants and can also be used to make up foliar spray applications to correct calcium deficiencies. Do not apply calcium nitrate just before significant rainfall or before excessive watering, to avoid leaching the nitrate-nitrogen below the root zone. Other sources of nitrogen, such as ammonium sulfate, lower soil pH and so would be more appropriate for use in the Interior.

Dribble the fertilizer alongside the plant row. Do not place fertilizer in direct contact with plants, but keep it back about 10 cm from the roots. If the soil is dry, water afterwards to wash the fertilizer into the root zone. If soil is high in organic matter, or manure or compost was applied, side-dressing should not be necessary.

Fertilizing Lawns

Prior to seeding or sodding a new lawn, apply one of the following fertilizer formulations and incorporate it into the top several centimeters of the soil.

Fertilizer	Fertilizer Rate kg/100 m^2
Coastal Lawns:	
13-16-10	8
8-10-6	13
Interior Lawns:	
21-0-0	6
16-20-0	7.5

Once established, the lawn will require periodic fertilizer applications to maintain vigour. Apply one of the above fertilizers at half rate, or a dressing of well rotted, screened manure or compost, in the spring and again in the fall.

Broadcast fertilizer evenly over the lawn and water afterwards to wash fertilizer into the root zone and prevent burning of the grass. Slow release fertilizers such as SCU (sulphur-coated urea) are useful in prolonging the nutrient release and reducing the danger of burning.

Some lawns, particularly those growing on soil low in organic matter , or sandy soils low in clay content, will require 2 or 3 additional applications of nitrogen during the season. Example: 46-0-0 at 1 kg/100 m^2. Slow-release fertilizers are helpful on sandy soils.

Fertilizing Flower Beds, Ornamental Trees and Shrub Borders

For annual or newly established perennial flower beds, apply a complete fertilizer such as 4-10-10 at 12-15 kg/100 m^2 and incorporate into the top several centimetres of the soil before planting.

For trees and shrubs, apply a complete fertilizer high in nitrogen, such as 28-14-14 or 12-4-8 at label rates, four to six weeks after planting. An annual spring application thereafter will be sufficient to maintain vigour. Fertilizer should be broadcast over the area extending from the trunk to slightly beyond the spread of the branches. As a rule of thumb, use about 200 g of 10-5-5 for each cm of trunk diameter.

Micronutrients

In addition to nitrogen, phosphorus and potassium, plants require small amounts of other micronutrients including calcium, magnesium, sulphur, iron, manganese, boron, copper, zinc and molybdenum. Where manures or other organic materials are applied regularly, deficiencies of these nutrients rarely occur. Commercially synthesized, complete fertilizers may be purchased that will supply these micronutrients as well as nitrogen, phosphorus and potassium.

Where limited manure or compost has been used or under certain soil and climatic conditions, a micronutrient deficiency may occur in a crop or landscape planting. These deficiencies can be corrected by adding a fertilizer containing micronutrients to the soil or by spraying micronutrient solutions onto the plants. A reliable diagnosis or soil test should be carried out before beginning a corrective program. The micronutrients most commonly found to be deficient in B.C. are boron, calcium, magnesium and zinc.

One of the easiest ways to apply micronutrients is to use a chemically-synthesized, complete fertilizer which, in addition to containing nitrogen, phosphorus and potassium, also contains micronutrients, for example: "20-20-20 plus minor elements". Follow package instructions to determine rates of application. If using fertilizers containing minor elements (micronutrients), careful measuring is essential to prevent accidental overdoses.

Fritted-trace-elements (F-T-E), containing boron, iron, magnesium and zinc carried on glass beads, can be purchased for garden plantings and houseplants. Only use F-T-E at the recommended rates on the label and mix thoroughly into the soil. Micronutrients are also available in chelated or organic based forms.

Boron (B)

Boron deficiency is found in fruit trees in some parts of the Interior. Boron deficiency shows up in the youngest leaves and terminal buds. Leaf tips and margins of affected plants may have a scorched appearance. Young leaves of trees may become pale green, twisted and often die. If severe enough, terminal buds will die. Similar symptoms can be caused by diseases and other factors, so a laboratory diagnosis may be needed to eliminate other causes.

Root vegetables such as beets, carrots, rutabagas and parsnips may be affected by boron deficiency at the Coast or in the Interior. Affected roots may crack, or internal tissues may become discoloured and darken, resulting in a disorder known as

"blackheart". A mild boron deficiency symptom frequently seen in beets is a series of whitish concentric rings in the roots when they are sliced open. "Blackheart" of potatoes is usually caused by other factors.

Other boron deficiency symptoms in vegetables include brown curd of cauliflower where the normally white cauliflower florets develop a tan or brownish cast; hollow stem in cole crops where stems are hollow and cracked; and, cracked stem of celery characterized by ragged, crosswise cracking and stiff, brittle, bitter-tasting stems.

In strawberries, boron deficiency causes stubby, distorted fruit and crinkled, distorted leaves. However, these symptoms are also caused by mites, viruses and other factors, so a good diagnosis is important.

In flowers, boron deficiency typically causes blackening of young shoots and flower buds. Calcium deficiency or virus infection can cause similar symptoms. Boron deficiency is rare in flower gardens and woody shrubs and perennials.

While boron is a required element, most plants can be damaged by an excess of this nutrient. Therefore, when applying a boron fertilizer, careful measuring is essential. In the Interior especially, boron carry-over may be a problem because there is less leaching of boron from soils over the winter. Therefore, do not apply boron unless a soil test indicates a need.

The most common method of applying boron is to mix borax, which contains 11% boron, in water and either spray this solution on foliage, or water it into the ground at planting time. For foliar sprays, mix one level tablespoon of borax with 4 L of water; to apply to the soil, use 2 tablespoons per 4 L and apply to 3 m of row with a watering can.

Note: Do not apply boron to areas where cucumbers or beans are to be grown.

Calcium (Ca)

Calcium deficiency is not always apparent in the growing plant but shows up at harvest or shortly thereafter. Bitter pit of apple, blossom end rot of tomatoes and peppers and black heart of celery are all due to shortage of calcium in the fruit tissues. Calcium is taken up by the roots but is not readily translocated (moved) between parts of the plant, so foliar sprays of calcium on vegetable crops after fruit are formed are usually ineffective. On apple trees, calcium foliar sprays are beneficial if applied early enough, before the fruit size up. There is some evidence that calcium foliar sprays might be beneficial to reduce fruit drop in particular varieties of highbush blueberries (e.g., Draper). Calcium nitrate at 1-2 teaspoons (5-10 grams) /L of water should be sprayed on the fruit as it is sizing up to increase calcium uptake. For tomato, pepper and other vegetable crops, reduce nitrogen fertilizer, check that soil pH is appropriate, avoid drought-stress at flowering and early fruit stage, and apply calcium-containing soil fertilizers in the spring.

Calcium deficiency also causes distorted and twisted leaf tips on strawberry and blackening of buds and young shoot growth on garden flowers, although this is more common in commercial greenhouses than in outdoor home gardens. It can be mistaken for boron deficiency, mites, aphids or other factors. For strawberries grown on sandy soils, follow recommendations above for tomatoes and peppers.

Iron (Fe)

Iron deficiencies can occur on broad-leaved evergreens, bush fruit and strawberries growing on high pH soils, especially in the Interior. It can also occur on rhododendrons at the Coast. Iron chlorosis appears first on the youngest leaves as interveinal yellowing, progressing to an overall pale green or yellow leaf colour. Iron fertilizers specially formulated as an iron chelate (Fe + EDTA) should be used at rates indicated on the label. Iron deficient plants may also be sprayed with ferrous sulphate at 1 teaspoon (5 grams) in 2 L of water.

Magnesium (Mg)

Magnesium deficiency is frequently observed in conifers growing at the Coast. The typical symptom is a general yellowing of the needles, starting with the oldest needles. Addition of dolomite lime to the soil at planting should prevent Mg deficiency (see "Liming and Soil pH", above). Epsom salts (MgSO4) at 2 teaspoons (10 grams)/L of water, sprayed on the plants or other fertilizers containing magnesium, can be used to alleviate this problem temporarily.

Zinc (Zn)

Zinc deficiency on fruit trees is characterized by an interveinal yellowing of younger leaves followed by a reduction in leaf and shoot growth. If severe enough, leaves may grow in a "rosette" form. Zinc deficiency is most commonly observed in the Interior, since zinc availability decreases with increasing soil pH.

Organic Fertilizers De-Mystified

Fertilizer application can be a challenge in terms of understanding the correct amount to apply to your garden plants. This can be even more challenging when organic sourced materials are used. The following table provides some detail on many types of organic soil amendments including the nutrients they contain and a recommended application rate. The application rates are conservative but are designed to provide sufficient plant nutrients under average soil and climatic conditions.

Organic Fertilizers

Material	Guaranteed Analysis (N-P_2O_5-K_2O)	SOURCES OF NITROGEN (N)	Duration	Pounds per 100 Sq. Ft.	Kg per 10 m^2
Alfalfa Meal/Pellets	3 - 0.5 - 2.4 (or 2 – 1 – 2)	contains calcium, sulphur, magnesium & traces of boron, manganese, copper and lime; also root stimulant tricontinol; breaks down quickly	4 - 6 mo. 1 – 4 mo.	5	2.5
Blood Meal	12 – 2 - 0.5 12 – 0 – 0	moderately fast acting; can burn plant stems; repels rabbits, deer, but attracts dogs; slightly acidifying; costly.	3 - 4 mo. 1 - 4 mo.	2	1
Canola Meal	8 – 3 - 4	contains nitrogen, phosphorus & trace minerals; fast-acting.	4 - 6 mo	2.5	1.2
Fish Meal	5 – 3 - 5 to as high as 10 – 6 – 2	has major & micronutrients; relatively fast acting; fishy odour, relatively inexpensive.	6 - 8 mo.	3	1.5
Material	**Guaranteed Analysis (N-P_2O_5-K_2O)**	**SOURCES OF PHOSPHORUS (P)**	**Duration**	**Pounds per 100 Sq. Ft.**	**Kg per 10 m^2**
Bone Meal	1 - 16 – 0 3 – 15 – 0	fast-acting; relatively expensive; promotes root/vegetative growth	6 - 12 mo. 1 – 4 mo.	1	0.5
Hard Rock Phosphate	0 - 4 - 0	slow acting; rich in calcium, supplies micronutrients/ & iron, fairly inexpensive; soil needs to be pH 5 - 6.5 for uptake by plants	5 yrs	2.5	1.2
Colloidal Rock Phosphate	0 - 2 - 0	by-product of mining rock phosphate; faster acting, ground up; supplies same nutrients. May contain 20% phosphate but only 2 – 3 % is available.	3 - 5 yrs	2.5	1.2
Material	**Guaranteed Analysis (N-P_2O_5-K_2O)**	**SOURCES OF POTASSIUM (K)**	**Duration**	**Pounds per 100 Sq. Ft.**	**Kg per 10 m^2**
Greensand (Glauconite)	0 – 1 - 6	rich in micronutrients; good soil conditioner for both clay and sandy soils; good for long-term soil improvement; not a fast fix; moderately expensive.	5 - 10 yrs	3	1.5
Langbeinite (Sulphate of Potash-Magnesia)	0 - 0 - 22	fast-acting; don't use with dolomite lime as you will get too much magnesium; also supplies sulphur; better for alkaline soils.	3 - 6 mo.	0.5	0.25
Wood Ashes	0 – 2 - 7	fast-acting; supplies micronutrients; rich source of calcium; will raise soil pH about 2/3 as much as lime; do not use if soil pH is above 6.5; not good for acid-loving plants	2 yrs.	1	0.5

Material	Guaranteed Analysis (N-P_2O_5-K_2O)	SOURCES OF CALCIUM	Duration	Pounds per 100 Sq. Ft.	Kg per 10 m^2
Dolomite Lime	25% Ca; 8 – 20% Mg	supplies abundant magnesium; raises soil pH. Use lower rates on sandy soil, higher rates on clay.	3 - 4 yrs	3 - 7	1.5 – 3.4
Oyster Shells (Crushed)	34% Ca	no Mg; raises soil pH slowly; if finely ground dissolves like limestone. Use lower rates on sandy soil, higher rates on clay.	3 - 4 yrs.	3 - 7	1.5-3.4
Wood Ashes	10 – 30% Ca; 3 – 6 % Mg	fast-acting; supplies micronutrients; rich source of calcium; will raise soil pH about 2/3 as much as lime; do not use if soil pH is above 6.5; not good for acid-loving plants; apply 3 weeks before planting the vegetable patch.	2 yrs.	3.5	1.7
Material	**Guaranteed Analysis (N-P_2O_5-K_2O)**	**SOURCES OF MICRONUTRIENTS**	**Duration**	**Pounds per 100 Sq. Ft.**	**Kg per 10 m^2**
Kelp Meal	2 - 1 – 2 (another source suggests 1 – 0 – 4)	+62 trace vitamins/minerals; increases plant's resistance to stress; a good soil conditioner; 1 lb dry = 9 lbs fresh seaweed	immediate to 1 month	8	4

This table was adapted from the following information by Linda Rehlinger, Master Gardener, B.C.

1. Chapter 2 "Soils and Fertilizers" from the MG Training Manual, written by Craig Cogger, Extension Soil Scientist, Washington State University.
2. "Secrets to Great Soil", by Elizabeth P. Stell
3. 25 kg bag of kelp meal, (*Ascophyllum nodosum*) by Multi-Crop Industries Inc.
4. Additional reference: Colorado Master Gardener Program Garden Notes #234 revised December 2006, www.cmg.colorado.edu

Soil Salinity and Sodicity

The level of soluble salts (i.e., salinity) in the soil is determined in the laboratory by measuring its electrical conductivity. Excessive salt levels in the soil water will prevent normal growth. Such levels can occur naturally and are common in soils in low rainfall areas in the Interior of British Columbia or in areas affected by ocean water spray or intrusion along the coast. Incorporation of organic matter into poorly drained saline soil is a recommended practice.

Excess soil salinity is also found elsewhere in British Columbia, generally caused by over-fertilization, by chemical fertilizers or composts for example. A typical symptom is of excess salinity is lack of growth or plant dieback, or browning of leaf edges after substantial fertilization. In dry areas, the only remedy is to wash, or "leach" the excess salt from the soil root zone with intensive and frequent waterings. In Coastal B.C., tile drainage will allow the excess salts to leach out during the winter rains. During dry weather, sprinkler irrigation may be necessary to grow a good crop in such soils. Prevention of salt buildup by using a sound fertilization program is the most environmentally friendly method to deal with this common problem.

Sodicity refers to the presence of excessive sodium attached to soil particles. The result is poor soil structure, leading to poor drainage and aeration. Applying gypsum helps reclaim sodic soils where sodium levels have become too high. The most economical way is to add gypsum which supplies calcium. The calcium displaces the sodium held on the clay-binding sites. The sodium can then be leached from the soil with low-sodium irrigation water or rainfall.

Within B.C., naturally-occurring sodic soils are rare and mostly found in the Peace River region. Salt from road de-icing may also cause salinity where runoff water accumulates.

Crops vary in their ability to grow in saline soils. The following vegetables are best able to grow in "salty" soils: beet, spinach, tomato, broccoli, cabbage, cucumber, cantaloupe, potato. The least salt-tolerant vegetable is bean.