CHAPTER 3.0

## Cropping Practices

This chapter provides information on a wide range of beneficial management practices suited to cropping practices and production in Alberta.

## 3.1 General Considerations

Soil testing and record keeping are fundamental to managing your operation in an agronomically, economically and environmentally sound way. Alberta's *Agricultural Operation Practices Act* sets the minimum standards for soil testing and record keeping for producers who apply more than 500 tonnes of manure (wet weight) annually. However, all producers can benefit from regular soil testing and good record keeping.

### 3.1.1 Soil Sampling and Testing

Soil testing provides an inventory of plant-available nutrients and other soil chemical factors important for crop production. This information gives a basis for recommending applications of additional nutrients. Tailoring fertilizer applications to the crop's needs is the key to avoiding overapplication and reducing impacts on water, soil and air quality. It also helps save money and conserve energy.

**Sampling**

The key to any soil testing program is taking samples which accurately represent the field's nutrient levels. A fertilizer recommendation based on a sample that is not representative will not be correct.

For representative samples, you need to take into account the variability in soil nutrient levels that often occurs within fields, even on fields that seem uniform (see following section on "Soil Sampling Strategies"). Nutrient levels can be influenced by many factors such as topography and soil type. For example, nutrient levels can change along a slope, especially if erosion carries nutrient-rich topsoil from the hilltop to the low area. Saline spots, poorly drained depressions, and eroded knolls should not be sampled unless they represent a significant portion of the field. If they do represent a significant part of the field, they should be sampled separately.

Collect samples from 20 to 30 locations per field. At each location, take samples at depth intervals of: 0 to15 cm (0 to 6 in), 15 to 30 cm (6 to 12 in), and 30 to 60 cm (12 to 24 in). Including the three depths allows monitoring of leachable nutrients. Record the sampling locations and the soil conditions at sampling (temperature, moisture, crop cover).

Mix the samples from the same depth intervals, creating one large sample for each of the three depth intervals. Remove about 0.5 kg (1 lb) from each large sample. Submit each of the 0.5 kg sub-samples to a commercial lab for analysis.

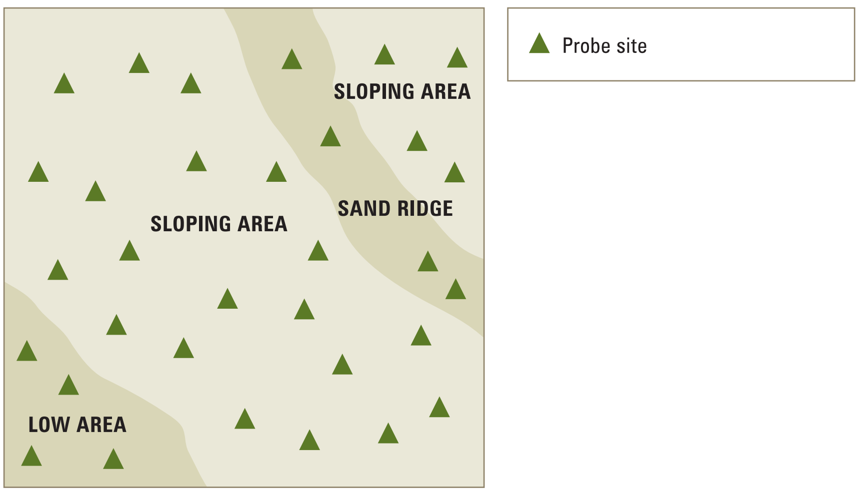
## Soil Sampling Strategies

### Whole Field Composite Sampling

Take 20 to 30 cores from representative locations throughout the field (Figure 3.1). Mix the cores together, and submit about a 0.5 kg (1 lb) sub-sample for each of the three depth intervals.

FIGURE 3.1

WHOLE FIELD COMPOSITE SAMPLING

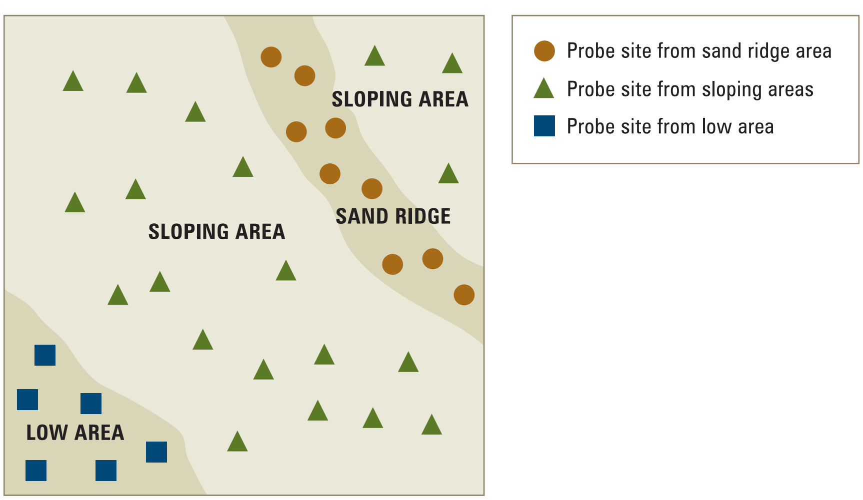



### Landscape-Directed Sampling

Divide the field into several areas based on such factors as soil characteristics, management history, yield potential or slope position. Take a set of samples from each of the areas (Figure 3.2). Additional resources are used to develop the sampling design such as: land use history, yield maps and yield history, air photographs, and soil survey information.

FIGURE 3.2

LANDSCAPE-DIRECTED SOIL SAMPLING

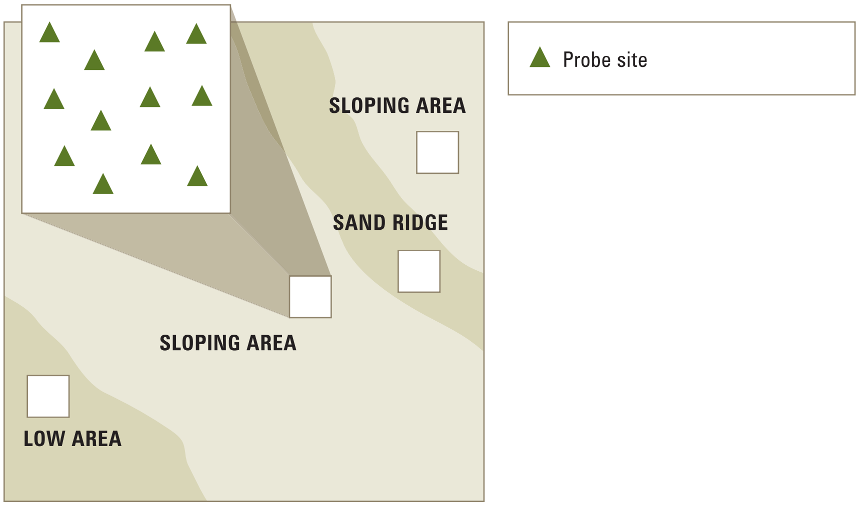


### Benchmark Sampling

Divide the field into several areas based on such factors as soil characteristics, management history or yield potential. Take 15 to 20 samples from each area in a location that is representative of that area of the field (Figure 3.3). Sample at the same locations each year. For each area of the field, mix the samples from the same depth interval.

FIGURE 3.3

**BENCHMARK SOIL SAMPLING**

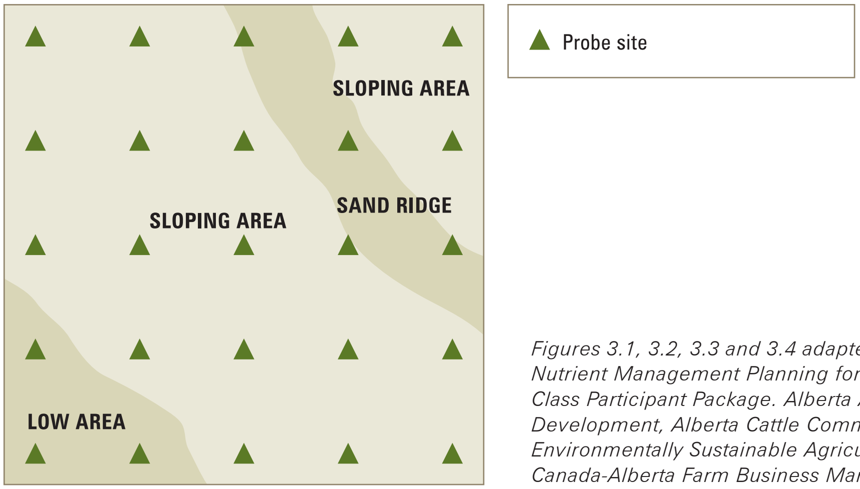



### Grid Sampling

Sample soils at regular intervals throughout the field (e.g. every 100 m) (Figure 3.4). Do not mix the cores together. For most producers, the large number of samples required in this approach is not justified in terms of the economic returns.

FIGURE 3.4

**GRID SOIL SAMPLING**




*Figures 3.1, 3.2, 3.3 and 3.4 adapted from: McNeil et al. 2002. Nutrient Management Planning for Livestock Production: Class Participant Package. Alberta Agriculture, Food and Rural Development, Alberta Cattle Commission, Alberta Environmentally Sustainable Agriculture Program, and Canada-Alberta Farm Business Management Program.*

**Testing**

Soil test reports provide soil nutrient results and recommend fertilizer rates. The lab will test for the nutrients you specify. You can also ask for tests to assess specific soil concerns, such as levels of salt or heavy metals.

The lab's fertilizer recommendations are based on the soil nutrient levels as well as such factors as the location of the field, previous crop, intended crop, expected yield, and soil moisture content. For more information on nutrient application rates, see Section 3.6.

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD), *Crop Nutrition and Fertilizer Requirements* (AAFRD) and *Alberta Fertilizer Guide* (AAFRD), or contact your local fertilizer dealer.

## 3.1.2 Sampling and Testing Manure

The nutrient content of manure can vary greatly depending on the type of animal and how the animal is managed as well as on manure handling and storage practices. Manure sampling and testing is used to determine the manure's actual nutrient content, determine the appropriate application rate, and identify what other nutrients may be required by the crop.

**Sampling**

The best time for sampling is during loading or land application. Submit the sample for analysis as soon as possible after sampling. Generally, a sample of about 5 lb (2.25 kg) from the possibly hundreds of tons of manure is sent for analysis. (See box for sampling procedures.)

Manure sampling and testing is used to determine the manure's actual nutrient content.

*Courtesy of PAMI*

### Sampling Liquid Manure

1. Take samples each time the storage is emptied because the nutrient status varies with the time of year.
2. Agitate the storage completely before sampling.
3. Collect the sample from various depths as the storage is being emptied because the nutrient status varies with depth. Thoroughly mix 10 to 20 samples from each depth and transfer a portion to a plastic jar. The jar should be only half full to avoid gas buildup and potential explosion.
4. Seal the container tightly, and store it in a cool place.
5. Label the sample, including name, date and storage identification.
6. Submit the sample to the lab within 24 hours.

### Sampling Solid Manure

1. Sample manure each time the storage is emptied until a trend is evident in the results. Then sample every few years or when a change in management occurs (e.g. bedding, storage).
2. Remove the crust to sample the pile.
3. Take a sample (using a pitchfork, for example) from various parts of the pile. Try to take into account visible variations in bedding and moisture content.
4. Place the samples on a clean cement pad or plywood. Chop the samples with a shovel or fork, and mix the samples as thoroughly as possible. Divide the manure into four portions and discard three.
5. Continue dividing and mixing the manure until you can fill a half-litre shipping container.
6. Store the sample in a tightly sealed container in a cool place.
7. Label samples, including name, date and storage identification.
8. Submit the sample to the lab within 24 hours

*Adapted from: McNeil et al. 2002. Nutrient Management Planning for Livestock Production: Class Participant Package. Alberta Agriculture, Food and Rural Development, Alberta Cattle Commission, Alberta Environmentally Sustainable Agriculture Program, and Canada-Alberta Farm Business Management Program.*

## Testing

Alberta labs that test manure are listed on the ManureNet website (http://res2.agr.gc.ca/initiatives/manurenet/manurenet_en.html). Samples should be tested for moisture content (solid manure), total nitrogen, ammonium nitrogen, and total phosphorus. If the soil has other nutrient deficiencies, you can test the manure to see how much of those nutrients it can supply. You can also request additional analyses such as: electrical conductivity (to determine salt content), sodium adsorption ratio, carbon:nitrogen ratio, pH and sodium.

Manure nutrient results should be on a wet (or "as is") basis because manure is spread wet. Manure test results should be in the same units as used when calibrating the manure application equipment (pounds or kilograms). Take special care when converting units. For information on determining manure application rates, see Section 3.6. You can also contact a qualified professional agrologist for more information and advice.

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD).

### 3.1.3 Record Keeping

Maintaining detailed records for your farm helps you assess your current techniques and refine them for better agronomic, economic and environmental performance.

Use your records to make management decisions.

*Courtesy of AAFRD*

Keep records by field and by year. Include all the practices used, the types, rates and dates of application of all inputs used, maps of soil sampling locations, results from soil and manure tests, the crop type and yield, details of any crop disease, weed and/or insect problems, and weather conditions. Keep your records up to date, and retain them for at least five years. Use your records to make management decisions.

See AAFRD's website for lists of software available for field record keeping (http://www.agric.gov.ab.ca/agdex/agsoft/soft205.html).

### 3.1.4 Farm Management Planning

Farm management planning helps farm families to consider and discuss their long-term goals for the family and the farming operation, and to determine the steps needed to reach those goals. It also enables farm families to put environmental considerations in the context of the whole operation.

Along with an overall management plan for the farm, many producers choose to develop plans focusing on specific elements of their operation. For example, an environmental farm plan helps producers to assess their environmental risks and develop a plan to address those risks, and a nutrient management plan helps producers determine the best way to manage nutrients.

## 3.2 Tillage and Seeding Practices

### 3.2.1 Conservation Tillage Systems

**Conventional tillage** systems use multiple tillage passes for weed control, fertilizer application, seed bed preparation and seeding. **Conservation tillage** systems reduce the amount and intensity of tillage.

**Conventional tillage systems can create a number of environmental problems such as:**

- increasing the rate of organic matter decomposition,
- drying out the soil,
- reducing the size and stability of soil aggregates, which increases the risk of compaction and crusting, and
- burying crop residues, which leaves the soil prone to erosion.

Conservation tillage systems include zero tillage, direct seeding and reduced tillage.

#### Direct Seeding and Zero Tillage

**Direct seeding** and **zero tillage** are cropping systems that aim to enhance soil quality and conserve soil moisture.

In a zero tillage cropping system, planting is the only operation that disturbs the soil. In general, not more than 40% of the soil surface is disturbed for seed and fertilizer placement. Many zero till farmers strive for less than 25% disturbance, and some zero tillage systems achieve as low as 10%. The amount of soil disturbance during planting varies with the type of opener.

In direct seeding systems, the soil is not tilled before planting. However, in contrast to zero tillage, direct seeding allows some soil disturbance to deal with special situations. These special instances may include some tillage in the seeding operation to solve immediate weed problems, harrowing to deal with soil crusting or excessive crop residues, or a fall fertilizer injection. Any fall soil disturbance must leave the soil surface level, minimize stubble knock-down and keep most of the crop residue on the surface, in order to conserve soil moisture and increase snow trapping.

➡ Direct seeding conserves soil moisture and improves soil quality.

*Courtesy of RTL*

**The advantages to reducing soil disturbance include:**

- soil moisture is conserved;
- fuel requirements and equipment wear-and-tear are reduced because fewer passes are needed to complete field operations;
- standing stubble is maintained, trapping snow for increased spring soil moisture and reducing erosion;
- weed seeds are less likely to grow on the undisturbed soil surface, and are more likely to be eaten by rodents, birds and insects; and
- soil erosion is reduced.

Direct seeding and zero tillage offer several other benefits over conventional tillage, such as improved moisture-holding capacity, improved yield potential, better fertilizer use efficiency, and less time spent on field operations. However, changing to these systems requires changes in management of crop residues, weeds and soil fertility. It may also require crop rotation changes to prevent specific pest problems that were previously kept in check by tillage. Some of these considerations are discussed in Sections 3.4 and 3.5.

### Reduced Tillage

**Reduced tillage** systems leave a crop residue cover to prevent erosion and conserve soil moisture. These systems also save time and energy, and costs are usually similar to or lower than those for conventional tillage systems.

Tillage is reduced by replacing some tillage operations for weed control with herbicide applications or by using tillage equipment that helps maintain a good residue cover (e.g. rodweeder).

### Minimizing the Impacts of Tillage

If you choose to till:

- avoid fall tillage so the crop residue cover is retained to trap snow and prevent soil erosion during the fall, winter and spring.
- replace deep tillage with shallow tillage to minimize disturbance of soil.
- reduce the number of tillage passes.
- reduce tillage speed.
- use implements that bury less residue (see Table 3.1).
- where possible, use contour tillage. Till and plant crops across the slope, rather than up and down the slope, to prevent runoff from eroding channels down the slope.
- avoid tillage when the soil is wet.

TABLE 3.1

**EFFECT OF TILLAGE EQUIPMENT ON CROP RESIDUE**

| IMPLEMENT | PER CENT OF RESIDUE COVER REMAINING AFTER ONE PASS |
|---|---|
| Moldboard Plow | 10 |
| Chisel Plow (less than 12-inch) | 50 to 70 |
| Sweeps (20-inch to 30-inch) | 80 |
| Blade (more than 30-inch) | 90 |
| Offset Disc | 50 |
| Tandem Disc | 60 |
| Harrow – springtooth | 65 |
| Harrow – steel Tooth (more than 12-inch) | 95 |

*Source: Timmermans, J. and Larney, F. 1998. An Introduction to Wind Erosion Control. Alberta Agriculture, Food and Rural Development, Agdex 572-2.*

### Conservation Fallow Systems

**Summerfallowing** can be defined as leaving a field without crop growth for a growing season. However, the term is often used to describe one particular type of summerfallow, called **conventional fallow**, in which the fallow field is tilled frequently. Fields may be left fallow during the growing season to control difficult weed problems, conserve soil moisture, increase short-term nutrient availability, and/or reduce the risk of residue-borne plant diseases.

**Conservation fallow** systems maintain plant residues on the soil surface to reduce soil erosion, while still providing weed control and soil moisture conservation during the fallow period. These systems include **reduced tillage fallow** where a combination of tillage and herbicides is used, and **chemfallow** where herbicides alone are used to control weeds.

Chemfallow provides protection against soil erosion.

*Courtesy of AAFRD*

In comparison to continuous cropping, both conventional and conservation fallow systems decrease organic matter levels over time because fewer plant residues are returned to the soil during fallow years. Fallow systems also increase the risk of nutrients being lost from the soil – emitted to the air or leached away – rather than being used by growing plants. In addition, they increase the risk of formation of saline seeps because soil moisture not used by plants may percolate down to the groundwater, carrying salts that can form a saline seep where the groundwater discharges.

Conventional fallow has additional negative impacts. The lack of crop residue cover leaves the soil vulnerable to erosion, and increases the risk of impacts on water quality, air quality and wildlife habitat from erosion. Tillage raises the soil temperature and increases soil aeration, leading to faster decomposition of soil organic matter. Excessive tillage can also result in crusting and poor soil moisture infiltration.

Therefore, if fields must be summerfallowed, use a conservation fallow system. If summerfallow is used to conserve soil moisture, a direct seeding or zero tillage system may allow summerfallow to be used less often because these tillage systems conserve soil moisture.

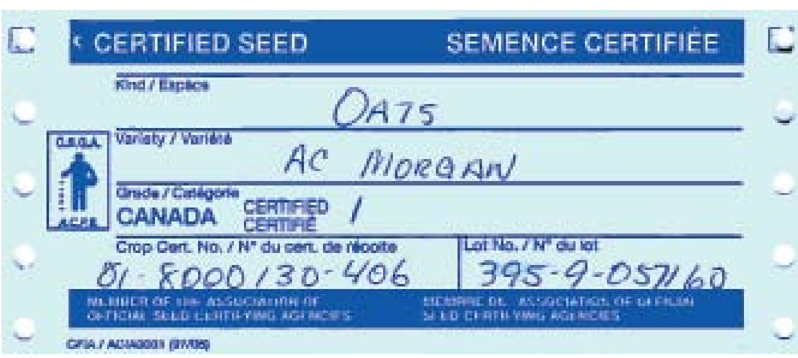
For more information, see Alberta Agriculture's Direct Seeding factsheet series available on its website (http://www.agric.gov.ab.ca), *No-Till: Making it Work* (AAFC), *Summerfallow and Soil Conservation* (AAFRD), or go to the Reduced Tillage LINKAGES' website (http://reducedtillage.ca/).

### 3.2.2 Seed Quality and Seeding Practices

Seed quality and seeding practices can help to reduce pest problems in crops. A healthy, vigorous crop stand is better able to withstand diseases and insect pests, and the crop emerges faster and covers the ground more completely, allowing it to compete more successfully against weeds.

**Seeding practices for healthy stands include:**

- Use new, plump, vigorous, high germination seed. Use certified seed if possible. Avoid cracked, split or damaged seed.
- Choose crop varieties that are resistant to common diseases in your area.
- Choose crop types that can outcompete problem weeds.
- Use a seed treatment to control seed-borne diseases in susceptible crops.
- Test seeds for disease.
- Use balanced fertilizer applications (see Section 3.6).
- Band fertilizer close to the seed so the young crop will have the advantage over weed seeds. However, avoid placing the fertilizer so near to the seed that it damages the plants.
- In direct seeding systems, seed shallowly where the soil is warmer.
- As much as possible seed at the optimum seeding time for the crop. Seeding too early or too late may reduce crop yields and quality.
- Ensure good seed-to-soil contact. In direct seeding, choose a ground opener that provides this in your soil and moisture conditions. Pack the soil after seeding to seal in moisture.
- Plant at the proper depth for the seed type.




➡ Good quality seed helps to produce healthy stands.

*Courtesy of AAFRD*

For more information, see *Seed Row Spacing and Seeding Rates in Direct Seeding* (AAFRD), *Ground Opener Systems* (AAFRD), Canada Grains Council's *Complete Guide to Wheat Management*, and the Flax Council of Canada's *Growing Flax*.

## 3.3 Erosion Control

In many cases, practices like reduced tillage or direct seeding are sufficient to control wind and water erosion. However, areas that are especially prone to erosion may require additional actions.

### 3.3.1 Water Erosion Control Structures

The following measures are used to control severe erosion problems such as **gullying**. For such problems, obtain technical advice to find the best solution for your situation.

**Grassed waterways** are broad, shallow channels designed to carry surface water without causing soil erosion. The grass cover slows the water flow and provides protection against the cutting action of water. The grass also helps trap sediments and other contaminants in the water.

Grassed waterways are broad, shallow channels.

*Courtesy of AAFRD*

**Lined channels** are a means of dropping water to lower elevations along steep parts of a waterway. The steep portions are precisely shaped and carefully lined with heavy-duty erosion control matting, a type of geotextile product. The lining is covered with a layer of soil and seeded to grass. The resulting channel is very resistant to erosion. Lined channels are appropriate for waterways that carry water only occasionally and have slopes up to 10%. Companies that sell geotextile products can provide detailed information on installation of their products.

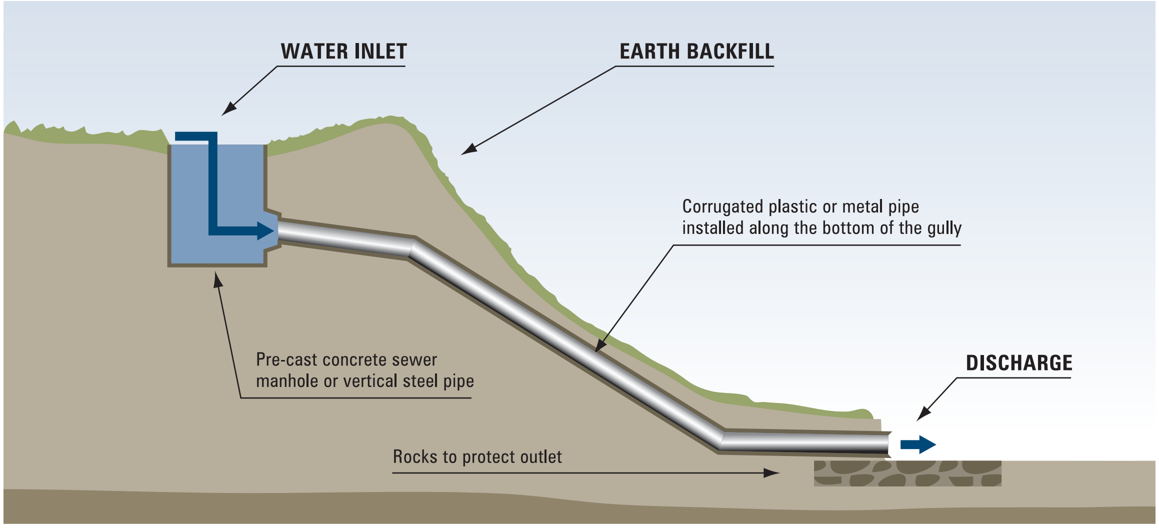
➡ Construction of a lined channel.

*Courtesy of AAFRD*

**Drop structures** are constructed along waterways to drop water to lower elevations without causing erosion (Figure 3.5). They are constructed of concrete, wood, metal or rock. Drop structures are the most costly but occasionally the most appropriate form of erosion control at specific locations along a waterway.

FIGURE 3.5

**DROP STRUCTURE**




*Adapted from: Vanderwel, D. and Abday, S. 1997. An Introduction to Water Erosion Control. Agriculture, Food and Rural Development, Agdex 572-3.*

For more information, see *An Introduction to Water Erosion Control* (AAFRD), *Watercourse Improvement and Gully Restoration* (AAFRD) and *Grassed Waterway Construction* (AAFRD).

## 3.3.2 Buffer Zones and Riparian Areas

A **buffer zone** is an area of land developed or conserved to reduce erosion, intercept contaminants and provide wildlife habitat along the side of a stream or lake. **Riparian areas** are lands adjacent to streams and lakes where the vegetation and soils are strongly influenced by the presence of water.

Healthy, well-vegetated buffer zones and riparian areas minimize impacts from runoff on streams and lakes by filtering out some of the soil particles and other contaminants before the runoff enters the water body. They also protect stream banks and lake shorelines from erosion, and they store water, help in recharging groundwater, reduce flood damage, and enhance fish and wildlife habitat.

Healthy buffer zones and riparian areas can remove up to 50% of phosphorus, 90% of sediment and 80% of nitrate runoff from fields before the runoff reaches the water body. In general, the wider the buffer zone, the more buffering it provides.

Buffer zones and riparian areas minimize impacts on streams and lakes.

*Courtesy of Cows and Fish Program*

To fulfil these functions, the buffer zone and riparian area must be well vegetated with a variety of plant types suited to the local conditions. If these areas are seriously damaged, for example by erosion or flooding, the damage should be repaired.

For more information, see *The Health of Our Water* (AAFC) or Cows and Fish's *Caring for the Green Zone*, or visit the Cows and Fish Program website (http://www.cowsandfish.org/).

### 3.3.3 Shelterbelts

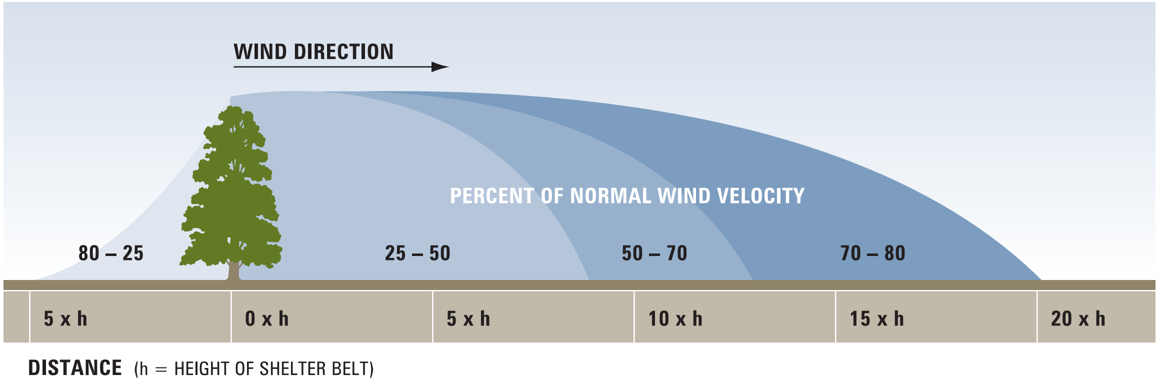
A shelterbelt is a barrier of trees or shrubs. **Field shelterbelts** are used to shelter agricultural fields, while farmstead shelterbelts are planted around farmyards or livestock facilities. Trees and shrubs are also planted in blocks for woodlots or wildlife habitat.

Field shelterbelts decrease wind erosion by reducing wind speeds for distances up to 20 times the height of the trees (Figure 3.6). They also trap snow for increased spring soil moisture, reduce wind damage to crops, decrease evaporation of soil moisture, and store carbon.

Shelterbelts are most effective when planted across the prevailing wind direction. For increased sheltering effects, the shelterbelts can be spaced more closely together; for maximum wind erosion control, plant the rows less than 200 m (660 ft) apart.

FIGURE 3.6

**APPROXIMATE REDUCTION OF WIND SPEED BY A SINGLE-ROW SHELTERBELT**




*Adapted from: Figure 1 in Timmermans, J. and Casement, B. 1994. Field Shelterbelts for Soil Conservation. Alberta Agriculture, Food and Rural Development, Agdex 277/20-3.*

To get the maximum benefit from your shelterbelts, you will need to design the belt, select species suited to your site, prepare the site for planting, control weeds for the first few years after planting, and do pruning, watering and other maintenance. New options for shelterbelt weed control – such as plastic, fabric or bark mulches – have reduced the effort required to establish shelterbelts. Manage shelterbelts for longevity; for example, if some of the trees in the shelterbelt die, they should be replaced.

➡ Multispecies shelterbelts reduce the risk of a single disease wiping out an entire shelterbelt system.

*Courtesy of Agriculture and Agri-Food Canada – PFRA*

For more information on planning, planting and maintaining field shelterbelts and to obtain trees, contact your local AAFC – PFRA office or your Agricultural Service Board. Shelterbelt publications include *Field Shelterbelts for Soil Conservation* (AAFRD), *Shelterbelt Planning for the Farm and Field* (AAFC), and *Weed Control for Alberta Shelterbelts* (AAFRD).

### 3.3.4 Strip Cropping

**Strip cropping** is the practice of alternating strips of crops with strips of fallow. The strips run along the contours of the land if the main purpose is to reduce water erosion. They go across the prevailing direction of wind if the main purpose is to reduce wind erosion. Crop residues on the fallow strips are retained with reduced tillage fallow or chemfallow. The strip width is based on the convenient width for equipment operation.

Strip cropping helps to reduce erosion on fallow land.

*Courtesy of AAFRD*

For more information, see *Strip Farming for Wind Erosion Control* (AAFC – PFRA).

### 3.3.5 Cover Crops

A **cover crop** for erosion protection is usually planted later in the growing season (e.g. early August) to provide enough leafy top growth to protect the soil. It may be planted just before a fallow year or after crops such as sugar beets, potatoes and beans that leave little residue cover.

Cover crops are typically spring cereals, which are inexpensive to seed, killed by freezing over the winter, and competitive with weeds in the fall but not competitive with the following crop.

Cover crops use some of the nutrients in the soil but only for a short time, and the used nutrients are cycled back through decomposition, becoming available to the subsequent crop. The amount of soil moisture used by the cover crop is small and comes from shallow depths, and it is usually replaced over the winter.

i For more information, see *Summerfallow and Soil Conservation* (AAFRD).

### 3.3.6 Emergency Wind Erosion Control

Wind erosion may still occur even if preventive measures are taken. Dry soil, poor snow cover, poor residue cover from low-yielding crops, and persistent strong winds make controlling erosion a formidable challenge.

Emergency controls are used when wind erosion is imminent or has started. The two basic types of emergency measures are: increasing the surface roughness of a field; and covering the soil with straw or manure.

➡ A straw crimper can be used to anchor straw for emergency erosion control.

*Courtesy of AAFRD*

Rows of square bales can be set at right angles to the wind.

*Courtesy of AAFRD*

For more information, see *Emergency Measures for Control of Wind Erosion* (AAFRD).

## 3.4 Cropping Rotations

Although growing a more varied crop rotation requires increased management skills, it can provide many rewards. For example, it helps to reduce diseases, insect pests and weeds in the rotation, in comparison to a cropping system that relies on one or two crops. As well, varied rotations can help to diversify the operation and widen the windows for seeding and harvesting, lowering the production risk.

Rotations can be selected to achieve a variety of objectives, such as to: help manage crop residues, make the most of available moisture, build organic matter, reduce nitrogen fertilizer inputs, vary herbicide types (to avoid creating herbicide-resistant weeds), and lower excessive levels of soil nutrients.

Table 3.2 provides information on the typical amounts of crop residues produced per bushel of grain when planning a rotation to manage residue amounts. For example, after growing a crop that produces very little straw, you may wish to grow a crop that produces more straw.

Cropping rotations can help to diversify the operation and widen the windows for seeding and harvesting.

*Courtesy of AAFRD*

TABLE 3.2

**TYPICAL AMOUNTS OF STRAW AND CHAFF PER BUSHEL OF GRAIN**

| CROP | SOIL ZONE | POUNDS OF STRAW PER BUSHEL OF GRAIN * | POUNDS OF CHAFF PER BUSHEL OF GRAIN ** |
|---|---|---|---|
| HRS Wheat | Brown | 50 | 20 - 25 |
| | Dark Brown | 65 | |
| | Black, Gray | 80 | |
| CPS Wheat | Brown | 40 | 20 - 25 |
| | Dark Brown | 50 | |
| | Black, Gray | 60 | |
| Barley | Brown | 30 | 5 - 10 |
| | Dark Brown | 35 | |
| | Black, Gray | 45 | |
| Oats | Brown | 30 | 5 - 10 |
| | Dark Brown | 35 | |
| | Black, Gray | 45 | |
| Canola | Brown | 40 | 15 - 20 |
| | Dark Brown | 50 | |
| | Black, Gray | 60 | |
| Peas | Brown | 40 | 20 - 25 |
| | Dark Brown | 50 | |
| | Black, Gray | 60 | |

* Amount of harvestable straw, assuming about 80% recovery in cereals, and 50% in peas and canola, with 2- to 4-inch stubble left.

** Amount of harvestable chaff, assuming little or no weed chaff.

*Adapted from: Hartman, M. 1999. Estimating the Value of Crop Residues. Alberta Agriculture, Food and Rural Development, Agdex 519-25.*

Crop rotations in drier areas can be designed to improve moisture use efficiency. A logical water-based rotation alternates shallow-rooted crops with deep-rooted crops and combines good agronomic and economic performance while making the most efficient use of water over a wide range of moisture conditions. Table 3.3 provides the average moisture use efficiency for four crops.

TABLE 3.3

**AVERAGE MOISTURE USE EFFICIENCY (BU/AC/IN) FOR FOUR COMMON CROPS**

| SOIL ZONE | WHEAT | BARLEY | CANOLA | OATS |
|---|---|---|---|---|
| Brown | 3.75 | 5.70 | 2.60 | 7.10 |
| Dark Brown | 4.00 | 6.20 | 2.80 | 7.75 |
| Black | 4.25 | 6.40 | 3.20 | 8.20 |
| Gray | 4.75 | 7.20 | 3.60 | 9.10 |

*Adapted from: EnviroTest Laboratories, Soil Climate Zones of the Canadian Prairies.*

### 3.4.1 Continuous Cropping

In **continuous cropping**, crops are grown every year with no fallow years in between. As noted in Section 3.2, summerfallow decreases soil organic matter content and soil quality in most situations. Where summerfallowing is used to conserve soil moisture, direct seeding and reduced tillage systems may allow summerfallow to be used less often because these systems conserve soil moisture by reducing evaporation and increasing infiltration.

Rotations benefit all crops in the rotation. For example, wheat or barley grown after peas or canola usually performs better by about 10 to 20% than a cereal grown after a similar cereal crop.

In annual crop rotations, it is best to avoid planting a field with the same crop two or more years in a row. Alternating long-season crops with short-season crops can improve weed control because pre-seeding and in-crop herbicides can be applied earlier or later in the spring. Also, a short-season crop may be harvested early enough to allow the seeding of winter wheat or fall rye, which can take advantage of early spring moisture (see Section 3.4.2).

Rotating cereals with broad-leaved crops, such as oilseeds or pulses, allows weeds to be controlled with herbicides from different herbicide groups, reducing the risk of developing herbicide resistance. This type of rotation can also break the cycles of most diseases, except for those diseases that remain dormant in the soil or persist on crop residues for long periods.

i For more information, see *Crop Rotations in Direct Seeding* (AAFRD).

### 3.4.2 Fall-seeded Crops

Like any crop, fall-seeded crops have their challenges, but they can be a valuable part of a crop rotation, providing a range of agronomic and environmental benefits. Fall-seeded crops grown in Alberta include winter wheat, winter triticale and fall rye.

Fall-seeded crops provide erosion protection during fall and winter, especially if the crop is seeded into stubble. The stubble also traps snow that insulates seedlings against cold temperatures and increases spring soil moisture. As well, a fall-seeded crop seeded into stubble can provide spring nesting cover for waterfowl and other ground nesting bird species.

Fall-seeded crops also help in reducing pest problems. For example, seeding a fall cereal into stubble from broad-leaved crops, such as canola, mustard and peas, reduces the risk of insect, disease and weed problems developing in the rotation. Fall-seeded crops are also able to outcompete some weeds that emerge in spring, reducing the need for herbicides.

Although these crops can suffer winterkill and be damaged by spring frosts, they are better able to take advantage of early spring moisture than spring-seeded crops. And when spring weather conditions delay seeding, the fall-seeded crop is already in place. Since these crops mature earlier than spring-seeded crops, they may avoid damage from late summer droughts or frosts. In addition, the earlier seeding and harvesting dates for these crops help to spread out the farm workload and to increase marketing options.

For more information, see *Direct Seeded Winter Wheat* (AAFRD), *Winter Wheat in the Parkland Area of Alberta* (AAFRD) and *Fall Rye Production* (AAFRD).

### 3.4.3 Perennial Forages

Perennial forages in long-term rotations help to build up soil organic matter, prevent wind and water erosion, and to reduce pest problems in subsequent crops. Several years of forages break some disease and insect cycles, and help to control perennial and annual weeds as long as the forage stand is healthy and vigorous. Weed control is improved if the forage crop is harvested as hay or silage since the weed seeds are often not yet viable at the time of cutting.

Perennial forages protect and improve the soil.

*Courtesy of AAFRD*

Hay, pasture, and grass seed crops can be grown in rotations for varying lengths of time. The longer the forage cycle, the lower the cost of rotating into and out of forages in a rotation with annual crops. However, when the forages include legumes, particularly alfalfa, the marginal benefit to subsequent crops decreases after the stand is three years old.

Forages can be successfully established by direct seeding. The higher soil moisture content in direct seeded fields allows these small-seeded crops to be seeded near the soil surface for better germination and emergence. A cover crop can be used to protect an establishing forage crop. To improve forage establishment and to decrease competition for nutrients, light or water, it is best to remove the cover crops as greenfeed or silage.

Methods to remove forages and the choice of crop to be seeded after forage cycle depend on the type of forage stand. Terminating forage stands using herbicides and then direct seeding an annual crop is a recommended practice.

For more information, see *Alberta Forage Manual* (AAFRD), *Crop Rotations in Direct Seeding* (AAFRD), and *Removing Forages from the Rotation in a Direct Seeding System* (AAFRD).

### 3.4.4 Permanent Cover

**Permanent cover** refers to forage, grass or tree cover. Areas at high risk for such problems as erosion or soil salinity are usually better suited to permanent cover than annual crops because permanent cover protects the soil all year long, year after year. In addition, permanent cover enhances soil organic matter, carbon storage and wildlife habitat.

**Lands benefiting most from permanent cover include the following:**

- Areas with steep slopes or very erodible soils can be used for forage production.
- Wooded areas with poor soils and steep slopes can be managed as woodlots.
- Non-irrigated corners of pivot-irrigation fields tend to be focal points for wind erosion. Growing forages or grass on these corners reduces erosion.
- In areas prone to soil salinity, both the recharge areas and the discharge areas benefit from permanent cover.

### 3.4.5 Green Manuring

**Green manuring** is the practice of growing a short-term crop to improve soil tilth, add organic matter and nutrients (especially nitrogen) to the soil, and reduce erosion by providing soil cover. After eight to 10 weeks of growth, the green manure crop is worked into the soil, desiccated with herbicides, or hayed. If a green manure is allowed to grow too long, it will deplete the soil moisture reserve for the next year.

While almost any crop may be used as a green manure crop, annual legumes, such as peas and lentils, or biennial legumes, such as sweet, red or alsike clover, are preferred because these crops can fix nitrogen; that is, with the help of *Rhizobium* bacteria, taking nitrogen from the air and convert it into a form that plants can use.

Tilling down the crop returns most of the fixed nitrogen to the soil. However, it is important to leave some of the crop residues on the soil surface to reduce the risk of soil erosion. Desiccating or haying the crop returns about 60% of the plant material and nitrogen to the field, so these options provide almost as much nitrogen benefit as tilling down the crop. Desiccating the crop maintains a crop residue cover to reduce erosion and enhance snow trapping over the winter. Haying the crop also leaves stubble to prevent erosion and trap snow, and it offers the added advantage of economic returns from the hay.

Green manures add organic matter and nutrients to the soil.

*Courtesy of AAFRD*

A well managed green manure crop boosts the yield of a subsequent cereal crop. Over the long term, the practice of green manuring will improve soil organic matter content and productivity. In addition, a well established cover crop can provide good weed control. Sweet clover and its residues maintain excellent weed control without cultivation or herbicide applications into the year following the green manure crop.

For more information, see *Legume Green Manuring* (AAFRD).

## 3.5 Crop Residue Management

Crop residues include straw, chaff and roots. Crop type, variety and yield influence the amount of crop residue produced (Table 3.2). Crop residues can benefit a crop production system, but straw and chaff require proper management.

### 3.5.1 Spreading Crop Residues

Retaining the straw and chaff on the surface of a field offers many benefits. These include increased snow catch and water infiltration, reduced evaporation, increased soil organic matter, improved soil structure and plant nutrient cycling, decreased erosion, and reduction of some weed species.

In direct seeding, crop residues must be spread evenly to avoid or reduce such problems as: equipment plugging; poor seed germination; disease, weed and insect infestations; nitrogen tie-up in the chaff or straw rows; and cold soil.


The most practical way to manage crop residues is with the combine.

*Courtesy of RTL*

**Key techniques to manage residues in direct seeding systems include the following:**

- The most practical way to manage chaff and straw residue is with the combine.
- Residue should be spread uniformly over the entire width of the header cut.
- Harrowing can spread straw but not chaff.
- If harrowing, it is better to harrow in the fall before the straw settles.
- Increased residue clearance of direct planting equipment is crucial.

For more information, see *Residue Management for Successful Direct Seeding* (AAFRD), *Equipment Issues in Crop Residue Management* (AAFRD) and *Managing Crop Residues on the Prairies* (AAFC).

### 3.5.2 Removing Straw and Chaff

The value of straw and chaff differs greatly from area to area. Deciding whether to sell straw for short-term economic returns or to retain straw on a field to sustain long-term soil productivity can be difficult. Consider the following factors in your decision:

- If the risk of wind or water erosion is moderate to severe, do not remove straw.
- Do not remove straw in drought-prone areas.
- Chaff removal is an option in many areas because chaff does not have much erosion control benefit and is a source of weed seeds.
- If the soil is low in organic matter, retain crop residues.
- Crop residues contain economically significant amounts of macronutrients. However, the actual nutrient contents vary greatly. Test samples for an accurate assessment.

For more information, see *Estimating the Value of Crop Residues* (AAFRD).

### 3.5.3 Handling Difficult Residue Conditions

High crop yields and unusual weather often leave hard-to-handle crop residue conditions such as crops not harvested due to hail, severe frost or other damage, lodged or snow-flattened crops and crops producing heavy residues such as viny pea crops, sunflowers and flax.

**Options for managing residues in these difficult conditions include:**

- **Harrowing:** Harrows spread straw, press loose straw into the soil surface, and disperse straw clumps. This reduces plugging in direct seeding planters.
- **Mowing:** Even very heavy residue or very tall standing stubble is not usually a problem if it is mowed or shredded. However, mowing can be expensive.
- **Tillage:** If you decide to till, then you must use enough tillage to mix the straw into the soil so that the planter's ground openers will work without plugging. The first tillage pass after harvest leaves a very poor seed bed condition. Tillage should be followed by harrows or packers to reduce soil moisture loss. Waiting until spring to till allows the residues to break down over the winter.
- **Baling:** Baling is an option for handling excessive residues.

Harrows can spread straw to reduce plugging in direct seeding planters.

*Courtesy of AAFRD*

For more information, see *Handling Difficult Crop Residue Conditions* (AAFRD).

## 3.6 Nutrient Management

Plants require nutrients in certain amounts, depending on the specific crop. The soil can provide some of these nutrients (Figure 3.7), but additional nutrients usually need to be applied. If insufficient nutrients are supplied, crop yields will drop. However, application of excess nutrients poses a threat to the environment. **Matching nutrient levels to crop demand protects the environment and maximizes the benefit of supplying valuable nutrients to crops.**

The total amount of plant nutrients removed from the soil by a crop depends on the yield: the greater the yield, the greater the amount removed. Based on equal seed yields per unit area, whole barley, wheat and oat plants extract about the same combined quantities of nitrogen, phosphorus, potassium and sulphur from the soil, but considerably less than canola (Table 3.4). When only the seed is removed, and all straw is left on the field, barley removes slightly more nutrients from the soil than oats but less than wheat or canola.

TABLE 3.4

NUTRIENTS USED BY CROPS (KILOGRAMS PER HECTARE)*

| CROP | CROP PART | NITROGEN | PHOSPHORUS ($P_2O_5$) | POTASSIUM ($K_2O$) | SULPHUR |
|---|---|---|---|---|---|
| Wheat (3225 kg/ha or 48 bu/ac) | Seed | 79 | 32 | 21 | 5 |
| | Straw | 32 | 7 | 64 | 8 |
| | Total | 111 | 39 | 85 | 13 |
| Barley (3225 kg/ha or 60 bu/ac) | Seed | 65 | 24 | 22 | 5 |
| | Straw | 34 | 9 | 73 | 8 |
| | Total | 99 | 33 | 95 | 13 |
| Oats (3225 kg/ha or 84 bu/ac) | Seed | 58 | 24 | 17 | 8 |
| | Straw | 40 | 15 | 70 | 10 |
| | Total | 98 | 39 | 87 | 18 |
| Canola** (3225 kg/ha or 57 bu/ac) | Seed | 120 | 57 | 29 | 21 |
| | Straw | 70 | 26 | 121 | 17 |
| | Total | 190 | 83 | 150 | 38 |

* To convert kg/ha to lb/ac, multiply by 0.89.

** Canola yield is extremely high, but to make the comparison, it was left at the same weight as the other grains.

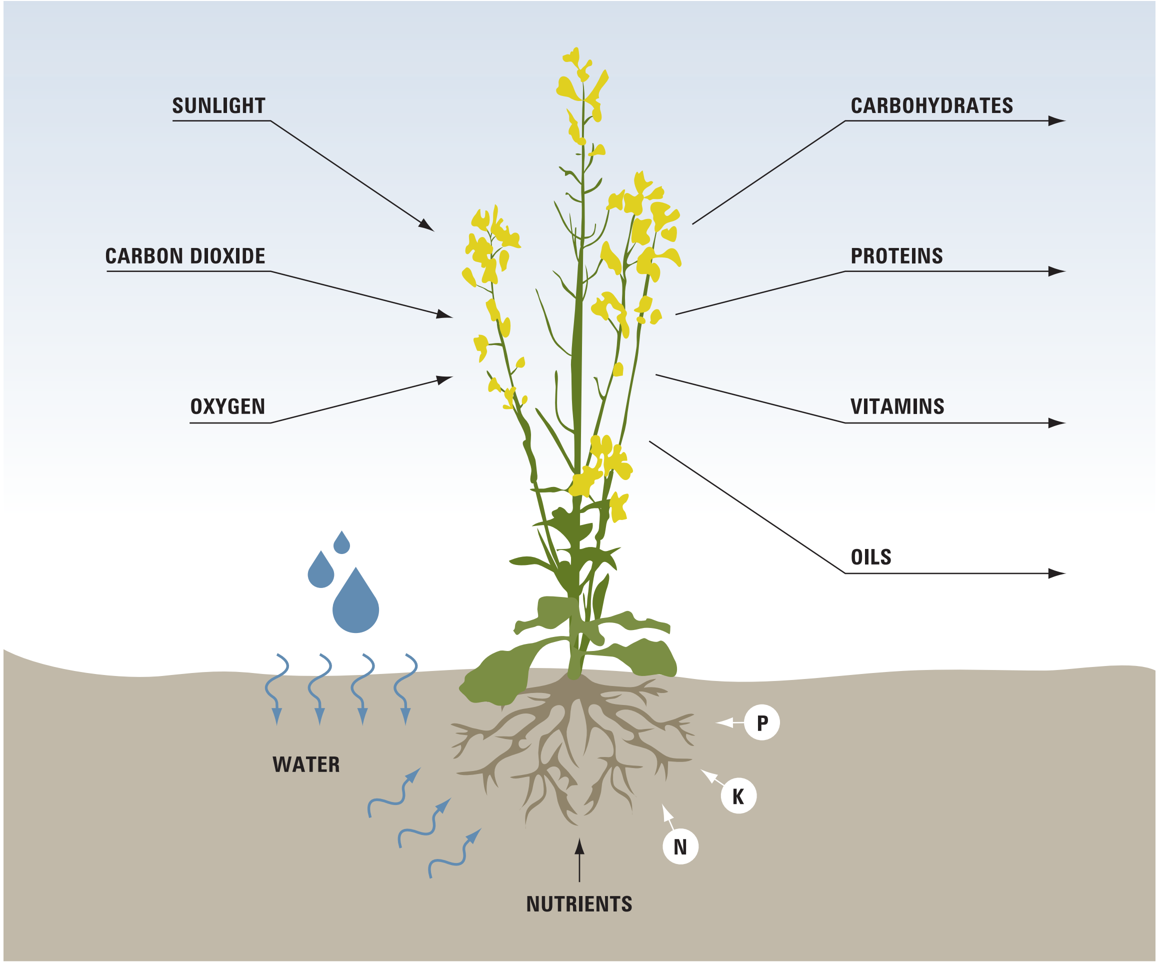
*Source: Western Canada Fertilizer Association,* in *Penney, D. 1998. Fertilizer Requirements of Cereals. Alberta Agriculture, Food and Rural Development.*

**Organic fertilizer** is fertilizer from organic sources, including manure, compost, decaying plant matter and sewage sludge. These fertilizers add organic matter to the soil and supply needed nutrients. Organic fertilizers release nutrients slowly over several years. These fertilizers may contain pathogens that can contaminate water sources. Overapplication of these fertilizers can increase the amount of salt in the soil. Organic fertilizers may not precisely meet the crop's nutrient requirements, and so you may need to supplement an organic fertilizer application with commercial fertilizers.

**Commercial fertilizer**, also called inorganic fertilizer, is manufactured from non-renewable resources. The nutrient content of these fertilizers is known and consistent, unlike organic fertilizers. Commercial fertilizer can be applied evenly and accurately, and nutrients can be applied at the rates required by the crop.

FIGURE 3.7

**GREEN PLANTS CONVERT LIGHT, WATER, AIR AND PLANT NUTRIENTS INTO FORMS USEFUL TO PEOPLE AND ANIMALS**




*Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food. 1994. Best Management Practices: Nutrient Management. Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food. p. 2.*

Crop residues are also a source of nutrients. Retaining crop residues on the field allows part of the nutrients taken up by the crop to be returned to soil. Nitrogen fixed from the air by legume crops, especially forage legumes, can add significantly to the supply of this nutrient in soil. Residues from cereals and grasses tend to be lower in nitrogen. Because soil microorganisms require nitrogen to break down these residues, the supply of nitrogen available to crops can be temporarily reduced when large quantities of crop residues are returned to the soil.

All agricultural operators must manage nutrients in accordance with the standards in the *Agricultural Operation Practices Act* (AOPA). Your first step is to ensure that your operation meets these standards (see Section 9.1.1); BMPs take your operation beyond these basic requirements.

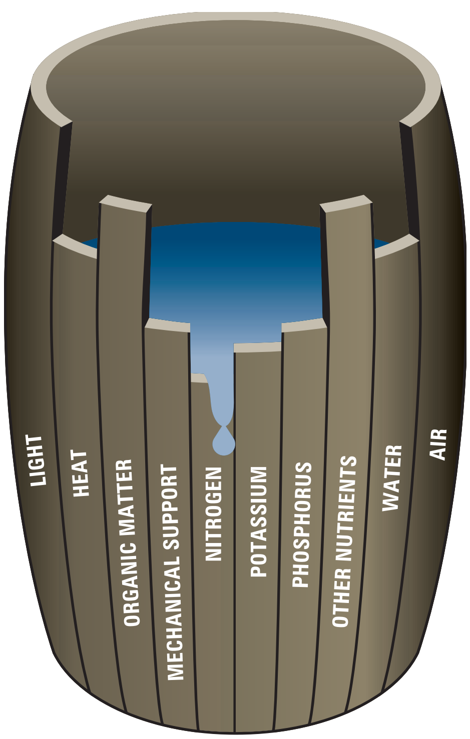
## 3.6.1 Nutrient Management Planning

**Nutrient management planning** aims to optimize crop yield and quality, minimize fertilizer input costs, and protect soil and water. It focuses on applying the right amount of the right product in the right place at the right time. This involves setting realistic target yields, choosing the correctly balanced blend of nutrients, placing the nutrients as close to the growing plant as possible without damaging the plant, and applying the fertilizer as close as possible to the time the plants need the nutrients.

Nutrient management planning uses a balanced fertility perspective, considering the amounts of all nutrients in the soil and the crop's requirements (Figure 3.8). Basing fertilizer recommendations on only one nutrient results in unbalanced soil fertility. Calculating and applying the appropriate amount of each nutrient is called **balanced fertility**.

FIGURE 3.8

**PLANT GROWTH IS DETERMINED BY MOST LIMITING GROWTH FACTOR**




*Adapted from: Agriculture and Agri-Food Canada. 2000. Nutrient Management Planning. Water Quality Matters Factsheet series.*

Balanced fertility increases nutrient use efficiency, thereby reducing the risk of nutrient loss to the environment. A slight deficiency in one nutrient can affect the plant's ability to take up another nutrient. This results in unused nutrients that may be susceptible to leaching, runoff or gaseous losses. A well-fed crop produces a healthier, more extensive root system able to explore a greater area in search of nutrients and water. This results in more efficient extraction of nutrients and water, and because a higher yield is produced with the same amount of water, crop water use efficiency is improved.

Balanced fertility management also reduces erosion potential. The crop grows faster so the soil surface is covered more rapidly. In addition, more biomass is produced so more crop residues can be left behind to protect against erosion.

**The eight steps to the nutrient management planning process are:**

1. Know the regulations that apply to your operation.
2. When using manure, test the manure for its nutrient content (nitrogen, phosphorus and potassium), and know the amount you will be applying.
3. Test the soil in your fields to determine nutrient levels, soil EC and soil pH.
4. Follow the soil test recommendations to meet your crop's nutrient requirements based on the soil test results, crop to be grown and expected yield.
5. When applying both manure and commercial fertilizer to a field, determine the rates of both to achieve balanced fertility.
6. If you are going to apply manure, prioritize your fields for manure application suitability (see box).
7. Calibrate your fertilizer application equipment.
8. When applying manure, take into consideration options to reduce odour nuisance for neighbours.

### Prioritizing Fields for Manure Application

You may have one or more fields suitable for manure applications. It is important to consider several factors when comparing manure management options. For example, there may be some negative impacts to the environment on fields with higher nitrogen leaching or runoff potential.

The following check list provides some of the field characteristics that you should consider when selecting fields suitable for manure applications.

- Soil test N
- Soil test P
- Crop N requirement
- Leaching potential
- Erosion potential
- Runoff potential
- Slope
- Distance to water bodies

Rank each of the factors for the suitable fields with a relative ranking of low or high. Fields with a higher number of factors ranked low would get manure applied first.

For more information, see *Nutrient Management Planning* (AAFC), *Nutrient Management Planning for Livestock Production* (AAFRD), and *Alberta Fertilizer Guide* (AAFRD).

### 3.6.2 Reducing Nitrogen and Phosphorus Losses

Losses of nitrogen and phosphorus from the soil through erosion, leaching or gaseous emissions can have serious environmental impacts (see Chapter 4) as well as economic impacts due to the loss of valuable crop nutrients.

**BMPs to reduce losses of nitrogen and phosphorus include:**

- Develop and implement a nutrient management plan.
- Soil test annually to determine the soil's nutrient levels.
- Manage the four main aspects of nutrient application – application rate, application timing, application method and nutrient form
  1. The **application rate** is determined by taking into consideration soil test results, crop requirements and having realistic yield goals.
     - Set yield goals based on such factors as anticipated growing conditions when determining crop nutrient requirements. If the yield potential turns out to be higher than expected, you may be able to apply additional nitrogen later.
     - Based on the soil test recommendations, apply fertilizers to balance all nutrients to meet the crop's needs and anticipated moisture availability.
     - If the soil test shows excessive nitrate levels, reduce the nitrogen application rate to draw down nitrate reserves in the soil. If soil phosphorus levels are excessive, reduce phosphorus applications so crop uptake will draw down the phosphorus levels, or grow crops such as alfalfa or grass hay that remove significant amounts of phosphorus.
     - Avoid overapplication.
  2. **Application timing** is crucial to maximize efficiency and reduce potential environmental hazards.
     - When possible, apply nitrogen in the spring just before or during seeding. Avoid applying large amounts in late summer, fall or winter.
  3. The **application method** can affect nutrient use efficiency and nutrient losses.
     - Incorporate solid manure or inject liquid manure.
     - Band nitrogen to the side of the seed row, rather than broadcasting. If placing nitrogen directly in the seed row, make sure you are using rates that will not damage the seed.
     - Band phosphorus with the seed or to the side of the seed row, because of its low mobility, for efficient crop utilization. Use caution when applying high rates of phosphorus directly with the seed because these rates may cause crop damage.
  4. The **nutrient form** affects how much of the nutrient is available to the crop. Chemical and physical properties differ among commercial fertilizers. The availability of nutrients in organic nutrient sources, such as manure, is controlled by microbial processes.
- Check the fertilizer application equipment at least once per job to make sure it is working properly and is properly calibrated.
- Avoid applying nitrogen to wet areas.
- Take measures to prevent soil erosion (see Section 3.3).
- Decrease the amount of summerfallow land.
- Leave a buffer zone around lakes, streams and wells that meets or exceeds AOPA's setback requirements. Do not apply manure or commercial fertilizers to the buffer.

Banding reduces losses of valuable nutrients.

*Courtesy of RTL*

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD) and *Nutrient Management Planning* (AAFC). Consult a professional agronomist or crop specialist for advice on nutrient management.

### 3.6.3 Manure Application

Manure can provide organic matter and nutrients, but it must be properly managed. Overapplication can lead to problems such as contamination of water sources with nutrients and pathogens, emission of odours and greenhouse gases, nutrient loading in the soil leading to crop lodging and lower yields, and salt accumulation resulting in poor yields.

Testing soil and manure to determine their nutrient levels is the only way to be sure about how much manure to apply. Remember that some nutrients are released only gradually from manure and other organic fertilizers.

AOPA provides regulations for manure application and storage; BMPs take your operation beyond the basic requirements set by AOPA.

**BMPs for manure applications:**

- Develop and implement a nutrient management plan.
- Determine manure application rate based on:
  - soil and manure tests,
  - the crop to be grown, and
  - realistic yield goals.
- Use commercial fertilizers to supplement the nutrients supplied by manure.
- Incorporate solid manure as soon as possible, preferably within 12 hours, or inject liquid manure. Incorporation considerations should include measures to reduce soil erosion.
- Check the manure spreader at least once per job to make sure it is working properly and is properly calibrated.

- Apply manure uniformly.
- Rank fields by their suitability for manure application.
- Don't apply manure or other fertilizers on frozen ground.
- Apply manure in the spring if possible.
- Leave a buffer zone around lakes and streams, and do not apply manure or other fertilizers to the buffer.
- Ensure that the regulations for minimum setback distances from water bodies are met (see Section 9.1.1). If site-specific conditions (such as a high runoff potential) indicate that contamination may occur with the minimum setback distance, increase the distance.
- Compost manure and other organic fertilizers to reduce the amount of material that needs to be applied and to reduce transportation costs.
- Monitor potassium, calcium and magnesium ratios in forage grown on manured soils to prevent grass tetany and milk fever in livestock. Watch for high nitrate levels in annual cereal greenfeed or silage on heavily manured soils. Problem feeds should be diluted to safe levels.

i For more information on manure management, see *Nutrient Management Planning for Livestock Production* (AAFRD) and *Beneficial Management Practices: Environmental Manual for Feedlot Producers in Alberta* (Alberta Cattle Feeders' Association and AAFRD, http://www.agric.gov.ab.ca/livestock/beef/bmp/bmp_feedlot.html). Refer to AOPA for manure management regulations. Consult a professional agronomist or crop specialist for advice on nutrient management.

## 3.7 Pest Management and Pesticides

### 3.7.1 Integrated Pest Management

Crop pests include plants, insects, birds, mammals and diseases that reduce crop yield and/or quality. **Integrated pest management** (IPM) involves using a combination of control methods (cultural, biological, chemical and mechanical) in a program that is both economically and environmentally sound. IPM considers the overall management of a pest species, not just the control measures used during destructive outbreaks. The objective of IPM is to prevent pest outbreaks.

**This pest management system offers a variety of advantages compared to using a single management tool to control a pest including:**

- fewer pesticide applications, resulting in more efficient use of inputs such as pesticides, fuel, water and time.
- less potential impact on soil, water and non-target species of fish, wildlife and insects.
- more stability in the pest complex with the potential of fewer emerging problems because competitors and beneficial species are not eliminated.
- no loss of quality or yield in the long term.

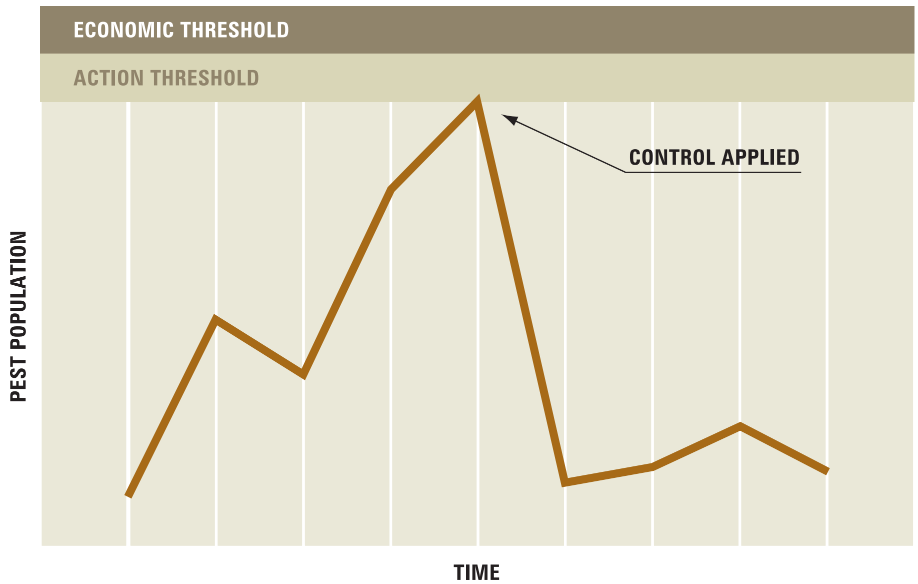
However, IPM presents some challenges. It requires a greater understanding and long-term commitment on the part of farmers. Farmers must be willing to keep up to date with research findings and monitoring techniques, and keep complete records. On some crops, IPM principles require a more complete, longer-term focus to make economic sense. There may be some added expenses for monitoring equipment, field scouting and consultants. And IPM programs are not always easily transferred from area to area because of variations in climates and pest complexes.

**IPM has four basic steps:**

1. Identify the pest and use pest control methods that focus on prevention of outbreaks.
2. Monitor pest and beneficial species populations, and use **economic thresholds** (Figure 3.9) for implementing control measures.
3. Choose control options, implement them when thresholds indicate control is needed, and assess their effectiveness.
4. Keep records of all pertinent data and results.

FIGURE 3.9

**THRESHOLD LEVELS FOR PEST CONTROL**




*Adapted from: Agriculture and Agri-Food Canada. 2000. Pest Management and Water Quality. Water Quality Matters Factsheet Series.*

### Threshold Identification

Two pest threshold levels are identified in an IPM system. The first is the economic threshold, which occurs when pest density causes damage equal to the cost of control measures. The second is the action threshold, which is defined as the pest density when control measures should be applied. The action threshold is lower than the economic threshold to allow time for treatment to take effect.

## Pest Control Methods

### Cultural control:

- Manage the crop for a vigorous, healthy stand that is better able to withstand pests.
- Choose pest-resistant varieties.
- Use rotations to reduce or eliminate the conditions the pest needs to thrive.
- Varying planting and harvest dates can help to prevent certain pest problems.

- Eliminate materials or places where pests live and reproduce by:
  - purchasing clean, treated seed.
  - cleaning all tillage, seeding and harvesting equipment between fields.
  - removing contaminated crop residue.
  - removing nearby plant species that can act as alternate hosts for diseases or insects.
- Use trap strips to draw the pest's attention away from the crop (see box).
- If possible, leave strips of a forage or hay crop standing when harvesting (called strip harvesting). This will prevent the migration of pests to another field, preserve natural enemies of pests and improve snow management.

**Biological control:**

- Use an introduced agent (insect, pathogen) to control the pest.
- Introduced pest has to be established in sufficient numbers to be effective.
- Avoid pesticides that will kill the introduced agent.

**Mechanical control:**

- Mowing, tilling, grazing and hand pulling can be used to control weeds.
- Silage weedy fields to stop the weeds from going to seed.

**Chemical control:**

- Select and apply pesticides according to label instructions to minimize harmful effects on non-target species and to reduce environmental hazards (see Section 3.7.2).

**Trap Strips**

Trap strips are strips of crops grown around the main crop to draw insects away from the main crop. The pest can be more easily controlled while it is contained in a concentrated strip.

Typically the timing of the trap crop's growth cycle is somewhat different from that of the main crop. For example, a strip of Polish canola can be seeded around the outside of an Argentine canola crop to control cabbage seedpod weevils. Polish canola blooms earlier so its flowers attract the weevils to the trap strip.

For more information, see *Integrated Pest Management in Canada: A Directory of Expertise* (AAFC), *Natural Enemies of Pests Associated with Prairie Crops* (AAFC) and *Using Cultural Practices to Reduce Pest Problems in Crops* (AAFRD).

Trap strips draw insects away from the main crop.

*Courtesy of Agriculture and Agri-Food Canada, Lethbridge*

### 3.7.2 Pesticide Application

Producers have the legal right to apply pesticides on their property provided that the pesticide application does not contravene any bylaws, regulations or generally accepted practices.

Producers have the legal responsibility to ensure that any pesticide application performed on their property does not cause harm to adjacent properties or people. When using custom applicators, ensure that applicators are certified. Also ensure that the applicator is aware of potential hazards in advance of an application.

**If pesticides are part of your integrated pest management plan, follow these practices:**

**Deciding if pesticides are needed**

- Use timely and regular field scouting to accurately assess your pest problems and to assess economic threshold levels, so you can apply pesticides only when they are needed.

**Determining application rates**

- Apply pesticides according to the label instructions. Avoid overapplication.

**Selecting pesticides**

- Do not use persistent herbicides on flood-prone or sandy soils.
- Rotate chemical groups to prevent the development of resistant pest populations.

**Minimizing transport of pesticides off the field**

- Reduce movement of pesticides attached to soil particles through measures that control wind and water soil erosion such as maintaining a crop residue cover, growing shelterbelts and establishing grassed waterways (Table 3.5).
- Leave wide buffer zones around environmentally sensitive areas, including streams, rivers, wells and dugouts. As a minimum, these zones should meet all buffer width regulations.

- Avoid irrigating soon after a pesticide application. Check the product label for details.
- Avoid applying pesticides if rain is expected soon.
- Do not wash spray equipment in a water body or move this equipment through a water body.

### Reducing spray drift

- Reduce sprayer travel speed, lower the boom, use shrouds and/or use a properly adjusted air assist to reduce the risk of spray drift.
- Increase droplet size to reduce spray drift. Use spray nozzles that deliver a larger droplet size, lower the spray boom, and avoid spraying in high temperatures or low relative humidity.
- Create less drift-prone sprays by reducing pressure, increasing carrier volume, using low drift nozzles or using a drift-reducing adjuvant.
- Stop application when wind speeds are above 16 to 20 km/h.
- Check pesticide labels for wind speed limits to avoid spray drift.
- If you must spray near environmentally sensitive areas, such as water sources, neighbours' yards and shelterbelts, spray when the wind is blowing away from them.
- Use a buffer zone to capture the major portion of drifted droplets to minimize risk to adjacent areas.
- Avoid spraying during a temperature inversion (see Section 2.7.3).
- Avoid spraying volatile products on or just before hot days to decrease vapour drift.

TABLE 3.5

**LOSS POTENTIALS OF SOME COMMON AGRICULTURAL CHEMICALS**

| PESTICIDE | RUNOFF POTENTIAL* | LEACHING POTENTIAL |
|---|---|---|
| Banvel | Small | Large |
| Basagran | Small | Medium |
| 2,4-D Amine | Medium | Medium |
| Lexone, Sencor | Medium | Large |
| Linuron | Large | Medium |
| Poast | Small | Small |
| Roundup | Large | Small |
| Treflan | Large | Small |
| Counter | Medium | Small |
| Dyfonate | Large | Medium |
| Bayleton | Medium | Medium |
| Tilt | Medium | Medium |

* Runoff potential: potential for transport of pesticide in runoff water.

*Source: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food. 1992. Best Management Practices: Field Crop Production. Agriculture and Agri-Food Canada, and Ontario Ministry of Agriculture and Food.*

Reduce spray drift damage by using low drift nozzles or using a drift-reducing adjuvant.

*Courtesy of Agriculture and Agri-Food Canada – Tom Wolf and AgTech Centre – AAFRD*

For more information, see the latest edition of AAFRD's *Crop Protection* manual (the 'blue book'), *How Herbicides Work: Biology to Application* (AAFRD) and *Pesticide Drift Management* (Alberta Environmental Protection).

## 3.8 Irrigated Crop Production

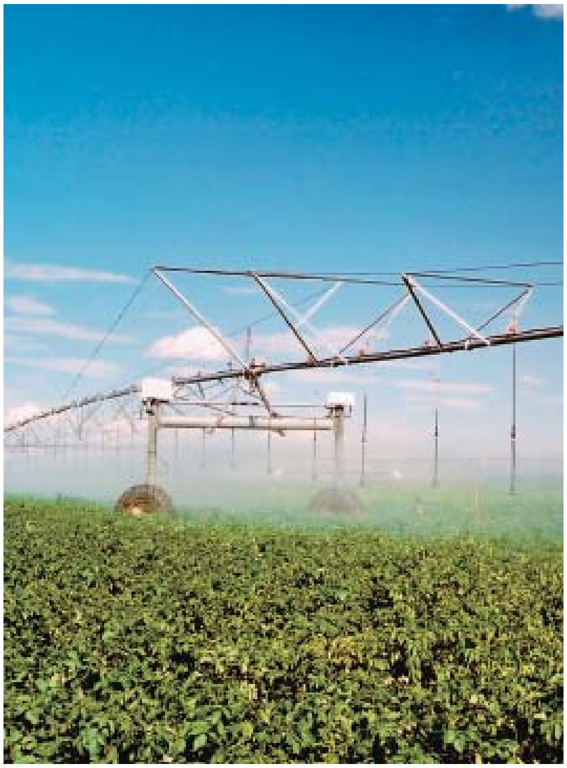
Environmental considerations in irrigation farming include ensuring the efficient use of water and preventing soil salinity and associated drainage problems that can be caused by canal seepage, poor water management and poor irrigation practices.

On a farm level, irrigation water management involves the determination and control of the rate, amount and timing of irrigation water in a planned and efficient manner. The purpose of irrigation management is to effectively use the available water supply in managing and controlling the moisture environment of crops to promote the desired crop response, minimize soil erosion and protect water quality. Proper irrigation management requires a good understanding of soil, crop and climatic properties that affect soil water movement and storage, and crop water use. This knowledge leads to the development of workable and efficient irrigation schedules.

### 3.8.1 Water-efficient Equipment

Irrigation systems have become more efficient in recent decades, reducing water losses through deep percolation, runoff, evaporation and wind drift. Some of these advances have also improved energy efficiencies.






➡ Irrigation systems are more efficient reducing water losses through deep percolation, runoff, evaporation and wind drift.

*Courtesy of AAFRD – Irrigation Branch*

The most water-efficient systems are pivot or lineal move systems with drop tubes and low pressure spray nozzles that are designed to meet crop and soil requirements. Drip systems or other similar systems apply water to the plant rooting area only. Efficiencies of surface irrigation systems have been improved through use of gated pipe, surge valves and siphon tubes and other measures to reduce water use and runoff.

**Beneficial management practices for irrigation equipment include:**

- Choose a water-efficient system, or upgrade your current system to reduce water losses, energy costs and environmental costs. Water losses result in increased runoff and increased movement of nutrients, sediments and other substances into water sources, harming water quality and aquatic habitats. As well, nutrient losses represent wasted input costs.
- Ensure your irrigation system is properly designed and sized for your operation.
- Conduct regular maintenance checks, and make needed repairs such as stopping leaks and replacing worn nozzles.
- Investigate options for upgrading your system about every five to 10 years.

Within an irrigation district, canal maintenance is the responsibility of that irrigation district. With assistance from the Alberta and Canadian governments, Alberta's Irrigation Districts are replacing, relocating, and lining canals on an ongoing basis to eliminate seepage and improve water delivery efficiency.

### 3.8.2 Irrigation Applications

Appropriate timing and amounts of irrigation water improve crop yields and decrease the amount of water lost to percolation and runoff. Reducing water loss improves water efficiency, minimizes the risk of nutrient losses, soil salinity, drainage problems, and keeps operating costs down.

**Beneficial management practices for irrigation applications include:**

- Select crops suited to your local soil and climate, choose healthy seed, and fertilize to meet the crop's needs.
- Know how much plant-available water your soil can hold at field capacity and then irrigate to 90% of the capacity, while leaving 10% for possible rainfall. Use the texture-based guide in Table 3.6.
- Learn about the water needs of your specific crop variety. Water requirements depend on the crop type, variety and stage of growth, target yield and crop management.
- Use irrigation scheduling to ensure that soil moisture is kept sufficiently high to promote active plant growth, while avoiding unnecessary water applications.
- To prevent runoff , ensure that the irrigation application rate is equal to or less than the soil's infiltration rate (Table 3.6).
- Fertilize according to the soil test recommendations to ensure that soil fertility does not limit the crop's ability to use water efficiently.
- Use computer software and weather data to continuously adjust your irrigation schedule.
- Monitor soil moisture on a weekly basis. Monitoring options include soil moisture sensors, crop water use models, direct measurement of crop use, or the feel method.
- Monitor and record water application rates and volumes.
- Avoid irrigating soon after pesticide or fertilizer applications. Check product label for details.

Land must be assessed as to its suitability for irrigation prior to irrigation development within or outside of an irrigation district. Land classification for irrigation is required: a) as input to an agriculture feasibility report to obtain a water licence for irrigation development outside an irrigation district; and b) to obtain a water right for irrigation development within an irrigation district. Only land classified as suitable for irrigation can be granted a licence or water right for irrigation in Alberta. The economic risk and risk of on-site and off-site environmental impacts are reduced by irrigating only those lands that are suited to irrigation.

TABLE 3.6

**PLANT-AVAILABLE WATER AND INFILTRATION RATE BASED ON SOIL TEXTURE**

| SOIL TEXTURE | PLANT-AVAILABLE MOISTURE IN 1-M ROOT ZONE | | BASIC IINFILTRATION RATE WHEN SOIL IS SATURATED |
|---|---|---|---|
| | (mm) | (in) | (mm/h) |
| Loamy Sand | 112 | 4.4 | 26 - 60 |
| Sandy Loam | 140 | 5.5 | 25.6 |
| Loam | 180 | 7.0 | 6.8 |
| Sandy Clay Loam | 152 | 6.0 | 4.3 |
| Silt Loam | 200 | 8.0 | 13.2 |
| Clay Loam | 200 | 8.0 | 2.3 |
| Silty Clay Loam | 220 | 8.7 | 1.5 |
| Sandy Clay | 172 | 6.8 | 1.2 |
| Silty Clay | 212 | 8.3 | 1.0 |
| Clay | 192 | 7.6 | 0.6 |

*Adapted from: Alberta Agriculture, Food and Rural Development. 2000. Procedures Manual for the Classification of Land for Irrigation in Alberta. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta.*

i For more information, visit your AAFRD irrigation specialist for individual irrigation management recommendations, the Alberta Irrigation Management Model software, and publications. AAFRD's website has irrigation information, climate and weather data, and a list of trained land classification consultants.

## 3.9 Managing for Special Conditions

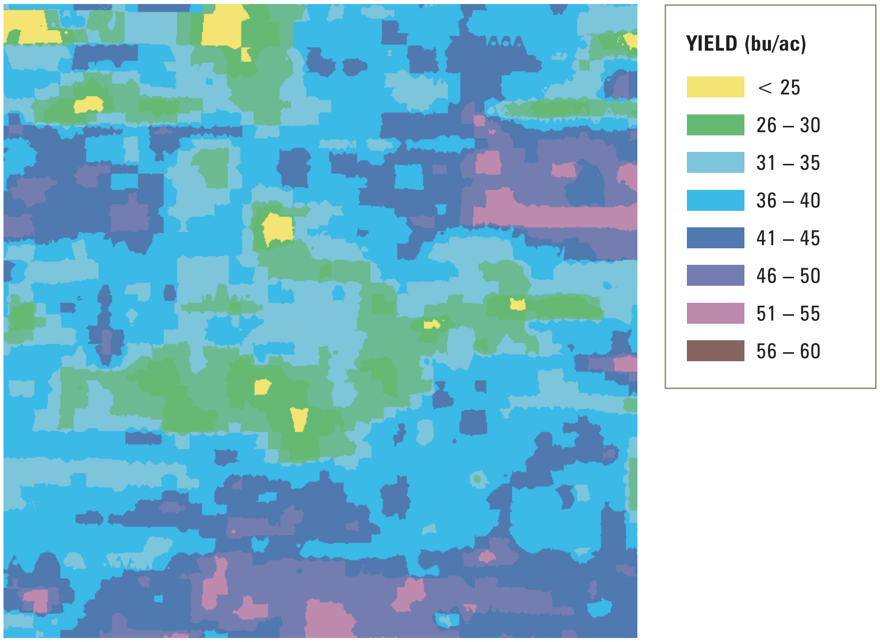
### 3.9.1 In-field Variation

**Site-specific management** or precision farming is the practice of tailoring farm inputs according to differences in growing conditions within farm fields. It offers the potential to increase economic efficiency and reduce environmental impacts. For example, a uniform fertilizer rate results in overapplication in areas where yields are limited by other factors, such as on eroded knolls, and in areas where nutrient levels are already high. Overapplication increases the risk of nutrient losses to the environment and such problems as crop lodging. Site-specific management allows producers to apply inputs only where they are needed.

Site-specific management can also be used to limit inputs in areas prone to loss of that input. An example is reducing nitrogen applications to low-lying areas that are periodically saturated. In wet conditions, nitrogen is easily lost to the atmosphere as nitrous oxide, a greenhouse gas, harming the environment and reducing the nitrogen available to the crop.

There are many inexpensive tools to aid site-specific management. These include soil sampling at benchmark locations to represent different site conditions (see Section 3.1.1), air photo interpretation to identify the extent of different soils or landform units that should be managed differently, and variable rate controllers to change input rates.

More costly options include global positioning system (GPS) tools to locate soil and yield sample areas, yield monitors to measure yield variation, and geographic information system (GIS) software and other software tools to map crop and soil information. Whether these tools are economically justified will depend on the specifics of your operation.




Yield map showing yield variation within a sample field.

*Courtesy of AAFRD*

Tractor mounted with GPS to locate soil and yield sample areas.

*Courtesy of AgTech Centre – AAFRD*

For more information, see PFRA's *Questions and Answers on Precision Farming.*

### 3.9.2 Saline Soils

**Agricultural practices can play a role in increasing or decreasing saline seeps. Practices to manage soil salinity include:**

- Test soil samples from the area suspected of having excess salts to determine whether you have saline, saline-sodic, sodic soils or some other condition (see Section 2.3).
- Contact a soil specialist to identify existing and potential recharge areas and to develop a plan for controlling salinity.
- In recharge areas:
  - Use deep-rooted, high-moisture-use crops like alfalfa. These crops help dry out the subsoil and lower the water table so less water and salt move from the recharge area to the discharge area.
  - Avoid summerfallowing these areas.
  - Use grassed waterways to remove excess water.
  - Use snow management to evenly distribute snow and prevent ponding in the spring.
- In discharge areas:
  - As much as possible, have growing plants in the discharge area to help lower the water table. Use continuous cropping if possible (see Table 2.2), or convert the area to permanent cover with salt-tolerant grasses (see Table 3.7).
  - Consider using subsurface (tile) drainage systems to remove water and salts from the seep. Although subsurface drainage is expensive, not suited to all salinity types and requires engineering design, it will lower water tables in seeps if the conditions are right, and the system is properly designed, installed and managed.
  - Avoid applying manure to this area because manure contains salts.
- Monitor the extent and intensity of the saline areas over time. If they continue to grow, consider increasing control measures. For example, convert a greater portion of the land around the recharge area into deep-rooted perennial forages.

TABLE 3.7

**GRASS SPECIES RECOMMENDED FOR SEEDING INTO SALINE SEEPS**

| SPECIES | SEEDING RATE (kg/ha) | RATE OF ESTABLISHMENT | SOD OR BUNCH | SALINITY TOLERANCE* | LONGEVITY | WINTER HARDINESS | FLOODING TOLERANCE | DROUGHT TOLERANCE |
|---|---|---|---|---|---|---|---|---|
| Creeping Foxtail | 5 - 10 | Average | Sod | High | Long | Good | High | Poor |
| Meadow Foxtail | 5 - 10 | Average | Sod | Medium | Long | Good | High | Poor |
| Smooth Bromegrass | 5 - 10 | Slow | Sod | Medium | Long | Excellent | Medium | Good |
| Meadow Bromegrass | 5 - 10 | Slow | Sod | Medium | Long | Excellent | Medium | Good |
| Slender Wheatgrass | 5 - 10 | Very Fast | Bunch | High | Short | Good | Medium | Good |
| Intermediate Wheatgrass | 5 - 10 | Fast | Sod | Medium | Short | Excellent | Medium | Good |
| Pubescent Wheatgrass | 5 - 10 | Fast | Sod | Medium | Short | Excellent | Medium | Good |
| Tall Wheatgrass | 5 - 10 | Fast | Bunch | High | Long | Excellent | High | Poor |
| Western Wheatgrass | 5 - 10 | Fast | Sod | High | Long | Excellent | High | Good |
| Russian Wildrye | 5 - 10 | Very Slow | Bunch | High | Long | Good | Poor | Good |
| Altai Wildrye | 5 - 10 | Very Slow | Bunch | High | Long | Excellent | Medium | Good |
| Beardless Wildrye | 5 - 10 | Very Slow | Sod | Very High | Long | Good | Medium | Good |
| Nuttall's Alkali Grass | 5 - 10 | Average | Sod | Very High | Long | Good | Medium | Good |

* Salinity tolerance: medium – tolerates up to 6 to 8 dS/m; high-tolerates up to 8 to 12 dS/m; very high – tolerates greater than 12dS/m.

*Source: Wentz, D. 1997. Perennial Crops for Salinity Control in Discharge Areas. Alberta Agriculture, Food and Rural Development, Agdex 518-1.*

i For more information, see *The Health of Our Soils* (AAFC), *Perennial Crops for Recharge Control of Saline Seeps* (AAFRD), *Perennial Crops for Salinity Control in Discharge Areas* (AAFRD), and *Structural Controls for Dryland Saline Seeps* (AAFRD).

### 3.9.3 Acid Soils

**Acid soils can occur naturally or as a result of the long-term use of nitrogen fertilizers. To manage these soils, follow these guidelines:**

- Sample and soil test to find out the extent and severity of soil acidity, determine the rate of lime required, and obtain an estimate of crop response to lime. Divide the field into areas on the basis of soil type or differences in crop growth and sample each of these areas separately.
- Apply lime to neutralize excess acidity and raise pH levels (Table 3.8). Some areas of a field may require higher rates than others, and some areas may not require any.
- Grow acid-tolerant crops (see Section 2.4).
- Avoid overapplication of nitrogen. Avoid extensive use of ammonium sulphate (21-0-0-24) on acid soils; it has greater acidifying properties compared to other nitrogen fertilizers.

TABLE 3.8

**EFFECTS ON CROPS OF LIMING ACID SOILS**

| RATING | SOIL PH | DIRECT EFFECTS OF LIMING ON CROPS |
|---|---|---|
| Slightly Acid | 6.1 to 6.5 | No direct effect on most crops. |
| | | Fields with an average pH just above 6.0 may have areas where the pH is below 6.0. Alfalfa and sweet clover yields will be increased on the more acid areas. |
| Moderately Acid | 5.6 to 6.0 | Survival and growth of *Rhizobium* bacteria, which fix nitrogen in association with alfalfa and sweet clover, are improved. |
| | | Yields of alfalfa and sweet clover are increased. |
| | | Small increases in barley yields occur in the first two or three years following lime applications with larger increases (25 to 30%) occurring in subsequent years. Yields of wheat and canola are increased less than barley yields. Yields of more acid-tolerant crops may be increased as a result of indirect effects of liming (such as improved physical properties of some soils and improved phosphorus availability). |
| Strongly Acid | 5.1 to 5.5 | Nitrogen fixation and yields of legumes are increased. |
| | | Soluble aluminium and manganese are reduced to non-toxic levels. |
| | | Yields of most crops are increased as a result of reduced levels of aluminum and manganese, and improved availability of phosphorus and other nutrients. |
| Very Strongly Acid | Less than 5.1 | Same effects as for strongly acid soils. |
| | | Yields of most crops are severely reduced unless the soil is limed. Very strongly acid soils are very infertile. Acid-tolerant crops (oats and some grasses) do moderately well if adequately fertilized. |

*Adapted from: Penney, D. 1996.* ***Liming Acid Soils****. Alberta Agriculture, Food and Rural Development, Agdex 534-1.*

For more information, see *Liming Acid Soils* (AAFRD).

### 3.9.4 Peat Soils

Peat soils, sometimes called organic soils, occur in the cooler and wetter areas of Alberta. Peaty areas are often located in low, wet spots within normal fields.

Peat soils are highly variable in acidity and fertility. There are two main types of peat soils: bog peatland and fen peatland. Bog peatland (or moss peat) is very acidic (pH lower than 5.5) and has low fertility. They are not recommended for agricultural development. Fen peatland (or sedge peat) is less acidic (pH 5.5 to 7.5) and has higher plant-available nitrogen, phosphorus and potassium than bog peatland. Fen peatland is considered suitable for agriculture. However, bog and fen peatland soils often occur together.

In most cases, forages are the best crop option for peat soils. Choose forage crops that tolerate peaty soils such as timothy, creeping foxtail, reed canary grass, and meadow foxtail.

i For more information, see *Management of Organic Soils* (AAFRD), *Establishing Perennial Hay and Pasture Crops* (AAFRD) and *Farm Enterprise Information: Crop Production – Management*.

### 3.9.5 Solonetzic Soils

Solonetzic soils have a tough, impermeable hardpan horizon from 5 to 30 cm (2 to 12 in.) or more below the surface. This hardpan severely restricts root and water penetration, resulting in poor growth and low tolerance to drought. Compared to other soils, Solonetzic soils generally have much greater in-field variation in topsoil depth, pH, fertility and in subsoil characteristics, increasing the difficulty of managing these soils.

Solonetzic hardpan horizons restrict root and water penetration.

*Courtesy of AAFRD*

Irregular crop growth pattern to due to presence of Solonetzic soils.

*Courtesy of AAFRD*

Test soil samples from the area suspected of having Solonetzic soils to ensure that the problem is correctly identified. If the soils are Solonetzic, the best option is to keep them under a permanent cover of trees, shrubs or pasture. If the land is in pasture, use a well managed rotational grazing system to avoid **overgrazing**.

If you wish to grow crops on these soils, consult an agronomist. Although deep plowing and subsoiling can make some Solonetzic soils more productive for cropping, not all Solonetzic soils benefit from these practices.

For more information, see *Management of Solonetzic Soils* (AAFRD).

### 3.9.6 Soil Compaction

The dense structure and low porosity of compacted soils restrict the growth of plant roots and limit the plant's ability to obtain water and nutrients.

**To prevent or minimize soil compaction:**

- Avoid field work when the soil is wet.
- Try to avoid driving over the same area repeatedly.
- Use practices that add organic matter to the soil (see Section 2.1).
- Use tillage practices that minimize the disturbance of soil (see Section 3.2). Avoid the use of tillage implements that pulverize soils.
- Reduce axle weight and use flotation tires.

Use of flotation tires helps prevent or minimize soil compaction.

*Courtesy of AAFRD*

For more information, see *The Health of Our Soils* (AAFC) and *Solving the Wheel Track Dilemma in Direct Seeding* (AAFRD).

### 3.9.7 Marginal Crop Lands

**Marginal crop lands** are lands with characteristics that severely limit annual crop production. They include land that is very prone to erosion or flooding, land with steep slopes or rocky soils. For both economic and environmental reasons, these lands are better kept under some form of permanent cover such as perennial forages, pasture or trees.

Well managed woodlots provide a diversity of timber products.

*Courtesy of Agriculture and Agri-Food Canada – PFRA*

Before you remove natural permanent cover from an area, contact an agronomist for technical assistance in determining the agricultural potential of the land. It may be more profitable to leave the land with its natural cover.

If an attempt has already been made to convert marginal lands to annual crop production, it is best to replant them to a form of permanent cover.

## 3.10 Information Sources

### 3.10.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: http://www.agric.gov.ab.ca
- Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada by phone or visit the PFRA website (www.agr.gc.ca/pfra)
- Your local agricultural service board
- Reduced Tillage LINKAGES: phone: 1-780-422-7922; website: http://reducedtillage.ca
- Alberta Environment: phone: 1-780-944-0313; website: http://www3.gov.ab.ca/env/
- Alberta Irrigation Projects Association: phone: 1-403-328-3063; website: www.aipa.org
- Canola Council of Canada: website: www.canola-council.org
- Cows and Fish Program (the Alberta Riparian Habitat Management Program), phone: 1-403-381-5538; website: http://www.cowsandfish.org/index.html
- Ducks Unlimited Canada, phone: 1-780-489-2002; website: http://www.ducks.ca/index.html
- Woodlot Association of Alberta: phone: 1-800-871-5680; website: http://www.woodlot.org/
- Alberta Environmental Farm Plan: phone: 1-866-844- 2337 (toll-free); website: www.albertaefp.com

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