General Topics

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A FACTSHEET SERIES ON

ENVIRONMENTAL GUIDELINES FOR HORTICULTURAL PRODUCERS

CONTENTS

1. INTRODUCTION

The Environmental Farm Practices Guidelines Project for Horticultural Producers in Newfoundland and Labrador, November 2001, was funded by the Canada/Newfoundland Agreement on Green Plan (Sustainable Agriculture), managed by the Newfoundland and Labrador Federation of Agriculture, supported by the Newfoundland and Labrador Department of Forest Resources and Agrifoods. Gardner Pinfold Consulting Economics Ltd. and P. Jacobs and Associates Ltd. prepared the initial version of the document

These guidelines describe management systems and practices that will reduce the risk of pollution from horticulture operations. They establish acceptable farming practices for horticulture producers in Newfoundland and Labrador. The objectives of these guidelines are:

- to assist horticulture producers in their efforts to prevent pollution;
- to provide a standard that may be used by industry and government in determining normal, acceptable farming practice;
- to provide local governments with a basis for evaluation of horticultural operations; and,
- to provide information to the general public and government officials who evaluate horticultural operations for their potential effects on the surrounding area.

These guidelines are not legislated. They merely provide the horticultural industry with various options for managing their operations in an environmentally sound manner.

As technological changes occur, revisions of the Guidelines will be necessary periodically. Your comments on this publication and future revisions are encouraged. Contact the Department of Forest Resources and Agrifoods, Agrifoods Branch, at 709-637-2082, for inquiries.

2. LEGISLATION/REGULATIONS

It is important to understand the various federal, provincial and municipal acts and bylaws that affect farm operations and practices. Producers must understand how these laws affect their operations. When provincial and federal acts or regulations change, producers must meet the new requirements.

The Government of Canada defines pesticides to include insecticides, fungicides, herbicides, rodenticides, miticides, avicides, plant growth regulators and fumigants. All pesticide products used in Canada must be registered under the Federal Pest Control Products Act.

Pesticides can be an environmental and health hazard when used improperly. In addition to meeting the requirements of the Federal Pest Control Products Act, any use of pesticides must be in accordance with the Province's Pesticides Control Regulations (CNR 1166/96) under the provincial Pesticide Control Act.

Pesticide Applicators must be licensed by the Pesticide Control Section, Department of Environment. Currently, no person shall store, use or apply a pesticide without an existing license of a prescribed class for that purpose unless exempt under the conditions for storing, use or application prescribed for the pesticide or unless exempted under the regulations (such as home or garden).

Protection of water resources from pollution is at the forefront of environmental concerns in this province. Water pollution is an environmental and health concern, and is regulated under federal (by Environment Canada) and provincial (by the Department of Environment) legislation. Pollution of water sources is illegal, and these agencies are responsible for preventing pollution, detecting pollution if it has occurred and taking legal action if necessary.

Pursuant to Section 10(2) (a) of the Environment Act, SN 1995, C. E-13, no person shall place, deposit, discharge or allow to remain within a protected water supply area any material of any kind that might impair the quality of the water. You must exercise great care when handling and applying pesticides, fertilizers or manure in water supplies.

You should obtain information on the various legislation relating to the operation of your horticulture operation.

2.1 Federal Legislation

1. Canadian Environmental Assessment Act, S.C. 1992, c. 37

2. Canadian Environmental Protection Act

   - Environmental Code of Practice for Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products
   - Environmental Code of Practice for Aboveground Storage Tank Systems Containing Petroleum Products

3. Fisheries Act, R.S.C. 1985, c. F-14

   - Meat and Poultry Products Plant Liquid Effluent Regulations
   - Meat and Poultry Products Plant Effluent Guidelines
   - Potato Processing Plant Regulations
   - Toxicity Guidelines for Potato Processing Plants

4. Meat Inspection Act, R.S.C. 1985, c. 25 (1st Supp.)

5. Canada Water Act, R.S.C. 1985, c. C-11

   - Guidelines for Canadian Drinking Water Quality

6. The Transportation of Dangerous Goods Act, R.S.C. 1989. c. T-19

7. Canadian Environmental Assessment Act, S.C. 1992, c. 37

   - Exclusion List Regulations, SOR 94-639
   - Law List Regulation, SOR 94-636

8. Pest Control Products Act.

2.2 Provincial Legislation

1. Environment Act, S.N. 1995, C. E-13, which includes:

   - Storage and Handling of Gasoline and Associated Products Regulations, CNR 775/96
   - Air Pollution Control Regulations, CNR 957/96
   - The Environmental Control (Water and Sewage) Regulations, CNR 1078/96

2. The Public Health Act, S.N. 95, C, P-37.1, which includes:

   - Sanitation Regulations, CNR 803/96

3. Pesticides Control Act, RSN 1990, c. P-8:

   - The Pesticide Control Regulations, CNR 1166/96

4. Waste Material Disposal Act, RSN 1990, c. W-4

5. Urban and Rural Planning Act, RSN 1990, c. U-7

6. Municipalities Act, RSN 1990, c. M-23

7. Meat Inspection Act and Guidelines

8. Lands Act:

   - Development Area of Wooddale (Agriculture) Regulations, 1996
   - The St. John's Urban Region (Agriculture) Development Area Regulations, 1996

2.3 Guidelines

1. Farm Practice Guidelines for Producers in Newfoundland and Labrador:

   - Livestock;
   - Poultry; and,
   - Horticultural Producers.

2. Environmental Guidelines for Agriculture Development - Livestock and Poultry Operations Less Than Five Animal Units

3. Environmental Guidelines for Agriculture Development - Non-Livestock or Poultry Production

4. Guidelines and Conditions for the Approval of Swine, Poultry and Other Livestock Enterprises

5. Information Guide for Livestock Facilities, Manure and Waste Management in the Province of Newfoundland, May 1992.

3.0 PREVENTING WATER POLLUTION

Pesticides, organic animal wastes or inorganic fertilizers used in horticulture operations have the potential to affect water quality in several ways:

- they can directly contaminate surface or groundwater through direct spraying or drift;
- they can leach from soils into water sources; and/or,
- field runoff from sloping or improperly drained areas can carry them into surface water.

Growers must ensure that no production practice has any adverse effects on water quality. This section provides guidelines to reduce the risk of water pollution from horticulture operations. Proper field drainage and farm practices aimed at minimizing the potential for water pollution in greenhouse operations are also discussed.

3.1 Pesticides

You can avoid contaminating water sources during pesticide use by:

- never storing pesticides near wells, ditches or bodies of water;
- choosing a mixing site away from water sources when outdoors;
- only mixing or applying pesticides in still or low wind conditions not stronger than a gentle breeze or no more than 15 kilometres per hour (for example, in the early morning or early evening);
- never applying pesticides just before a heavy rain;
- leaving a buffer zone when the spraying area is next to sensitive crops or water bodies (30 metres [100 ft] around drinking wells and 30 metres[100 ft] for field boom sprayers along fish-bearing waters);
- rinse water that cannot be added to the sprayer tank can be applied to a non-crop area which is on your property and which is at least 200 metres (656 feet) from waterbodies and wells;
- using an anti-backflow device on the pump used to fill the sprayer; and,
- keeping an air gap between the filler hose and the top of the spray tank.

3.2 Manure

Animal manure from livestock farms or poultry farms is used in some horticulture operations as a source of plant nutrients and soil organic matter. You must ensure that land spreading is performed at proper rates so that water sources are not polluted.

For more information on guidelines for proper manure storage and handling, see the documents, Farm Practices Guidelines for Livestock Producers in Newfoundland and Labrador or Farm Practices Guidelines for Poultry Producers in Newfoundland and Labrador.

Buffer Areas for Manure Spreading

A buffer area is necessary to protect water supplies from contamination during manure spreading. Guidelines exist for both spreading near surface water and sensitive groundwater areas.

Surface Water

It is important to consider the slope of the land in the absence of buffer areas to reduce runoff when spreading manure. As the slope increases, so does the chance that manure may run off. On steeply sloping land (greater than 15%), extra caution must be used when applying manure. It is recommended that the spreading be supervised at all times to ensure that run off is not occurring. Sloping land must be maintained with a reasonable amount of crop cover to provide additional protection against erosion.

A buffer area is necessary to absorb the runoff and prevent it from traveling down a slope, thereby reducing the risk of runoff entering surface waters. The effectiveness of a buffer depends on factors such as land use conditions, vegetation and slope. Good judgment must be used in all cases to ensure runoff cannot enter water sources.

Private Water Supplies

A general guideline for spreading manure is to not spread on land situated less than 75 metres (250 ft) from the source of supply of water used for drinking purposes. When the draining of the land is towards the water supply, a buffer of 75 metres (250 ft) has to be maintained. Consequently, a buffer of less than 75 metres (250 ft) may be acceptable depending on the topography of the area.

Public Water Supplies

Draft guidelines for agricultural operations and associated activities such as manure spreading within protected water supplies do not permit development within the buffer zones as follows:

- intake pond/lake: a minimum of 150 metres (500 ft);
- river intake: a minimum of 150 metres for a distance of 1 kilometre (0.62 miles) upstream and 100 metres (328 ft) downstream;
- main river channel: a minimum of 75 metres (250 ft);
- major tributaries/lakes/ponds: a minimum of 50 metres (160 ft); and,
- other water bodies: a minimum of 30 metres (100 ft) along and around water bodies.

Buffer zones may be broadened or imposed around sensitive areas such as steep or unstable slopes, bogs, marshes or any other areas as deemed necessary by the Department of Environment. For further interpretation of these guidelines contact the Land Management Specialist, Agrifoods Branch or the Water Resources Officer, Department of Environment.

To protect watercourses (non-water supply), manure must not be spread:

- within a distance of 15 metres (50 ft) plus 1.5 times the percentage of the slope; and,
- on newly cleared land within 30 metres (100 ft) of a watercourse.

Manure may only be spread on land between 15 and 30 metres (50 and 100 ft) of a watercourse if there is a naturally vegetated buffer within 0 to 15 metres (50 ft) of the water course.

Salmon Rivers

Buffer requirements may be greater along salmon rivers. The Environmental Assessment Act requires all development within 200 metres (660 feet) of a salmon river to be registered under the Act. Farmers must consult with the Department of Environment if contemplating expansion within 200 metres (660 ft) of a salmon river.

Sensitive Groundwater Areas

Both soil and groundwater conditions can be sensitive to agricultural practices which involve the application of either inorganic or organic (manure) fertilizers. Summer-fallowing is another agricultural practice that has the potential to influence surface and groundwater quality. The degree of sensitivity depends on:

- the type and depth of the overburden above an aquifer; and,
- the type of vegetation at the soil surface.

In order to prevent groundwater pollution during manure spreading, you must be careful to consider the following practices:

- care should be taken when spreading manure where the water table in shallow aquifers is near the ground surface;

- care should be taken when spreading manure in areas where very permeable soils such as coarse sand or gravel and sand are found at the surface and the water table is close to the surface;

- do not spread manure where the overburden above an aquifer is very shallow; and,

- care should be taken when spreading manure in areas where shallow bedrock occurs.

Nutrients applied to the soil surface may leach rapidly downward beyond crop rooting depths and eventually reach the aquifer. Since areas with the above noted characteristics tend to be well drained, crop vegetation is often relatively sparse and plant uptake of nutrients is low.

Where such sensitive groundwater conditions exist, manure applications must be avoided or manure must be applied at greatly reduced rates. Consult a professional Agrologist for site specific recommendations in these sensitive areas before applying manure.

Field Drainage

Horticultural operations in this province must ensure adequate drainage during periods of high precipitation. This is important since soils in Newfoundland and Labrador are generally shallow (approximately 0.5 metres or 20 inches of topsoil), most agriculture areas have a high water table throughout the year and any soil compaction can increase the potential for subsurface drainage problems. Inadequate drainage systems increase the risk of water pollution.

Drainage ditches must be properly maintained and kept free flowing. Properly installed and maintained drainage tiling will help to minimize drainage problems. Ensure that:

- drainage is adequate and repair or replace tiles that do not work;

- tile outlets are protected to prevent damage to ditchbanks; and,

- header tiles are used to reduce the number of outlets entering a ditch to prevent ditch damage and reduce the loss of field areas due to slumping.

Greenhouses

There is the potential for groundwater contamination from greenhouse fertilizers, pesticides, wash-down waters and roof shading cleaning. Several practiceswillhelp to reduce the potential for water pollution from your greenhouses. These are:

1) **Minimize Leaching.** Plastic sheets or troughs can be used to collect and hold excess water and fertilizer needed by the plant. Fertilizer diluters must be equipped with an anti-siphon valve to prevent fertilizeror pesticides from returning to water sources.

2) **Adjustment and Recirculation.** Once collected, the solution is recirculated immediately or held for later recirculation. In both cases, the solution may have to be reconditioned in various ways for re-use.

3) **Solution Disposal.** In some instances, reuse will not be possible. This may be due to salt imbalances, end of a crop cycle, disease or contamination. Do not discharge this liquid into tile drains or surface water. You must dispose of this in a sewage disposal system or apply it to land in consultation with advice from crop specialist.

4. NUTRIENT MANAGEMENT

Good use of nutrient management will improve both your production and the environment. Cost-effective application of manures and fertilizers will produce the best yield potential while minimizing costs. Soil and manure testing is an important first step. Soil test results will give you a base on which to analyze soil needs. Plant tissue tests can also show what plant nutrient levels are at that point in time, as opposed to what is available in the soil (particularly important for perennial crops). Be sure to test leaf tissue before bloom, particularly in poor soil areas.

4.1 Soil Testing

It is recommended that producers perform the necessary soil and manure tests and consult with a soils or crops specialist to determine application rates that more closely match their specific needs.

Guidelines for testing include:

- **Annual testing** (or at least once every three years especially for fields receiving annual applications of manure). Fields receiving annual applications of manure should be tested annually. Ideally, the samples should be taken at 0 to 15 cm (0 to 6 in) depth for vegetable land and 0 to 10 cm (0 to 4 in) depth for blueberry land. These samples should then be analyzed for pH, nitrogen, phosphorous and potassium.

- **Add additional fertilizer**. At the start of a series of annual applications to a field, 30 to 40 kg/ha (25 to 35 lb/ac) additional nitrogen fertilizer may be needed to achieve yield potentials. The reason is that not all of the manure nitrogen is available in the year of application. The nitrogen not available will be a source of residual nitrogen for crops in succeeding years.

Consulting with a soils or crop specialist is also useful for unusual site-specific conditions. A method for calculating manure application rates is provided in the documents, “Farm Practices Guidelines for Poultry Producers in Newfoundland and Labrador” or “Farm Practices Guidelines for Livestock Producers in Newfoundland and Labrador”. This method uses information on the manure’s composition, soil information and the nutrient needs of the crop in question to determine annual application rates and additional fertilizer requirements.

Soil Fertility

Many chemical and biological processes such as biological content, acidification, soil’s nutrient reserves and organic matter affect soil fertility. Physical degradation such as erosion also affects soil fertility.

Biological

Soils contain living organisms ranging from microscopic bacteria and fungi to burrowinganimals. All play a part in maintaining the natural soil processeswhich are vital for maintaining the fertility of the soil.

Earthworms are one of the most obvious organisms that benefit the soil. They along with other organisms are sensitive to chemicals and contaminants which you apply to the soil. Always choose pesticides carefully according to the purpose for which you need them and to minimize affecting soil biology.

Excessive amounts of fertilizers and fertilizer containing a high proportionof nitrogen in the form of ammonium may reduce the number of earthworms. Maintaining earthworm populations is achieved by not applying slurry or liquidmanure on wet, poorly drained soils (although this can have the long-term effect of increasing numbers by providing more food).

Earthworm populations can be increased by:

- including grasses in your crop rotation;
- regularly applying bulky organic manures or crop residues;
- using shallow cultivation over deep ploughing;
- maintaining higher soil pH; and,
- using minimum tillage systems to help maintain burrows which improve soil drainage.

Acidification

Acidification is a natural process which occurs in all soils but can be increased by horticultural production practices. The extent of acidification depends on:

- soil composition;
- acid precipitation;
- cropping practices;
- the use of nitrogen fertilizers; and,
- other management practices.

Very acidic soils (pH below 4.0) will only supporta limited range of plant species and are generally not suitable for horticultural production. Virgin soils in this province generally have a pH of between

4.5 and 4.7. The pH of peat soils is about 3.8.

Soil pH in the cultivated layer can only be raised by using liming materials containing calcium or magnesium carbonate. The pH of soil below the depth of cultivation can only be changed very slowly by applying lime to the surface of the land. Raising soil pH by liming can best beachieved if you:

- prevent soil pH (other than peats) from falling below 5.5;
- determine your liming needs by testing the soil;
- apply lime evenly;
- work the lime into the soil before the crop is planted; and,
- do not over-lime soils.

Plants need good supplies of the major nutrients such as nitrogen, phosphorous, potassium, magnesium, calcium and sulphur. Smaller quantities of trace elements such as iron, manganese, copper, zinc, molybdenum, boron and chlorine are required. Trace elements will generally be supplied by the soil, but may need to be supplemented by inorganic fertilizersand organic manures. The addition of trace elements is essential for the production of crops on peat soils.

4.2 Manure as a Fertilizer

When considering manure as a fertilizer the important characteristics are:

- nitrogen content;
- phosphorous content;
- potassium (potash) content and minerals such as sulphur;
- micro-organisms; and,
- organic matter content.

Nitrogen (n)

Nitrogen promotes rapid vegetative growth and givesplants their healthy green colour. To maximize the fertilizervalue, manure must be stored and handled to reduce nitrogen losses. This is important since nitrogen in manure exists in two forms:

- the largest portion is contained in the complex molecules of digested feed and is known as organic nitrogen; and,

- ammonium nitrogen and nitrate nitrogen (the general assumption for Newfoundland and Labrador is that ammonium nitrogen equals 50% of total N and nitrate nitrogen equals 5% of total N).

Organic nitrogen is not available for use by plants until it mineralizes to the nitrate form, the same form as the nitrogen in some commercial fertilizers. The rate of mineralization will depend on the composition of the manure, soil type, temperature and moisture content. Generally, 30 to 50% of the nitrogen will be mineralized during the first cropping season with the balance mineralized during the next three years.

Nitrate-nitrogen is dissolved in water and can move away from the root zone in the soil. This process is known as leaching. When manure is handled and spread on land, some of the nitrogen in the manure that exists as ammonia gas will be released to the atmosphere. It is important to minimize the time of exposure by incorporating the manure into the soil as quickly as possible. Most nitrogen losses occur within the first 24 hours after the manure is spread due to volatilization.

Phosphorous

Phosphorous stimulates early growth and root formation, hastens maturity, promotes seed production and makes plants hardy. The phosphorous in manure exists in both the organic and inorganic forms, but unlike nitrogen, phosphorous is not released to the air. As with nitrogen, the inorganic form is readily available to be used by plants, but the organic form is not available until the phosphorous is mineralized. Phosphorous is not removed from the root zone unless very high levels build up in the soil. Most phosphorous loss is due to soil erosion.

Potassium (Potash) and Minerals Such as Sulphur

Potassium improves the plant's ability to resist disease and cold and aids in the production of carbohydrates (energy producing organic compounds). Potassium is especially important for stem strength in grasses. Sulphur is needed in small amounts and is essential for protein production.

Manure potassium, chiefly present in the urine, is equivalent to fertilizer potassium and is available for plant growth in the year it is applied. It accumulates in the soil which is generally desirable because it supplies the plant needs. Like phosphorous, however, potassium can accumulate to excessive levels and have detrimental effects on plant growth.

Micro-organisms

Although manure contains large numbers of micro-organisms, very few can carry diseases to people. The micro-organisms that carry or cause diseases are known as pathogens. The easiest transfer of pathogens from animals to people is through direct contact. The potential for disease transmission is very low since pathogens are rapidly destroyed by drying and exposure to sunlight. Proper preparation of food including the use of clean water further minimizes the likelihood of contaminating food.

Organic Matter

Repeated long-term application of manure at reasonable rates will add organic matter to the soil thereby improving soil tilth, structure, aeration, water holding properties and reduction of susceptibility to soil erosion.

When fields are cropped, a portion of the organic matter is removed from the field. The use of commercial inorganic fertilizers does not replenish the lost organic material. Depending on the soil type, a steady depletion of soil organic matter can result in a soil structure that is more susceptible to erosion and one which requires high levels of fertilizer to maintain adequate levels of fertility.

Application Rate

Land application of manure has many benefits:

- land application can significantly decrease crop production costs (fertilizer) by providing plant nutrients; and,

- manure acts as a valuable soil amendment when properly managed by adding organic matter which improves soil tilth, structure, aeration, water holding and warming properties (organic matter affects soil color), reduces soil stickiness and helps to minimize soil erosion.

Manure is an excellent fertilizer that poses an environmental risk only when mismanaged. Too much of a good thing, however, can lead to problems such as damage to crops or the risk of pollution. Soil assay tests must be carried out before manure spreading is undertaken to ensure the nutrients applied meet only the crop requirements. Once these results are known, there are two main strategies for manure use on land: maximum nutrient efficiency or maximum application rates.

If maximum nutrient efficiency is the goal, rates of application need to be based on the nutrient present at the highest level in terms of the crop needs. In many cases, this is phosphorous. Manure must be applied at a rate which will meet the crop requirements for phosphorous. Additional nitrogen and potassium can be supplied with commercial fertilizers. This strategy is least likely to cause undesirable environmental effects and makes the most efficient use of all nutrients in the manure.

The other strategy for utilizing manure on cropland is to determine a rate of application whichwill satisfy the crop's requirement for nitrogen without causing environmental problems. This strategy maximizes the rate of applications, making less efficient use of phosphorous and potassium than the first strategy outlined above. It is important to note that a manure application strategy based on crop nitrogen requirements will lead to an accumulation of potassium in the long term, especially with repeated applications. Excessive soil test levels of potassium can result in surface water quality problems.

Nitrogen is usually the nutrient that limits manure application rate. The rate of application will ultimately be determined by:

- the rate at which the nutrients are used by the crop; and,
- by the reserves of nitrogen in the soil.

1) **Soil and manure testing is important.** The application rate is often based on estimated soil and manure nutrient levels. These inaccuracies may lead to application rates lower or higher than required. The fertility of a field can be determined by soil testing. Ideally the manure must be tested since its nutrient content can vary depending on how the manure has been handled. The application rate can be calculated from this information, together with knowledge of the method of application, timing and soil conditions.

2) **Do not over-apply manure.** A moderate over-application will not immediately lead to pollution problems or crop damage, especially in dryland conditions. With excessive application rates, nitrogen and phosphorous will generally accumulate in the soil and this accumulation can be detected through subsequent soil fertility tests. If an accumulation occurs, the rate of application must be reduced accordingly. Recording the manure spreading time and rate on each field is one way to avoid long-term over-application.

Local sources of natural fertilizer are an inexpensive method of improving fertility and therefore are very important from both an agronomic and economic perspective. Application of other natural fertilizers such as fish offal, kelp, crab shells and similar materials is regulated under the Waste Materials Disposal Act and subject to the approval and conditions of the Government Services Centre. These are sometimes added to the soil as a conditioner and can cause odour and fly problems. The soils or crop specialists with the Agrifoods Branchcan provide advice on the use of natural fertilizers and compost.

Losses During Storage and Application

The nutrient content of manure (particularly nitrogen) declines during collection, storage and disposal/application. This is due to ammonia volatilization, as well as leaching and surface runoff of all soluble forms of nutrients (particularly nitrate). Proper management is important to:

- reduce nitrogen losses;

- maximize the nutrient value of the manure; and,
- minimize the potential for soil and water pollution.

Suggested management techniques include:

- using proper facilities for storage and handling; and,
- applying manure to cool, moist soil in fall or early spring and incorporating it immediately.

The documents, Farm Practice Guidelines for Livestock Producers in Newfoundland and Labrador or Farm Practice Guidelines for Livestock Producers in Newfoundland and Labrador, provide detailed information on proper manure storage and handling techniques.

Soil and Crop Implications

It is important to know the soil characteristics of the field where manure will be spread. On sandy soils, time the spreading of manure to maximize use of the nutrients by the crop. Limit the application to avoid ponding. Manure must not be applied to soil that has a moisture content greater than its field capacity. The soil is at field capacity if free water is visible when a handful of soil is squeezed.

The yield potential and nitrogen requirement is considerably higher on heavier textured soils than on well-drained sandy soils. In addition, the risk of groundwater pollution by the leaching of nitrates is greater on lighter textured soils than on clays. Therefore, the allowable manure application rate is higher on heavier textured soils. A practical way to determine if there is a problem with nitrate nitrogen is to test groundwater (preferably a well) for nitrates.

There is considerable variation in the amount of nitrogen required by different crops. Cole crops can utilize much more nitrogen than rutabagas. Deep-rooted forage crops such as alfalfa are capable of withdrawing nitrates that may have leached out of the soils near the surface.

Acceptable Application Rate

Over-application of manure can lead to the following problems:

- negative effect on crops such as excessive vegetative growth, lodging, and/or delayed maturity;
- an accumulation of salt in the soil from some manures (periodic soil tests can monitor these situations and indicate if management adjustments are necessary); and,
- greater loss in storage, especially in root crops.

Do not apply manure at too high a rate. Deep rooted crops such as forages must be included in the crop rotation to retrieve any nitrates that may have leached down into the soil profile. During vegetable crop rotations, it is important to recognize that:

- the longer the rotation, the better; and,
- rotations are much more effective between different families of crops.

Often the costs of handling and applying manure are high, making it non competitive on a pound-per-pound nutrient basis with commercial mineral fertilizers. However, proper periodic applications can result in substantial long-term improvements in the physical, chemical and biological characteristics of the soil.

4.3 Commercial Fertilizers

Commercial fertilizers contain one or more plant nutrients. The main plant nutrients found in commercial fertilizers are Nitrogen (N), Phosphate (P_2O_5) and Potash (K_2O). However, other nutrients such as Calcium (Ca), Magnesium (Mg), Sulphur (S), Boron (B) and Chloride (Cl) may be present. Fertilizer manufacturers must guarantee the analysis of all fertilizers. Total N must be expressed as percent N, available P as percent P_2O_5 and soluble K (potash) as percent K_20.

Commercial fertilizers can be divided into two groups:

- Fertilizer chemicals
- Mixed fertilizers.

Fertilizer chemicals generally contain only one or possibly two nutrients. They are relatively pure compounds of standard composition with the plant nutrient as a component of the compound. Fertilizer chemicals are identified by name and percentage of the plant nutrient, eg. Ammonium nitrate - 33.5% N; Superphosphate - 20% P_2O_5.

Mixed fertilizers are mixtures of various fertilizer chemicals. The content or analysis of mixed fertilizers is expressed in three numbers. The first number designating the percentage of total N, the second number designating the percentage of available P and the third number designating the percentage soluble K (potash), eg. the fertilizer 6-12-12 contains 6% N, 12% P_2O_5 and 12% K_2O.

Application of Commercial Fertilizers

The advantage of commercial fertilizers is that the nutrients are generally concentrated, quickly available, consistent in content, easy to handle and apply and they can be applied evenly and placed accurately.

- Banding - applying the fertilizer in narrow bands to the side and below the seed is one of the most efficient methods for fertilizing row crops.

- Drilling- some fertilizers can be applied in the drill with the seed of some crops. Damage to seeding is possible when using fertilizers containing urea and/or diammonium phosphate.

- Top dressing - the fertilizer is broadcast over the soil, without working into the soil. This method is most common for hay land, pasture and landscape sod.

- Broadcasting and working into the soil - is useful when high applications are required. However, broadcasting in general does not result in an efficient use of fertilizer. Where soils are acid, broadcasting allows maximum fixation of P by the soil, resulting in less P being available to the crop.

- Side dressing - applying fertilizer in a narrow band along the row and cultivating the fertilizer into the soil is usually done when the crop requires additional fertilizer during the growing season.

Application Rate

Because commercial fertilizers are expensive and usually highly concentrated, it is important that these fertilizers are applied according to the recommendations received after soil testing. These fertilizer recommendations take into account the existing levels of P and K in the soil and the type of crop to be grown.

Soil test results are usually expressed as ppm (parts per million) or lbs/acre of nutrient left in the soil or as a rating. In general, the ratings indicate the following for the intended crop to be grown:

Low (L)	-	profitable to apply that nutrient at the recommended rate.
Medium (M)	-	profitable to apply that nutrient at the recommended rate.
High (H)	-	usually not profitable to apply that nutrient.
Very High (H+)	-	not profitable to apply that nutrient.
Excessive (E)	-	wasteful to apply that nutrient and damage to environment is possible.

It is important to select a commercial fertilizer which approximates as closely as possible the required nutrients according to the fertilizer recommendations. The exact amount of Nitrogen must be applied. Amounts of phosphate and potash applied are not as critical. A method for determining the best commercial fertilizer from the soil test report is provided in Appendix C.

Fertilizer Handling and Storage

Commercial fertilizers are chemicals and if improperly handled and stored may pose a threat to surface water and ground water. Mixing and loading of fertilizers and storage of fertilizers should be done well away from surface water and domestic water supplies such as wells.

- Minimum separation distances to watercourses and wells required for chemical

fertilizer mixing and loading areas and storage are **30 m (100 ft)** from watercourses and **60 m (200 ft)** from wells. The same minimum separation distances apply when mixing and/or loading fertilizers in the field.

- When mixing and/or loading dry fertilizers, have clean up material such as a shovel and waste container at hand in case of a spill.

- When mixing and loading liquid fertilizers use the same precautionary measures as for mixing and loading of pesticides.

- Dry chemical fertilizers should be stored on an impermeable surface under cover or in a building. Clean up material such as a shovel and waste container should be at hand in case of a spill.

- Liquid chemical fertilizers should be stored on an impermeable floor such as concrete. The floor should have a curb that will hold up to 125% of the volume stored in case of a spill.

- Fertilizers should be stored in a place secure from children, animals, vandalism and theft. Chemical fertilizers high in nitrogen content especially should be stored well away from any gasoline storage, as the combination of the two is highly explosive.

5.0 PEST MANAGEMENT

Pest management is an important component of crop production. Pests can have a detrimental effect on horticultural operations by affecting the quantity, quality and ultimately, the marketability, of the crops grown.

Pests in Horticulture

A pest is any animal, insect, weed or disease that attacks a crop. Pests come in many forms:

- **Animals.** Grazing wildlife (moose, deer, rabbits and rodents) and birds can eat and destroy crops in the field.

- **Insects.** These pests come in many forms. They include foliage and root-feeding insects which feed on leaves or flowers or attack roots. Examples include the cabbage root maggot and many species of caterpillars and beetles. Insects with beak-like mouthparts used for piercing the plant and sucking plant juices include aphids, thrips and spider mites (which are not insect but are more closely related to spiders). Leafminers, like the beet leafminer, are small larvae of flies, beetles or moths that tunnel between upper and lower leaf surfaces. There are also many species of insects which bore into twigs or trunks (examples include the bronze birch borer, the elderberry borer and bark beetles).

- **Weeds.** Weeds are really any plants growing where they are not wanted. A plant can be a weed in one situation, and a desirable plant in other situations. Weeds compete with crops for space, light, water and nutrients. They can also act as hosts to diseases such as clubroot.

- **Diseases.** For a vegetable, fruit or ornamental crop to become severely diseased, several conditions must be present. These include having a susceptible host plant, a pathogenic organism (an agent causing disease), a good method of distributing the organism (sometimes by an insect and known as a vector), and the proper environment for it to exist, enter the plant and thrive. When all phases are satisfactory, infection may occur, and a disease agent may become established. A variety of diseases infect horticultural crops. These include various forms of rot, wilt, scab and leafspot. Late blight fungus is an aggressive pathogen of potatoes.

Management of Pests

Pest management requires much more than a "see and spray" approach - **use pesticides only when essential**. The goal of pest management is to provide effective, economical, and safe long-term pest control. It usually involves suppression of pest numbers to acceptable levels rather than total elimination of the pest.

Horticulture operators must be aware that while the use of pesticides in crop production is an accepted practice, there is the potential for water pollution when pesticides are improperly stored, prepared, applied or disposed of. This section presents information on alternative pest management systems to help minimize pesticide use and provides guidelines for pesticide use.

Good pest management includes the following steps:

1. **Pest Monitoring**. Regularly inspect crops or traps to determine if pests are present in numbers that should be treated, and if they are, at a growth stage most suitable for treatment. Monitor weather conditions favourable to pest development as well as the presence of beneficial organisms that may help control the pest. Methods of monitoring pests include using traps, counting pests on a number of leaves, or simple observation. Good monitoring practices allows control action to be taken only if and when needed and at a time when it will be most cost effective (which can reduce the number of sprays required each season).

2. **Pest Identification and Biology**. Accurately identify the pest and know something of its habits, life cycle (some insect pests overwinter on other crops or weeds) and natural enemies. Correct identification is the key to good pest management because some treatments will only control certain pests. Sometimes it is easier to identify the damage caused by the pest than to locate the pest itself. This is true not only of microscopic disease organisms but of pests which remain out of sight. A hand lens with at least 10 x magnification is also useful.

3. **Considering All Available Management Methods**. An effective control program uses a combination of pest management methods to try and prevent a pest from getting a good start or reaching levels where costly treatment is needed. Pest management controls can be divided into five categories: sanitary, cultural, mechanical, biological and chemical.

4. **Slowing the Development of Pest Resistance**. Pests can produce thousands of offspring. Offspring born with characteristics that make them more resistant to a pesticide may survive. They soon multiply and pass on their resistance to thousands of their own offspring. Successive treatments of the same or similar pesticide repeats this process which accelerates selection of a strain of resistant pests. Eventually the pesticide and others similar to it become less effective or not effective at all. There has been no known incidence of this happening in Newfoundland and Labrador. This underscores the importance of slowing pest resistance by using a variety of control methods (chemical and non-chemical), using pesticides only when needed and alternating pesticides from different chemical groups.

5. **Making Sound Pest Management Decisions**. Rarely is it necessary to eliminate all pests. The goal is to manage these pests in the most economical and safest manner possible. Consider the following in your decision-making:

(i) What loss will the pest cause if not controlled?

(ii) How much will each control method cost and how effective will it be?

(iii) What are the risks to the applicator and environment of each control method?

(iv) Is it possible to combine control methods for more economical and effective results?

6. **Keeping Records to Evaluate and Refine Your Pest Management Program**.

The best decisions are those that relate directly to your land, crops, weather, farming methods and the pest in question. Keep records of pests encountered, the control measures used, the conditions and when they were used, and the costs and effect on the pest. This information when combined with records of your cropping (varieties and rotations) and cultural practices (time of planting, harvesting, fertilizing, etc.) will better enable you to plan future prevention and treatment of pests.

7. **The Use of Integrated Pest Management Control Measures**.

Integrated Pest Management Control Measures

Integrated Pest Management, also known as IPM, is an approach to pest control which integrates the preceding management practices and control methods into one pest management program. A common definition of IPM is a broadly based method that uses all suitable control measures to reduce pest-related losses to an acceptable level with the goal of respecting genetic diversity and reducing risks to human health and environment. This is considered the national definition of IPM and was developed by the federal Pest Management Alternatives Office.

The main IPM control measures are grouped in five main categories:

1) **Sanitary Controls**. Simply stated, do not give the pest a place to breed or a way to spread. You can accomplish this in the following ways:

! using certified disease-free and clean seed and transplants;

! grading potato seed carefully while cutting and discarding suspicious looking tubers and seed pieces;

! destroying plant trash which can harbour pests (cull piles, dropped fruit, etc.) and tilling under or burying vegetable culls;

! controlling vectors which can carry disease;

- controlling weeds in ditches, along roads and fencelines, etc.; and,

- sterilizing soil and equipment in greenhouses (including storage facilities).

2) **Cultural Controls**. Adopt growing methods that discourage pest establishment. For example:

   - choosing crop varieties or cultivars with natural resistance to the pest;

   - rotating between crops of different families to break the lifecycle of the pest, for example, rotate cole crops such as cabbage or cauliflower with potatoes to help combat clubroot (in some cases, limited landbase restricts the ability to implement an effective program of crop rotation).

   - using cover crops to provide shelter for the main crop to allow it time to grow and compete for space, nutrients and moisture;

   - using trap crops to attract the pest away from the main crop (pests can then be eradicated in a more localized area with less pesticides and labour);

   - increasing plant and row spacing to reduce canopy density;

   - intercropping by planting a mixture of crops to reduce damage (be aware though that competition may reduce yields);

   - reducing infection hot spots to reduce the production and spread of disease by bagging and destroying individual plants; and,

   - following other good growing practices (proper fertilizers, limestone, irrigation, etc.) that strengthen crops, make them more resistant to damage by insects and diseases, and allow them to compete more successfully with weeds.

Late blight prevention and control techniques also include using proper hilling to reduce tuber infections and reducing plant densities in potatoes. For more information on controlling this pest, refer to Factsheet S96-02 in the Sustainable Pest Management Series, *"Integrated Management of Late Blight on Potatoes"*, from the Pest Management Regulatory Agency of Health Canada.

3) **Mechanical Controls**. Pests can be kept out, disrupted, captured or killed by mechanical or physical controls such as:

   - tilling and mowing of weeds;

- pruning and trellising (allows better air movement and penetration of pesticides);
- installing screens on greenhouse openings; and,
- using fences, ditches, traps, nets, noisemakers, vacuums and flamers.

4) **Biological Controls**. Pests can be controlled by using predators, parasites and diseases to help keep pests at management levels. Adding natural enemies in field situations has not received widespread use in the horticulture industry in this province mainly because they are not commercially available. Natural enemies, however, have been successfully used in some greenhouse operations. This includes the use of beneficial organisms such as:

   - the beetle, *Aleochara bilineata*, which can parasitize and kill a large number of cabbage root maggot pupae (a major pest of cole crops in this province);
   - syrphid flies and ladybugs which eat aphids in fields and on vegetables;
   - predatory mites which control two-spotted mites and western flower thrips on greenhouse cucumbers (note that conserving some mites such as apple rust mites is important since they are an alternate food source for these predatory mites early in the season before the pest appears);
   - parasitic wasps (such as those to control whiteflies in greenhouses);
   - grazing animals which eat weeds;
   - insect pheromones (chemicals produced by insects which may repel or attract other insects, affect mating patterns, stimulate or deter feeding or to attract insect pests to a trap); and,
   - decoy sterile insects to lure breeding insects away from fertile mates so that egg production is reduced.

5) **Chemical Controls**. Pesticides are very effective when used correctly. However, they should only be used when absolutely necessary to minimize the risk to humans and animals, pest resistance, damaging beneficial organisms, leaving a residue on crops and providing a risk to the environment (water, ground and air contamination).

   Pesticides can be either selective (affect certain pests and not others) or

non-selective (kill many living organisms). Pesticides may have a residual effect (effective for some time after they are applied) depending on soil type, climate, moisture, or they may be non-residual. (Contact your Regional Crop Specialist to obtain issues of the document, "Atlantic Provinces Vegetable Crops Guide to Cultivar Selection and Chemical Pest Control").

Proper use of these IPM control measures will provide a number of benefits including:

- more cost-effective pest control;
- slowing the development of pest resistance;
- reducing the dependence on one type of control; and,
- addressing consumer and governmental concerns about the careful use of pesticides.

The Factsheet, SLM013, Pesticides, provides accepted guidelines for transporting, storing, applying and disposing of pesticides to minimize the risk of contamination of the environment. Appendix A provides metric/imperial unit conversion tables.

6.0 PESTICIDES

Farmers must have an application licence to purchase or apply commercial or restricted pesticide.

It is important to understand safe and responsible handling and application procedures once the decision has been made to use a pesticide. Before purchasing a pesticide, you must first ensure that:

- you have correctly identified the pest;
- the product is registered for the intended use;
- the pesticide is suitable for use with the application equipment on your farm;
- the pesticide will work effectively under your specific farm conditions and for that specific pest;
- you understand the life cycle of the pest and know when the pesticide should be applied to be most effective;
- you have the appropriate protective clothing and equipment; and
- you calculate the correct amount of pesticide needed for no more than one year of use and purchase only that amount.

Once identified, it is important to understand the life cycle of the pest you wish to control and the limits to the effectiveness of the pesticide you have chosen. For example, a major pest of cole crops in Newfoundland and Labrador is the cabbage root maggot which attacks many vegetable crops such as cabbage, turnips, rutabagas, broccoli, cauliflower, Brussels sprouts and some Chinese vegetables. Large numbers of this pest can cause complete crop loss by larvae feeding on the roots. Some maggots can be tolerated in healthy, well-established cole crops as the marketable part is not damaged. Therefore, only the first generation of the pest needs to be controlled. However, even a small amount of feeding on a mature rutabaga lowers the grade and affects marketability, forcing control of the second generation of the pest as well.

Some operators have in the past applied granular forms of pesticides to control this pest. (The Department of Environment is not encouraging the use of granulars. The Department instead recommends farmers first scout and monitor fields and then apply drenches when eggs are found.) Granular pesticides only remain effective in the soil over a prescribed period. Late emergence of the pest can render the pesticide treatment ineffective if the application and emergence periods do not overlap.

The use of pesticide drenches (high water volume and low pressure spray containing the pesticide directly over the plants) has proven effective in controlling this pest. More information on control of this pest is provided in the document "*The Cabbage Root Maggot in Newfoundland and Labrador*" which can be obtained from the Pest Management/Crop Specialist or the Agricultural Representative of the Department of Forest Resources and Agrifoods, or from the Entomologist at

the Agriculture and Agri-Foods Canada Research Station in St. John's.

Transporting

When transporting pesticides you must:

- cap and pack containers securely to prevent them from leaking or being punctured or broken;
- place pesticides in a metal or plastic storage box or on a waterproof tarp to prevent leaks;
- do not transport pesticides on a wooden truck bed which will absorb spilled pesticides and contaminate future loads;
- never transport pesticides with food, animal feed, fertilizer, clothing, household goods or living plants which could lead to contamination;
- lock your vehicle as you are responsible during transport if anyone is accidentally poisoned by pesticides you have left unattended;
- protect paper or cardboard containers from rain;
- never transport pesticides in the passenger compartment of the vehicle where you or any other passenger is at risk from fumes or residues of spilled containers;
- placard your vehicle or sprayer and carry shipping papers as per the Transportation of Dangerous Goods Act for loads more than 500 kilograms (1,100 lb) of solid material, liquid formulations in containers greaterthan 100 litres (22 gallons) each or if carrying fumigants; and,
- carry protective clothing and gloves, clean-up materials (such as absorbent materials eg: kitty litter, peat moss), plastic bags and a shovel and bucket in case of a spill.

Storage

Safe pesticide storage must include the following:

- store all restricted and commercial pesticides in a shed, room or locker which is locked, well ventilated, has warning signs and a source of water in or near the storage area;
- alert emergency agencies (such as the fire department) as to the location and type of hazardous chemicals stored on your farm;
- store pesticides in their original containers with original labels;
- keep herbicides separate from insecticides and fungicides;
- never store pesticides near livestock, food, animal feed, wells, water supplies, or in your home;
- ensure there is an approved fire extinguisher for chemical fires located nearby (but not in the storage area); and,
- store protective clothing and equipment near, but not in, the storage area.

Mixing and Loading

Spills are more likely to occur when you are mixing or loading pesticides. During mixing and loading, you must:

- put on protective clothing and safety equipment such as coveralls, rubber gloves, a waterproof hat and rubber boots, a face shield or goggles, a waterproof apron and, if necessary, a respirator (the label on the pesticides container will give you a list of the necessary protective clothing for safe mixing);
- choose a mixing site away from other people, livestock, pets and water sources when outdoors;
- ensure there is good ventilation and lighting when mixing indoors;
- always let someone know what you are mixing and make sure they are familiar with poisoning symptoms, first aid treatment and have emergency phone numbers on hand;
- keep soap, water, emergency first aid equipment and a spill clean-up kit nearby;
- mix and weigh pesticides on a sturdy level bench or table made of non-absorptive material;

- mix in still or low wind conditions outside and stand upwind of mixing areas;
- cut bags rather than tearing;
- mix only the amount you will use immediately;
- label and use all measuring and mixing equipment for pesticide use-only;
- pre-mix wettable powders with a small amount of water before adding to the spray tank to prevent lumps and airborne dust;
- fill the sprayer half full with water, turn on the agitator and then slowly add the pesticide;
- rinse pesticide containers as soon as they are empty - rinse three times for empty containers which held liquids and rinse bags with solids once and then pour the rinse water into the sprayer;
- rinse all measuring equipment and replace container caps and close bags before returning them to the storage area;
- stop mixing and clean up immediately if you splash or spill any pesticide;
- use clean water with the correct pH (take a sample to your local laboratory) since alkaline spray water leads to chemical breakdown of many organophosphates and carbamates (pesticides work best at a pH of 5.0 to 7.0); and,
- leave an air gap between the end of your filling hose and the water in your spray tank to avoid contamination of the water supply.

Application

Many horticulture operators in Newfoundland and Labrador have fields which are small and fragmented. Consequently, windy conditions may cause problems related to spray drift. Some pesticides also work better under specific environmental conditions. For example, synthetic pyrethroids are considered more effective in cool temperatures while others such as carbamates and organophosphates work best in warmer conditions.

During outside application, you must:

- use a calibrated sprayer suited to your needs;
- wear protective clothing;
- watch the weather and do not spray in winds stronger than a gentle breeze or no more than 15 kilometres per hour (for example, in the early morning or early

evening);

- never apply pesticides just before a heavy rain;
- post warning signs if necessary to keep people out of treated areas;
- make sure no livestock are in the area;
- consider when honey bees or other beneficial insects are most active;
- apply the pesticide at the recommended rates;
- shut off spray nozzles when you turn unless you have calculated this into your spray area and want to control the pest on headlands;
- use and maintain the correct tractor speed chosen during calibration;
- plan the spray route through your field so you avoid passing through airborne spray or freshly treated areas;
- leave a buffer zone when the spraying area is next to sensitive crops or water bodies (30 metres [100 ft] around drinking wells and 30 metres [100 ft] for field boom sprayers along fish-bearing waters);
- reduce spray drift by:
  - adding a drift control agent in the spray mix;
  - setting the boom only as high as necessary for good coverage;
  - using the correct nozzle and replace worn nozzles;
  - using low pressures to produce large droplets that will still cover the plant;
- never spray when the temperature exceeds 25ÄC or if the humidity is below 50%;
- spray downwind from sensitive areas such as houses or beehives; and,
- clean application equipment well before switching pesticides (use an ammonia based bleach to the rinse water which is suitable to neutralize most pesticide residue).

Be courteous to your neighbours. Where nuisance complaints are anticipated, notify neighbours of your intention to spray prior to pesticide application. This is very important where neighbors with sensitivities live nearby (such as an asthmatic neighbor).

During inside application (for example, in greenhouses or barns), you must:

- follow the same appropriate safety precautions as listed for outdoor use;
- seal treated areas for the time specified on the label, then thoroughly ventilate before re-entry and keep people and animals away from exhaust fans during ventilation; and,
- place a warning sign at all entrances to the building.

Disposal of Pesticides

Pesticides and pesticide containers will be safely disposed of if you:

- triple or pressure rinse empty drums, glass bottles, plastic and metal containers and empty rinse liquid into sprayer;
- single rinse paper or plastic bags containers and empty rinse liquid into the sprayer;
- apply rinse water that cannot be added to the sprayer tank to a non-crop area which is on your property and is at least 200 metres (660 ft) from watercourses;
- crush, puncture (several times) or damage empty containers so they cannot be reused once they have been rinsed; and,
- clean empty pesticide containers (never burn as the residues may not be destroyed and toxic fumes may be released) and then dispose of them at a landfill. Inform the landfill manager in casethere is an area for more hazardous materials.

7.0 SOIL MANAGEMENT

This section provides useful information on the characteristics of soil and important soil management practices.

What Is Soil?

The four main components of soil are mineral and organic matter, air and water. A well structured soil will have as its components approximately 45% mineral matter, 25% air, 25% water and 5% organic matter.

Mineral Matter

Mineral matter refers to the proportions of sand, silt and clay particles which make up the mineral component of soil. Soil texture is described by terms such as sand, sandy loam, clay loam and clay. Approximately 95% of all soils in this province are sandy loam meaning high in silt and sand but low in clay.

Soil structure refers to how well soil particles are organized and held together as soil crumbs or clods. Soil structure is important in that it influences:

- water movement through the soil;
- the resistance of soil to erosion, crusting and compaction;
- aeration; and,
- development of a good root system and nutrient up-take.

Organic Matter

Organic matter is a mixture of naturally occurring materials such as roots, leaves, decayed plant parts and microorganisms. It is important to soil fertility and ultimately, good yields. Humus, the relatively stable component comprising about 80% of all soil organic matter helps the soil store water and nutrients and reduces erosion.

The optimum amount of organic matter in the soil is a difficult question because of the variability of soil systems. It accounts for less than 5% of soils in other agricultural areas. Undisturbed soils in Newfoundland contain, on average, 11-19% organic matter (duff layer incorporated). Cultivated soils range from 4% in the central region to 5% (Western) and 7% in the Eastern region. (Source: Soil Organic Matter, J.B. Whalen, Soils Specialist, Agrifoods Branch, Newfoundland and Labrador Forest Resources and Agrifoods.)

Air and Water

The amount of air and water in the soil is referred to as soil porosity. Since large particles such as sand create larger pores than do smaller particles (such as in clay soils), water erosion is not as major a problem as in other provinces.

Maintaining Soil Structure

Many production practices can have a negative impact on soil structure. Excessive tillage and harvesting operations can cause soil compaction problems, reduced water infiltration rates and erosion.

Soil Compaction

Many soils in the province have naturally occurring compacted layers usually at depths of about 50-60 cm (20-24 in). It is difficult to break up these compacted layers. Tillage and cultivation tend to break down soil clods and organic matter. At the same time, production of high-quality horticultural crops requires careful attention to the timing of various crop management procedures. Sometimes, this means tilling, spraying or harvesting on soils that are too wet. Running heavy equipment in wet conditions may cause soil compaction, where the soil has become compressed and pore spaces reduced. This limits the soil's ability to hold air and water. This problem is more pronounced in shallow soil conditions.

You can reduce soil compaction by the following practices:

- avoid working on wet soils;
- never use deep tilling or subsoiling without first consulting with a soils specialist;
- reduce the number of trips over a field;
- limit traffic to certain areas or rows and use the same travel lanes each year;
- use four wheel drive tractors;
- keep the weight on an individual axle to below 5 tonnes;
- where and when possible, use trailers with tandem wheels;
- use radial tires where extra traction is needed; and,
- practice good crop rotations using deep-rooted crops or cover

crops.

While tillage and crop roots usually break up shallow or surface compaction, deep compaction requires special consideration. A combination of natural and production processes can help in combating this problem. These include:

- Frost. Research in other areas shows that frost takes at least three winters to reduce soil compaction, assuming that no further compaction has taken place.

- Using deep-rooted crops.

- Deep tillage or subsoiling can be used for the worst areas. Please note, that subsoiling is only a temporary solution and does not remove what caused the compaction in the first place. Consult with a soil specialist before subsoiling.

Potato production is particularly hard on soil structure. To counteract this, try to rotate out of potatoes for at least one year and use cover crops to protect the soil. This is important since compaction can lead to soil crusting, reduced plant emergence and the occurrence of misshapen potatoes.

Reduced Water Infiltration Rates

Generally, water infiltration (the penetration of water into the soil) is good in this province. Infiltration rates can be increased in problem areas by increasing the organic matter in the soil and reducing compaction.

7.1 MAINTAINING SOIL ORGANIC MATTER

Organic matter is a small but very important portion of the soil. Cool and wet climates reduce the amount of oxidation in the soil thereby maintaining high levels of organic matter in the soil. Maintaining adequate soil organic matter levels is crucial to consistent production of horticultural crops. Excessive tillage, soil erosion and poor crop rotation speeds up the loss of organic soil matter. Good practices for maintaining and improving organic matter include:

- practicing good crop rotations that return a variety of residues to the soil;

- underseeding rotational cereal crops (cereal crops are grain crops used for food such as rye and wheat) with either clover or alfalfa if vegetable crops are to be planted after the cereal;

- using winter cover and green manure crops to add plant material to the soil;

- reducing tillage where possible;
- keeping tillage shallow to prevent organic matter dilution;
- adding organic material such as manure, compost, peat, etc.;
- maintaining proper soil pH; and,
- reducing erosion losses.

Crop rotation provides several other benefits:

- it limits the build-up of disease organisms in the soil;
- crop rotation interrupts the life cycle of insects and diseases; and,
- it provides the opportunity to apply a broader range of herbicides to a parcel of land which will prevent the build-up of specific weeds or resistant strains of weeds.

7.2 PREVENTING SOIL POLLUTION

Applying pesticides, manures, and inorganic fertilizers to horticulture crops can potentially pollute soils. It is important to understand how these practices can lead to soil pollution and to minimize this potential by using accepted farm practices.

Pesticides

It is important to follow the manufacturer's recommendations for all pesticide products. Most pesticides are organic compounds which are broken down in the soil by physical, chemical and biological processes and by micro-organisms. Regularly using certain pesticides (such as some herbicides) may leave residues which take several years to break down. Under Newfoundland and Labrador's climate soil conditions, most pesticides take longer to break down than in the rest of Canada. This is important for crop rotation strategies.

Manure

Over-application of manure to soils can result in the build up of nutrients such as phosphorous, potassium, nitrates, nitrites and ammonia. High concentrations of manure are toxic to plants. A prolonged over-application of manure can lead to an imbalance in the soil chemistry which will result in reduced crop yields. When concentrations become too high, groundwater can be affected. After one year of manure application, grasses, root crops or some type of flora must be planted to take up the nutrients applied to the soil. The level of manure application can be determined through analyzing

the soil and manure and then matching these results with the requirements of the crops to be grown (see the documents, Farm Practice Guidelines for Livestock Producers in Newfoundland and Labrador" or "Farm Practice Guidelines for Poultry Producers in Newfoundland and Labrador", for a method to calculate manure application rates).

The timing of manure spreading throughout the year is important. Manure will gradually decompose in the soil zone. As decomposition occurs, nutrients from the manure become available for use by the plant. These nutrients, however, also become susceptible to losses through leaching or runoff depending on the weather and soil conditions.

Spring may be the best time to apply manure, since the crop will be able to use the nutrients as they become available. Soil compaction can be a problem in spring, however, since the land is often too wet to handle the heavy wheel loads involved with certain types of spreading methods.

Winter is the least desirable time for manure application, since nutrient loss can be high and the potential for runoff is the greatest. Currently, producers are advised not to spread manure on frozen or snow covered ground.

Inorganic Fertilizers

Increasing amounts of inorganic fertilizers (chemical fertilizers that are either mixed or manufactured) are being used in the production of horticulture crops in Newfoundland and Labrador. The benefits of using inorganic fertilizers include consistent analysis and ease of handling.

You must ensure that elements found in commercial fertilizers do not accumulate in the soil to high concentration levels. Base the amount of inorganic fertilizer used in your operation on soil analysis and follow recommendations for fertilizer use.

7.3 PEATLAND FARMING (For further information, see Management and Conservation Practices for Vegetable Production on Peat Soils, Eastern Canada Soil and Water Conservation Centre, May 1997.)

Bog farming is increasing in Newfoundland and Labrador partly because of limited mineral land base. Peat soils are used to grow a variety of vegetables, cranberries, forage crops, sod or used as pasture land across Newfoundland and Labrador. Peat soils are very high in organic matter (from 30% to 98%) and require extensive drainage when used for agricultural purposes. Careful attention must also be paid to loss of organic matter and the possibility for the accumulation of contaminants from production practices. As a grower you must be aware of specific conditions that may affect both production and potential environmental problems on peatland. For specific information on production practices or drainage requirements contact the Soil Drainage Specialist.

Many herbicides are not effective when used on peat soils because of the high organic matter content. The organic matter acts as an absorptive surface whereby the herbicide is bound up and unable to kill the weed.

7.4 EROSION CONTROL

Highly productive land is valuable in Newfoundland and Labrador. In many areas, the supply is limited. While water and wind erosion are not major concerns in most areas of this province, it is important for growers to understand that erosion can remove nutrients, other crop inputs, soil and organic matter from the land. Crops may be damaged or stressed by erosion, increasing the possibility of disease.

There are a variety of water and wind erosion control measures that can be used in horticulture operations facing erosion problems:

- the use of cover crops to protect the soil surface and maintain soil structure;
- tillage and residue management where some crop residues are left to protect the soils;
- strip cropping involving planting strips or sections of a field with crops having different growth habits to better protect the soils surface; and,
- the use of structures such as earthen berms or terraces (water control), windbreaks and wind barriers (offer wind control by reducing the speed of the wind and reducing its ability to carry soil).

Cover Crops

When soil is left bare, the potential for soil erosion, nutrient leaching and run-off is increased. Undesirable environmental effects such as siltation of water ways and fertilizer (nutrient) contamination of water bodies can occur. Nutrient contamination of water bodies increases the growth of aquatic plants and algae which lowers the oxygen levels in the water. This is in turn harmful to fish and other aquatic organisms. High nitrates in drinking water can cause potential health problems, especially in children.

Cover crops can be used to help control erosion, especially where vegetable or other row crops are grown for long periods of time. Cover crops also help tie up excess nutrients, add organic matter and improve soil tilth. A variety of cover crops are available. Some are suited for specific uses and therefore you must know what you want from a cover crop when making a selection.

Good cover crops for Newfoundland and Labrador include oats, annual ryegrass and fall rye.

1) Oats. This crop can be planted during spring to early summer at a seeding rate of 136 kg/ha (120 lb/ac) and in soil with a pH of about 6.0. (If potatoes are to be grown in rotation, the pH should not be raised above 5.8.) A general fertilizer recommendation is 340 kg/ha (300 lb/ac) of 17-17-17. Please note, a representative soil sample should be tested and the recommended fertilizer treatment followed. Oats can then be ploughed into the soil the following spring. This cover crop can also be used for animal feed or mulch for strawberries.

2) Annual Ryegrass. Spring and early summer is the best time to seed annual ryegrass as a cover crop. Annual ryegrass can be seeded until early August for erosion control but successful establishment may be hampered by lack of moisture after seeding. Annual or cereal rye is usually the best cover crop used in conjunction with long-season vegetables since they grow well in cooler weather.

   Generally, ryegrass requires about 340 kg/ha (300 lb/ac) of 17-17-17. The pH of the soil should be at least 6.0. Since ryegrass is a heavy feeder, topdressing with nitrogen during the growing season may be required.

   Italian ryegrasses and the leafy Westerwolds ryegrass Promenade produce a large root mass which averages about almost 12 tonnes/ha (5 tons/ac) of dry matter in the seeding year. Aubade, Barspectra and Marshall Westerwold ryegrasses produce about 7 tonnes/ha (3 tons/acre). Seeding rates for diploid ryegrass such as Marshall are about 23 -28 kg/ha (20 to 25 lb/ac). Tetraploids such as the Promenade, Barspectra and Aubade varieties require about 28 - 40 kg/ha (25 to 35 lb/ac).

3) Fall Rye. This grain crop makes an excellent cover crop and can be plowed down as a source of organic matter. It can be grazed late in the fall or early spring, or left to mature and be harvested as a grain crop the following year. The straw can also be used to mulch strawberries. Fall rye can also be seeded in late August and early September at a rate of about 125 kg/ha (110 lb/ac).

   A general fertilizer recommendation would be about 565 kg/ha (500 lb/ac) of 10-20-20 at seeding and then topdressing the following May when growth starts with about 280 kg/ha (250 lb/ac) of 34-0-0. The soil pH should be 6.0.

Contact a crop specialist for more information about using cover crops in your horticulture operation.

Tillage and Residue Management

Crop residues left in the field are beneficial in that they:

- protect the soil from impact of raindrops and the resulting movement of soil particles and crusting; and,

- act as small dams or windbreaks slowing the movement of wind and water across a field and reducing their ability to carry soil.

To protect soils, leave at least 20% residue cover in the field.

Strip Cropping

Strip cropping involves planting alternate strips of early vegetables with late-seeded vegetables to provide better soil protection. Although management may increase, the soil surface is better

protected.

If a field is particularly prone to wind erosion, broadcast oats or barley prior to planting vegetables. This will help to shelter the seedlings and can later be controlled with a timely application of contact grass herbicide before the cover crop competes with the vegetable.

Erosion Control Structures

These structures are often used in field crop production. They include earthen berms and terraces for water control, and a variety of wind barriers to control erosion such as tree windbreaks, grass strips or fence-like materials to protect vegetables. The area protected by a tree barrier is usually about 10 times its height. The amount of protection offered by other structures depend on their height and flexibility. For example, grass wind barriers are more flexible and can be pushed down by high winds, reducing the protection distance to about five to seven times the barrier height.

8. BLUEBERRY PRODUCTION

Some blueberry farming practices deserve special mention. Blueberry producers commonly use burning as a means of encouraging new upright growth in blueberry fields. Proper burning practices must be used to minimize environmental problems, reduce the potential for soil erosion and prevent plant injury.

Blueberry mowing requires level ground. Land leveling is gaining in popularity as it allows mechanical pruning over burning. Land levelingmust be done in such a way that prevents damage to the soil. For more information, contact the office of the Small Fruit Specialist.

Burning

Pruning by burning does the most thorough job with no injury to the plant while at the same time eliminating most of the stubs and other growth which interfere with raking during harvesting. Burning can be through free burn (wild fires), using straw (expensive and time consuming) or using petroleum products.

A good burn kills lateral buds and shoots above ground level. Deep burns affect the soil organic matter layer that lies just under the leaf litter on the soil surface. Continued hard burns will deplete the soil organic matter levels, leave the rhizome stem sites exposed and decrease nitrogen levels. This results in poor growth than can lead to fields becoming "run-out" (short stems and low yields). Research has shown that as organic matter levels increase, so does the plant stem length. Hard burns also force growers to use nitrogen fertilizersto replenish the soil. This is costly and leads to potential problems in the buildup of soil nitrates.

Effective field burning must include the following practices:

- obtain the required permission from the local forestry office (this is law in Newfoundland and Labrador); inform the nearest RNC or RCMP Detachment and your local fire department;
- if possible, always burn when the ground is frozen or contains some moisture;
- only burn fields when the plants are dormant, in the spring or fall after the plants have dropped their leaves (an advantage of fall burning is that new stem growth can begin as soon as spring conditions permit);
- establish a fire break around the outside of the fields to prevent spreading into forest areas; and,
- have a crew at the site equipped with the necessary fire control equipment (such as backpack water pumps or a large water tank with hoses mounted on a vehicle) which is specified on the burning permit.

Land Leveling

Land leveling in wild blueberry fields refers to improving land to:

- facilitate work with machinery and to minimize mechanical breakdowns;
- ensure a more uniform spread of pesticides and fertilizer;
- prepare the ground for the mechanization of pruning and harvesting;
- consolidate the fields;
- solve the problem of labour shortages during harvesting and pruning periods;
- improve the working speed of agricultural operations;
- diminish production costs; and,
- improve the profitability of the farm.

To ensure land leveling is properly done, you must:

- only level land when plants are approaching dormancy, typically around the first autumn frosts or before regrowth in the spring;
- prune prior to land leveling since rhizomes can become exposed (this has the added benefit of further exposing the terrain and stumps);
- reduce plant stress by completing the leveling in the same year;
- limit leveling to relatively moist field conditions since drought periods cause damaged or disturbed rhizomes to dry out;
- minimize soil loss;
- avoid wet conditions that will lead to soil compaction of seedbeds;
- minimize the impact on the density of plants and the percentage of field cover;
- allow a few years to pass after clearing operations before leveling (stumps are easier to pull and fresh stumps damage too large an area when removed);
- not leave bare steep slopes that could erode; and,
- avoid sharp turns with heavy equipment that breaks the soil surface.

Consider carefully the placement of windrows and ensure they are not pushed into streams. For

more information on land leveling and burning, contact the Small Fruit Specialist.

9.0 DISPOSAL OF FARM WASTES

Likemost business enterprises, every farm produces some type of waste material.Likemanure, these waste materials must be disposed of in an environmentally acceptable manner to minimize the likelihood of contaminating soil and water.Common waste materials found on horticulture farms include:

- waste fruit and vegetables (including organic waste dumps);
- general packaging (for example, boxes, bags, plastics);
- petroleum products such as used motor oil;
- paints and preservatives;
- machinery and equipment including inert components, tires and restricted use components such as batteries; and,
- farm structures such as old buildings including building components.

Waste Fruit and Vegetables

Many of these wastes are wet and decompose readily. Under these circumstances, problems with odour, leachate and contaminated runoff may easily develop. You can avoid these problems by practicing the following:

- following the harvest, plow in plant refuse to reduce the spread of disease an minimize odour;
- if possible, process vegetable and fruit wastes into animal feed quickly to reduce the amount of waste and decomposition and help to reduce feeding costs;
- provide adequate storage facilities (preferably covered) appropriate for the material;
- locate the storage facilities away from, and where possible, downwind from neighbors;
- avoid water quality problems by collecting, storing and properly disposing of leachate or liquor from the stored material (it can be a highly concentrated pollutant); and,
- bury or spray, culled potatoes should be buried or sprayed to prevent them from growing (otherwise they can be a source of late blight).

General Packaging

Reuse or recycle farm plastics (containers, for example, silage wrap, black plastic mulch, greenhouse plastics and greenhouse transplant flats) and other packaging materials whenever possible. Packaging materials that once contained toxic materials, such as pesticides need to be disposed of as per guidelines for the disposal of pesticide containers.

Materials not reused or recycled such as rock wool must be disposed of at an approved municipal land-fill site or any other approved facility. Burning of plastics is also considered acceptable in Newfoundland and Labrador but only after you have contacted the Department of Environment for details.

Petroleum Products (including handling and storage)

All farms use petroleum products such as gasoline, diesel fuel, machinery oil and hydraulic fluids, and produce petroleum wastes such as used motor oil and hydraulic fluids. These should be stored in a double tank. Improper storage and handling of petroleum products presents a threat to public health and water quality. A few quarts of gasoline in the ground water may be enough to severely pollute your drinking water supply. At low levels, fuel contaminants cannot be detected by smell or taste but present a very real health threat. Petroleum products contain a number of potentially toxic compounds that are known carcinogens (cancer causing agents) to laboratory animals and humans.

Storage and handling of petroleum products are regulated under "The Storage and Handling of Gasoline and Associated Products Regulations" of the Environment Act. These regulations are administered by the Government Services Centre, Department of Government Services and Lands. Additional information on requirements or applications to install systems in accordance with the regulations are available from the Government Services Centre's regional offices. Dispose of unwanted waste oil and hydraulic fluids by first collecting them in either a tank or containers and then transporting them to a local oil recycling depot or a licensed waste oil collection contractor. Used motor oil can be used as a lubricant on equipment. Waste oil should not be burned.

Any floor drainage from a service area where oil is being used has to be routed through an oil separator before being discharged. The used waste oil floating in the separator must be removed regularly and deposited in the waste oil tank or container.

In the case of a petroleum storage and handling leak or spill, immediately call the Environmental Emergencies 24-Hour Report Line. For more information, refer to the Factsheet, Storage and Handling of Petroleum Products on the Farm, Publication GT005, November 5, 1996.

Paints and Preservatives

These and other materials such as adhesives and lubricants must be safely stored on farm and used up as needed, shared with a neighbor or brought to a recycling depot.

Machinery and Equipment

Reuse and recycle whenever possible. If this is not possible, equipment must be collected and disposed of at an approved municipal waste disposal site or facility or to a scrap dealer.

Disposal of oil, fuel and antifreeze should be done through a licensed oil contractor. Disposal of refrigerant is regulated under the regulations for refrigerant and halons. Contact your regional Government Services Centres for information on proper disposal methods for these materials.

Farm Structures and Building Components

Building components include such materials as wood frames, glass, sheet steel, plastic, shingles. Store materials on farm for future reuse or recycling. The remaining materials must be collected and disposed of at an approved municipal waste disposal site.

Restricted use old building components include materials such as insulation, pressure treated materials, asbestos materials, composite products and treated lumber. Reuse or recycle where possible. Otherwise, the materials must be taken to an approved landfill, waste disposal site or depot for hazardous materials. For the proper disposal of asbestos, contact your regional Government Services Centre.

For further information, obtain a copy of the following:

- Disposal of Household and Farm Wastes, Department of Forest Resources and Agrifoods, 1997.

- Disposal of Dead Animals, Department of Forest Resources and Agrifoods, 1997.

10. INFORMATION SOURCES

These guidelines present a summary of the information available on environmentally sustainable horticulture production practices.

Provincial and Federal Agriculture

Both federal and provincial departments of agriculture are valuable sources of information to the horticulture industry. Regional agricultural engineers provide engineering advice related to barn and greenhouse design. The Department of Forest Resources and Agrifoods employs specialists in a variety of disciplines such as soil science and crop production. Newfoundland and Labrador agriculture staff work cooperatively with other professionals across Canada and have a wide range of publications and standard plans available on a variety of subjects. Information can be obtained from the following offices.

a) Newfoundland and Labrador Forest Resources and Agrifoods:

Soil and Land Management Division
Tel: 709-637-2081 (Director's office, Corner Brook)
Fax: 709-637-2586

Land Use Planning
Tel: 709-729-6647/6633 (St. John's)
Fax: 709-729-6046
Tel: 709-637-2084 (Corner Brook)
Fax: 709-637-2586
Tel: 709-686-5262 (Pynn's Brook)
Fax: 709-686-2491

Structural and Environmental Specialist (Vacant)
Tel: 709-729-6868 (St. John's)
Fax: 709-729-2674

Soil Specialist
Tel: 709-637-2085 (Corner Brook)
Fax: 709-637-2586

Soil, Plant and Feed Laboratory
Tel: 709-729-6734
Fax: 709-729-6046

Drainage Specialist (Vacant)
Tel: 709-637-2081 (Corner Brook)
Fax: 709-637-2586

Pest Management Specialist
Tel: 709-637-2087 (Corner Brook)
Fax: 709-637-2586

Small Fruit Specialist
Tel: 709-637-2662
Fax: 709-637-2586

Crops Specialist
Tel: 709-729-2635 (St. John's)
Fax: 709-729-2674
Tel: 709-686-2702 (Pynn's Brook)
Fax: 709-686-2491

b) Agriculture and Agri-Food Canada:

Research Station
Tel: 709-772-4619 (St. John's)
Fax: 709-772-6064 (St. John's)

Other Resources

The provincial and federal offices for agriculture and the environment offer a variety of publications. Please contact the following offices for more information on the subject material found in this report:

a) Agriculture and Agri-Food Canada
Information Services (Publications)
Tel: 613-759-6626

b) Environment Canada
Environmental Protection Service
Tel: 709-772-5488 (St. John's)
Tel: 709-637-4375 (Corner Brook)

c) Government Service Centre:
Tel: 709-729-3699 (St. John's)
Tel: 709-466-4060 (Clarenville)
Tel: 709-256-1420 (Gander)
Tel: 709-292-4206 (Grand Falls)
Tel: 709-637-2204 (Corner Brook)
Tel: 709-896-2661 (Goose Bay)

d) Department of Environment Pesticide Training Officer
Pesticide Control Section
Tel: 709-729-5707 (St. John's)

In addition to the resources available through extension engineers and publications, private consultants can also provide information and detailed designs for horticultural production systems.

In case of an environmental emergency such as a chemical spill, you must contact:

Environmental Emergencies 24-Hour Report Line:
Tel: 709-772-2083 (St. John's)
Tel: 1-800-563-2444 (Other Areas)

APPENDIX A

TABLE A.1

CONVERTING METRIC UNITS TO IMPERIAL

Length		**Area**	
1 millimetre (mm)	0.04 inch	1 square centimetre (cm^2)	0.16 square inch
1 centimetre (cm)	0.40 inch	1 square metre (m^2)	10.77 square feet 1.20 square yards
1 metre (m)	39.40 inches 3.28 feet 10.09 yards	1 square kilometre (km^2)	0.39 square mile
1 kilometre (km)	0.62 mile	1 hectare (ha)	107,636 square feet 2.5 acres
Volume		**Volume (Dry)**	
1 millilitre (ml) 1 litre (L)	0.035 fluid ounce	1 cubic centimtre (cm^3)	0.061 cubic inch
	1.76 pints 0.88 quarts 0.22 gallons (Imp) 0.26 gallons (U.S.)	1 cubic metre (m^3)	1.31 cubic yards 35.31 cubic feet
		1,000 cubic metre (m^3)	0.81 acre-foot
		1 hectolitre (hl)	2.8 bushels)
Weight		**Speed**	
1 gram (g)	0.035 ounce	1 metre per second	3.28 feet per second
1 kilogram (kg)	2.21 pounds	1 metre per second	2.24 miles per hour
1 tonne (t)	1.10 short tons	1 kilometre per hour	0.62 miles per hour
1 ton (t)	2,205 pounds		
Pressure		**Temperature**	
1 kilopascal (kPa)	0.15 pounds/sq.in	$^oF = (^oC \times 9/5) + 32$	
		$^oC = (^oF - 32) \times 5/9$	

TABLE B.2

CONVERTING IMPERIAL UNITS TO METRIC

Length		**Volume (Dry)**	
inch	2.54 cm	cubic yard	0.76 m^3
foot	0.30 m	bushel	36.37 L
yard	0.91 m		
mile	1.61 km		
Area		**Volume (Liquid)**	
square foot	0.09 m^2	fluid ounce (Imp)	28.41 millilitre (ml)
square foot	0.84 m^2	pint (Imp)	0.57 L
acre	0.40 ha	gallon (Imp)	4.55 L
		gallon (U.S.)	3.79 L
Weight		**Pressure**	
ounce	28.35 g	pounds per sq. inch	6.90 kPa
pound	453.6 g	ton	0.91 tonne

APPENDIX B

SOIL AND MANURE SAMPLING

Soil testing for total nitrogen, phosphorous and potassium is preferably done each year to determine the kind and rate of fertilizers to be applied to get good plant growth and to prevent over application and consequently "nutrient loading" of the soil, especially nitrogen. Sampling depths of 150 mm (6 in) for vegetable and forage production and 4 inches for blueberries is usually adequate. Soils in Newfoundland and Labrador are not analyzed for nitrate-nitrogen given the rapid volatization of nitrate-nitrogen and the non-availability of on-site testing (by the time the sample has been received by the lab, most of the nitrate-nitrogen is lost from the sample).

B.1 Soil Sampling

Reliable results can only be made if the samples are fully representative of the field or area from which they were taken. In addition, proper sampling and handling procedures must be followed.

B.1.1 When to Sample

Soil sampling can be done at any time, but the fall of the year is generally considered the best time for the following reasons:

- spring sampling tends to leave one short when requiring fertilizer and limestone recommendations for planting that year;
- fall sampling assures you that your results are returned in time for your next planting and allows for planning; **and,**
- early fall sampling allows you to receive results for the fall liming.

B.1.2 Selecting Areas to Sample

Soil sampling is normally done on an individual field basis with a single composite sample representing the whole field. Individual fields that are not uniform should be divided into smaller sampling units with a single composite sample representing each unit. The soil in each of these sampling units should have the same colour, texture, cropping history and fertilizer or manure treatments. Look for differences in slope, erosion, crop growth and yield. Any area that is different in these features and large enough to have manure applied at a different rate should be sampled separately.

Problem areas should not be sampled unless they represent a significant portion of the field. If they do, obtain separate samples. Examples of these areas include:

- bottom and uplands soil;
- large low or poorly drained areas;
- soils of different color and texture; and,
- soils of different liming, fertilizing or cropping practices.

All abnormal areas such as old manure piles, dead furrows, areas close to trees or fence lines, haystacks, corrals, fencerows or farmstead sites should also be avoided as well as locations of past chemical or fertilizer spills. Samples should not be taken along headlands, within 15 metres (50 ft) of field borders or shelterbelts or within 45 metres (150 ft) of built up roads.

If the field has been cultivated, take the sample from the compacted soil in the wheel track.

A minimum of 15 sample locations per individual field or sampling unit should be taken. A single composite sample is then formed from 15 or more samples.

B.1.3 Equipment and Supplies

Special augers or probes designed for soil sampling may be used (sample bags and information sheets are available from your local Agriculture Representative's office). However, a clean shovel or garden trowel are both equally effective.

Use two clean, labeled plastic pails for collecting samples. Information sheets, sample containers and shipping boxes are available from the lab conducting the analysis.

If a shovel is used, follow these directions:

- dig a V-shaped hole in the soil and take care to clear away the surface litter;
- take a 12 mm (½ in) slice down one side of the hole to a depth of 150 mm (6 in). Anywhere from 50 to 75 mm (two to three in) is suitable for sod crops; and,
- trim both sides of the slice to leave a one inch width of soil. This is an individual sample to be placed in a clean pail. Take 5 to 10 such samples and mix them thoroughly to make a representative, composite sample.

Note: All mechanical and hydraulic samplers may yield poor samples on very dry or very wet soils. In all cases, avoid getting the topsoil in the subsoil samples, or subsoil in the topsoil samples. For example, in very dry soils, be careful not to let topsoil spill into the hole before taking deeper samples.

B.1.4 Handling Samples

Take care to keep samples clean and uncontaminated. Clean the sampler and take a couple of dummy samples between fields.

Send samples to the laboratory as soon as possible. If a delay of more than a week is anticipated air-dry the samples. Follow these steps to dry samples:

- mix the soil in each thoroughly, breaking lumps less than 12 mm (½ in);
- remove about 0.6 litre (1 pint) of soil and spread on a piece of clean paper;
- completely dry at a temperature of not more than 30ºC. Do not dry in an oven at a high temperature since this can change the phosphorus, potassium, and sulphur levels;
- care should be taken to avoid contamination of the samples with foreign materials such as commercial fertilizer, manure salt, baking soda, water, dust, etc. Samples should not be dried on old fertilizer or feed bags or in areas where fertilizers have been handled; and,
- a fan may be used to ensure constant air flow over samples and enhance drying.

Once the sample is thoroughly dry, fill the soil sample containers. Label each container with the correct field number and sample depth. Complete an information sheet for each field.

B.1.5 Keeping Records

It is wise to keep past records on fields sampled. The records should include:

- fertilizer and manure application rates;
- previous soil test results;
- soil condition at sampling (temperature, moisture, crop cover, etc.);
- a map of where the soil samples were taken in each field; and,
- production information.

These records may give clues to variations in lab results from year to year, and allow for customizing manure application recommendations.

B.2 Manure Sampling

The most important part of testing manures is getting a representative sample. For liquid manures, agitate or mix the manure in the pit, lagoon, slurry store, or other storage structure before taking

samples. If complete mixing is not possible, combine samples taken from 10 -15 different areas within the storage pit, combine samples taken at 10-15 different times during the removal of the manure.

Mix these composites and fill a clean 0.6litre (1 pint) plastic bottle about three-quarters full. Before sealing the bottle with its lid, squeeze the bottle to remove some of the excess air. This allows room for gas expansion during the shipment without excess pressure building up.

For solid manures, take samples from 10-15 different locations of the manure stack or pile ortake samples from 10-15 loads of manure when removing and applying manures in the field. Mix thoroughly and place about 0.6 litre or 0.5 kg (1 lb) of the composite manure sample into a clean, heavy duty plastic bag and seal.

For either type of sample, refrigeratethe sample overnight or longer and send to one of the provincial laboratories. It is preferable to ship early in the week and with boxes containing adequate packing to protect the sample containers during handling. Labs willprovide sample bottles upon request. Do not use glass bottles.

APPENDIX C

CHANGING REQUIRED APPLICATIONS INTO FERTILIZER RECOMMENDATIONS

Determining the fertilizer recommendations from the required application is a matter of deciding:

(1) what fertilizers are available, and
(2) how many different fertilizers you wish to use on your farm.

The main point to remember is that you must apply the exact amount of required nitrogen. Applied phosphate and potash are not as exact. Extra phosphate and potash remain in the soil to the next growing season.

$$\text{Rate to be spread (lb/ac)} = \frac{\text{required nutrient (lb/ac)}}{\text{\% of nutrient in fertilizer}} \times 100$$

Example: Suppose that the required amount of nitrogen is 98 lb/ac. If the fertilizers you want to use contains 15% nitrogen, you would want to spread:

(98 ÷ 15) x 100 or 653 lb/ac. This can be rounded off to 650 lb/ac of fertilizer.

Similarly:

Fertilizer	% Nitrogen	Amount of Fertilizer to Provide 98 lb/ac of N
12-24-24	12	(98 ÷12) x 100 = 817
15-15-15	15	(98 ÷15) x 100 = 653
10-20-20	10	(98 ÷10) x 100 = 980
15-5-15	15	(98 ÷15) x 100 = 653
12-24-16	12	(98 ÷12) x 100 = 817

The situation becomes more complex when there are 3 nutrients to work on. An example is taken from the previously discussed data sheet:

		Required Applications		
		N	P_2O_5	K_2O
Field No. 1	Turnip	98	169	134

From the previous discussion, we know:

Type of Fertilizer	Ratio $N = P_2O_5 = K_2O$			Amount Needed to Provide 98 lb/ac of N
12-24-24	1	2	2	817 lb/ac
15-15-15	1	1	1	653 lb/ac
10-20-20	1	2	2	980 lb/ac
15-5-15	3	1	3	653 lb/ac
12-24-16	3	6	4	817 lb/ac

Using the above, 817 lb/ac of 12-24-24 (1-2-2) will give us: 98 lb/ac of N.

(98 x 2) or 196 lb/ac of P_2O_5
(98 x 2) or 196 lb/ac of K_2O

Similarly:

Fertilizer	N	P_2O_5	K_2O
653 lb/ac of 15-15-15	98	(98 x 1) or 98	(98 x 1) or 98
980 lb/ac of 10-20-20	98	(98 x 2) or 196	(98 X 2) or 196
653 lb/ac of 15-5-15	98	(98 x 1/3) or 33	(98 x 1) or 98
817 lb/ac of 12-24-16	98	(98 x 6/3) or 196	(98 x 4/3) or 131

Comparing these calculations to the required applications:

Required Applications				Amount	Content of		
N	P_2O_5	K_2O	Fertilizer	(lb/ac)	N	P_2O_5	K_2O
98	169	134	12-24-16	817	98	196	131

We see that 817 lb/ac of 12-24-16 best meets the nutrient requirements. Finally, because the fertilizer is being used on turnips, boron should be added.

APPENDIX D

REFERENCE MATERIAL

(1) The Provincial Environment Act, 1995

(2) Environmental Guidelines for Producers, Province of B.C., Ministry of Agriculture and Food, 1998.

(3) Pesticides Control Act, 1990.

(4) Pesticide Control Regulations, Newfoundland and Labrador

(5) Federal Pest Management Alternatives Office.

(6) Atlantic provinces Vegetable Crops Guide to Cultivar Selection and Chemical Pest Control.

(7) Public Health Regulations, 1991.

(8) Guidelines for Preparing Development Plans for Agricultural Operations Within Protected Water Supply Areas, Government of Newfoundland and Labrador, Department of Environment and Lands, Water Resources Management Division, February 1994.

(9) Soil Organic Matter, J.B. Whalen, Soils Specialist, Agrifoods Branch, Newfoundland and Labrador Forest Resources and Agrifoods.

(10) Management and Conservation practices for Vegetable Production on Peat Soils, Eastern Canada Soil and Water Conservation Centre, May 1997.

(11) Disposal of Household and Farm Wastes, Department of Forest Resources and Agrifoods, 1997.

(12) Environmental Farm Practices Guidelines for Horticultural Producers for Newfoundland and Labrador.

APPENDIX E

GLOSSARY OF TERMS

Pollution

Pollution is a situation where naturally occurring substances and/or contaminants in water (surface water and groundwater), soil or the air (odor and noise) exceed allowable levels and adversely affect their uses. The Provincial Environment Act (1995) defines pollution as including an alteration of the physical, chemical, biological or aesthetic properties of the air, soil or waters of the province, including a change of temperature, taste or odor, or the addition of a liquid, solid, radio-active, gaseous or other substance to the air, soil or waters, or the removal of those substances from the air, soil or waters which will render or is likely to render the air, soil or waters of the province harmful to public health, safety or welfare, or harmful or less useful for domestic, agricultural, industrial, power, municipal, navigational, recreational or other lawful uses, or for animals, birds, or aquatic life.

Aquifer

A layer of rock or soil able to hold or transmit much water.

Overburden

An area where rainwater and runoff seep into the soil to replenish the ground water.

Duff Layer

The layer of organic material (needles, leaves, peat, moss, etc.) found on the surface of the ground in forested areas.

Soil Clods

Larger clumps of soil held together by binding substances such as clay and decayed organic matter.

Cereal Crops

Cereal crops are grain crops used for food such as rye and wheat.