Soil Management

Good soil management begins before planting. Assess the soil conditions of each field and understand the potential problems as a first step to planting a vegetable crop. Land may be inadequately drained, have shallow topsoil, have impermeable subsoil or be too steeply sloped for successful cropping.

Resources

Use the following resources to help identify potential problems:

- soil survey reports and maps (some are available on the web at: http://www.env.gov.bc.ca/terrain/terrain_files/info_sources.html or sis.agr.gc.ca/cansis/publications/bc/index.html);
- BCAGRI publications: "Soil Management Handbook for the Lower Fraser Valley" and
- specific vegetable sections in this guide; and
- professional soil management consultants.

The handbooks discuss general soil management topics including: identification of soil texture and structure, tillage, recognition and reversal of soil compaction, and issues surrounding soil conservation practices. Recommendations in all manuals, including this production guide, are general guidelines only. Qualified soil management consultants are available on a fee-for-service basis to give recommendations specific to each farm. Growers planning to plant a new parcel of land should consult with a professional for recommendations on soil suitability and management. Management includes advice on nutrient management, irrigation and drainage.

Soil Management Problems

Soil management problems are generally related to:

- soil texture;
- soil structure;
- drainage; and
- erosion.

Soil Texture

The mineral materials in soils are simply small fragments of rock or mineral materials derived from rock, but which were altered by water and chemical reactions in the soil. Soil particles are grouped into four particle sizes: gravel, sand, silt and clay. In describing soil, "texture" refers to the relative percentages of sand, silt and clay sized particles in the soil material. Soil texture is a permanent characteristic. Texture will not change unless a large quantity of soil material of another texture is added to it, such as might occur during land clearing or very deep plowing into a subsoil of a different texture.

Problems related to soil texture are common. Stony soils may reduce the suitability for some root crop vegetables such as potatoes or carrots. Stones can interfere with tillage and reduce the overall nutrient and water storage capacity when they cover greater than 50% of the surface area or make up more than 75% of the soil volume. Fine-textured soils (silts and clays) are often subject to compaction or drainage issues.

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Soil Structure

In soil, individual sand, silt and clay particles become more closely packed and bonded together to form larger particles called aggregates. "Soil structure" refers to the type and arrangement of aggregates found in soils. Aggregates occur in almost all soils, but their strengths, sizes and shapes vary considerably among soil types. Some of these aggregates are in stable forms that are not easily broken down by water or physical forces. In addition to the soil texture, the organic matter content can play a significant role in the development of good soil structure.

The formation of soil structure results from many different processes, including the growth of plant roots, activities of soil organisms, wetting and drying, freezing and thawing, and tillage. Plant roots excrete sugars and resins that bind aggregates or create pores in the soil when they die. Soil organisms also bind aggregates with "glues" or, in the case of earthworms, create channels that improve drainage and aeration.

Soil structure also affects the internal drainage of the soil, water holding capacity, temperature and the growth of plant roots. In soils under cultivation, most aggregates at the surface tend to break down under the forces of rainfall, irrigation, tillage and traffic. When soils are left exposed to rainfall or are excessively cultivated under less than ideal moisture conditions, the result is the degradation of soil structure. Structure degradation leads to crusting or puddling of the soil surface, or compaction deeper within or below the root zone. This can lead to poor crop growth, poor drainage and soil erosion.

Maintaining Soil Structure

Soil structure is the most important soil characteristic to consider when managing soils as it is most affected by farming practices. It also is one of the most important factors in crop growth, along with water and nutrients. The main objective in soil management is to promote and maintain good soil structure that will be favorable to crop growth.

Soil structure degradation can be reversed by carefully using these cultural practices:

- Adding organic matter from manure or compost;
- Using appropriate and timely tillage;
- Protecting the soil surface by using cover crops; and
- Encourage beneficial soil fauna such as earthworms.

Adding Organic Matter: Soil organic matter has a significant influence on soil structure. Other benefits are holding soil moisture and improving nutrient levels. Careful use of manure or compost can increase soil organic matter levels. However, the nutrient content of these materials must be the first consideration for their use. Added nutrients from manure or compost must match the crop's nutritional requirements. Growing and tilling under cover crops can also increase organic matter levels.

Refer also to "Nutrient Management" section of this guide, for information on adding manure or compost.

Appropriate and Timely Tillage: When a tillage operation is carried out, ask the following questions:

1. What is the purpose of the tillage operation?
2. Is the timing of the tillage operation best for the soil moisture and weather conditions?
3. Is the tillage implement the best for the intended purpose?

Tillage is used to:

- prepare a suitable planting bed;
- bury or incorporate crop residues, fertilizers, lime, manure or other soil amendments;
- kill weeds; and
- form raised planting beds.

There are two groups of tillage implements. **Primary tillage** implements, such as plows, discs, subsoilers and rotary spaders, are used to break soil, reverse compaction and incorporate residues. **Secondary tillage** implements such as cultivators, harrows and rotovators are used to prepare planting beds and incorporate soil amendments. Secondary implements can have a large impact on soil structure by breaking soil aggregates.

Using cover crops: Cover crops have many benefits in addition to improving soil structure. Refer to "Cover Crops", below.

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Encouraging beneficial soil insects: There are many soil insects and other fauna that can assist in maintenance and improvement of soil structure. Worms can create drainage passages that move water and air through the soil. Bacteria, fungi and worms can improve soil fertility and nutrient availability. Additions of organic matter (manure/compost), use of cover crops and crop rotations can increase beneficial soil fauna. Reduced tillage can maintain or improve worm populations and benefit the survival of mycorrhizae colonies that provide nutrients such as phosphorous to plants.

Drainage

Vegetable crops require moderately to well-drained soils with at least 0.5 m unrestricted rooting depth for successful cropping. Many lowland soils in B.C. have poor natural drainage with a high water table during the fall, winter and spring. These soils often need a subsurface and regional drainage system to remove excess water from the rooting zone for vegetable production.

Soil in upland areas may have a subsoil hardpan within 0.5 m of the surface. In most cases, this hardpan will not allow the soils to drain during the fall, winter and spring. Such soils require a subsurface drainage system to remove excess water from the rooting zone. Hardpan soils may also require deep tillage with a subsoiling implement.

Refer to "Water Management" section of this guide, for more information on drainage.

Erosion

Topsoil is valuable and very difficult to replace. Sediments entering watercourses can cause negative impacts to fish populations and to drainage systems.

In the coastal region, all soils are susceptible to water erosion when cultivated and left bare over the winter. Surface channels, bare or compacted soils are the greatest cause of soil erosion losses under winter rains. In interior regions, fine textured soils are susceptible to water erosion during peak run off events from storms, snow melt or poor irrigation practices. Water erosion damage is most severe on long (over 100 meters) or steep slopes (over 5 to 10%) where the crop rows run up and down the slope or where cropping practices leave the soil surface exposed to rainfall impact. It can also occur on sites where soil becomes saturated. Valuable topsoil is washed away from the upper slopes and can bury plants on the lower slopes. Evidence collected from field sites in the Lower Fraser Valley indicates that when crops are planted up and down slopes soil losses may exceed 10 tonnes per hectare per year. In long duration rainfall events as much as 55% of the rain runs off the field.

Wind erosion is most serious on light sandy soils that are left bare over the winter. Wind erosion has been a serious problem on the soils of the Sumas Prairie during winter outflow wind conditions. Wind erosion can occur on most soils if the surface soil layer is dry, unprotected and has poor structure.

Erosion Control

Where possible, use the following practices to minimize the loss of soil by water or wind erosion. Although any of the listed practices will help control erosion, the best control is achieved by using as many of the practices together that are appropriate.

Water erosion:

- drainage systems (refer to "Water Management" section of this guide);
- contour planting (across the slope);
- winter cover cropping; and
- permanent cover cropping on field roads, field margins and water runs.

Wind erosion (these slow the wind speed at the crop or soil surface):

- windbreaks (e.g. tree rows, snow fences or hedges);
- crop residue (it should be anchored to the soil); and
- cover cropping.

Cover Crops

Cover crops are grown to protect against soil erosion, to improve soil structure and soil fertility, to suppress some insect pests and weeds, and to promote some beneficial insects. They are not usually grown for harvest or forage. They are planted when portions of the field, or the entire field, are left bare. Cover crops are also called green manure, living or dead mulches, plow down,

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companion, relay, double or catch crops depending on their specific use. Cover crops are known to reduce water erosion by over 50% in the South Coastal area.

Before planting a cover crop, it is important to know the soil problem that needs to be addressed. For example, cover crops will not prevent flooding, but if a field is drained they can help to improve the movement of rain water into the soil so it can get to the drains without staying on the soil surface. In addition, planning future crop rotations will assist in choosing the correct cover crop. Some cover crops can harbour beneficial insects such as lady bug beetles or ground beetles. Other cover crops may act as a green bridge for harmful insects or diseases. The risk of pest transmission can be limited by choosing the correct cover crop to fit the desired crop rotation. This will allow the vegetable grower to reap the soil conservation benefits of the cover crop.

Choosing a Cover Crop

Spring cereals sown in late summer or early fall will usually provide good early growth and soil cover. They are often winter-killed, leaving a protective mat on the soil. Spring cereals breakdown early in the spring and will tend to release any trapped nitrogen at a time when it can be utilized by the subsequent crop.

Winter cereals will usually grow slowly over the winter, producing the majority of their growth in the spring. These crops tend to be more resistant to damage from waterfowl grazing than either spring cereals or any of the legumes or brassicas. These overwintering cereals may require a change in nitrogen management practices as they tend to release any trapped nitrogen late in the summer. Winter cereals require a spring management program which may include additional discing or mowing to chop the crop and make it easier to incorporate.

Legume crops, such as hairy vetch or crimson clover, can be used if early planting dates are available (i.e. after early potatoes). These legume

Table 1.1 Cover Crops For Vegetable Production

Types	Seeding Rate	Recommended Seeding Dates
Spring cereals (barley or oats)	80 - 150 kg/ha (30 - 60 kg/acre)	• before September 10
Winter cereals (winter wheat or fall rye)	80 - 150 kg/ha (30 - 60 kg/acre)	• after August 15 and before September 30 • fall rye better for late seeding
Winter legumes (hairy vetch or winter pea)	15 - 30 kg/ha (6 - 12 kg/acre)	• before September 15 • best seeded in mix with winter cereals
Legumes (crimson clover)	10 - 20 kg/ha (5 - 9 kg/acre)	• September 10 (later plantings will fail) • need drained conditions
Brassicas (forage rape or kale)	10 - 15 kg/ha (4 - 6 kg/acre)	• after August 15 and before September 30
Annual grasses (annual ryegrass)	20 - 40 kg/ha (8 - 16 kg/acre)	• up to September 15 • can be seeded as in season cover • use tetraploid, biennial Italian ryegrass for relay cropping in corn
Grass mixes (containing creeping red fescue, Sheep's fescue, hard fescue or perennial ryegrass)	20 - 40 kg/ha (8 - 16 kg/acre)	• generally recommended for spring seeding or when soil moisture is available in late summer

Source: Canada – BC Soil Conservation Groups, 1991-1994.

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crops are normally grown in a mix with a cereal crop to provide some protection from waterfowl. Hairy vetch is the most reliable. Both crops will provide nitrogen to the subsequent spring crop after they are tilled under in the spring. Hairy vetch exhibits 'hard seededness' and may volunteer in subsequent crop years. Winter peas may be used but they can act as a 'green bridge' for diseases if peas are part of the crop rotation.

Brassica crops, such as forage rape or kale, are excellent at tying up soil nitrogen. Their limitations include low resistance to waterfowl grazing and 'green bridge' effects from insects and diseases.

Mixes of grasses are recommended for permanent covers along field margins, ditch banks or roadways.

Some specific varieties of cover crops have been reported to suppress pests or increase the population of beneficial insects. Others may be useful for specialized conditions such as organic vegetable production or specific soil management concerns. Table 1.1 lists the best types, seeding rates and planting dates for cover crops used in vegetable production.

Spring Management of Cover Crops

For spring cereal crops, crop residues can be disced, or disced and plowed, depending on the amount of residue. Chop heavy residues first to prevent an undecomposed mat from forming.

Winter cereal crops or cover crops that survive the winter should be mowed or killed with a broad spectrum herbicide before plowing down. If large amounts of plant material are to be turned under, apply a light application of manure or 20-30 kg/ha of fertilizer nitrogen to speed decomposition. Chop and incorporate the crop residue with a disc prior to plowing. *Rotovating or plowing alone is not recommended.*

Mulches

Organic vegetable production systems are the most likely to use living or non-living organic mulch materials. Woodwaste (shavings or sawdust) is used as a soil amendment to improve the tilth of mineral soils, and as a mulch around established plants for improved weed, soil moisture and temperature control. In some row crops, straw or wood chips can be used between rows to control weeds and reduce moisture loss by evaporation. In U-pick operations, wood chips or straw mulch can help in soil management and in keeping pickers' feet clean.

By far the greatest use of mulches in vegetable production is the use of plastic mulches and row covers. Refer to " Plasticulture", in the Planting section of this guide, for more information.

Woodwaste

"Woodwaste (as defined under the "Code of Agricultural Practice for Waste Management") includes hog fuel, mill ends, wood chips, bark and sawdust, but does not include demolition waste, construction waste, tree stumps, branches, logs or log ends." Under the Code, woodwaste can be used for plant mulch, soil conditioner, ground cover, and on-farm access ways as long as the storage or use of the woodwaste does not cause pollution. This means that any leachate or particulate matter from the woodwaste must not enter ground or surface water. Woodwaste must not be used as landfill. It is generally accepted that the depth of woodwaste should be limited to 30 cm. This is the depth that it can be readily incorporated into the soil.

Vegetable producers intending to utilize woodwaste as a soil amendment should have a plan to manage the carbon-nitrogen ratio of the soil after woodwaste application. Smaller particles breakdown more rapidly placing a higher demand on the soil for nitrogen. Large particles are harder to manage from a tillage stand point.

Revised: March 2012

Managing Coastal Peat and Muck Soils

Organic soils can be divided into two groups. The first group, the peat soils, are slightly to partially decomposed organic materials generally found in lowland or flood plain areas. The second group, the muck soils, are mainly highly decomposed organic materials and may contain significant portions of mineral soil. In the Cloverdale area, muck soils are the predominant soil type although some peat soils are present. There are also some "highly organic" mineral soils in the area that are the result of cultivation and mixing of the peat or muck with underlying or exposed mineral soils.

Peat and muck soils undergo a natural process of decomposition and subsidence when they are drained and cultivated. Subsidence may also occur from erosion and compaction of the organic matter.

Maintaining high water tables and flooding reduces subsidence but these practices can be risky for water sensitive vegetable crops or when vegetable production occurs during the early spring or fall. Saturated soils are susceptible to damage from traffic and tillage. Further, soil structure is degraded by the lack of free movement of air saturated soils. Flooding leaves the soil surface susceptible to structural degradation, thin layer compaction and sealing. It also damages the roots of vegetable crops, sometimes causing plant death.

To reduce the rate of subsidence and decomposition:

- avoid excessive tillage;
- increase organic matter inputs;
- cover crop during the growing season and winter; and
- use good water management practices.

These practices will improve soil structure in both organic and mineral soils.

Tillage contributes to the decomposition of peat by increasing the exposure of the soil particles to air. Excessive tillage with any implement and particularly rotary cultivators, such as rotovators, increases the breakdown of these soils. Also, the fine soil particles may become compacted by traffic, tillage, rainfall, or irrigation. Compaction leads to reduced air and water movement, and eventually restricted workability of the soil. The use of minimum tillage equipment or practices is suggested as one means of reducing compaction and subsidence.

For further information refer to *Final Report: Part 3, Organic Soil Management for Vegetable Farmers*, Cloverdale Soil Conservation Group, 1994, available at BCAGRI, Abbotsford.

Revised: March 2012