Nutrient Management

Soil Testing

Soil analysis is the most accurate guide to nutrient and lime requirements for most crops. It is especially useful before planting to determine soil fertility and pH levels. The necessary lime and fertilizer can then be added during the field preparation. Soil testing combined with tissue testing are useful tools for determining fertilizer requirements in established crops. However, sampling must be done accurately and carefully so the samples are representative of soil and crop conditions. Refer to the BCAGRI Soil Factsheet, "Soil Sampling" for more information on collecting and handling a soil sample.

The basic steps for soil sampling are:

- Use the same sampling method and pattern every year.
- Use clean tools (e.g. garden trowel) to collect the sample.
- Use a clean pail (e.g. ice-cream bucket) to hold all the samples for one combined analysis.
- Mark the locations on a field map where samples are to be collected. Avoid non-uniform areas.
- Record relevant information about the location and type of sample.
- Wear disposable gloves when sampling for micronutrients.
- Take 10 to 20 individual samples to a depth of 15 cm (6 in) for most nutrients. Sample to 30 cm (12 in) when sampling for nitrate-nitrogen in the fall for 'report card' testing. Try to collect a uniform sample width through the entire 0-15 cm (or 30 cm) profile. Purposefully designed soil samplers remove a core about 2.5 cm (1 in) wide.
- Thoroughly mix the soil in the collecting pail.
- Put about 300 ml (1 cup) of the mixed soil into a clean plastic bag or box.
- Store the sample in a cooler until it is taken to the laboratory.

Where possible, use local laboratories as they have knowledge of local conditions, since these laboratories can better conduct the appropriate analyses and give correct recommendations. Use the same laboratory each year for consistent interpretations and recommendations. Contact the BCAGRI office for a list of private laboratories that conduct soil testing in B.C.

Tissue Testing

Specific plant tissue testing methods—including when and where to sample—and interpretation are limited for many plants. Tissue testing can be used to compare plants when a problem such as a nutrient deficiency is suspected. For a listing of laboratories conducting tissue testing, contact the BCAGRI office.

Follow these guidelines when sampling for tissue analysis:

- Take sample for normal analysis at the same time of plant development each year. Standard reference materials such as the "Knott's Handbook for Vegetable Growers" suggest the state of maturity of the plant and the portion of the plant to be taken for analysis. For example the petiole of young mature leaves at mid-growth for carrots, broccoli or spinach.
- Sample for possible nutrient deficiencies (diagnostic sampling) at any time during the growing season.

Revised: March 2012

- Use an X-pattern from corner to corner of the planting, if possible.
- If possible, sample for each variety separately. On smaller plantings, a combined sample of mixed varieties should give a reasonable result and may be more affordable.
- Sample the youngest, fully opened leaves of sample plants.
- Do not take samples from the outside edges of the planting.
- Avoid dirty leaves or leaves damaged by insects or machines.
- Sample using clean hands, or use plastic gloves.
- Put samples in a clean paper bag.
- Take samples to the laboratory as soon as possible. If they must be held, keep in a cooler to avoid spoilage.
- Consult the laboratory that will conduct the analysis for more specific information, especially if samples must be mailed.

Record Keeping

For the most effective nutrient management program, it is essential to keep track of soil and tissue testing results along with all information about the rates, type and timing of fertilizer, manure or soil amendment applications. Other observations on crop growth, yield, quality and weather during the growing season are also useful.

Use test strips ('checks' or 'control strips') to test changes in a nutrient management program. Then the old practice can be compared to the new practice to see if the crop is affected. This comparison can only be made when the old and the new practices are evaluated under the same field and management conditions.

Fertilizers

Recommendations

Fertilizer recommendations in this section of the guide are general guidelines only. Specific recommendations are given in most crop sections.

If a soil test is not available, appropriate rates should be based on information from previous fertilizer use, cropping history and basic nutrient requirements of the crop to be grown. Some soils are known to be deficient in one or more of these elements and, therefore, soil testing is highly recommended.

Vegetable crops in B.C. are known to respond to nitrogen (N), phosphorus (P), potassium (K) and boron (B) fertilizers, and to the addition of lime to adjust the pH of acidic soils. The rate will vary from soil to soil. In most cases general recommendations are not made for the application of sulfur (S), magnesium (Mg),or trace elements such as boron (B), copper (Cu), zinc (Zn) or manganese (Mn). Applications of these nutrients should be done with caution—such as starting with test strips only—since additions in excess of plant requirements could result in damage to the crop and the environment.

Nitrogen (N)

Recommendations are made in each vegetable crop section. There are no specific soil test based nitrogen recommendations systems developed for vegetable crops grown in British Columbia. Therefore for all vegetable crops, the recommendations are guidelines only.

In South Coastal B.C., all mineral nitrogen (nitrate and ammonia) left in the soil in the fall is lost or not available to crops in the spring. Nitrogen applications can be based on soil or tissue testing, but applications should not exceed the recommendations given for each crop. A 'report card' soil test for nitrate-nitrogen (0-30 cm depth) in late-August gives an indication of the surplus amount applied. If the nitrate-nitrogen is more than 20 ppm (NO_3-N), then too much nitrogen was applied from all sources and less nitrogen should be added in the following season.

For areas outside of the South Coastal region, most of the soil nitrogen in the mineral form left at the end of the growing season is available to the crop in the next season. Soil testing for nitrogen in the fall or spring gives an indication of the amount available. This can be compared to the general nitrogen recommendation given in the individual crop sections.

For vegetable growers who utilize cover crops and/or manure in their soil management system, care must be taken to account for the nitrogen contribution from these sources. Nitrogen from manure is covered in the Manure Management section of this chapter. In most years, cover crops which overwinter (i.e. fall rye, winter wheat or Italian rye grass) will provide up to 50 kg N/ha later in the growing season if they are ploughed under in the spring. Winter killed cereals (barley or oats), planted in late summer, are capable of releasing up to 90 kg N/ha in the spring following ploughdown.

Phosphorus (P) and Potassium (K)

Notes:

- The following recommendations for phosphorus (P) and potassium (K) are valid for the South Coastal and Vancouver Island regions only.
- Where two types of testing methods are listed in the tables, check with the laboratory conducting the analysis to find out the extraction method used and follow the appropriate recommendations.

Table 3.1 Phosphate Fertilizer Recommendations From Soil Test Results

Group I - beans, corn, cucumbers, dill, eggplant, lettuce, melons, peas, pumpkins, spinach, squash, zucchini.

Group II - asparagus, beet, broccoli, Brussels sprouts, cabbage, cauliflower, carrot, celery, garlic, leek, onions, parsnip, pepper, potato, radish, rhubarb, rutabaga, tomato.

"BRAY P1" METHOD				"KELOWNA" METHOD		
Rating	**Soil Test** P(ppm)	**Requirement** (kg/ha P_2O_5)		**Soil Test** P(ppm)	**Requirement** (kg/ha P_2O_5)	
		Group I	*Group II*		*Group I*	*Group II*
V. Low	5	190	225	10	170	200
Low	10	160	190	15	120	145
Mod.	20	90	135	30	60	60
High	50	30	40	75	30	40
V. High	70+	0*	0*	100+	0*	0*

** Soils with >70 ppm (Bray P1 method) or 100 µg/mL (Kelowna method) have sufficient P for crop needs. Application of P in either manure or fertilizer form may lead to loss of P to the environment, causing water pollution.*

Source: *Soil and Plant Tissue Testing Methods and Interpretations of Their Results, BCAGRI, 1996.*

Table 3.2 Potassium Fertilizer Recommendations From Soil Test Results

Group I – beans, corn, cucumbers, dill, eggplant, lettuce, peas, spinach.

Group II – asparagus, beet, broccoli, Brussels sprouts, cabbage, cauliflower, carrot, celery, garlic, leek, melons, onions, parsnip, pepper, potato, pumpkin, radish, rutabaga, squash, tomato, zucchini.

"NH4-ACETATE" METHOD				"KELOWNA"METHOD		
Rating	**Soil Test** K (ppm)	**Requirement** (kg/ha K_2O)		**Soil Test** K (ppm)	**Requirement** (kg/ha K_2O)	
		Group II	**Group II**		**Group II**	**Group II**
V. Low	25	225	280	25	200	250
Low	35	200	260	65-80	150	200
Mod.	80	90	170	125-150	60	80
High	150	45	70	190-220	40	40
V. High	175+	0*	0*	250+	0*	0*

** Application is not normally required but in some situations, such as early in the season, a starter treatment (30kg/ha) may be beneficial.*

Source: *Soil and Plant Tissue Testing Methods and Interpretations of Their Results, BCMAFF, 1996.*

Boron (B)

Boron deficiency causes a wide range of abnormalities in vegetable crops.

When required, broadcast a boron-containing compound evenly over the soil using a cyclone-type spreader or use a fertilizer blend that contains boron.

Caution: Do not exceed the recommended amount of boron per hectare as it may cause plant injury.

If boron deficiency symptoms occur during the growing season, boron can be applied as a spray. Apply Solubor following the manufacturers' directions. See also the discussion in "Nutrient Deficiencies", in this chapter.

In the Interior, do not plant beans or cucumbers the year following an application of boron to other crops.

In the Interior, boron should be applied in the fall. At the Coast, it should be applied in the spring where a need for boron application has been shown.

Calculating Fertilizer Rates

Fertilizers are labeled by percentage according to their guaranteed minimum analysis of nitrogen (N), phosphate (P_2O_5), potash (K_2O) and other nutrients that may be present. Five-20 kg bags (100 kg total) of 12-51-0 contain 12% nitrogen (12 kg N), 51% phosphate (51 kg P_2O_5), and no potash (0 kg K_2O). The rest of the material in the five bags is other elements that are part of the fertilizer compounds carrying the nitrogen, phosphate, and potash. Sample calculations for determining the amount of fertilizer and nutrients to apply are given below.

A) Calculating the Amount of Fertilizer to Apply:

$$\text{Amount of fertilizer required} = \frac{\text{recommended rate X 100}}{\text{fertilizer analysis}}$$

Example:

Recommended rate of potash = 135 kg/ha

Fertilizer analysis = 0-0-60

$$\text{Amount of fertilizer required} = \frac{\text{135 kg/ha X 100}}{60}$$

= **225 kg/ha**

Apply 225 kg/ha of 0-0-60

B) Calculating the Amount of Nutrients Applied:

$$\text{Amount of nutrients applied} = \frac{\text{fertilizer applied X analysis}}{100}$$

Example:

Amount of fertilizer applied = 225 kg/ha

Fertilizer analysis = 13-16-10

$$\text{Amount of N supplied} = \frac{\text{225 kg/ha X 13}}{100}$$

= **29 kg N/ha**

$$\text{Amount of } P_2O_5 \text{ supplied} = \frac{\text{225 kg/ha X 16}}{100}$$

= **36 kg P_2O_5/ha**

$$\text{Amount of } K_2O \text{ supplied} = \frac{\text{225 kg/ha X 10}}{100}$$

= **22.5 kg K_2O/ha**

Revised: March 2012

Methods of Fertilizer Application

Definition of Terms

Broadcasting and incorporating. Refers to spreading fertilizer on a soil surface before the crop has been planted, then incorporating the fertilizer into the soil by tillage.

Top-dressing. Refers to spreading fertilizer on a field when a crop is growing. It is not incorporated, but sprinkler irrigation or rain will wash fertilizer off the leaves which prevents burning and moves the nutrients into the top few centimeters of soil.

Banding. Refers to the application of fertilizer at the time of planting in continuous bands 2.5 cm or more to the side of the plant and 5 cm or more deep, depending on the crop.

Side-dressing. Refers to the banding of fertilizer after plants are established. Care should be taken not to disturb the roots of the plants. In row crops, side-dressing is used in place of top-dressing as it keeps the fertilizer off the foliage and reduces the chances of burning the crop.

Fertigation. Refers to the application of fertilizer in irrigation water.

Deep-banding. Refers to banding fertilizer at a depth of 5 cm or more prior to planting. There is scientific evidence indicating that this results in greater fertilizer efficiency than surface broadcasting for deep-rooted row crops.

Fertilizer Materials

Some basic fertilizer materials are listed in Table 3.3 below. These materials are used as the basis for many custom fertilizer blends for vegetables. Please see your local fertilizer dealer for the custom blends available.

Soil pH

Soil pH refers to the acidity or alkalinity of the soil. pH is very important to vegetable production as it affects the availability of nutrients to the plant. Most vegetable crops do not respond to fertilization when the pH is very low (extremely acid soils, pH less than 5.0) or very high (extremely alkaline soils, pH above 7.5).

Calcium, phosphorus, magnesium and molybdenum are the nutrients that are most likely to be deficient under acid soil conditions. Test the soil to determine pH before planting and every 2 to 3 years to monitor changes. Soil pH can usually be modified to obtain a suitable pH for good vegetable production.

Table 3.3 Fertilizer Materials—Primary Nutrients

Nitrogen Materials	Guaranteed Minimum Analysis
Urea	46-0-0
Ammonium sulfate	20.5-0-0 + 24S
Polymer coated urea	39-0-0 + 12S & other various grades
Calcium nitrate	15.5-0-0 + 19Ca
Phosphate Materials	**Guaranteed Minimum Analysis**
Mono Ammonium Phosphate	11-52-0
Triple Super Phosphate	0-45-0
Potash Materials	**Guaranteed Minimum Analysis**
Muriate of Potash	0-0-62
Sulphate of Potash	0-0-50 + 17S
Suphate of Potash Magnesia	0-0-22 + 22S + 11Mg

Revised: March 2012

Table 3.4 Vegetable Tolerance to Low Soil pH

Slightly Tolerant (pH 6.8 - 6.0)	Moderately Tolerant (pH 6.8 - 5.5)	Very Tolerant (pH 6.8 - 5.0)
Asparagus	Bean	Chicory
Beet	Brussels sprouts	Endive
Broccoli	Carrot	Potato
Cabbage	Corn	Rhubarb
Cauliflower	Cucumber	Watermelon
Celery	Eggplant	
Swiss Chard	Garlic	
Chinese Cabbage	Kale	
Leek	Parsley	
Lettuce	Pea	
Muskmelon	Pumpkin	
Onion	Radish	
Parsnip	Rutabaga	
Spinach	Squash	
	Tomato	
	Turnip	

Source: *Knott's Vegetable Handbook, 4th Edition, 1997.*

Raising Soil pH

Soils in South Coastal B.C. are typically acidic and, for most vegetable crops, usually require lime applications to raise the pH.

Agricultural grade limestone (calcium carbonate $CaCO_3$) is generally recommended. For the Fraser Valley, the general application rate is 1 to 2 tonnes per hectare per year (400 to 800 kg/acre) for pH sensitive crops. Rates higher than 2 to 4 tonnes (800 to 1600 kg/acre) are not recommended due to soil reactivity and the difficulty of incorporation. Lime should not be applied within 1 week of a nitrogen fertilizer or manure application as the high soil pH that occurs shortly after application will increase the loss of ammonia.

If calcium levels are low in soils being used for vegetable production, gypsum or fertilizers such as calcium nitrate may also be used to supply calcium, rather than using lime.

Effects of Lime

- Corrects soil acidity.
- May improve the physical condition of the soil.
- Provides the nutrient calcium (and magnesium if dolomite limestone is used) and increases the availability of other plant foods.
- Favours bacterial action, thus hastening the decomposition of organic matter and release of additional plant foods.
- Improves conditions for availability of other nutrients, notably phosphorus and some minor elements.
- High rates of lime may help digest organic matter and release nitrogen for a short period after application.
- Reduces the toxicity of some elements such as manganese and aluminum.
- Above 5 tonnes/ha may tie up some micronutrients such as boron. Magnesium deficiencies may be aggravated, especially in sandy soil. Where this is a problem, some dolomite lime should be used.
- Excessive use of lime may cause nutrient imbalances, so lime should be used in conjunction with a planned soil testing and fertilizer program.
- Increases rate of organic matter depletion.

Forms of Lime Used

Ground limestone. Calcium carbonate ("Agricultural Lime"). The most convenient form to handle. May be applied at any time of the year. It dissolves slowly and lasts longer in the soil. (Usually gray lime material, sold in bulk in South Coastal B.C.)

Ground dolomite. Calcium-magnesium carbonate. May be substituted for ordinary limestone; contains magnesium.

Calcium hydroxide. Hydrate or slaked lime. Should only be used as a spring application for rapid results. Excessive rates above 1100 kg/ha (445 kg/acre) may be quite caustic and "burn out" organic matter. ***Only occasional use is recommended on agricultural land.***

Calcium oxide. Quicklime, caustic lime, burnt lime. ***Not recommended on agricultural land.***

Notes:

- Fineness of grind is very important. The finer grinds (100 mesh and above) react in soil much quicker than the coarser grind (10 to 100 mesh). Very coarse limestone (less than 10 mesh) is not recommended. Some coarse material is desirable to facilitate handling of the lime. Excessively fine material will not flow readily and is subject to wind drift during spreading.

Revised: March 2012

- Lime does not move through the soil—it must be incorporated.
- Gypsum ($CaSO_4$) is not a liming agent. It will not increase soil pH, and under certain conditions it is used to lower pH.

Lowering Soil pH

Sometimes it is advantageous to lower the soil pH (acidify) the soil. In Interior areas, alkaline mineral soils may need to be acidified for vegetable production.

The principal materials used to lower soil pH are elemental sulfur, sulfuric acid, aluminum sulfate and iron sulfate (ferrous sulfate). Ammonium sulfate, ammonium phosphate and other ammonium containing fertilizers are also quite effective in reducing pH when the soil receives sufficient water, though they are primarily sources of plant nutrients.

For large areas, elemental sulfur is probably the most economical product to use. The finer ground the sulfur, the more quickly it will react in the soil to lower the pH. Flower sulfur is a very fine (powder) and reacts relatively quickly. Solid sulfur prills (granules) are less finely ground and therefore react more slowly and they are more convenient to apply. Finely ground sulfur is sometimes available in prills that contain a mixture of flower sulfur and bentonite clay which improves the handling, stability and safety of the material.

Soil test laboratories can, by request, determine total soil acid and calculate the sulfur required to attain a desired pH. As a general recommendation apply the equivalent of 2 tonnes/ha (800 kg/acre) in a band where the planting beds will be formed.

Starter Solutions

High analysis, readily soluble or liquid concentrate starter solution fertilizers are available for use with seedlings and transplants to help get them off to a quick start. Often, during warm, dry weather, only water is needed. However, starter solutions are particularly helpful in cool planting weather since the dissolved nutrients are immediately available to immature root systems. Most starter solutions are high in available phosphorus. Some typical fertilizers include: 0-52-0, 20-20-20, 10-50-10, 10-52-17, and 21-53-0. Fertilizers containing approximately 50% P_2O_5 should be dissolved at approximately 0.8 to 1.0 kilogram per 100 litres (22 gallons) of water. If a highly soluble type fertilizer such as 20-20-20 is used, it should be dissolved at 0.2 to 0.3 kilograms per 100 litres (22 gallons) of water.

Manure Management

Code of Agricultural Practice for Waste Management

The storage and use of livestock manure and agricultural vegetation wastes is covered by the "Code of Agricultural Practice for Waste Management". This code is part of the "Agricultural Waste Control Regulation" under the "Environmental Management Act". The code describes general practices for the use, storage and management of agricultural waste in an environmentally sound manner. Growers are encouraged to take advantage of the Canada-BC Environmental Farm Plan Program. Farmers participating in this program will gain more detailed information on a range of environmental issues including proper use of manure and woodwastes. See the following link (http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/index.htm) for information on the Environmental Farm Planning Program.

Storage

The code requires that agricultural waste, particularly manures, be kept in a storage facility or covered if not used immediately. The storage must prevent escape of manure to the environment that would cause pollution. Manure may be stored uncovered in the field for up to 2 weeks prior to use. Manure may be stored in the field for up to 9 months if it is kept in a temporary storage facility that prevents the escape of nutrients to the environment, e.g. securely tarped on a dry site. In the Lower Fraser Valley and Vancouver Island regions, stored manure must be covered from October 1 to April 30. The field storage facility must be 30 meters from a watercourse or a water source used for domestic purposes.

Nutrient Value

Manures supply plant food over a period of time. Table 3.5 shows the typical amount of nutrients supplied in various types of livestock manure. Note the moisture and nutrient content varies as a result of storage method, litter content, and age of manure.

Revised: March 2012

The nitrogen values given in the table are for total nitrogen. For all types of manure, the amount of nitrogen that is available to the crop after it is applied on the field may vary from the total nitrogen listed in the table. Incorporate all manure (solid or liquid) within 12 to 24 hours of spreading to reduce ammonia volatilization and achieve the greatest benefit from the manure nutrients. Nitrogen losses after spreading range from less than 10% if the manure is incorporated soon after spreading, to as much as 50% if the manure is left on the soil surface.

Have the manure tested for nutrient content after it is delivered to the farm. The nutrient content will not change significantly if the manure is kept covered by either a roof or a tarp. If a manure test is unavailable, the table values can be used but they may require adjustment of moisture content for the manure to be used.

Nutrient applications from all sources, including manure and commercial fertilizer, should be balanced to meet the crop requirements for nutrients. The release of nutrients from manure is not consistent. Therefore, in any year manure should only be used to supply up to 75% of the crop's nitrogen requirement. About 50% of the phosphorus in manure is readily available in the year it is applied. Where manure has been used repeatedly, phosphorus is assumed to be 100% available. All potassium from manure is available in the year of application.

Table 3.5 Typical Nutrient Content of Various Manures

Manure	Moisture	Nutrient Content* kg/tonne (kg/m^3)		
	%	Total N	P_2O_5	K_2O
Beef (solid)	68	4.2 (2.1)	4.8 (2.4)	8.2 (4.1)
Dairy (solid)	77	3.9 (2.0)	3.4 (1.7)	9.0 (4.5)
Dairy (liquid)	91	2.9 (1.5)	2.1 (1.1)	4.5 (2.3)
Swine (covered pit)	93	6.3 (3.2)	3.3 (1.6)	3.9 (2.0)
Swine (uncovered pit)	98	3.5 (1.8)	1.5 (0.8)	1.7 (0.8)
Horse (with shavings)	72	2.4 (1.2)	1.7 (0.8)	3.2 (1.6)
Spent mushroom compost	70	5.8 (2.9)	2.5 (1.2)	8.5 (4.2)
Poultry (broiler)	25	31.6 (15.8)	22.8 (11.4)	12.2 (6.1)
Poultry (layer)	50	22.8 (11.4)	29.2 (14.6)	11.2 (5.6)

Source: BCAGRI, Resource Management Branch.

* *Nutrient values for manure assume proper storage, handling and application to minimize losses.*

Conversions:

1 tonne of liquid manure = approximately 1000 litres = 1 m^3 = 220 Imp. gallons

1 m^3 = 1.25 yd^3 = 28 bushels

1 tonne of solid manure = approximately 2 m^3 = 2.5 yd^3

To convert kg/tonne to lb./ton, multiply by 2.0

To convert kg/m^3 to lb./yd^3, multiply by 1.7

Revised: March 2012

Compost

The nutrient content of composted manure is slightly higher than fresh manure. However the availability of the nutrients is lower as they are held in a more stable form by the organic matter of compost. Composted manure may be expensive for field application. The benefits of compost use include reduced nitrogen leaching in environmentally sensitive areas, and usefulness as a supplement or replacement for other organic matter in plant propagation. Composts should be checked for salt content prior to use as media for seedling or transplant production. Generally less than 50% of a growing media by volume should be made up from compost.

Soil Conditioner

Manure can be used as a soil conditioner if the amount of nutrients in the manure is determined and the application rate is no more than the crop requires for nutrients. Using manure together with cover crops can improve soil structure. The decomposition of the manure in the presence of cover crop roots stimulates biological activity, and increases aeration, permeability, and water holding capacity of the soil. **Do not apply manure to bare ground in either the fall or winter (mid-September to March 1).** Manure may be applied in February, or later, to fields that have a well established and actively growing cover crop during the fall and winter period.

Applying Manure

Under the code, manure can only be applied to land as a fertilizer or soil conditioner.

South Coastal B.C. Apply manure to vegetable crops between mid-March and early-July. Be sure that the amount of manure applied is no more than needed to fertilize the crop that is growing. Manure can be applied to a cover crop between July and October if, based on a soil test, the application rate matches the nutrient requirements for that cover crop.

Interior B.C. Spread manure only when the risk of runoff is near zero. Manure should not be applied to frozen or snow-covered ground. Manure may be applied in the fall if the application rate is equivalent to the crop's nutrient requirements and there is a cover crop in place.

Additional Precautions

Recently concerns have increased over potential contamination of watercourses with constituents of manure. Vegetable growers are encouraged to use best management practices to avoid direct discharge or runoff losses of manure into watercourses. This concern applies not only to the nutrient and solid fractions, but also to the potential pathogens that may exist in animal manure.

Water in ditches is often used for irrigation and crop washing, so water quality is important. Refer to the "Water Management" section of this guide for water quality criteria, and the "Food Safety" section of this guide for additional information. Growers are encouraged to avoid direct contact between the harvestable portions of plants and any manure applied to the crop as a fertilizer. Vegetable growers may wish to follow the "British Columbia Certified Organic Production Operation Policies and Farm Management Standards" which indicates that the use of raw manure is allowed only prior to seeding a cover crop or green manure crop. Crop Production Standards for individual organic certification organizations suggest using composted manure or incorporation of the manure prior to planting a cover crop. In either case this places sufficient time between the application of manure and the growth of the cash crop to allow the soil to effectively assimilate nutrients and for the pathogen risk to be eliminated.

Revised: March 2012

Determining the Amount of Manure to Spread on the Field

To spread manure as a fertilizer the following must be known:

- the nitrogen content of the manure,
- the amount of nitrogen supplied by the manure to the crop,
- the amount of manure the spreader can hold (its capacity),
- the nitrogen needs of the crop, and
- the number of spreader loads of manure per area in the field.

Follow the steps on the following page to calculate the amount of manure to spread.

<u>Note:</u> This is a simplified scenario which may be suitable if soil tests do not show excessive levels of phosphorous (P) and potassium (K). If soil P + K levels are excessive, a Nutrient Management Plan is recommended to help better determine how much manure should be spread on a field.

CALCULATING MANURE APPLICATIONS

Step 1. Determine the nitrogen content of the manure.

Refer to Table 3.5 for typical total nitrogen contents of various types of livestock manure. Use these values if a laboratory or quick test value is not available. Nitrogen comes in several forms in manure. The amount of nitrogen in manure also varies and is subject to many management and environmental conditions that can result in nitrogen losses.

Step 2. Calculate the approximate amount of nitrogen supplied by the manure (kg N/yd^3).

Losses of nitrogen upon application of manure can range from a low of 20% if manure is incorporated within 24 hours, to as much as 50% by volatilization if the manure is left on the soil surface.

$$\frac{\text{N supplied by manure(kg/m}^3\text{)(see Table 3.5) X initial application loss factor*}}{1.31\ (\text{m}^3/\text{yd}^3)}$$

* Initial application loss factor = 100% - %nitrogen lost

Step 3. Determine the capacity of the manure spreader (yd^3).

$$\frac{\text{Box length(ft) X width(ft) X average depth of manure in spreader(ft)}}{27\ \text{ft}^3/\text{yd}^3}$$

Step 4. Determine the nitrogen needs of the crop (kg/ha).

Refer to specific crop recommendations in the appropriate crop sections or the results of a soil test.

Step 5. Calculate the number of spreader loads of manure per area in the field (loads/ha).

$$\frac{\text{Crop N requirements (kg N/ha)} \div \text{spreader capacity (yd}^3\text{ /load)}}{\text{N supplied by the manure (kg N/yd}^3\text{)}}$$

Revised: March 2012

Example:

A spreader has a box that is 7.5 feet long and 4 feet wide. It is filled with a solid poultry (broiler) manure to an average depth of 2.25 feet. The manure will be spread prior to planting a carrot crop that, based on soil testing, requires about 80 kg/ha (32 kg/acre) of nitrogen. The manure is to be broadcast over the entire area using a conventional spreader. How many loads are needed to supply the crop's nitrogen requirements?

Step 1. Determine the nitrogen content of manure.

From Table 3.5, poultry manure contains 15.8 kg N/ m^3

Step 2. Calculate the approximate amount of nitrogen supplied by the manure (kg N/yd^3).

$$= \frac{15.8 \text{ kg N/m}^3 \text{ (from Table 3.5) X } 0.80}{1.31 \text{ (m}^3\text{/yd}^3\text{)}} = 9.6 \text{ kg N/yd}^3$$

Step 3. Determine the capacity of the manure spreader (yd^3).

$$= \frac{7.5 \text{ ft long X } 4 \text{ ft wide X } 2.25 \text{ ft deep}}{27 \text{ ft3/yd}^3} = 2.5 \text{ yd}^3\text{/load}$$

Step 4. Determine the nitrogen needs of the crop (kg/ha).

80 kg N/ha (32 kg N/ac) (established carrot crop, based on soil testing)

Step 5. Calculate the number of spreader loads of manure per area in the field (loads/ha).

$$\frac{80 \text{ kg N/ha} \div 2.5 \text{ yd}^3 \text{ /load)}}{9.6 \text{ (kg N/ yd}^3\text{)}}$$

= 3.3 loads/ha (÷ 2.47 = 1.3 loads/acre)

Non-Agricultural Wastes (Biosolids, Whey, Yard Waste, Pulp Sludge, Fish Waste, Etc.)

Caution: Many wastes generated off-farm are being offered, or sold to farmers for use as soil conditioners or fertilizers. The use of all agricultural wastes is covered by the "Environmental Management Act" in B.C. Use of these materials may be allowed under Regulation or an authorization under the Act. Many of these materials can provide benefits to the soil or crop. However, they come with characteristics or contaminants that can be undesirable to vegetable growers. Refer to the BCAGRI Factsheet "Use Caution When Bringing Non-Agricultural Waste or Products on to Your Farm."

Nutrient Reactions in Soil

Nutrients added to the soil may become more or less available depending on the type of fertilizer, the soil moisture, the pH conditions, the nature of the soil and the amount of organic matter, rainfall, and temperature. Some nutrient elements may be completely lost, others may be "tied-up". This section gives information on nutrients from conventional fertilizer sources (i.e. not organic sources such as manure).

Revised: March 2012

Nitrogen (N)

The most common forms of fertilizer nitrogen are nitrate (NO_3), ammonium (NH_4) and urea ($CO[NH_2]_2$). All three forms are highly water-soluble. Urea is converted to the ammonium form by enzymes in the soil. Ammonium nitrogen is adsorbed (chemically bound) to clay minerals and organic matter, and is retained by the soil. Some ammonium and urea nitrogen may be converted to ammonia gas that escapes into the atmosphere. This usually occurs in dry soil with surface-applied fertilizer. Ammonia losses are reduced or eliminated by making sure that the fertilizer is well covered with moist soil. Losses are minimized by banding, immediate incorporation after broadcasting, irrigation following application or broadcasting onto moist soil in cool weather.

Slow release forms of fertilizer have the same reactions in the soil as non-slow release forms, once the nitrogen is released. The slow release mechanism, whether it is a capsule like sulfur coating or a blend like a polymer, is designed to overcome problems with nitrogen losses and availability.

Nitrate-nitrogen is not held by the soil and can be leached by water. Leaching losses of nitrate-nitrogen are most severe in sandy soils, in areas with high rainfall, and under intense irrigation. Some nitrate-nitrogen may be converted to gases that escape into the atmosphere. This frequently occurs in wet soils during fall, winter and spring.

Phosphorus (P)

All phosphorus fertilizers are phosphate salts. They are water-soluble but tend to form insoluble compounds when incorporated into the soil. Unlike nitrogen and potassium, phosphorus does not readily move in the soil. It tends to remain where it is placed. Therefore, it is important to place phosphorus fertilizer in the rooting zone of the crop before the crop is established, or to band it next to the roots in the established crop. Surface applied phosphorus without incorporation is the least efficient way of utilizing phosphorus fertilizer. In some soils, phosphorus becomes “tied-up” at a pH below 6.0 or above 7.5.

Note: In general, very little phosphorous leaches from the soil, **unless** soil phosphate levels are excessively high. Phosphorous can also be lost in soil sediment during erosion.

Potassium (K)

Potassium fertilizers are all simple potassium salts, such as potassium chloride, potassium sulfate, potassium-magnesium sulfate, or potassium nitrate. All are readily water-soluble. Potassium is adsorbed to some extent to organic matter and clay minerals. However, it is subject to leaching, especially in sandy soils.

Nutrient Deficiencies

A nutrient deficiency may be the problem when parts of vegetable crops that are not yet mature become off-coloured such as yellow or purple, or show unusual growth, stunting, cracking, or a combination of these symptoms. The nutrient required may be present in the soil but unavailable to the plants because of weather or soil conditions.

Some nutrients will slow down the uptake of other nutrients unless they are present in the correct proportion. All nutrients have a pH range at which they are most available to the plants, providing other factors are favourable.

Too much of a nutrient may cause growth problems as well. Excess fertilizer may cause leaf “burn” or stunted growth.

Calcium (Ca) is applied as lime and is, therefore, rarely deficient in soils. Many common fertilizers contain calcium.

Magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) are sometimes deficient in the soil for optimum crop production.

Micronutrients are required only in very small amounts and it is important to ensure that micronutrient fertilizers are applied at the correct rate. High levels of micronutrients, especially boron and manganese, are toxic to plants. Soil and/or tissue testing are the only accurate ways to determine if these elements are lacking. If they are needed, micronutrients can be added to blended fertilizers and applied along with the routine fertilizer program. If necessary, micronutrients can be applied in irrigation water (fertigation) or with a crop sprayer (foliar feeding).

Characteristic symptoms of nutrient imbalances are listed in Table 3.6.

Revised: March 2012

Table 3.6 Foliar Symptoms of Nutrient Deficiencies and Corrective Treatments

The following nutrients may be deficient at certain times in B.C. soils. Foliar sprays often give fast response but they should not be applied at higher than recommended concentrations or crop damage may result. Use enough water to wet the foliage. Apply under slow drying weather conditions.

Nutrients	Nutrient Deficiency Symptoms	Materials	Application Rate	Comments
Nitrogen	Slow growth; pale green to yellow and sometimes purple foliage. Leaves are smaller than normal. See crops such as corn for side-dressing rates.	15.5-0-0 46-0-0 20-20-20	15 kg/ha (6 kg/acre) 10 kg/ha (4 kg/acre) 3 kg/ha (1.2 kg/acre)	Apply in 1000 L/ha (400 L/acre) water.
Phosphorus	Slow growth; reddish purple colour. Delayed maturity.	20-20-20	3 kg/ha (1.2 kg/acre)	Apply in 1000 L/ha (400 L/acre) water.
Potassium	Slow growth; mottled foliage; bronzing and drying on leaf tips & margins.	20-20-20	3 kg/ha (1.2 kg/acre)	Apply in 1000 L/ha (400 L/acre) water.
Calcium	Slow growth; terminal growth die-back; leaf margins chlorotic & scorched; leaf spotting; black heart of celery; blossom end rot of tomato.	calcium nitrate (20%) calcium chloride (36%)	5 to 10 kg/ha (2 to 4 kg/acre)	Apply at full leaf, in 1000 L/ha (400 L/acre) of water.
Magnesium	Yellowing between veins beginning with older or lower leaves; veins remain green; scorching & brittleness.	sul-po-mag (11%) or dolomite lime magnesium sulphate (11%) or Epsom salts magnesium nitrate	250 to 300 kg/ha (100 to 120 kg/acre) 10 to 15 kg/ha (4 to 6 kg/acre) 5 to 7.4 kg/ha (2 to 3 kg/acre)	Apply and incorporate into soil in spring. Apply at full leaf and under cool, slow drying conditions in 1000 L/ha (400 L/acre) of water. Add 0.5 kg urea (46-0-0) in 1000 L of water (not for magnesium nitrate).
Boron	Dead growing points; distorted stems & leaves; hollow, rough stems; brown curd of cauliflower; corky scars on broccoli; cracked stem of celery.	Solubor Borosol	1.0 kg/ha (0.4 kg/acre) 1.2 to 2.5 kg/ha (0.5 to 1.0 kg/acre) (See Table 6)	Apply at full leaf in 1000 L/ha (400 L/acre) of water. Avoid high rates of lime, manure or irrigation.
Iron	Pronounced yellowing and whitening of new leaves at growing tips/between the veins.	ferrous sulfate (20%) chelated iron (12%)	2 to 3 kg/ha (0.8 to 1.2 kg/acre) 1 kg/ha (0.4 kg/acre)	Apply in 1000 L/ha (400 L/acre) of water.
Manganese	Stunting; smaller than normal leaves; yellowing between veins on young leaves.	manganese sulfate (27%)	3 kg/ha (1.2 kg/acre)	Apply in 1000 L/ha (400 L/acre) of water.
Molybdenum	Dead growing points; distorted leaf blades on cole crops (whiptail).	sodium molybdate (39%) or molybdic acid	500 g/ha (200 g/acre)	Apply in 1000 L/ha (400 L/acre) of water.
Zinc	Green and yellow broad striping at base of corn leaves; delayed silking; poor filling of ears; yellowing between veins of new leaves; marginal burning of beet leaves.	zinc chelate (14%) zinc sulfate (23%)	1 kg/ha (0.4 kg/acre) 2 to 4 kg/ha (0.8 to 1.6 kg/acre)	Apply in 1000 L/ha (400 L/acre) of water.
Copper	Severe stunting; yellowing of new leaves; cupping of lettuce leaves. Onion bulbs are soft with thin, pale-yellow scales.	copper sulfate (25%) or copper oxide (80%) copper chelate (10.5%)	2 to 5 kg/ha (0.8 to 2 kg/acre) 0.6 kg/ha (0.25 kg/acre)	Apply in 1000 L/ha (400 L/acre) of water. Use extreme care when applying copper sulfate, as foliage can be damaged.

Source: Knott's Vegetable Handbook and BCAGRI Berry Production Guide (2005/2006)