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 burrowing animals. All play a part in maintaining the natural soil processes which 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 proportion of nitrogen in the form of ammonium may reduce the number of earthworms. Maintaining earthworm populations is achieved by not applying slurry or liquid manure 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 support a 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 be achieved 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 fertilizers and 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 gives plants their healthy green colour. To maximize the fertilizer value, 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 which will 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 Branch can 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.