Fertilizer Reactions in Soil

Fertilizers added to the soil may become more or less available, depending on the type of fertilizer, soil moisture and pH conditions as well as temperature. Some nutrient elements may be completely lost; others may be temporarily "tied up."

All plants, ginseng no exception need 16 elements to grow properly. Any plant may need more or less of a particular one but all are necessary. Carbon (C), hydrogen (H) and oxygen (O) are all derived from the air and are free elements.

The other thirteen are divided into two groups, macronutrients and micronutrients. The macro group is nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S). The micro group is boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn). All of the micronutrients are as important as the macro group but are only required in less quantity. Ginseng is not a legume so it cannot fix any nitrogen (N) from the air so it must all be supplied.

Keep in mind that an excess of some nutrients, especially the micro group can be worse than not enough. Boron as an example can be toxic in quite low amounts so care needs to be taken on the amount applied. Always do a soil test to determine whether any nutrient is necessary before adding any one of them.

Nutritional Deficiencies

Deficiencies can result in complete crop failure as early as the seedling stage to differences detectable only with good experimental work. Just because you don't see a problem doesn't mean your crop is completely healthy. This is called hidden hunger and may reduce yield and quality without visible signs on the plant.

Soil / tissue sampling are guidelines that give a close proximity of where nutrient levels are at. Soil sampling at present is the best guide as little correlation work has been done with tissue data and how it relates to soil data (see Soil Sampling page 13).

When soil and tissue sample reports show deficiencies, it is hard to change some things immediately but are indicators of what needs to be done for next year. There are critical need periods of a plant, as an example, the nitrogen requirements for ginseng would be in the spring early growth stage, while the need for P and K would come later, during the reproductive stage and for root growth.

Soil Testing in a Lab is only an average of what is in the soil and many other factors will determine if the nutrient is available to the plant and at what rate.

Conditions reducing the availability of nutrients in soil:

- pH of soil solution >7*
- low temperature
- available water (too wet)
- other soil chemistry (interrelationships)
- soil type (sand / silt / clay) sandy = lowest availability
- very low or very high organic matter
- leaching and erosion problem
- phosphate levels too high
- herbicide damage, insects, disease
- soils high in Fe or Al
- inadequate levels in the soil of a nutrient
- removal by crops

* *All nutrients except Mo are more soluble as the pH decreases and below 5.0 some toxicity problems can occur with Fe, Al and Mn. High lime soils have a buffering effect on this toxicity of these elements. See table 11, for the ranges of micronutrients that determine a deficiency or a toxicity in a soil.*

Note: *Different varieties of crops such as corn, can be grown side by side and one will show a deficit and the other won't, showing genetic diversities. Because ginseng has such great genetic diversity this may be the reason for apparent differences between individual plants.*

TABLE 11. Ranges for levels of micronutrients in soil (µg/ml)*

		Deficiency	Medium	Adequate	Toxic
Boron	B	< .4	0.5 - 1.0	> 1.0	> 7.0
Chlorine	Cl	< 8.0 –deficiencies are very rare so Cl is not routinely tested for			
Copper	Cu	< 0.3	0.3 - 1.0	> 1.0	—
Iron	Fe	< 2.0	2.0 - 4.5	> 4.5	—
Manganese	Mn	< .5	0.5 - 1.0	> 1.0	—
Zinc	Zn	< 0.5	0.5 - 1.0	> 1.0	—

* *Most soil labs will record soil analysis data in ug/ml and is equivalent to ppm (parts per million).*
If you multiply µg/ml x 2, you get the approximate lbs/acre of a nutrient that is in the soil structure

Sources of Nutrients

There are only three sources of plant nutrients, and all plants can absorb these nutrients only as specific forms. These sources are:

- from the breakdown of parent soil
  - on soil colloids
  - in soil moisture
- from organic matter in soil or applied
- from applied fertilizers either organic or chemical

Soil Testing and Fertilization For Ginseng

Because the selection and treatment of soil is a most important area for overall success, we have given this section a fairly large part of this pamphlet. It is critical that the fertilizer elements (with the exception of nitrogen) required for the life of the crop, be thoroughly incorporated into the soil prior to seeding.

Before buying land or making any preparations for establishing ginseng, it is important to determine whether a soil has the desirable combination of chemical properties for growing this crop. A soil test interpretation will indicate which fertilizer or amendment additions are required to ensure adequate nutrient reserves and provide the optimum root environment for crop growth. Each ginseng garden should be sampled yearly. See the soil sampling procedures pages 13-14.

Manure, if available can be incorporated into the soil in the preparation year. Amounts up to 40 tons per acre have been used. If manure is added earlier, a soil sample, just prior to bed preparation, would then be necessary to see what additional nutrients were needed, that the manure did not supply. See manure in the Site Preparation section, page 34.

It is efficient and economical to adjust soil fertility before seeding and maintain it with annual additions as indicated by the recommendations on your soil test report. Remember, phosphorus, limestone, copper and zinc are very immobile in the soil; potassium and magnesium are moderately mobile; and nitrogen, boron and sulphate can be quite mobile. Incorporation of the immobile and moderately mobile plant nutrients in the root zone before seeding (when the soil can still be worked with a rotovator for example) is particularly important as the crop may otherwise experience nutritional deficiencies because added fertilizers have remained near the soil surface and consequently may not be accessible to plants.

Soil Organic Matter (OM)

Organic matter, also called humus at times, is an important indicator of soil quality. The soil level should probably be above 2% but below 8%. Levels that are near 8% or higher suggest that the soil may not be (or was not) well drained. Organic matter influences not only the supply of plant nutrients in a soil but also its structure. For example looking at opposite ends of the scale, the heavy textured soils (clays, silts, silty clays), are at one end and at the other end, very light textured (sandy) soils. Heavy textured soils retain too much water; light textured soils not enough moisture and plant nutrients. Organic matter improves the drainage of heavy textured soils and allows air to move more readily through the soil, warming it up earlier in spring. Organic matter additions to sandy soils improve its moisture and plant nutrient holding capacity.

Soil pH

American ginseng grows naturally in acid forest soils with relatively high rainfall. These usually have pH values situated between 4.8 and 6.0. In British Columbia a much wider natural variation in soil pH is observed than is optimum for growing ginseng. Values commonly range from about 4.5 to 9.0. The more acid soils (lower pH) are generally lower in fertility. Plant nutrients have been leached over the years from the root zone of these soils. Furthermore, acid soils may contain plant-toxic levels of aluminium and/or manganese.

Potential toxicity of these elements to plants can easily be controlled by keeping soils at pH 5.5 or slightly higher. Soil pH values above 8.0 should probably be avoided as ginseng may have difficulties absorbing adequate amounts of micro-nutrients for optimum growth. The availability of many micro-nutrients is reduced with increasing pH values. This crop can probably be best grown at a soil pH situated between 5.5 and 7.5. High pH soils can be amended but not easily or quickly so timing needs to be considered.

Salt (Conductivity)

The electrical conductivity (EC), or salt level, of a soil is a measure of the amount of salts in the soil solution. In its natural habitat of high rainfall and low soil fertility (acid soils), ginseng is rarely exposed to significant salt concentrations. It therefore would have little need to have a natural tolerance. Accordingly, it is suggested that the conductivity level of a soil should be below 1.0 dS/m (deci-Siemens per meter = millimho per centimetre) as determined by a soils lab testing.

Higher salt levels frequently occur in British Columbia, particularly in the arid and semi-arid interior. The cause of salt accumulation is a rainfall deficit: i.e., an insufficient precipitation relative to evapotranspiration. More abundant precipitation would leach (move) soluble salts to below the root zone. Salt levels are quite variable in a field and tend to accumulate in seepage areas. Over-fertilization may also cause excessively high salt levels. Some of the accumulated salts may be plant nutrients. Generally, significant salt levels in the soil solution reduce water availability to plants. An excessive salt level will usually show its effect on hot days when crop water requirements are highest.

Excessively high salt levels will reduce and may inhibit crop growth. The salt level in a soil can be reduced by applying more water than required by plants; however, in practice it may be difficult to reduce soil salinity to the recommended value in a short period of time if the value is much above the recommended value. We also need to watch the water saturation of some soils, causing root rot problems to occur.

Nitrogen

The most common forms of fertilizer nitrogen are nitrate (NO_3), ammonium (NH_4) and urea ($CO[NH_2]_2$). All are highly water soluble. Urea is converted to the ammonium form when it is acted upon by enzymes in the soil. Ammonium nitrogen is absorbed by clay minerals and organic matter and is, therefore, not easily lost from the soil. Nitrate nitrogen is not absorbed by the soil and can be lost by leaching with water. Leaching losses of nitrate nitrogen are greatest in sandy soils and in areas with high rainfall.

Some ammonium and urea nitrogen may be converted to ammonia gas, which escapes into the atmosphere. This usually occurs in dry soil with surface-applied fertilizer. Ammonia losses are reduced or eliminated by ensuring 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.

Some nitrate nitrogen may be converted to gases, which escape into the atmosphere. This frequently occurs in wet soils during fall, winter and spring.

Nitrate is the preferred and most readily available form of nitrogen for plants. This soil test reveals its concentration in soils expressed in ug / mL (micrograms per millilitre of soil which is approximately equal to parts per million; ppm). The test value is used to calculate the recommended nitrogen fertilization rate by subtracting the readily available nitrogen reserve in the soil from a maximum recommended rate which would be applied when no reserves are present.

Maximum nitrogen requirements (soil levels + added fertilizer), increase with the age of gardens. These are approximately 40, 60, 80 and 100 kg N / ha for 1, 2, 3 and 4 year-old gardens, respectively. (Kg / ha x .89 = lbs / ac) It is important to monitor soil nitrate levels at least yearly. Fertilization should preferably be carried out during the dormant season at least 3 to 4 weeks before plants emerge to avoid fertilizer burn of plants and to be sure it is in the root zone when needed. Although plants generally prefer nitrate nitrogen over other forms, some ammonium will be absorbed. In any event, ammonium fertilizers are usually quickly converted to nitrate in soils by soil microbes.

Nitrogen is a major plant nutrient and it is usually absorbed by the crop in greatest quantity. The effects of optimum levels of nitrogen are noticeable when adequately supplied for rapid growth, as it imparts to plants a deep green, healthy colour. The most apparent effect of adequate nitrogen fertilization is the encouragement of above ground vegetative growth. On the other hand, literature suggests that excessive nitrogen may cause overly lush tops resulting in more disease problems and possibly a reduction in root yield. If available nitrogen, begins to fall short of the crop's needs, the characteristic general yellowing of mature leaves will occur.

Phosphorus

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 has been 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.

Some phosphorus becomes "tied-up" at low pH (below 6.0) and at high pH (above 7.5). Very little phosphorus leaches out of the soil.

Plant available soil phosphorus levels are expressed in ug P / ml soil (micrograms per millilitre). The soil test value is accompanied by a rating index (VL = very low; L = low; H = high; VH = very high). Table 12, page 42 shows the relationship between the amounts of recommended plant nutrients on the soil test report (N, P, K) and the amount of fertilizer required to meet the recommendation.

Phosphorus is relatively immobile in soils. It is, therefore, particularly important that soils be tested and fertilized before seeding so that the fertilizer can be incorporated into the soil layer where roots are going to proliferate. Fertilization before seeding can ensure an adequate phosphorus supply for the

duration of the garden. Should a low phosphorus level be discovered in an established garden, surface applications may be utilized, depending on how deficient it is, though such applications are generally quite inefficient.

Phosphorus is another important macro-nutrient and an adequate supply is essential in all phases of plant growth. It is important for the effective formation of above and below ground parts of plants as well as to ensure disease resistance. If the phosphorus supply is inadequate to meet the plant's needs, the existing phosphorus, like nitrogen, will move from the older to the younger tissues. Accordingly, visible signs of a deficiency, when they appear, show on the lower leaves. The symptoms may be a lack of chlorophyll, a deepening of the green colour, or a reddish-purple colour on the lower leaves.

Potassium

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

This is the third major plant nutrient (macro-nutrient). Potassium (K) is essential for growth and is absorbed by plants in very large quantities, more than any other nutrient except nitrogen. Plant available potassium measured by a soil testing laboratory represents essentially the exchangeable portion of the total potassium in the soil. Of the total potassium in soils only about 2% or so is plant available, the remaining is held as part of soil minerals. Soil test levels are expressed in ug K/ml soil (micrograms per millilitre). The soil test value is accompanied by a rating index (VL = very low; L = low; H = high; VH = very high). Table 12 shows the relationship between the amount of recommended plant nutrients on the soil test report (N, P, K) and the amount of fertilizer required to meet the recommendation.

Many soils in British Columbia are well supplied with potassium and generally if the soil test shows that it contains 250 µg K/ml soil or more, the soil can be considered to have an ample reserve to meet crop growth. Heavier textured soils are generally well supplied with potassium; sandy soils often have a deficiency. This plant nutrient is moderately mobile in soils and surface applied fertilizers can generally be brought down to the root zone within the growing season. Nonetheless, it is important to make any major applications before seeding when it can be readily incorporated in the rooting zone along with other fertilizers. Subsequently, an adequate supply can be maintained by adding only minor amounts during the dormant season.

TABLE 12. Relationship between the amount of phosphorus and potassium extracted from soils

with Kelowna extractant and the soil test ratings, fertilizer recommendations and comments. These are guidelines given by Griffin Laboratories Corporation and will be similar to other laboratories. This does not imply a recommendation of Griffin Laboratories over other ones.

PHOSPHORUS				POTASSIUM			
Soil Test P µg/ml	Rating	Phosphate Rec.	Comments*	Soil Test K µg/ml	Rating	Potash Rec.	Comments*
5	VL	200	PG	50	VL	400	KG
10	L-	170	PG	65	L-	350	KG
15	L	140	PG	80	L	300	KG
20	L+	100	PG	100	L+	300	KG
25	M-	80	PG	125	M-	250	KG
30	M	60	PG	150	M	200	KG
40	M+	50	PG	175	M+	150	KG
50	H-	40	P2	190	H-	100	KG
75	H	40	P2	220	H	50	KG2
100	H+	40	P2	250	H+	50	KG2
999..	VH	0	P3	999..	VH	0	KG3

* *Comments*

PG *Broadcast and incorporate the recommended phosphate rate into the root zone before seeding.*

P2 *Soil is well supplied with this nutrient, the phosphate rate is intended for maintaining soil fertility.*

P3 *No application of this nutrient is recommended as the soil already has an abundant supply.*

KG *Broadcast and incorporate the recommended potash rate into the root zone before seeding. If the crop is established, potash can be applied during the dormant period, in some instances the rate may be reduced. Contact your horticulturist.*

KG2 *Soil is well supplied with this nutrient, the potash rate is intended for maintaining soil fertility.*

KG3 *No application of this nutrient is recommended as the soil already has an abundant supply.*

Calcium

This is usually the most abundant plant nutrient in soils. It is largely held on the soil cation exchange complex when soil pH is lower than about 6.5. Levels are increased in soils by liming; a good quality limestone will contain up to 40% calcium. However, except for rare exceptions, calcium does not need to be added to soils to meet crop needs when the pH is in the desirable range as soils are generally well supplied for meeting plant needs. On soils containing appreciable sodium, calcium is often added to aid in improving or stabilizing soil structure. However, high sodium soils should probably be avoided for growing ginseng.

Plant roots and tips do not elongate in the absence of calcium. The element is related to protein synthesis, enhanced nitrate uptake, enzymatic activity, and is an important constituent in the building of cell walls. This element is considered immobile in herbaceous plants. However it is very rarely deficient.

Magnesium

Unlike calcium, magnesium is quite often deficient in soils. Deficiencies occur most often on coarse textured and acid soils. Like calcium, plant available magnesium is held on the soil cation exchange complex if soil pH is below about 6.5. A fertilization recommendation appears on the soil test report when the concentration is below 100 ug Mg / ml soil. Recommendations are expressed in kilograms magnesium (mg) per hectare.

Magnesium is absorbed by plants as an ion (Mg++). It is the only mineral constituent of the chlorophyll molecule and is located at its centre. The importance of magnesium is obvious for without chlorophyll photosynthesis would not be possible. This element is also used in plants for phosphorus metabolism and is considered specific in the activation of a number of plant enzymes. Magnesium is mobile in plants and is readily transferred from older to newer tissues. In many species the deficiency results in interveinal chlorosis of the leaf, where only the veins of the leaf remain green. In more advanced cases, leaves become uniformly yellow, and as the deficiency aggravates, leaves start to curl, brown and eventually die at the margins. If the latter symptoms appear by themselves without chlorosis, then the problem may be caused by other factors such as excessive salts or disease.

Sodium

Sodium is not considered as a plant nutrient, though it can substitute for potassium in some crops, notably sugar beets. Nonetheless it is one element that is desirable to have as little of as possible in soils. Levels below about 100 ug / ml can generally be considered as negligible, and this level is desirable. Sodium is important mainly because of its negative effect on soil structure. However, sodium concentrations should not only be considered alone, but also its relationship to the quantity of soil structure improving cations, like calcium.

Sulphur

Sulphur levels are generally determined routinely on all soil samples submitted to a soil laboratory. Analytical results are expressed in ug S / ml soil (micrograms per millilitre). A Sulphur fertilization recommendation should appear on the soil test report when soil test levels are 25 µg or lower. Sulphur deficiencies are quite common in British Columbia, in the Prairie Provinces, and Western United States; unlike Eastern Canada or the Eastern United States where relatively larger amounts of Sulphur are added to soils through acid rain. Sulphur fertilization is particularly important because a deficiency can have severe repercussions on crop yields (like other plant nutrients), and because ensuring its adequacy can be achieved at little or no cost by using appropriate fertilizers.

Like nitrogen much of the sulphur present in plants is reduced to different chemical forms; however, sulphate can be present in cell sap in quite large concentrations without any apparent harm. Sulphur is generally present in plants in comparable concentrations as phosphorus. A Sulphur deficiency has a retarding effect on plant growth, it is characterized by uniformly chlorotic plants — stunted, thin stemmed, and spindly. These symptoms resemble those of a nitrogen deficiency and diagnosis of deficiencies of these elements are often confused. However, unlike nitrogen, Sulphur does not appear to be easily translocated from older to younger plant parts when deficient. Sulphur is required for the synthesis of amino acids, proteins, and vitamins, it activates enzymes, and influences cold resistance in crops. When Sulphur is limiting, nitrate-nitrogen often accumulates in plant tissues instead of being synthesized into proteins.

Boron

Boron deficiency causes a wide variety of abnormalities in vegetable crops. When required, broadcast a boron compound evenly on the soil with a grass-seeder of the cyclone type. Fertilizers mixes which include boron can be obtained in most areas. In the Interior, boron should be applied in the fall. At the Coast, it should be applied in the spring where a need for it has been shown.

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 foliar spray. Apply a product like Solubor at label rates.

Boron is an essential micro-nutrient which is often deficient in British Columbia soils. Boron determination is an optional test and should be requested when submitting samples for testing. Analytical results are expressed in ug B / ml (micrograms per millilitre = parts per million (ppm)). When test levels are 0.5 ug B / ml or lower, a fertilizer recommendation is generally provided by a soils laboratory. Ginseng is not considered as a high boron requiring crop, but because soils are frequently poorly supplied with this micro-nutrient it is important that its adequacy be verified. Cost for maintaining adequate levels are usually quite low; however, considerable difficulties may be encountered in applying the low levels required. The recommended rates vary from 1 to 2 kg B / ha (kilogram elemental boron per hectare).

Great care should be exercised in applying boron at the recommended rates (do not double or triple rates without consultation), as boron can quickly become toxic to plants at relatively low levels. It is suggested that the concentration of this element be verified regularly (yearly) in soils. Probably the simplest procedure for applying boron accurately is to use a soluble boron compound (i.e., SOLUBOR) in a calibrated sprayer and spray the recommended rate on the soil during the dormant period. Boron can also be absorbed through the leaf and small foliar applications can be made to alleviate a deficiency. Several applications during the growing season may be required in such cases as boron is not translocated from older to meristematic (new) plant tissues.

Boron, like nitrate is quite mobile in soils. Shortages are more common on coarse textured soils. Soil moisture also influences availability. Therefore deficiencies may appear during drought periods on soils that are marginally supplied.

Boron is needed for cell division in actively growing plants and has an important role in carbohydrate metabolism. Boron is involved in the uptake of calcium by roots and its efficient use in plants.

Zinc

Zinc and boron are the most commonly deficient micro-nutrients in British Columbia. Like boron, zinc can be absorbed through the leaf and is toxic in anything but minute amounts. Experience in B.C. suggests that ginseng cannot extract zinc efficiently from soils; particularly if soil pH is 6.5 or higher. Zinc is relatively immobile in soils and its adequacy should be ensured before planting when the application can still be worked thoroughly into the root zone.

Deficiency symptoms vary with the crop and the severity of the deficiency; however, on many crops it appears as bleached tissue occurring on each side of the midrib. Deficiency symptoms can often be aggravated with phosphorus fertilization. Zinc is used in the functional component of many plant enzymes and for the regulation of crop phosphorus nutrition. Should deficiency symptoms be observed or suspected, this element can also be foliarly applied. In such cases several applications need to be made during the growing season, though, zinc can probably be applied in combination with some other crop sprays. Zinc sprays are used extensively in orchards and zinc is an active ingredient in many fungicides.

Our knowledge of ginseng fertilization and fertility management is evolving, and every effort is made to reflect current knowledge in the recommendations appearing on our soil test report. Fertilization is only a minor cost in ginseng production; its importance in successful crop production, however, cannot be overemphasized. Adequate levels of plant nutrients and appropriate soil fertility parameters help ensure a profitable industry. In conclusion, let us provide you with good advice “Soil Test — Don’t Guess” and discuss fertility management with your fertilizer dealer or laboratory. See the Appendix for a list of laboratories in British Columbia and Alberta.

There are many different tests, both chemical and physical that labs can do on soils. They can do partial or complete samples and can also do irrigation water. Write or phone them for general information about what they can supply and their pricing schedules.

Calculation of Fertilizer Rates

Fertilizers have been labelled by percentage according to their guaranteed minimum analysis in terms of nitrogen (N), phosphate (P_2O_5), potash (K_2O), and other nutrients when these are present.

Example: *Five 20 kg bags (100 kg) 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 are other elements (oxygen and hydrogen) that are part of the fertilizer compounds carrying the nitrogen, phosphate and potash.*

A. The amount of fertilizer required = $\frac{\text{recommended rate x 100}}{\text{fertilizer analysis}}$

Example: *Recommended rate of potash is 135 kg/ha*

Fertilizer analysis is 0-0-60

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

= 225 kg / ha

Thus you would apply 225 kg / ha of 0-0-60.

B. The amount of nutrient applied by a fertilizer = amount of fertilizer applied x $\frac{\text{fertilizer analysis}}{100}$

Example:

Am't of fertilizer applied: 225 kg / ha

Fertilizer analysis: 13-16-10

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

= 29 kg / ha of N

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

= 36 kg / ha of P_2O_5

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

= 22.5 kg / ha of K_2O

Methods of Fertilizer Application (terms defined)

- **BROADCASTING & INCORPORATION** Refers to spreading fertilizer on a soil surface before the crop has been planted, then incorporating the fertilizer into the soil with tillage.
- **TOP-DRESSING** Refers to spreading fertilizer on a field when a crop is growing. It is not incorporated, but sprinkler irrigation will wash fertilizer off the leaves to prevent burning of the leaves and move the nutrients into the surface few centimeters of soil.
- **BANDING** Refers to the application of fertilizer at 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. (Not applicable to ginseng.)
- **SIDE-DRESSING** Refers to the banding of fertilizer after plants are established. Care should be taken not to disturb the roots of the plants. (Not applicable to ginseng.)
- **FERTIGATION** Refers to the application of fertilizer in irrigation water. (Probably will not work well in ginseng gardens.)
- **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. (Not applicable to ginseng.)
- **FOLIAR** Refers applying weak solutions of a nutrient(s) with a sprayer directly on to the foliage of a plant.

Nutrient Deficiency Symptoms

When parts of green plants that are not yet mature become off colour (yellow, purple, etc.) or show abnormal growth, stunting, distortion, cracking, brittleness or a combination of these symptoms, a nutrient deficiency may be the problem. The nutrient required may be present in the soil but unavailable to the plants because of weather or soil conditions. It is common to see early planted corn turn purple during prolonged cold weather because the phosphate which the crop needs is not available to the plant, even though the soil supply is more than enough.

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. Tomato and bean plants may produce stems and leaves but not fruit when too much nitrogen is added. Excess fertilizer may cause leaf "burn" or stunted growth.

The following table 13, is offered as a guide for suspected nutrient deficiencies. For additional help consult your district agriculture office, or a soils laboratory.

TABLE 13. Symptoms of foliar nutrient deficiencies and corrective treatments

The following nutrients may be deficient at certain times in British Columbia soils. Foliar sprays should not be applied at higher than recommended label concentrations or crop damage may result. **Use enough water to wet the foliage to runoff stage**. Apply under slow drying conditions.

Note: *Ginseng may not fit these parameters exactly, as these are general symptoms and all the deficiency symptoms for ginseng are not known.*

Nutrients	Nutrient Deficiency Symptoms	Examples of Corrective Materials	Application Rate of Suggested Sources Soil kg/ha*	Foliar g/100 L
Nitrogen	Slow growth. Pale green to yellow colours	15.5-0-0	see laboratory results for amounts to use	1500
		46-0-0		1000
		20-20-20		300
Phosphorus	Slow growth. Reddish, purple colours	20-20-20		300
Potassium	Slow growth. Mottling followed by bronzing and drying of leaf tips and margins	20-20-20		300
Calcium	Slow growth. Die-back of terminal growth. Leaf margins chlorotic and scorched. Spotting of leaves	Calcium Chloride		500 - 1000
		Calcium Nitrate		500 -1500
		Lime	2 - 4 (tonnes)	
Magnesium	Yellowing between veins beginning with the older or lower leaves. Scorching and brittleness.	Dolomite Lime	250 - 300	
		Sul-po-mag	250 - 300	
		Epsom Salts or Magnesium Sulphate	170 - 225	1000 - 1500
Boron	Growing points may die. Stems and leaves may be distorted. Stems may be hollow and roughened.	Solubor Borax		100 - 150
Iron	Strong yellowing and sometimes whitening of the young or new leaves at the tips of the plants.	Ferrous Sulphate		200 - 300
		Chelated Iron		75 -100
Manganese	Stunting of plants. Smaller than normal leaves with yellowing between the veins.	Manganese Sulphate		200 to 400
Molybdenum	Growing points die	Sodium Molybdate		25 - 50
		Molybdic acid		50
Zinc	Yellowing between veins of new leaves	Zinc Sulphate	10 - 45	200 - 400
		Zinc Chelate	15 - 45	75 - 100
Copper	Severe stunting. Yellowing of new leaves.	Copper Sulfate		200 - 500
		Copper Oxide		200 - 500

* To change kg/Ha to lbs/Ac multiply by .89, i.e. 200 kg/ha x .89=178 lbs/Ac

TABLE 14. Soil laboratory report interpretation — example

There are 16 plant nutrients. All plants need some of all 16 but requirements vary greatly as to plant species. Plants will also absorb and store other things in their system, such as pesticides, heavy metals, and other minerals.

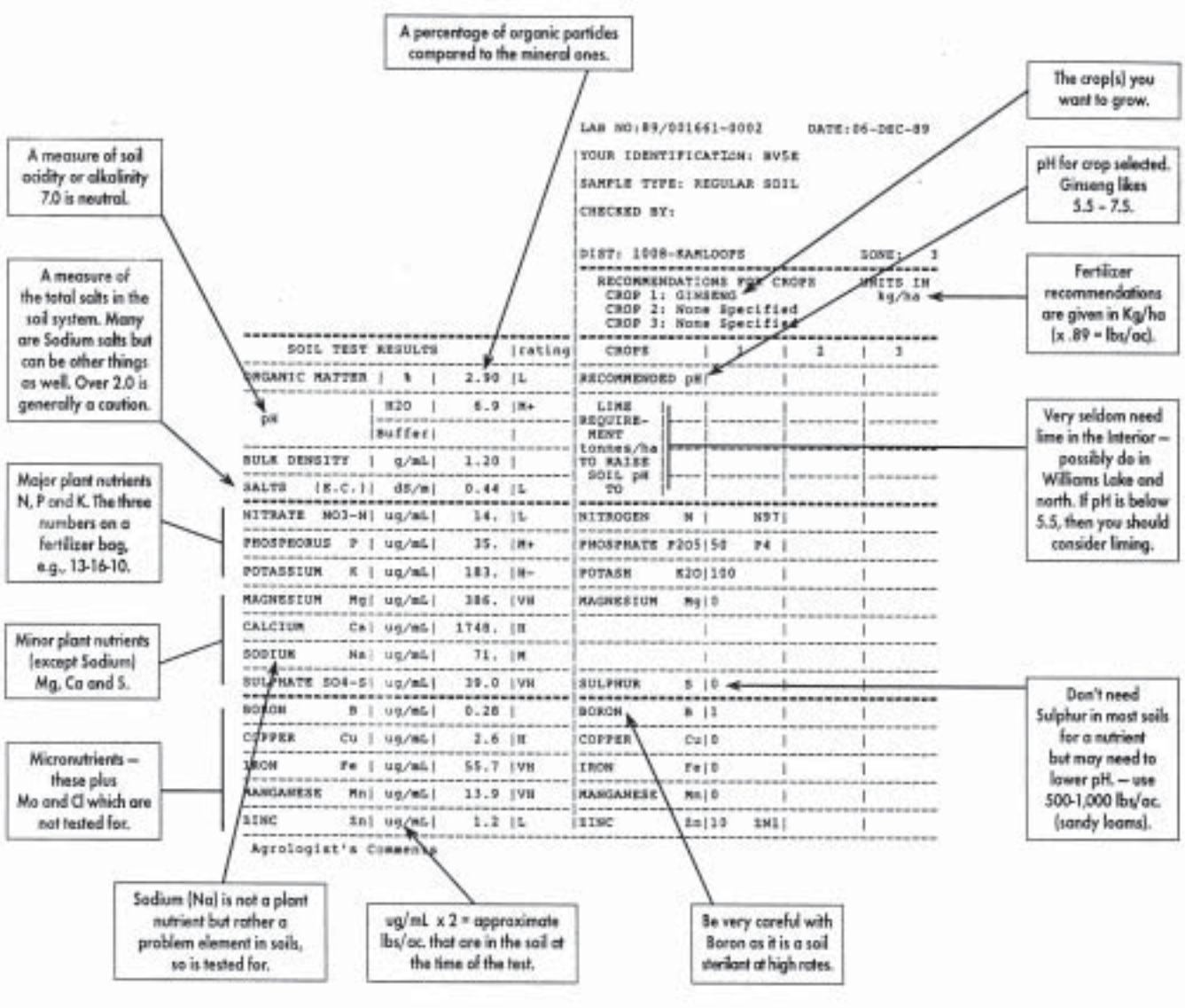
N, P, K, S, Ca, Mg, Bo, Cl, Cu, Fe, Mn, Mo, Zn, C, H, O

Soil is a mix of minerals, organic matter, soil micro-organisms, air and water.

Minerals are measured as:

Sand – coarse
Silt – medium
Clay – fine

Note: *Over 30% clay is a clay soil.*



A mature ginseng plant showing an immature seed cluster in the centre of the node where the leaf petioles attach.

Seed umbels ready for harvest. Each umbel has up to 50 berries that contain 1-3 seeds each.