SITE SELECTION FOR GINSENG GROWING

When starting a venture to grow ginseng, first look for a suitable property to grow it on. If you already own a property, don't assume it is okay or even that it can be amended and made suitable.

The intent of this publication is not to discuss all climate areas and soil types in British Columbia, but rather to highlight the arid southern interior. This is the area we feel has the greatest potential to grow ginseng. The reason for this is that it is in the best hardiness zone area and for the most part growers have control over the amount of moisture that is applied. When there is a heavy rainfall, the warm dry climate usually dries the mulch and foliage quickly. This quick drying is important to prevent diseases from starting. Since ginseng is grown under a shade canopy, with a straw mulch, it is apparent that a humid environment can easily be prolonged. This is an ideal location for pests like diseases and slugs to inhabit and prosper.

Selection Considerations

The following items are things to consider, to determine if your property or another property is suitable to buy or lease:

SOIL PHYSICAL PROPERTIES

All soil is categorized by the percentage of each of three sizes of soil particles. These are sand (coarse) silt (medium) and clay (fine). These are put, depending on the percentage of each, into twelve categories. Almost all soils have some of each size, except pure sand, silt and clay, which are rare. The ideal for ginseng are the soils that **do not** have clay(c) in their designation (see fig 5, page 12), with pure sand a possible poor choice as well, depending on the particle size. Amending these physical properties is almost impossible on a large scale. This charting system does not measure the organic matter in the soil. Physical properties are best established by a laboratory analysis but a texturing by hand chart is provided on page 16 (table 4), if you wish to do it yourself. You might try to determine your soil properties and then compare to a laboratory analysis the first time for added assurance. A list of laboratories are provided in the Appendices. See the more complete section on soil, "The Physical Nature of Soils" starting on page 11.

SOIL CHEMISTRY

An important factor as well is the chemistry of the soil. This is an area where you have some control. Specific contributions of nutrients and soil amendments will be discussed later in the Site Preparation section (page 21). Soil chemistry covers aspects such as pH, sodium content, salt levels (conductivity), and levels of all the nutrients necessary for plant growth. You cannot tell from looking at a soil what the quality is, only a laboratory test will determine this. For a listing of laboratories available to British Columbia Growers, see the Appendices. Unless a soil is very poor quality chemically, this aspect can be amended to be suitable. More complete information on this can be found in the Site Preparation section of this guide (page 21).

Some examples of possible corrections and general guidelines are:

- pH too low — add lime to correct
- pH too high — add sulphur — reject if can't correct
  (usually over pH 8.5 there is a combination of problems which are difficult to correct and would be very costly)
- Sodium too high — may need drainage
  add gypsum — reject site if can't correct
- Conductivity too high — generally can lower with watering but reject the site if can't
- Boron too high — reject site as it is a soil sterilant (See section on Nutritional Requirements for Ginseng, page 39 for details.)

It is uncommon for N, P, K, Ca, Mg, Mn, Zn, Cu, and Cl to be too high in British Columbia soils.

If N, P, K, etc. are too low, you can easily add and amend as needed.

Soil sampling procedures can be found in this section on page 13.

SOIL DEPTH

Soil needs to have a workable depth of at least 30 cm for growing ginseng. A site may not be suitable and ginseng probably is not an option if the following factors limit soil depth:

- bedrock at or near surface
- large boulders in soil profile
- thin soil over coarse gravel
- thin soil over clay hardpan

You need at least 30 cm of 'top' soil and an adequate drainage zone below that to present an ideal site. A very deep top soil could also be okay, as ginseng does not require a lot of water in the soil profile and it is not a deep rooted plant.

PREVIOUS CROPS

Do NOT underestimate this when purchasing or leasing for ginseng. Some insecticies used in the 50s, 60s, and 70s were very long lasting and are still active. All pesticides used now for various pests have shorter residual life spans but could be a problem for a few years. Be careful also if using manure: that the animals were not fed grass hay contaminated with tordon and that the farmer or rancher had not sprayed to control weeds in and around the barnyard where manure accumulates. Also, if corn was recently grown on the property, it is important that a list of chemicals used is available and accurate. There are labs available that can test soils for specific and / or a range of chemicals to ensure a problem does not exist. A list of laboratories is provided in the appendices.

Residual chemicals in British Columbia soils have been detected in soil testing and can be a potential problem.

COOL SITES

Another important aspect of site selection is coolness. A location that does not warm up quickly in the spring may not be suitable to grow ginseng. A good example is a site on the west side of a high hill, where the sun does not reach it till late in the morning. Trees could do the same thing by shading the site. Some valleys are naturally cooler than others and elevation will also play a part in site temperature. If this condition is connected to heavy soils (ones with increasing amounts of clay) the added water retention plus the cool site can compound the problem. Purchasing or owning a seed lot with low viability at the same time as the combination above can be disastrous. Cool moist soils are also more conducive to damping off organisms like Pythium, Rhizoctonia, Fusarium, and Phytopthora, the main fungi involved.

FROST POCKET AREAS

Certain areas are prone to spring frost problems. Although ginseng can stand a few degrees of frost if they are under the shade cloth, the limits are not established. It would be unwise to choose a known frost problem area for growing ginseng. Generally the local people or land owner will know whether the area is a problem. Having the shade canopy up before any plants emerge through the straw will give some protection (see the Physiological Disorders of Ginseng Plants section titled cold injury and frost, page 115). These areas are usually in a flat valley bottom, near the bottom of a large slope, or in an air drainage area from surrounding hills. You can't always look at a site and determine this as air movement is an invisible phenomenon.

SLOPE OF SITE

Many ginseng gardens today are placed on flat or nearly flat land. It is still preferable to have a slight slope, 1-4%, as the ideal location. Slopes over 5% will have a risk of water running on the shade cloth. Some slope gives air drainage for frost protection and a mechanism to get excess water out of the garden. Too much slope is not desirable for a number of reasons and there is a point where it is unworkable (over 15%) or very dangerous to operate equipment. As slope increases it will create more problems with water flowing too fast causing soil erosion. Excess slope (over 9%) will also make it very difficult to harvest ginseng with equipment as soil will not pass over the digger chain properly, or not at all, or side slippage of machinery will occur.

DIRECTION SITE IS FACING

This is probably of marginal significant compared to all the previous topics in this section, but it will determine to some extent the soil temperature or help determine if it is a 'cool,' 'warm,' or 'hot' site. A warm site combined with light soil would enhance soil temperatures and should lead to earlier and better germination and less damping off problems. A south facing slope (warm or hot site) may offset somewhat the negative effects of a heavier soil type. On the other hand a south facing slope may need more management to control heat stress on plants and / or seed production. (See Heat Stress Injury in the Physiological Disorders section page 117).

Note: *The above sections are dealt with in more detail in 'The climate of the Interior of British Columbia,' starting on page 17.*

GINSENG REPLANT 'DISORDER'

In the past, especially in Wisconsin and Ontario there is a belief that you should never plant ginseng on a site where ginseng has previously been grown. It is claimed that ginseng will never grow properly in this situation.

If we plan to continue the cultivation of ginseng in British Columbia, we must replant as our land base is too small. As well, over the years we have determined that success with ginseng is influenced by site selection, or a particular soil type. This further erodes our total land base for growing. Because of this, we have, in the last few years, replanted ginseng after ginseng to try to determine the cause of the problem, or determine if we have a problem here.

The old explanations for not replanting were as follows:

- Ginseng removes all the 'goodness' out of the soil so ginseng won't grow again.

- When you harvest ginseng it leaves a chemical in the soil inhibiting ginseng growth in subsequent years.
- There are too many disease organisms left in the soil to attack the next crop; or

The only one of the above that is a remote possibility is the last point above, namely disease carry-over. The other two would not last 'forever' as the belief goes. So after considerable replanting by various growers and researchers, it is determined that it is entirely possible to grow ginseng after ginseng. There are, however, some things to consider:

- How much disease was present in the previous garden? If lots, replant is not advisable in the short term.
- What is the soil type? If there is too much clay, a change in climate may create future problems, so replanting may be too risky.
- Should you fumigate before replanting? If you wish to grow soon after (1-3 years) it would be recommended. If 5 years or more, the need to fumigate would be questionable.

According to general agricultural practices, growing many crops for long periods of time on the same site will cause problems. Potato scab is a good example. Ginseng, because of its susceptibility to diseases, is one of these plants, and planting sooner than 5 years is not recommended. If waiting is not an option then fumigation should be considered.

Using a crop rotation, i.e. alfalfa for 3-5 years, a green manure crop to add organic matter for year and then ginseng for a 4 year period may be a good plan.

LEASING LAND — A CHECKLIST

Leasing land to grow ginseng has become a very common phenomenon here is British Columbia. There are a multitude of small details to consider if you are going to lease land for growing ginseng, or if you are a landowner about to lease land to a grower. A Ginseng Leasing Checklist has been developed to help in the discussion and hopefully reduce later frustrations. This checklist can be found in the Appendix: Farm Management Factsheet on Ginseng Leasing, page 139. It is meant as a guideline and in no way represents a contract between a landowner and a ginseng grower.

The Physical Nature Of Soils

SOIL COMPOSITION AND SOIL PROPERTIES

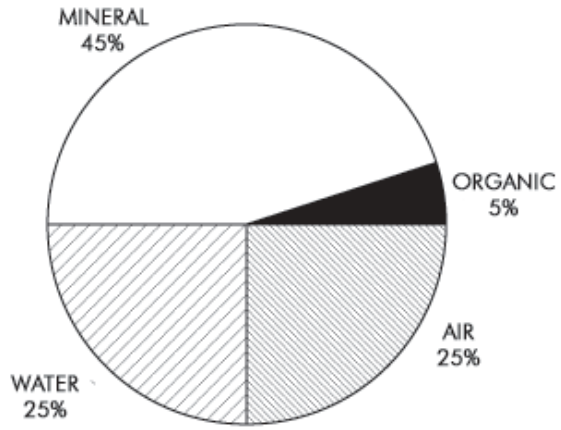
Soils are found in a wide variety of forms. Most commonly, soils are composed of mineral materials derived from rock, some accumulation of organic matter or humus, and a large population of soil organisms. Table 1 shows the four main soil types.

Whatever their composition, all soils have air spaces or pores which may hold air and water. The composition of a typical silt loam soil is shown in figure 4.

TABLE 1. The four main soil types

Soil type	Characteristics
Mineral Soils	Dominantly mineral matter. Various proportions of gravel, sand, silt and clay, containing less than 15% organic matter in topsoil layers.
Organic Soils	Over 30% organic material in all layers of the soil profile. Organic matter may be completely decomposed, as muck, or only partly decomposed, as in peat soils.
Muck Soils	Organic soil mainly composed of highly decomposed organic materials and may contain mineral matter.
Peat Soils	Organic soil composed of slightly decomposed organic material.

FIGURE 4. Composition of typical silt loam soil



The physical properties of the mineral and organic matter making up the solid portion of the soil have a marked influence on the size and number of pore spaces that may exist in the soil under different conditions. This in turn affects the soil's water-holding capacity, aeration, internal drainage, the ease of tillage and root growth, soil temperature, and the availability of plant nutrients.

In addition to these effects, the physical nature of soil materials also determines such properties as soil consistency and strength. Some knowledge of the physical properties of soils is required to understand the effects of agricultural practices on the soil, and how management can improve soil properties for agricultural purposes. The physical properties important in soil management are described in the following sections.

Soil Texture

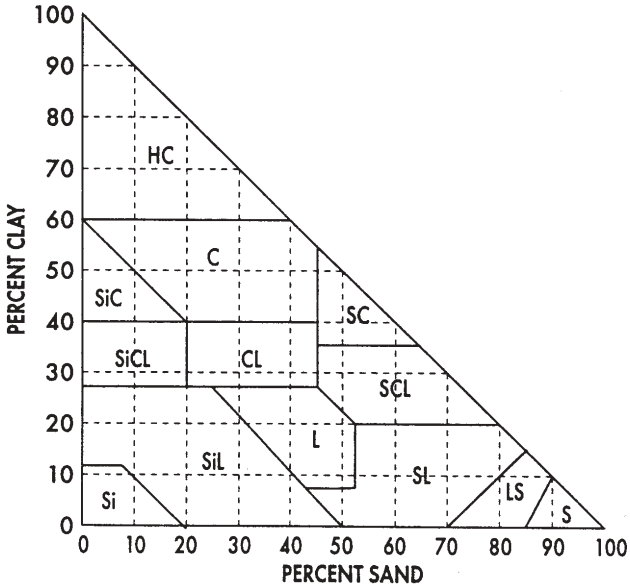
The mineral materials in soils are simply small fragments of rock or mineral materials derived from rock, but which have been altered by water and chemical reactions in the soil. Soil particles are grouped into four particle sizes as outlined in Table 2.

TABLE 2: Soil particle size and characteristics

Particle	Diameter	Properties
Gravel	2 mm – 7.5 cm	Rounded coarse rock fragments Single grained and loose
Sand	0.05 mm – 2.0 mm	Somewhat rounded, single grained and loose. Can be felt as grit
Silt	0.002 mm – 0.05 mm	Rounded, generally forms clods, easily broken, floury when dry, soapy or buttery, but not sticky when moist or wet
Clay	Less than 0.002 mm	Flat particles, forms hard clods when dry, sticky and plastic when wet or moist

In describing soils, texture refers to the relative percentages of sand, silt and clay sized particles in the soil material. Soil textures are shown in figure 5.

FIGURE 5. Soil textures



Soil texture may be further described using modifiers which indicate a dominant or additional feature of the soil. In the Okanagan and Similkameen Valleys, soils are often described as gravely or very gravely. These refer to 20 to 50% and 50 to 90% by volume of gravel size coarse fragments, respectively. Other modifiers could be mucky silt loam or sandy clay loam.

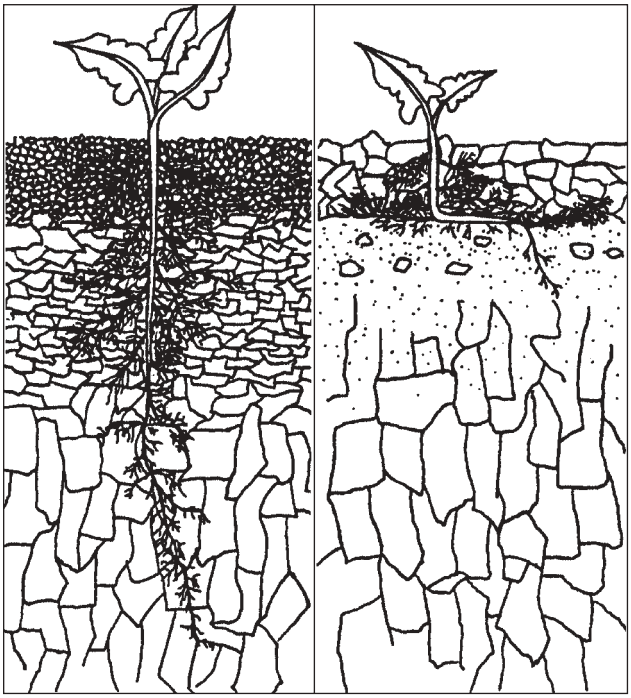
It is convenient to place soil textures into four main groups and describe the important properties common to each group, as in table 3.

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 the subsoil which is of a different texture.

Soil Structure

In soils, 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 strength, size, and shape varies considerably among soil types. Figure 6 illustrates well-structured and poorly-structured soils.

FIGURE 6. Well-structures versus poorly structured soils



Some of these aggregates may persist in stable forms which are not easily broken down by water or physical forces. In soils under cultivation, most aggregates at the surface tend to break down under the forces of rainfall, tillage, and traffic.

Soil structure also influences the internal drainage of the soil, affects its water-holding capacity, temperature, resistance to the growth of plant roots, and the emergence of seedlings. The formation of soil structure and factors which influence its breakdown are discussed in the section on Site Preparation (page 21).

Porosity

The porosity, or % pore space, in soils is the portion of the soil mass occupied by air and water. Porosity is determined by both soil texture and structure; therefore, porosity is influenced by practices which alter soil structure.

The size and distribution of pores in the soil is very important in determining the rates of air and water movement in soils, as well as influencing root growth. Plant roots require a balance of air and water for optimum growth.

Very small (micro) pores tend to restrict air and water movement while large (macro) pores promote good air and water movement.

Sandy soils have a low porosity (35 to 50% by volume), but the pores are relatively large. As a result of this, sandy soils tend to drain rapidly, to retain little water and to be well-aerated.

Medium and fine-textured soils have higher porosity (40 to 60% by volume), and a high proportion of the pores are small. These soils tend to retain more water, to drain more slowly and to be less well-aerated.

In finer-textured clay soils, those approaching 60% porosity with a predominance of small pores; structure and porosity, restrict air and water movement, a condition that ginseng cannot tolerate, causing breakdown of tissue, leading to diseases gaining entrance. In these soils, it is desirable to create larger pores by promoting a granular structure.

In addition to the effects of texture and structure on soil porosity, the activities of soil organisms is of equal importance. The burrowing activities of worms and soil insects result in the formation of larger pores which are beneficial to most soils. Practices which encourage the activity of soil organisms are of some practical significance in the management of finer-textured soils.

TABLE 3. Physical characteristics of soil textural groups

Soil Textural Group	Soil Textures and Types	Characteristics
Coarse to	Gravel Sand	Loose and friable when moist or wet. Loose to soft when dry.
Moderately	Loamy Sand Sandy Loam	Very high proportion of large pores. Low water-holding capacity.
Coarse	Fine Sandy Loam	Good bearing strength and trafficability when wet. Tends to form weak clods when cultivated. Easy to maintain good tilth.
Medium	Very Fine Sandy Loam	Slightly sticky and plastic when wet.
	Loam	Friable to firm when moist, soft to slightly hard when dry.
	Silty Loam Silt	Moderately easy to maintain good tilth. Moderately good trafficability and bearing strength when wet. Tends to form small to medium, slightly firm clods when cultivated. High proportion of medium to small pores, high water-holding capacity and available water.
Moderately Fine	Sandy Clay Loam Clay Loam	Sticky and plastic when wet. Friable to firm when moist, hard to very hard when dry.
to	Silty Clay Loam Sandy Clay	High proportion of small pores. Moderately difficult to maintain good tilth.
Fine and	Clay Silty Clay	Poor trafficability when wet. Tends to form large, firm clods when cultivated.
Very fine	Heavy Clay	High water-holding capacity, but less available water than medium-textured soils.
Organic Soils	Muck and Peat	Variably sticky, usually non-plastic, friable, slightly firm when dry. Very high water-holding capacity. Poor trafficability when wet. Tends to form small to medium clods when cultivated. Easy to maintain good tilth.

SOIL SAMPLING FOR LABORATORY ANALYSIS

A soil analysis is the most accurate guide to fertilizer and soil amendment requirements. It is especially important to determine soil fertility and pH levels before planting a crop, so that necessary amendments and fertilizers can be applied to the soil. Soil and tissue sampling must be done accurately and carefully if the samples are to be representative of soil and crop conditions.

Soil and tissue testing is provided by several private laboratories in the province of British Columbia. It is recommended that you use these local laboratories as they have the knowledge and experience of local conditions to conduct the appropriate analyses and give correct recommendations. Once a lab is chosen, it should be used each year in order to obtain consistent interpretations and recommendations. See the list of Laboratories available in British Columbia and Alberta in the Appendix.

Most Ministry offices have soil maps covering most of the farmland in British Columbia on display for general viewing and purchase. These maps can give a good indication of potential soil problems for ginseng production. Growers planning to move on to a new parcel of land can consult with the local office of the British Columbia Ministry of Agriculture, Food and Fisheries for recommendations for soil suitability and management.

A chain of events is required to develop a sound fertilization program or determine if a site is suitable for growing ginseng. The first link in this chain is to gather a soil sample that represents the fertility status of a problem area in a larger field, or a large area that will be used to produce a single crop.

WHAT A SOIL TEST CAN AND CANNOT DO

A soil test will not tell you what crops to grow or the value of your land. A fertilizer recommendation formulated from a soil test cannot provide the same returns under all weather conditions. Recommendations are based on research verified for British Columbia conditions. Since the weather cannot be predicted, crop response, and economic returns from fertilization will vary from year to year.

A soil test can be used to determine if a soil has levels of plant nutrients adequate for optimum growth. Regular soil analysis is a valuable management tool and soil test reports should be kept from year to year to enable you to follow fertility trends in your fields. One must not forget that soil fertility, while extremely important for economic production is merely a link in the chain. Other management factors, such as weed, disease and pest control, should not be neglected and so be allowed to become weak links in the chain of crop production.

The following are directions to guide you in a reliable sampling procedure to obtain a valid soil sample. Remember that a good fertilization program requires that:

- Soil samples be analyzed by an approved laboratory.
- Analytical results obtained by the laboratory be interpreted by someone qualified, who has access to the latest advances in soil science.
- The most advantageous fertilizer ingredients be selected.
- Recommendations in the soil test report be converted into rates of actual fertilizer. See the section on Nutritional Requirements for Ginseng, page 39, for details.
- Fertilizer be applied to the soil in a manner that will maximize its efficient utilization.

Samples should be submitted so that sufficient time is allowed to get a recommendation, decide what fertilizers and / or amendments will be used and, where necessary, stock the required supplies before fertilization is contemplated.

SAMPLE PREPARATION AND SHIPPING INFORMATION

Identify the soil sample carefully, fill out a corresponding sample information sheet and place it inside the soil box. Please do not place the sample information sheet inside the sample plastic bag as soil humidity may make it unreadable.

Identify and keep a record of each sample location so that you know which field should receive a particular fertilization.

SOIL TESTING PROCEDURES

Soil testing is a useful tool for determining fertility requirements of crops. A regular sampling program can also track the trends and efficiency of a fertilizer program. A soil testing program could be coupled with plant tissue testing for a more complete pool of information from which the producer can make crop management decisions.

In most areas of the interior of the province, the best time to soil sample is either spring or fall. As a general rule, it is best to soil sample several weeks prior to the start of any seedbed preparation. Perennial crops, such as forage and pasture or berries and ginseng, should have soil sampling done just prior to the beginning of each new flush of growth in the spring.

The value of the soil test is only as good as the method used to take the soil sample. It is important to be accurate in collecting the samples and when recording information about each sample.

When nutrient symptoms or other growth problems occur during the growing season, two samples should be taken, one each from the poor growth and good growth areas. A matching pair of plant tissue samples may also be useful for diagnosing a problem. These samples should be rushed to the laboratory so recommendations for any corrective action can be made rapidly. The following steps should be taken when collecting soil samples:

- Gather clean sampling equipment including a probe, auger or shovel and at least one plastic bucket for collection and mixing of the cores.
- Obtain the appropriate soil sample bags and boxes from the lab of your choice or use small plastic bags. Each sample needs to be about 300 ml (1 cup) in size.
- Make a simple map of your farm and identify each field or portion of a field which is to be sampled with a number or letter. Areas in any field that are different due to appearance, fertilization or cropping practice, soil type, slope or drainage should be sampled separately. Care should be taken to avoid small, low, wet areas, dead furrows and areas close to trees, for the sampling program. Do not sample near manure piles (new or old), old burn piles, fertilizer storage, fertilizer bands or livestock droppings. Samples should be taken from fields or portions of fields that are reasonably uniform and can be managed as one unit.
- Record all pertinent information about the area sampled as soon as the sample is collected. This information should include a cropping history and desired crops to be grown, any recent fertilizer or soil amendment applications and any information relevant to the reason for the collection of the soil sample.
- Wear disposable gloves when taking samples for micronutrient analysis, so perspiration from your hands won't contaminate the sample.
- Store samples in a cooler in the field to minimize microbial activity which could give an unrepresentative nitrate result.

Soil samples are usually taken from the top 15 to 20 cm (6-8 in) of the soil for most cultivated crops as this is the zone that is normally tilled and contains the major portion of the crop's roots. Sampling should be done with the tool that is most appropriate for the soil conditions. If the soil is stony or wet, an auger or shovel will work better than a tube type soil probe. Regardless of the implement chosen, the implement and the sampling bucket should be clean.

To begin sampling, remove excess plant residues. When using a shovel, create a V-shaped hole and slice a 2 to 3 cm ($^3/_4$ to 1 $^1/_4$ in) thick slice down one side to a depth of 15 to 20 cm. Trim this slice on either side to form a 2 to 3 cm wide core and place this in the sample bucket. This core is an individual sample that will be used to create the final composite sample.

When using a probe, push the tube into the soil to the desired sample depth and collect the individual sample.

Take 10 to 20 individual samples from each sampling area. For fields up to 10 hectares in size, a minimum of 20 individual samples is suggested. Once all the individual samples have been collected in the bucket, break up the lumps and remove the stones. Make sure the soil is completely mixed and then remove about 300 grams or 300 millilitres and place this composite soil sample in a plastic bag then in the soil sample box. The labelling on the sample should be the same as on the rough map of the farm or field.

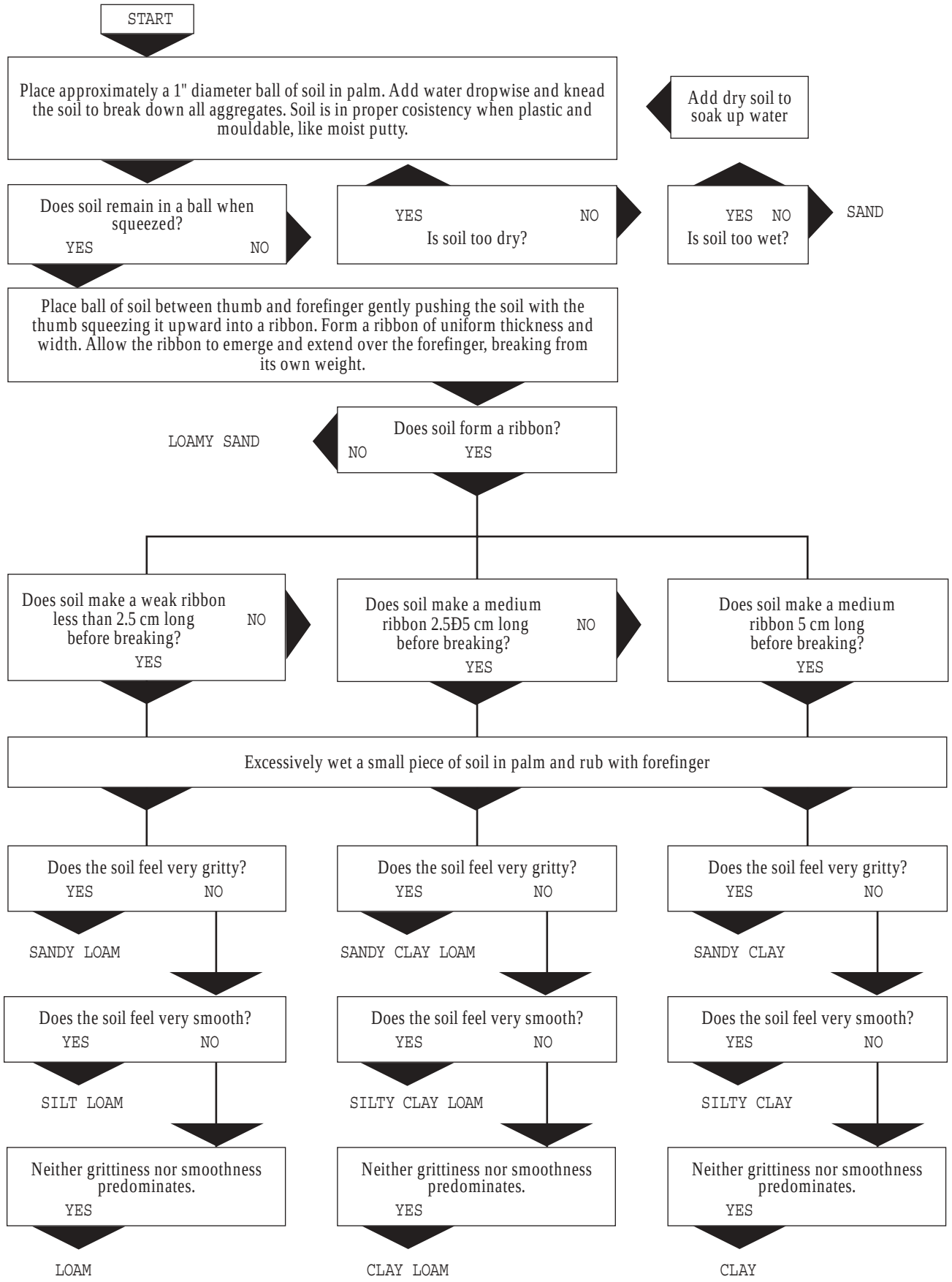
If, however, the sample is quite moist, it should be air dried before it is sent to the lab unless it is to be hand delivered within a few hours of collection. Moist samples can incubate in warm conditions, such as post offices, bus depots and the inside of warm vehicles, thus changing the chemistry of the soil. Soil samples should not be treated like dirt! To dry a sample place the soil on a clean plastic surface like a garbage bag.

Soil sampling is a useful farm management tool, but it is important to keep in mind that the soil test results are only as accurate as the sampling technique and the records kept on each sample. A good soil fertility program requires regular soil sampling, but it may also require feed or plant tissue testing as well. A sampling program that includes the preparation of a farm map each year outlining the location of each sample and the crop management practices that were associated with each field is recommended. Once you have chosen a soil testing lab, it is a good idea to stick with that lab, because each individual lab has its own "soil testing philosophy" for the determination of soil nutrient levels and also for the interpretations and recommendations that come from the test results.

PLANT TISSUE SAMPLING

There are no reliable tests at this time for ginseng, but if you do wish to sample for area comparisons, use the following as a guideline. Plant tissue sampling is another means of assessing fertility, but is only good for some specific crops and growth stages. In general, sample the youngest, mature leaves of representative plants. Plants should represent only one area, one fertilizer treatment and should be of the same vigour. For any crop, follow a pattern suitable to the field. Use the X-pattern wherever possible. Do not take leaves from the outside two beds or from beds within six rows of dusty roads. Samples should not be diseased or dead; tissue should not be damaged by insects or mechanical equipment. If leaves appear dirty, wash them in a mild detergent solution for one minute, rinse immediately in fresh water for one minute and drain on clean paper towel. Samples should be promptly sent to a laboratory to avoid spoilage, otherwise, they should be spread to air-dry prior to shipment. See the list of Laboratories available in British Columbia and Alberta in the Appendix.

TABLE 4. Instructional diagram for texturing by feel



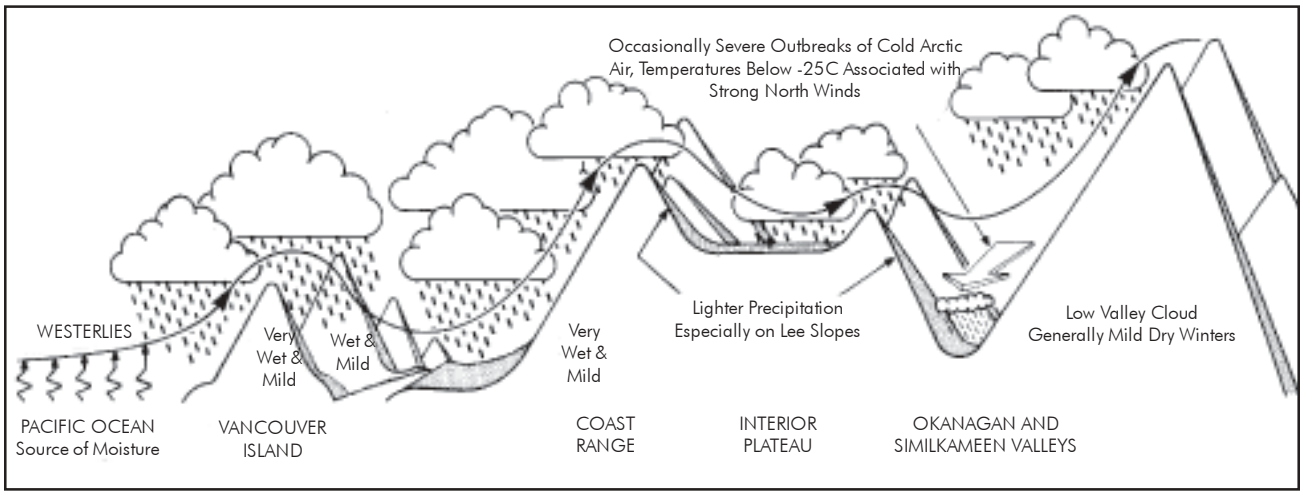
The Climate of the Interior of British Columbia

The climate in the interior is governed by the region's location in the lee of the Coast Mountain Range. These mountains, with peaks to over 2,450 meters (8,000 ft), are extremely effective at removing moisture from the precipitation bearing westerly winds through orographic lifting of the air mass, resulting in a wet mild climate west of the Coast Range. In the lee of the Coast Mountains, a rain shadow effect is produced and cloud and precipitation amounts are decreased, sunshine is increased, humidities are lowered and the range of seasonal temperature is greater than on the windward side (See figures 7 and 8).

PRECIPITATION AND OTHER MOISTURE RELATED PARAMETERS

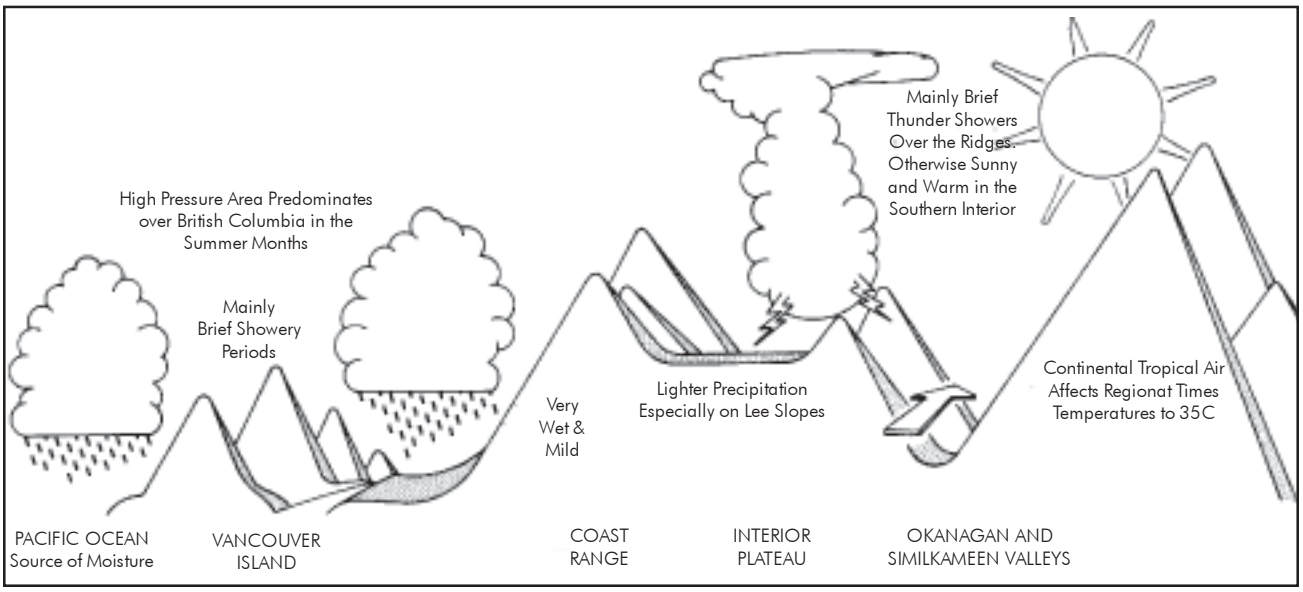
During the winter months, the predominantly westerly upper air flow contains weak weather systems which produce light rain or snow in the interior valleys. Frequently, severe outbreaks of arctic air penetrate into the area reducing minimum temperatures below -25°C. In the past 10 years, these outbreaks have brought about a 50% risk of severely reducing some crop production. Heavy snowfall often occurs as these cold air masses are replaced by more moist and mild Pacific air masses (see figure 7). Summer months are dry and warm with precipitation usually in the form of brief showers or thunderstorms. Although climate has a strong influence on crop production, mesoclimate is often the overriding climate consideration for perennial crop suitability. June is the wettest month while July, August, and September are usually dominated by a high pressure ridge which produces warm and dry conditions over the interior. The dry, hot summers lead to soil moisture deficits in most areas during the growing season and irrigation is required for the production of most agricultural crops (see figure 8). However, the northern section of the area will experience a higher rate of annual precipitation overall, i.e., Armstrong at 457 mm as opposed to Keremeos at 242 mm.

FIGURE 7. Typical winter weather patterns in southern British Columbia



Source: Atlas of suitable grape growing locations in the Okanagan and Similkimeen valleys

FIGURE 8. Typical summer weather patterns in southern British Columbia



Source: Atlas of suitable grape growing locations in the Okanagan and Similkimeen valleys

TEMPERATURE AND OTHER PARAMETERS DERIVED FROM TEMPERATURE

Brief, very hot periods occur when modified dry continental tropical air invades the area from the desert region of the southwestern United States often raising temperatures to 35°C or more. The highest maximum temperature ever recorded include Keremeos at 41.1°C, while at Winfield, the highest is 37.2°C. The lowest temperature ever recorded in Armstrong is -42.2°C, while at Winfield, the lowest is -25.5°C. Large bodies of water, especially slow moving ones, serve to moderate temperature effects on surrounding areas. Such bodies of water have a large heat storage capability, warming the surrounding areas in the winter. They have a cooling effect in the summer. In addition to this moderating effect, crops located on slopes close to large lakes or rivers benefit from the refection of solar radiation from the water surface increasing the length of the frost free period. Lakes or large rivers also increase the surrounding area humidity and cloud cover. All of these factors reduce the risk of late spring or early fall frosts and extend the growing season.

Irrigation in arid areas can modify the surrounding climate significantly. Overhead irrigation can be used to reduce stress on crop production through atmospheric cooling.

MESOCLIMATE

Mesoclimate refers to small areas of the earth's surface that may not be representative of the general climate of an area. It includes the climate created by moisture, solar radiation, small valleys, frost pockets, openings in a forest, hillsides, temperature, shelterbelts, and wind in the lowest areas of the standard weather stations.

Factors that influence mesoclimate include: solar radiation, soil type and texture, slope and aspect, heat unit accumulation, elevation, wind, water, and vegetation.

SOLAR RADIATION

Solar energy is the primary source for all biological processes. Radiation from the sun has an effect on air and soil temperature, transpiration, soil moisture, atmospheric humidity, all plant processes, cell division, tropism and factors such as sugar accumulation, bud fertility, wood maturity, etc. Yield and quality are also influenced. The amount of solar radiation received at a site and the duration of sunshine during the growing and harvesting season has a direct influence on all these factors. Shading from the afternoon and evening sun in mountainous areas, caused by topography or nearby trees, may have a negative effect on crop quality. Solar radiation is associated with heat summation at particular sites and factors such as the length of the growing season, although not directly related with heat accumulation, are associated with solar radiation. Long growing seasons with low heat unit accumulations are found in cool growing areas such as coastal climates where solar radiation is limited.

In cool climate areas, such as the Pacific Northwest, the selection of sites for some high value crop production must take into account slopes; aspects; elevation above sea level; protection from winds; proneness to fog in spring or fall; the best sources of solar radiation; and hence, increased heat accumulation and sunlight. The effect of solar radiation is also noticed on soils. Soil texture and soil water content differences can influence the heating and cooling rates in crop production. Dry, sandy soils have the greatest range of daytime to night-time temperatures. Clay soils at field capacity have the least fluctuation in temperature. These differences are greatest close to the soil where only a few centimetres change in elevation can be responsible for significant differences in temperatures. Table 5 below gives an indication of the effect of surface cover on temperatures within a crop.

The use of soil textures, soil moisture and soil cover for frost protection is an established practice. For example, wetting a dry soil improves the transfer of heat from the atmosphere to the soil and at the same time increases the heat storage capacity in the soil proportional to the volume it contains. Imposing a living vegetation barrier between the soil and the atmosphere reduces the transfer of heat to the soil.

The amount of radiation lost as heat from soil varies with the shape of valleys. Depressions are traditionally frost pockets, however, narrow, steep valleys, such as the Okanagan and Similkameen Valleys, tend to restrict the amount of radiation. Soil heat is transferred to the atmosphere in large amounts due to the relatively large ground surface area. The location of Okanagan Lake and the chain of lakes located in the Okanagan Valley contribute significantly to the collection and release of thermal radiation and cloud formation. Increased cloud cover, particularly in winter months, reduces the outgoing radiation keeping the area warmer than the surrounding plateau.

TABLE 5. Effect of soil surface cover on temperature within a crop

Surface Cover	Temperature (°C)
Bare, firm, moist soil	Warmest
Shredded cover crop, moist soil	1/2 degree cooler
Low cover crop, moist soil	1/2 degree cooler
Dry, firm soil	1 degree cooler
Freshly disced soil	1 degree cooler
High cover crop	1 to 2 degrees cooler

SLOPE AND ASPECT

The amount of solar radiation accumulated at a site varies depending on the slope of the land and the direction of the slope. In the northern hemisphere, southern slopes are the best choice to gain increased solar radiation. North facing slopes gain the least while west slopes intercept more solar radiation than east slopes. Total accumulated heat units are generally greatest near the midslope, less on the hilltops and lowest near the base of the slope. Exposed hilltops have lower maximum temperatures and slightly cooler minimum temperatures than midslopes. Cold air flows down slopes and collects at the base creating frost pockets and areas with late spring frost and early fall frost. The angle of the slope, in relation to the location of the sun, is very important to maximize the amount of solar radiation collected at a site.

South slopes may lose the protective snow cover in winter months, resulting in root damage from penetrating frost on light sandy soils. South slopes may demonstrate advanced bud break and increased water requirements. In warm areas of the Pacific Northwest, south slopes may be too warm for certain crops or varieties. In contrast, the growing season and winter conditions on north facing slopes are all negative except for slopes of less than 10 degrees. Such slopes in warm areas may be useful only for some early maturing crops or varieties.

ELEVATION

Crops are grown over a wide range of elevations in the interior. There are limits in elevation above sea level (ASL) where some crops can be grown economically. Increases in elevation of 100 meters may reduce the average annual temperature by as much as 1°C. For example, 600 meters (2,000 ft) ASL is considered to be the cut off for tree fruits in the Okanagan. Exceptions have been noted on south slopes and in areas where air inversions may form. Fields at higher elevations are, therefore, generally cooler than fields at lower elevations in the same region. Higher elevations are generally wetter due to increased precipitation during the growing season and winter months. Cooler temperatures at higher elevations delay bud break, flowering and seed ripening dates.

Ginseng obviously has an upper limit as far as elevation is concerned, but we don't know what it is. It has been grown at 2,500 feet near Clearwater. This limit would generally be higher in the southern interior than the north.

WIND

Many studies illustrate the negative effects of high wind on crop production and quality. Exposure to moderate and high winds has a desiccating effect (due to the high evapotranspiration rates) and causes physical damage. During the winter, wind removes snow cover; increasing the risk of soil drying, seed desiccation, as well as causing damage to roots of perennial crops as a result of low temperatures. High winds often result in tattered leaves, aggravated heat stress and physical structure damage.

Winds in excess of 12 km / hr cause stomata to close, resulting in reduced photosynthesis. Stomates are reported to recover slowly if the reason for their closure was high winds and more quickly if the wind speeds were moderate.

Note: *It is not known if this is true for ginseng.*

Windbreaks with 50% reduction of wind may be beneficial for areas of the interior where strong daily winds are typical weather patterns in spring and summer. Studies have shown that sheltered crops protected by artificial or natural windbreaks have better crop vigour, quality and yield. The benefits of wind shelters will vary, with the frequency and the degree of high winds.

The economic benefits of wind breaks depend on:

- wind behaviour
- crop species or variety
- soil moisture and temperature during the windy period
- growth phase of the crop when high winds occur
- design of windbreak
- cost of windbreak
- increase in income as a result of windbreak

Economical production may not be possible in some areas due to high winds. Not all wind is bad though. The turbulent effect of winds may help in sunny continental climes, such as the Okanagan and Similkameen Valleys where background levels of carbon dioxide are relatively low. Assimilation of carbon dioxide may be restricted by low concentrations in the leaf canopy.

TABLE 6. Summary of climatological data for some representative atmospheric environment service stations in the interior of British Columbia

Station	Lat.	Long.	Elev.	GDD	LSF	FFF	FFP	Ps	PEs	Ext. Min.	Ext. Max.	Jan. Min.	July Max.
Armstrong	50 26	119 12	375	1867	18-May	20-Sep	124	174	565	-42.2	40.6	-9.6	28.0
Creston	49 06	116 31	598	1939	29-Apr	7-Oct	148	186	473	-30.6	39.4	-5.8	26.3
Grand Forks	49 02	118 28	532	1951	12-May	22-Sep	121	174	615	-38.9	42.2	-9.1	28.2
Barriere	51 11	120 07	415	1852	24-May	20-Sep	118	210		-42.8	41.1	-10.7	27.7
Kamloops CDA	50 43	120 26	351	2337	2-May	3-Oct	153	120	564	-37.2	40.6	-8.4	28.3
Kelowna Airport	49 58	119 23	430	1801	26-May	20-Sep	116	129	489(1)	-36.1	38.6	-9.3	28.0
Keremeos	50 12	119 47	430	2424	18-Apr	17-Oct	181	103	534	-30.6	41.1	-6.5	29.0
Lumby	50 15	118 58	509	1711	25-May	11-Sep	108	193		-33.3	38.3	-10.4	27.4
Lytton	50 14	121 35	258	2539	20-Apr	24-Oct	185	90	517	-27.7	42.2	-5.5	28.1
Osoyoos	49 04	119 31	331	2459	18-Apr	16-Oct	180	126	517	-25.6	39.5	-6.1	29.1
Salmon Arm	50 42	119 15	506	1944	4-May	4-Oct	152	206	488	-35.0	41.1	-8.0	26.5
Summerland CDA	49 34	119 39	455	2196	22-Apr	10-Oct	165	127	513	-30.0	40.0	-6.3	27.8
Vernon	50 14	119 17	555	2011	22-Apr	15-Oct	175	151	471(2)	-31.0	38.5	-7.4	27.0
Williams Lake A.	52 11	122 04	940	1289	6-Jun	9-Sep	92	207	364	-42.8	35.8	-13.0	22.2

Sources: Environment Canada. Atmospheric Environment Service, 1982. Canadian Climate Normals, Volumes 2, 3, 4 and 6: 1951-1980. Downsview Ontario.

Air Studies Branch. Climate Capability Classification for Agriculture in British Columbia, RAB Technical Paper 1. Ministry of Environment, Victoria, British Columbia, 1978.

(1) Kelowna CDA
(2) Vernon Coldstream

GDD – Growing degree days above 5°C
LSF – Average date of last spring frost
FFF – Average date of first fall frost
FFP – Freeze free period (days)
Ps – May – Sept precipitation (mm)

PEs – Est. May-Sept potential evapotranspiration (mm)
Ext. Min. – Lowest minimum temp. ever recorded (°C)
Est. Max. – Highest maximum temp. ever recorded (°C)
Jan. Min. –Average Jan. minimum temp. (°C)
July Max. – Average July maximum temp. (°C)