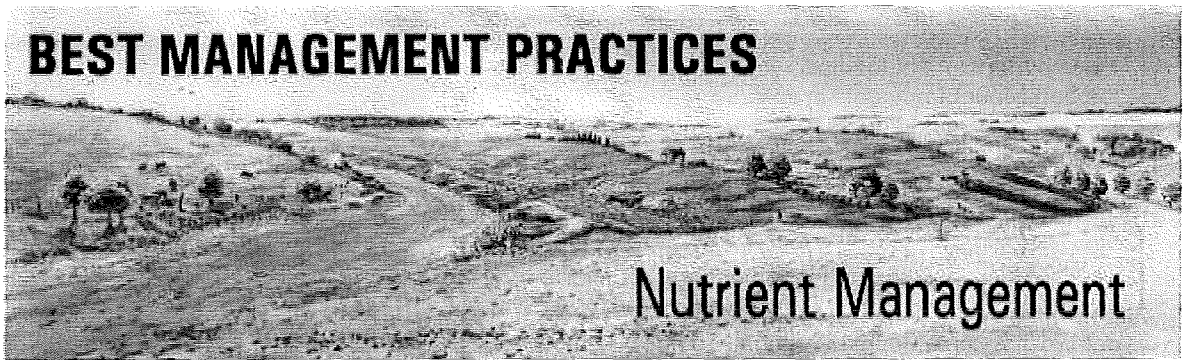
Nutrient Management



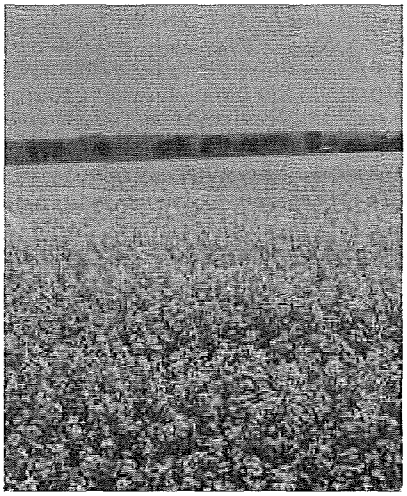
Introduction

All of the nutrients we eat originally came from soil or air. Most of the nutrients, however, cannot be used directly by people or livestock.

Crop production repackages plant nutrients - such as nitrogen (N), phosphorus (P), and potassium (K) - and energy into forms that we and other animals can use. The agriculture and food sector, which is a multi-billion dollar business in Ontario, depends on successful crop production.

Your crops will grow properly only if they obtain nutrients in the correct amounts, at the appropriate times. Soils can supply many of the nutrients needed by crops, but often require additional nutrients from sources such as commercial fertilizers, manures, and other organic sources.

Nutrients, whether in fertilizer or other materials, are both an essential input and a major cost for crop production. In Ontario, commercial fertilizer and lime applied to cropland cost farmers almost $275-million annually. The manure from about 2-million cattle, 3-million hogs, and 37-million chickens and turkeys is also applied to cropland.



Successful crop production depends on proper nutrient management.

Some farmers apply nutrients in excess of recommended rates in hopes of attaining higher yields. This is **NOT** a best management practice if it ignores costs, profits, and environmental quality. Neither is it a best management practice to apply too few nutrients. Yield and profits will drop.

Over time, poor nutrient and soil management practices can impair your land's ability to produce crops.

Poor nutrient management can also be costly to the environment. Applying more nitrogen than the crop can use will increase the risk of nitrate-nitrogen leaching from the soil, thereby polluting precious ground water resources.

Runoff from snowmelt or heavy rains can carry nutrients such as phosphorus to streams, drains, and rivers. Eroding cropland can pollute surface waters with sediment and nutrients attached to soil particles.

By adopting best management practices, you can do your part to reduce environmental risks.

This book will help you plan and implement a nutrient management strategy to use nutrients profitably while protecting the environment.

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More specifically, *Nutrient Management* will help you increase your understanding of:

- the importance of nutrients to your crops
- the behaviour of nutrients in soil
- sources that add nutrients to soil
- factors that influence the supply of nutrients available to your crops
- the effects of poor nutrient management.

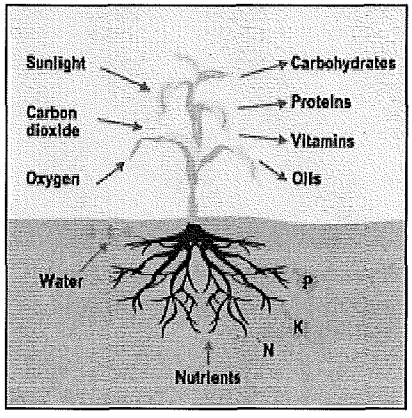
This book also describes best management practices for:

- determining the amount of nutrients to apply
- applying nutrients.

Throughout the book, we'll be referring you to other Best Management Practices books, especially *Soil Management*, *Livestock and Poultry Waste Management*, *Water Management*, *Field Crop Production*, and *Horticultural Crops*. We urge you to read these companion booklets: they'll help you see your nutrient program in the big picture of resource management on your farm.

Nutrients must be managed wisely to preserve the quality of our soil, air and water.

What are Nutrients?



Green plants convert light, water, air and plant nutrients into forms useful to people and animals.

Plant nutrients are chemical elements, or simple compounds formed from them, needed by plants. The most common elements in plants are carbon, hydrogen, and oxygen, obtained from air and water. All other nutrients are available in soil.

Six nutrients are required by crops in relatively large amounts. These are often referred to as **macronutrients**. The other nutrients are required in quite small amounts - often less than one kilogram per hectare per year. These are called **micronutrients**. See the next section, Understanding the Basics for more information.

Nutrients exist in either **organic** or **inorganic** (mineral) form. **Organic** compounds are produced by living organisms and contain carbon. **Inorganic** compounds result mainly from chemical reactions and do not contain carbon. For example, protein is an organic form of nitrogen; ammonium-nitrate is an inorganic or mineral form.

Nutrients are naturally present in soil in inorganic forms, as the result of the weathering of soil minerals. Nutrients taken up by living organisms may be converted to organic forms to make up the bodies of plants, animals, and micro-organisms. Organic forms of nutrients in living organisms return to inorganic forms when these organisms die and decompose.

For available nutrients to be used efficiently, soil must have good structure, proper drainage, and good moisture-holding capacity.

See Best Management Practices booklets, *Soil Management*, *Field Crop Production*, and *Horticultural Crops* for more information.

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Developing a Nutrient Management System

Profitable, sustainable crop production depends on proper nutrient management. Your nutrient program should meet the following goals:

- satisfy crop nutrient requirements for profitable yield and quality
- minimize the risk of damage to the environment
- minimize the cost of supplying nutrients
- be practical and feasible with current resources
- use manure and other organic materials to best advantage

See Best Management Practices book, *Nutrient Management Planning* for more information on developing a site-specific nutrient program.

These goals are not incompatible. When all nutrients available on your farm are used efficiently in meeting crop needs, the risk of damage to the environment (water quality in particular) should also be reduced.

Meeting Crop Nutrient Requirements

Nutrient Deficiencies

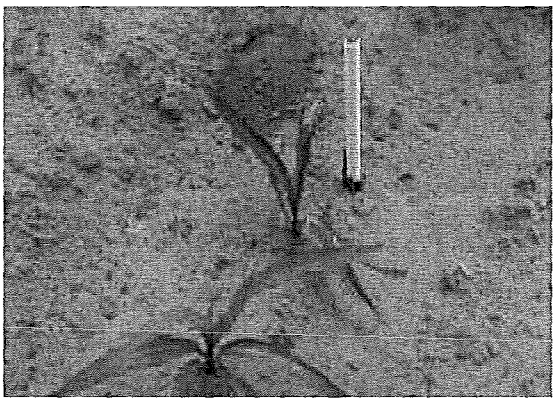
No nutrient is more important than another - all are essential. The majority of soils can supply most nutrients to most crops. Generally, a nutrient management program is only concerned with nitrogen, phosphorus, and potassium. However, deficiencies of other nutrients do occur.

Some soil types are prone to deficiencies of certain nutrients, because of the way in which the soils were formed. Similarly, some crops have a higher requirement for specific nutrients than do other crops.

The lack of a nutrient can limit growth and

Nutrient Toxicities

If available at excessive levels, some nutrients are potentially toxic to plants. For example, the margin between boron deficiency and toxicity is quite narrow, and varies among crops. Cole crops and alfalfa have relatively high requirements for boron. In the year following application, however, boron applied for cole crops can cause damage to sensitive crops such as soybeans, field beans and cereal grains.



In acidic soils, some nutrients become

quality. **toxic to most crops.**

For more information on nutrient deficiencies, see chart on "Nutrient Deficiencies in Ontario".

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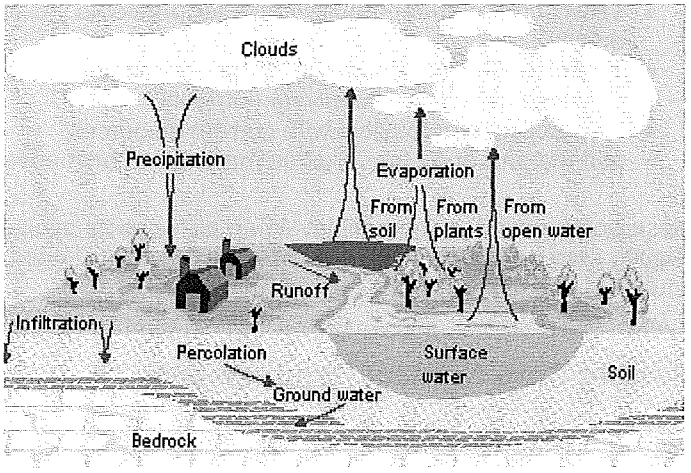
Nutrients and the Environment

Nutrients can pollute water. Nitrate-nitrogen can leach into ground waters. Phosphates can run off land to surface waters such as drainage ditches, streams, and rivers. Concentrations of these nutrients in water above tolerable limits are harmful to humans, livestock, and wildlife.

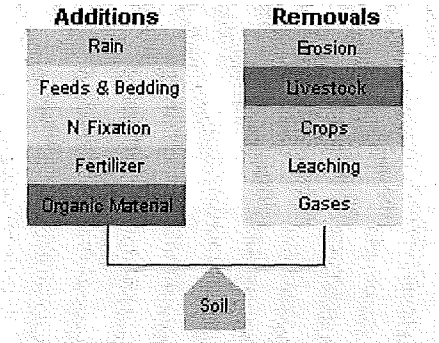
Agriculture is one of the sources of nutrient pollution in rural areas.

The Water Cycle



Making a Nutrient Management Program Work

Nutrient management programs are often viewed on a field-by-field basis. This ensures that each field can supply the nutrients needed by the crops to be grown there. However, in planning a nutrient management program, you must consider the production system of your entire farm.



Consider all factors affecting the nutrient balance on your farm in your management program.

The method you choose to supply nutrients can have an impact on other farm operations. Similarly, changes in other farm operations (e.g. tillage) can affect the way in which nutrients must be managed. Take all factors into account before making a change.

Unless you're deliberately building up or drawing down the level of nutrients in specific fields, the amount of nutrients on your farm will remain about constant over time.

Available in Published Version of Nutrient Management

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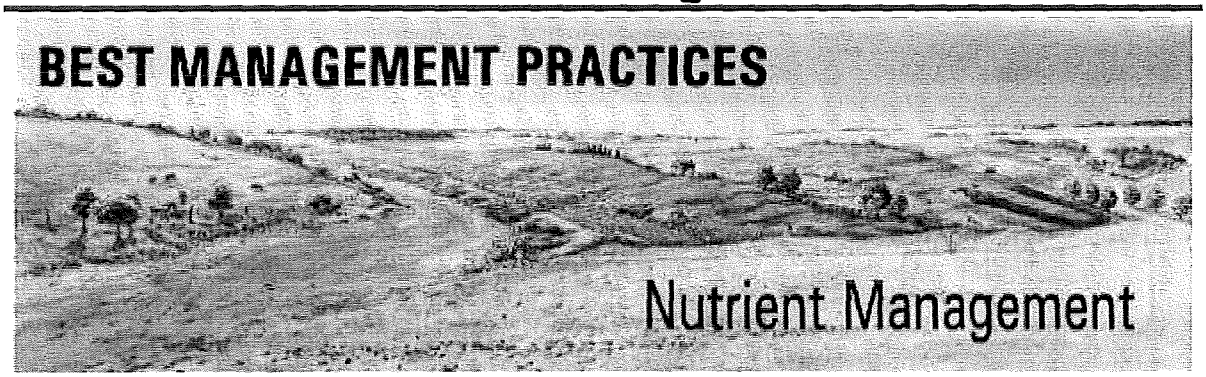
Nutrient Management



Understanding the Basics

Many things affect a crop's ability to obtain nutrients. To develop a successful nutrient management plan, you need to know what these factors are, and how they influence which options you should choose in supplying nutrients.

This section will help you learn more about:

- nutrients required by crops
- why crops may not be able to use all the nutrients you apply
- the components of a nutrient cycle
- how crop nutrients move through nutrient cycles
- why soils become acidic
- how soil pH affects nutrient availability and crop growth
- what happens to the fertilizer and other nutrients you apply
- how to diagnose deficiency symptoms.

The Macronutrients	The Micronutrients
• Nitrogen • Phosphorus • Potassium • Calcium • Magnesium • Sulphur	• Zinc • Manganese • Boron • Copper • Molybdenum • Iron

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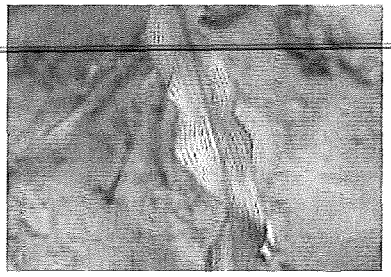
Nutrients in the Soil and in Plants

Learning about the type, function, and deficiency symptoms of the macronutrients and micronutrients essential for crop growth should help you diagnose and predict crop problems as they relate to nutrient deficiency.

Nutrient Deficiencies Encountered in Ontario

Boron deficiency causes hollow stems in cole crops such as broccoli.



In corn, magnesium deficiency causes striping of the youngest leaves.

A lack of potassium causes tomatoes to ripen unevenly.

This chart lists the nutrient deficiencies most commonly encountered in Ontario and the situations in which they are most likely to be a problem.

Nutrient Deficiencies Encountered in Ontario

	Most Often Deficient * In:	
Nutrient	**Crop**	**Soil Conditions**
Nitrogen	most non-legume crops	underfertilized soils; waterlogged soils
Phosphorus	most crops	underfertilized soils; marl soils
Potassium	alfalfa, most crops	sands & loams
Calcium	apples, pears, grapes, potatoes, tomatoes, Cole crops, tobacco, peanuts	acidic sandy soils
Magnesium	corn, tomatoes, apples, grapes, potatoes, carrots, celery, spinach	acidic soils; sandy soils; following use of high rates of potash; Central Ontario, east of Niagara Escarpment
Sulphur	forages, cereals, canola	Northwestern Ontario
Zinc	corn	eroded, high pH soils; following high rates of phosphorus
Manganese	soybeans, cereals muck crops, beets, tomatoes	soils that previously were poorly drained; muck soils; marl soils; eroded, sandy, high pH soils
Boron	alfalfa Cole crops apples, celery, beets, spinach	sandy soils; east of Niagara Escarpment most soils alkaline soils
Copper	onions, carrots winter wheat	muck soils coarse sandy soils
Iron	blueberries	neutral or alkaline soils
Molybdenum	cauliflower, broccoli, onions	acidic sandy soils; muck soils

* The deficiencies listed in this table can occur in Ontario.

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The Nutrient Cycle

- The Components in the Nutrient Cycle
  - Soil Components: Soil Organisms, Cation Exchange, Minerals and Chemical Compounds, The Role of Subsoil and Soil Parent Materials
  - Additions to the Soil: Residues, Manures, and other Organic Materials, Fertilizers, Atmosphere
  - Losses from the Soil

Nutrients in the Soil and in Plants

- The Macronutrients: Nitrogen, Phosphorus, Potassium, Calcium and Magnesium, Sulphur
- Macronutrient Types, Effects of Insufficient and Excessive Amounts - *Chart*
- Micronutrients: Deficiency Symptoms - Chart, Chlorine

Soil Acidity and Liming

- Effects of Soil pH

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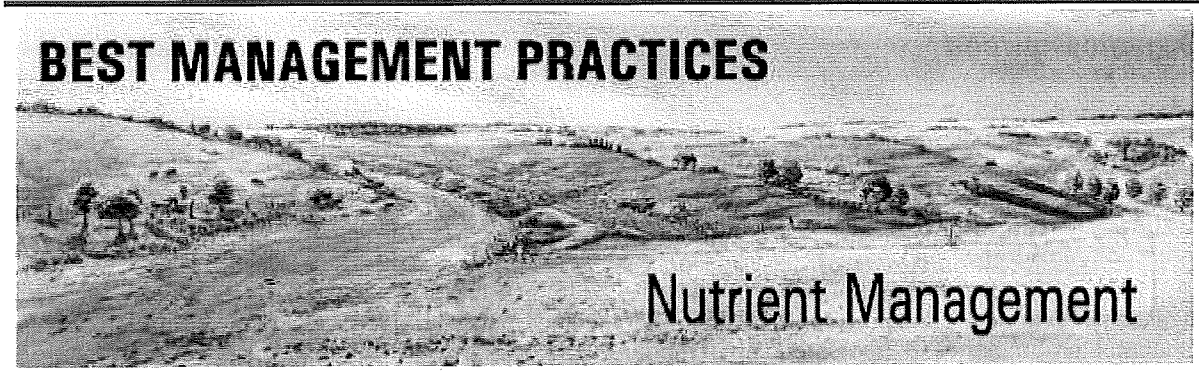

Sources of Nutrients

Most of the nutrients taken up by plants are supplied by the soil itself. Often, the levels of some nutrients in soil are too low to support adequate growth.

Materials, which can be added to the soil to supply nutrients are in two major forms:

- inorganic (e.g. commercial fertilizers)
- organic (e.g. manures, crop residues, biosolids, residuals).

Within each form there are many types, each with its own special properties, advantages, and disadvantages relating to cost, practicality, safety, and environmental protection. For some of the advantages and disadvantages to applying commercial fertilizers, manure and biosolids, see the Best Management Practices, *Nutrient Management Planning* book.

Commercial Fertilizers

Common Fertilizer Materials

Commercial fertilizer materials are one of the major sources of nutrients for crops. Here are some of their advantages and disadvantages.

Advantages	• nutrients are available very quickly • nutrients are concentrated • nutrient content is known and consistent • materials are generally easy to handle, transport, or apply • materials can be applied evenly • materials can be placed accurately • blends can match crop needs based on soil test results • timing of application can be flexible • where some nutrients are already present at high levels, only the nutrients that are needed can be applied
Disadvantages	• materials are made from non-renewable resources

	• materials must be purchased • some materials (e.g. anhydrous ammonia) require special handling precautions • no organic matter is added to the soil.

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Organic Sources

Many organic materials can be used to supply nutrients to cropland. These include crop residues and livestock manures. Biosolids and other organic residuals approved by the Ontario Ministry of Environment and Energy can also be used.

Livestock Manures

Livestock in Ontario produce a volume of manure equivalent to the sewage produced by 40-million people. Although storage, handling, and spreading of manure can pose several problems on livestock farms, manure is a valuable resource. Nutrients retained on your farm reduce both the risk of damage to the environment and the cost of what might otherwise have to be spent on fertilizers.

Average Nutrient Contents of Livestock Manures (1993)

Type	Dry Matter (%)	N (%)	NH_4-N mg/kg	P (%)	K (%)	Ca (%)	Mg (%)
DAIRY - solid liquid	20.4 6.3	0.52 0.28	1297 1412	0.14 0.07	0.50 0.27	0.31 0.11	0.11 0.051
BEEF - solid liquid	27.5 5.3	0.66 0.25	757 1604	0.16 0.08	0.64 0.18	0.29 0.08	0.12 0.041
SWINE - solid liquid	26.7 3.8	1.17 0.38	2884 2669	0.70 0.12	0.96 0.18	0.79 0.097	0.22 0.038
POULTRY - solid liquid	47.6 7.9	2.08 0.75	5855 5735	0.97 0.27	1.15 0.32	2.24 ---	0.38 ---

Crop Residues

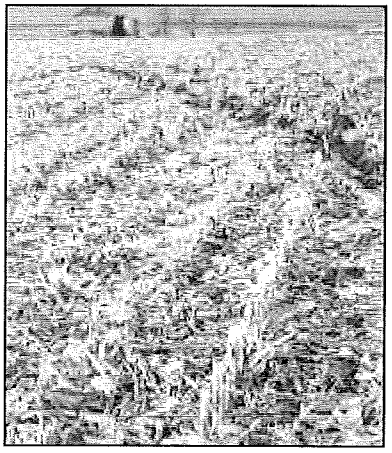
By returning crop residues to soil, you are:

- ensuring that part of the nutrients taken up by your crop is recycled
- helping maintain the organic matter content of your soil.

Residues left on or near the soil surface also help to reduce soil erosion. See related Best Management Practices books for more information.

The nitrogen fixed from air by some legume crops, especially the forage species, can add significantly to the supply of this nutrient in soil.

Residues from cereals and grasses tend to be low in nitrogen. Because soil micro-organisms require nitrogen to break down such materials, the supply of nitrogen available to crops can be temporarily reduced when large quantities are returned to the soil.



Crop residues return nutrients to the soil and help reduce erosion.

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Biosolids & Residuals

Biosolids resulting from municipal wastewater treatment plants, and approved by the Ontario Ministry of the Environment and Energy (MOEE), can be a valuable nutrient addition to cropland, when properly managed. Criteria for the use of biosolids on agricultural land can be found in the publication *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land*, co-authored by OMAF and the MOEE. Residuals, or off-farm generated wastes result from industrial and commercial processes (ie. pulp & paper processing, food processing wastes) and may be beneficially reused on agricultural land if they comply with the Guideline criteria and at the discretion of the MOEE.

Biosolids and residuals contain nutrients and organic matter that are beneficial to crop production and soil quality. When applied according to Best Management Practices (BMPs), biosolids can provide farmers with up to 135 kg/ha of plant available nitrogen and 235 kg/ha of fertilizer equivalent phosphorus. OMAF recommends that farmers use BMPs to obtain the most nutrient benefit from land applied biosolids and ensure proper management. OMAF also recommends that all farmers use a Nutrient Management Plan (NMP) to account for the nutrient component of biosolids in their crop rotation and fertilization program.

Some Factors Considered In Site Approval:

- soil test for phosphorus
- soil pH
- slope of field
- soil organic matter content
- natural soil drainage
- soil moisture content
- snow cover and frost
- distance to wells, water table, watercourses, bedrock, or homes.

Biosolids and residuals also contain some undesirable components like metals and may contain pathogenic organisms and other inorganic and organic compounds. Biosolids produced in Ontario have therefore been tested for a wide range of metals and potential contaminants. Some of these metals, like copper, zinc, manganese and nickel, are also essential micronutrients. Biosolids are deemed suitable for land application if metal concentrations do not exceed set limits, and specified safeguards are adhered to (e.g. setback distances from wells, waiting periods before grazing of livestock or harvesting of a crop) as outlined in the Guidelines. The Guidelines also recommend crops that are suitable for application, such as field corn, hay, soybeans, some cereal crops and tree fruits. Application directly to vegetables, tobacco and home lawn and gardens is not recommended in the Guidelines.

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Other Off-Farm Wastes

Our society produces a wide variety of other waste materials. These include leaves, residential garbage, wood chips, paper, pulp, and food processing wastes. Many of these materials could be beneficial to soil as a source of organic matter and some nutrients. Some wastes - lime kiln dust, for example - can also be used to correct soil pH problems, where appropriate.

The nutrient content of wastes depends on the type of material from which they were made. Those derived from leaves, paper, or wood usually are low in nitrogen and may require supplementation to avoid inducing nitrogen deficiency in crops.

Because of the potential for contamination of the soil and environment, only waste materials approved by the Ontario Ministry of Environment and Energy may be applied to approved sites. Before a material will be approved, you must show that:

- the nutrients or organic matter it contains will benefit the crop or soil
- it will not pose a risk to crops, soils, people, animals, or the environment.

Other guidelines relating to the use of wastes on farmland are similar to those for sewage biosolids. (See the Ontario Ministry of Agriculture and Food - Ontario Ministry of Environment and Energy Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Lands.)

If applied properly, many waste materials could benefit the soil.

Available in Printed Version of Nutrient Management

Actual Nutrients
- Nutrient Contents of Common Fertilizer Materials - *Chart*

Commercial Fertilizers
- Nitrogen, Phosphorus, Potassium
- The Steps in Manufacturing Nitrogen Fertilizers - *Chart*

Organic Sources
- Organic Nutrient Sources: Concerns and Significance - *Chart*
- Livestock Manures: Nutrient Content, Availability of Nutrients in Manure

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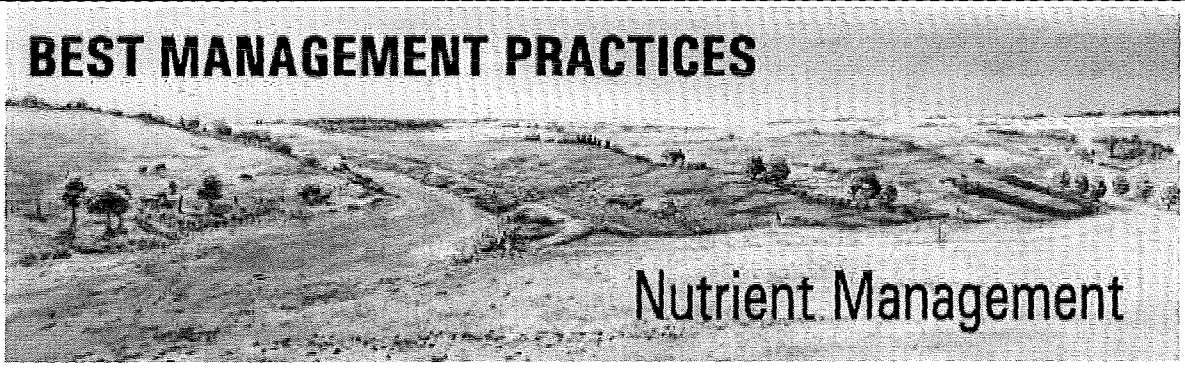

Testing For Nutrients and Interpreting Test Results

If you choose to read no further than the first paragraph of this section, remember and practice this key piece of advice: ***test for nutrient levels and follow the recommended rates.***

Whether it's soil fertility, pH, nitrate levels, plant tissue, manure, or other organic wastes - test first.

If you add too little, your yield and returns suffer. If you add too much, you've wasted energy, time, and money - and you risk polluting the environment.

Test, then follow the recommendations - it's just good business.

In this section you'll learn:

- how to take and handle samples for nutrients
- more about the different tests
- the advantages and disadvantages of several procedures for interpreting the test results.

Should I Get It Tested?

Using a test to apply what the crop needs will:

- improve crop growth and standability
- improve crop tolerance to insects and diseases
- improve crop maturity and quality
- increase yields
- reduce input costs
- protect the environment.

Tests are relatively **inexpensive** - e.g. if a 20-acre field was sampled once every three years at a cost of $15/analysis, the cost per acre per year would be $0.25.

Keep in mind the following considerations:

- sampling takes time and costs money
- you may have to wait for results at critical times
- poor sampling methods may make the results unreliable.

A soil sampling tube is the most convenient tool for taking samples.

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Soil Testing

The best way to estimate the fertility of the soil is through the use of a reliable soil test. You can't make good decisions for nutrient use without knowing the supply of available nutrients in soil.

Soil testing is also the only reliable way to determine soil pH. Test every field at least once every three years. Sandy soils should be tested every two years.

In soil testing, chemicals that remove nutrients from the soil sample are used to estimate the nutrients that plants will be able to take up. The soil test for nitrate-nitrogen is an exception.

Soil testing is not an exact measure of soil fertility, but it is the best estimate. The procedures used for the Basic Ontario Soil Test (phosphorus, potassium, magnesium, and pH) are well-defined and provide consistent results. Approved tests for zinc, manganese, and nitrate-nitrogen are also available.

For most other nutrients, testing procedures that provide a reliable basis for making fertilizer recommendations for Ontario soils have not been developed.

When fields are soil-tested regularly, changes in nutrient levels over time can be monitored and recorded. If the results of a soil test for a field differ greatly from the trend of previous results, contact the laboratory as soon as the results are received, so that your sample can be retested. Although poor results are usually the result of improper sampling, there are occasional errors in the laboratory.

Additional information on soil testing and the interpretation of results can be found in the crop production books published by the Ontario Ministry of Agriculture and Food. These include:

Publication 811, Agronomy Guide for Field Crops
Publication 812, Field Crop Protection Guide
Publication 360, Fruit Production Recommendations
Publication 363, Vegetable Production Recommendations

Publication 298, Tobacco Production Recommendations
Publication 371, Growing Greenhouse Vegetables
Publication 383, Production Recommendations for Ornamentals and Turf.

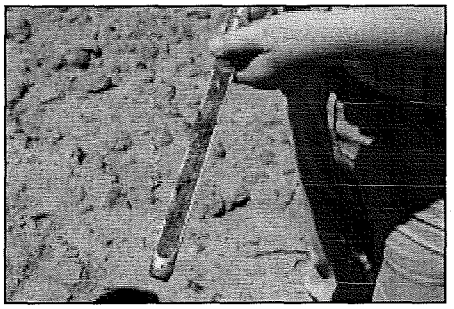
Soil testing should be the first step in making a nutrient management plan.

Approaches to Making Fertilizer Recommendations

Growers sometimes receive very different fertilizer recommendations for identical samples sent to different laboratories. Some difference in recommendations can be explained by the use of different testing procedures. Much of the difference, however, is due to the way in which test results are interpreted by the person making fertilizer recommendations.

Always remember and practice this piece of advice: *Test for nutrient levels and follow the recommended rates.*

In this section, we'll look at the principles underlying one of the approaches commonly used in Ontario and the weaknesses of this approach.



All approaches have two weaknesses in common. Little consideration is given to:

- the risk of damage to the environment in determining nutrient recommendations
- the effect of variability within fields on the overall optimum rate.

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Province-of-Ontario Recommended Approach

Research and on-farm experience continue to demonstrate that the phosphorus and potassium rates recommended by the Ontario Soil Test program are sufficient for yield levels well above those commonly obtained in Ontario.

The recommendations you receive are based on the results of field trials conducted for each crop to determine the optimum rate for each level of soil fertility. Only the amount that should maximize profit in the current cropping year is recommended.

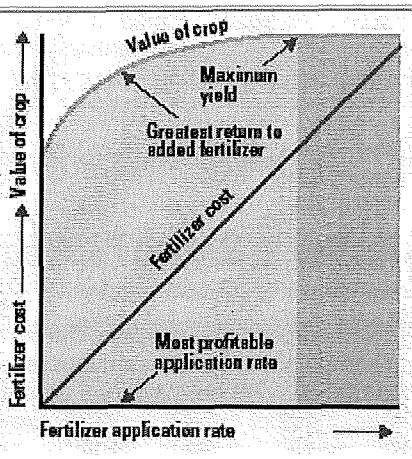
When nutrients are applied as recommended, this approach will maintain or gradually increase soil fertility, because crops do not capture all the nutrients applied in the year of application.

Crop yields show a pattern of diminishing returns to increasing soil fertility - the amount of extra yield decreases with each extra unit of fertilizer applied, and eventually will not cover the extra cost. The most profitable rate of nutrient application will produce a yield slightly lower than the maximum yield.

As the soil test value for a nutrient increases, application of that nutrient produces less increase in yield, and the most profitable application rate decreases. On soils testing High or greater, it doesn't pay to apply any of that nutrient.

Interpreting the Basic Ontario Soil Test

Reports from different soil testing laboratories may vary in format, but most contain the following information:



The response of crops to added nutrients decreases as the level of fertility is increased.

- the suggested amount of each nutrient to apply
  - the suggested rates are expressed in actual nutrients and must be translated into a recommendation for the amount and type of fertilizer or manure to apply
  - recommendations for lime are usually shown in tonnes per hectare of lime with an index of 75
- the numerical value of the soil analysis for each nutrient tested
  - nutrient recommendations are based on this soil test value, using the results from field trials
  - the soil test value is usually expressed in parts per million (ppm) - it is only an estimate of the nutrients actually available to crops. It's a good indicator of nutrient availability, but depending on soil conditions and crop species, the amount actually available to crops will vary.
  - crop nutrient requirements can be determined from tables in the Ontario Ministry of Agriculture and Food crop production recommendations publications
  - by recording soil test values over several years, you can chart changes in soil fertility, as another indicator of the suitability of the rates being applied
- the soil test rating for a nutrient is an indicator of how abundant, or deficient, that nutrient is for the intended crop - ratings may change if the crop is changed
  - ratings are also helpful in adjusting fertilizer recommendations, as indicators of whether to increase or decrease application rates from those suggested on the report
  - in general, the ratings indicate the following for the intended crop:

Low (L)	-profitable to apply that nutrient at the recommended rate in almost all cases
Medium (M)	-profitable to use that nutrient at the recommended rate in most cases
High (H)	-rarely profitable to use that nutrient
Very High (VH)	-it will not be profitable to use that nutrient at all
Excessive (E)	-level is higher than is required for any crop. Use of that nutrient will be wasteful, and could increase damage to the environment and limit the growth of some crops.

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Manure Testing

Sampling

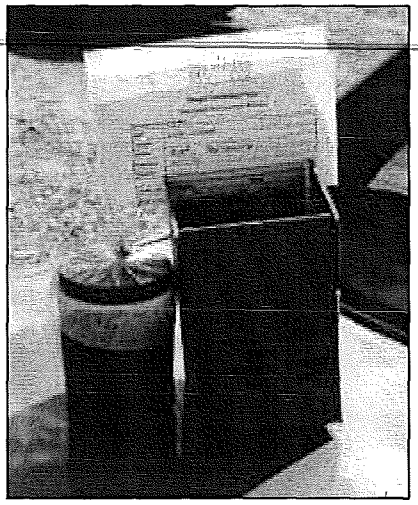
As with soil testing, proper sampling is the most important aspect of manure testing. It's essential that the sample represent the entire volume of manure, not just the surface.

Liquid Manure

- agitate completely prior to sampling
- collect 10 to 15 sub-samples from various places and depths within the storage
- mix the sub-samples together thoroughly in a clean plastic pail
- transfer about 1/2 litre of the mixture to the shipping bottle.

Solid Manure

- take sub-samples from several parts of the pile, as deeply as possible, and place on a clean area of floor or plywood for mixing
- chop the manure with a shovel or fork, and mix the sub-samples together as thoroughly as possible
- divide the manure into four portions. Discard three portions and remix the remaining portion. Continue sub-dividing the manure into quarters and remixing one quarter, until about 1/2 litre remains.
- transfer the well-mixed 1/2 litre to the shipping container.



Seal and pack manure samples securely before shipping.

Available in Published Version of Nutrient Management

Soil Testing

- Soil Sampling: Planning, Moisture Content, Equipment, Sampling Pattern, Variable Fields, Preparation

Approaches to Making Fertilizer Recommendations

- Crop Removal
- Buildup and Maintenance
- Base Saturation Ratios
- Ontario Soil Nitrate-Nitrogen Test
- Sampling and Testing Procedures for Field Corn
- Limitations and Special Consideration

Tissue Testing

Manure Testing

- Shipping

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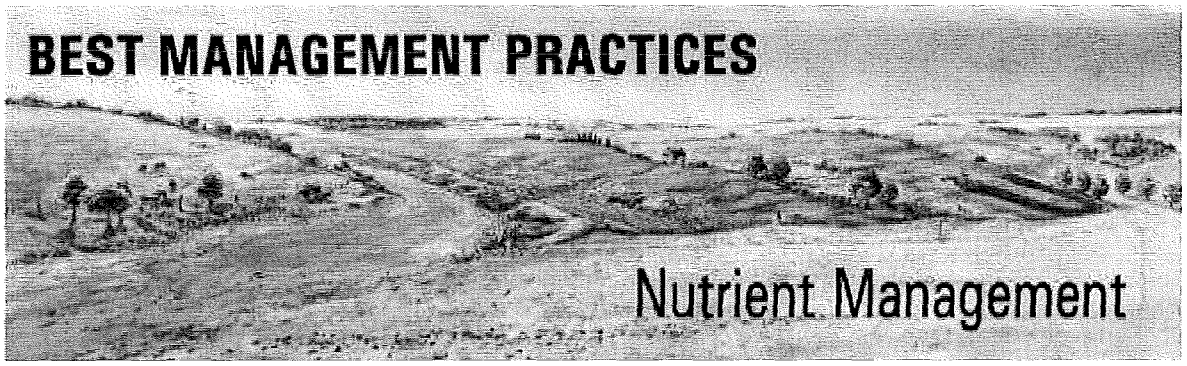

Best Management Practices for Applying Nutrients

Now that you know the type and amount of nutrients required, it's time to consider application. Best management practices for application can be summarized as follows:

For Production and Profit	• apply exactly what crops need when they need it • maximize the benefit of nutrients by reducing losses, and applying them where they will be used most efficiently
For Practicality	• crop rotation may use nutrients not taken up by previous crop
For Protection of the Environment	• if you meet your crop's needs by applying nutrients in the right amount at the right time, you'll protect the environment. (Sound soil, crop, and crop residue management practices will help too!)

In this section, you will learn about the following aspects of applying commercial fertilizers and organic nutrient sources:

- methods of application
- calibration for desired rates
- how to avoid fertilizer burn
- how to reduce nutrient loss
- how to protect environmental quality.

Nutrients applied unevenly affect both your crops and the environment.

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General

- locate fertilizer storage and loading areas on a concrete floor under a roof, away from wells and watercourses
  - minimize the amount of fertilizer stored
  - have containment for liquids in case of spills
- avoid spreading nutrients into watercourses or on surfaces from which they might run off (e.g. laneways).

Considerations In Selecting a Method of Applying Fertilizer

Application Method	Crop Safety	Efficiency of P Use	Cost Per Unit P_2O_5	Convenience	Other Considerations
Broadcast	high	low	medium	high	- low rates cannot be spread evenly - can be custom applied - should be incorporated
Banded at Planting: Dry Fertilizer to the side	medium	high	medium	medium	
with seed	low	high	medium	medium	- equipment may need changes to apply low rates - fertilizer is safe only at very low application rates*
Liquid Fertilizer with seed	low	high	high	high	- liquid application system must be added - fertilizer is safe only at very low application rates*

*This is not a problem for phosphorus-only fertilizers.

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Nutrient Accumulation in Soils

Nutrients are not present in organic materials in the same proportions as they are required by crops - often, more nitrogen, phosphorus, or potassium is present than can be used in the year of application.

Frequent applications to a field can cause these nutrients to build up to excessive levels in the soil.

Because organic materials are costly to transport, you may tend to concentrate them on fields close to the sites where they have been produced or stored. This is often a problem on farms where the amount of land available for spreading manure is too small relative to the number of livestock.

Recommendations for the amount of land required for spreading manure can be found in *The Agricultural Code of Practice.*

Use organic materials on all fields farmed as much as possible. Some livestock producers with small land bases have arranged with neighbours to apply excess manure to their crops or to trade the use of land. Including crops with differing nutrient requirements in the rotation may also help ease the problem.

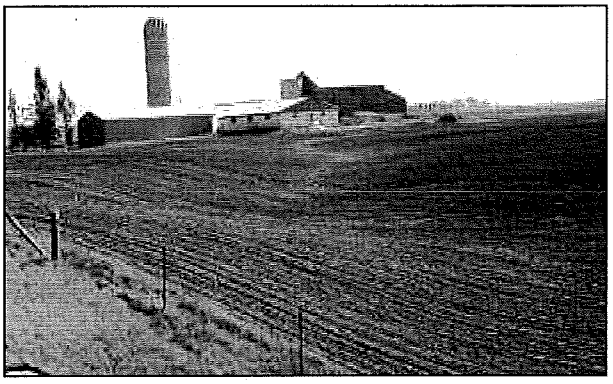
If you're applying livestock manure or other organic materials frequently to fields, be sure to soil-test regularly. Test for phosphorus, potassium, and nitrate-nitrogen (if corn is to be grown).

Adjust application rates to meet the requirement for the nutrient that will result in the lowest

application rate. Requirements for other nutrients not fulfilled by the organic material should be supplied from other sources.

The situation can occur where the lowest application rate is **zero.** In this case, you should consider the following options:

- apply the nutrients to another field or farm
- apply a rate equal to the next lowest application rate - provided P or K levels are not in the excessive range
- apply a rate less than or equal to the amount that will be removed by the crop to be grown
- talk to a neighbour about applying the nutrients to his or her land.



If you apply manure or other organic materials to your fields frequently, be sure to soil-test regularly.

In any case, don't apply more nitrogen than the crop to be grown requires.

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Available in Published Version of Nutrient Management

- **Nitrogen, Ammonia Toxicity, Phosphorus**
- **Starter Fertilizers**
- **Fertilizer Burn**
- **Micronutrients**
- **Other Nutrients**
- **Organic Materials**
  - Nutrient Losses from Manure
  - Odours
  - Nitrogen Losses
  - Equipment Calibration for Organic Materials
  - Estimating the Amount of Liquid Removed from Storage
- **Correcting Soil Acidity**
  - Increasing Soil Acidity

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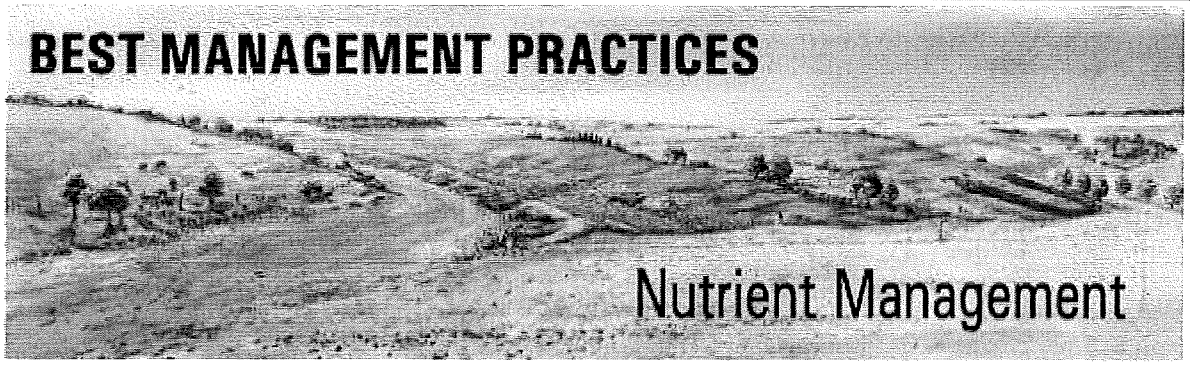

It's Up To You...
A Summary of Best Management Practices for a Nutrient Management Program

It's time to take theory and advice -- and put them into practice. In this section, the steps of a nutrient management program are outlined with a summary of related Best Management Practices.

There are many reasons to develop a nutrient management system for your operation. A well-planned system can:

- optimize yields
- save costs
- increase profits
- make more effective use of your available resources
- protect environmental quality

There are good reasons for understanding the basics:

- knowing what nutrients do for crops and how they behave in soil will help you better predict crop needs
- understanding the cycles of these nutrients helps prevent losses to the system - and make efficient use of nutrients applied
- knowing the advantages and disadvantages of nutrient sources - inorganic and organic - helps you choose the right combination for your operation.

Knowing your nutrient levels and crop needs provides the best estimate for application rates. And by adopting best management practices for application, you'll be (again) increasing profits, while protecting the environment.

All of this background information is essential to developing an effective nutrient management program.

Calculating your nutrient requirements can be as simple as completing the following table:

	N (lb/ac)	P (lb/ac)	K (lb/ac)

1. From the soil test determine the requirements of the crop.
2. Subtract the nutrients supplied by organic materials.
3. Subtract the nitrogen supplied by legume crops.
4. Nutrients left to apply

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There are six basic steps to a nutrient management program.

Step 1	Review	Take a hard look at all soil, cropping, and nutrient management aspects of your operation. Make sure that other problems are not limiting your crop's use of nutrients.
Step 2	Sample	Sample for nutrient levels: soil, tissue, manure, sludge, other.
Step 3	Interpret test results	Know what you have and what you need.
Step 4	Calculate application rates	Be accurate - account for the nutrients from all sources.
Step 5	Apply nutrients properly	Get the most out of what you apply - whether it's commercial fertilizers or organic sources.
Step 6	Observe and keep records	Monitor crop growth, look for irregularities - sample and treat separately

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Best Management Practices for Your Nutrient Management Program

Best Management Practices	
Step 1 - Review	• create maps of your land, complete with acreages, soil types, eroded areas, wet spots, slopes, water bodies, and other natural features • plan your soil sampling with the range of features in mind - some areas may require separate sampling • use this map as a basis for recordkeeping of crops, fertility levels, and all crop inputs • evaluate records to determine if land use changes are necessary: some parts of fields, like eroded hillsides, may be better removed from crop production and retired to grass, shrubs or trees • take an inventory of nutrient application equipment available to you - contact your neighbour, if necessary
Step 2 - Take Samples for nutrient levels of soil, crops, manure, and other organic materials	• the best way to estimate fertility levels is by using a reliable test • most inaccurate test results occur because samples were taken or prepared improperly - follow guidelines carefully • for soils, ensure sampling is done properly and they are collected in a clean, plastic container and mixed well • for liquid manure, be sure to agitate the sources, sample at several depths, mix and send at least 1/2 litre in a shipping bottle, and get the samples to the laboratory within 2 days • for solid manure, take samples from several places in the pile, mix thoroughly and systematically reduce the volume until you have 1/2 litre for the shipping container, also get the samples to the laboratory within 2 days • for tissue testing, use with, but not in place of, soil testing

Step 3 - Interpret Results	• for soil tests, use the Ontario Basic Soil Test approach • for soils reading High or greater, it doesn't pay to apply any of that nutrient • realize the limitations of other approaches to making interpretations
Step 4 - Calculate appropriate application rates - you can have the fertilizer dealer or crop consultant do it - or you may wish to do it yourself!	• use Nutrient Management Worksheet for Manure,* Section C, Crop Nutrient Requirements to compare the nutrients supplied by a fertilizer program with amounts recommended • use Nutrient Management Worksheet for Manure* to determine: the nutrients supplied by livestock manure and other organic wastes and the appropriate application rates based on soil test ratings and calculated nutrients from organic sources • use Nutrient Management Worksheets for Commercial Fertilizers* to calculate fertilizer application rates - based on soil test recommendations - for fertilizer analyses of your choice * available through your local office of the Ontario Ministry of Agriculture and Food
Step 5 - Apply Nutrients for commercial fertilizers	• follow recommended rates • if soil test levels are High or greater, don't apply more • band phosphorus where possible • avoid fertilizer burn by applying starter fertilizer at least 1 centimetre from seed • apply nitrogen fertilizers when crops can use them - early to mid season • control soil erosion • don't broadcast near watercourses • calibrate spreading equipment
for manure and other organic sources	• see *Livestock and Poultry Waste Management* for best management practices for storing, handling, and applying manure • incorporate within 24 hours of application • apply as close as possible to time of crop's peak demand • calibrate spreading equipment to know how much is being applied • don't try to meet all nutrient requirements from organic sources • use organic source additions as fertilizers, not for disposal as wastes • soil test regularly • be considerate of your neighbours • before emptying tank, agitate thoroughly for uniform distribution
Step 6 - Observe and Keep Records	• use notes, observations of natural features, crop rotation history, and records of crop inputs as a starting point • pay close attention to those areas different from the rest of the field • test and treat these areas separately where practical • note areas of runoff and erosion • adjust fertility program as needed • observe, record, and evaluate results • if adjustments to your fertility program have failed for a particular field, consider retiring unproductive areas to grasses, shrubs, or trees.

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