# Principles and Practices of Crop Rotation

**Introduction**

Crop rotations have received considerable attention for the past number of years. This attention has been concerned, in large part, with disease due to greater awareness of the problem, increased acreages of broadleaf crops, shorter rotations, reduced summerfallow, reduced tillage, and a focus on zero tillage. Recent advances in integrated weed management, and in optimizing water and nutrient use have broadened the focus to include environmental stewardship.

The title of this bulletin uses the term "crop rotation" because it is the term that is familiar with most producers. It must be recognized, however, that few producers in Saskatchewan follow a crop rotation where they grow a specific crop in a specific year of the rotation cycle, on each field (e.g. spring wheat - field pea - barley - flax). Rather, they follow a crop sequence (e.g. cereal - pulse - cereal - oilseed). The reason for this is that commodity prices fluctuate and the most important factor in deciding what to grow in an upcoming year is the anticipated commodity price. Another factor, maintaining accurate herbicide use records, is critical in crop and variety selection for rotations.

It must also be recognized that there is no one right rotation. There is not one rotation that will optimize water and nutrient use, minimize disease and weed problems, and most importantly, bring in the highest return per acre. The 'best' rotation depends on available moisture and nutrients, diseases and weed levels, herbicide use records, equipment availability, commodity prices, ability and desire to accept risk, and so forth. The 'best' rotation can vary from field to field on the same farm and from year to year for the same field.

**Rotating Crops to Optimize Water and Nutrient Use**

Low water and soil nutrient levels are usually the two most limiting factors to crop production in Saskatchewan. These factors affect, and are affected by, crop rotation. Thus, crop rotation can be used to optimize water and nutrient use.

**Optimizing Crop Use of Water**

There are 3 main ways to optimize crop water use:

- conserve moisture,
- choose an appropriate crop sequence, and,
- employ 'good' farming practices.

**Moisture conservation**
In a moisture-limited environment such as Saskatchewan, crops generally use all the available water in the root zone. Therefore, basic crop rotation decisions must consider spring soil moisture level and anticipated growing season rainfall.

Undisturbed stubble, six to nine inches tall left standing over winter to trap snow on the field, can result in one-half to one inch more water than stubble that was cultivated in the fall. (Photo courtesy of SSCA)

Crop yield is affected more by growing season precipitation than spring soil moisture content, but spring soil moisture can be improved by implementing moisture conservation techniques. Growing season precipitation cannot be improved (except by irrigating). The fundamentals of moisture

Government of Saskatchewan

conservation are to:

- improve spring soil moisture level by keeping over-winter snow on the field, and
- prevent the loss of spring soil moisture by sheltering the soil and crop from drying winds, by maintaining standing stubble and using low disturbance zero tillage or minimum tillage.

In Saskatchewan, the most widely used moisture conservation practice is to leave stubble standing over winter to trap snow on the field. Undisturbed stubble, 6 to 9 inches tall, can conserve 1/2 to 1 inch more water over winter than stubble that was cultivated and flattened in the fall. One inch more water can result in 2 1/2 to 9 more bu./ac., depending on the crop and soil climate zone (Table 1).

**Table 1.** "Average" moisture use efficiency (bu./ac./in) for major crops in Saskatchewan

| Soil Climatic Zone | CWRS Wheat | Barley | Canola | Oats |
|---|---|---|---|---|
| Dry Brown | 3.50 | 5.30 | 2.40 | 6.50 |
| Brown | 3.75 | 5.70 | 2.60 | 7.10 |
| Dark Brown | 4.00 | 6.20 | 2.80 | 7.75 |
| Moist Dark Brown | 4.12 | 6.20 | 3.00 | 7.90 |
| Black | 4.25 | 6.40 | 3.20 | 8.20 |
| Moist Black | 4.50 | 6.70 | 3.40 | 8.70 |
| Gray | 4.75 | 7.20 | 3.60 | 9.10 |

*Source: Soil Climatic Zones of the Canadian Prairies, EnviroTest Laboratories*

High disturbance direct seeding with flattened stubble. (Photo courtesy of SSCA)

Low disturbance direct seeding or zero till with standing stubble. (Photo courtesy of SSCA)

With low disturbance direct seeding (zero tillage) the stubble is also left standing after the crop is seeded. This reduces moisture loss from soil and plants until the crop canopy has developed. This also increases crop yield.

**Crop sequence**

The sequence of crops in the rotation affects the availability and use of water and consequently, crop yields. Rooting depth and time to maturity are two factors that should be considered when planning the sequence of crops in the rotation.

Rooting depth depends on a number of factors such as: crop type and variety, depth of moist soil, amount and frequency of precipitation, fertility and soil temperature. Generally, alfalfa, safflower and sunflower root deeper than barley, canola, mustard and wheat, which in turn root deeper than field pea flax and lentil (Table 2).

**Table 2.** Relative depth of rooting of various crops grown in Saskatchewan*

| **Deep** | **Moderate** | **Shallow** |
|---|---|---|
| Alfalfa | Barley | Field Pea |
| Safflower | Canola | Flax |
| Sunflower | Mustard | Lentil |
| | Wheat | |

* crops within a column have a similar (not 'equal') rooting depth.

The significance of rooting depth is that crop water use can be optimized by rotating between deep and shallow rooted crops. Shallow rooted crops appear best adapted to follow a deep rooted crop because water recharge is likely to occur only near the soil surface, and a shallow rooted crop will not expend energy in search of moisture that is not there. Medium or deep rooted crops appear better adapted to follow shallow rooted crops, as they are able to take advantage of any moisture left at depth that is not used by the previous shallow rooted crop.

Winter wheat and fall rye root to depth earlier in the growing season than spring wheat, taking advantage of early season moisture. The earlier development of fall seeded crops also means they (usually) flower prior to the time of peak summer moisture stress.

Crop sequence is also important because some crops are more affected by lack of moisture than others. For example, the experiment shown in Table 3, for the brown soil zone, found that sunflower and safflower yields were not much higher on fallow than on stubble. Stubble yields of field pea and lentil were 80 to 90 per cent of fallow yields whereas stubble wheat yield was 2/3 to 3/4 the fallow yield. Mustard yield on stubble was less than 2/3 the yield on fallow. This suggests that there is little reason to plant safflower or sunflower on fallow, whereas there is good reason to plant wheat and (especially) mustard on fallow. Lentil and (especially) field pea are also good candidates for stubble seeding.

**Table 3.** Average yields of alternative crops on fallow and stubble for all seven site-years and for a subset of four site-years with a terminal drought, 1992-96 at Swift Current and 1994-96 at Assiniboia.

| Crop | Fallow | | Stubble | | Stubble/Fallow | |
|---|---|---|---|---|---|---|
| | 7-yr | 4-yr | 7-yr | 4-yr | 7-yr | 4-yr |
| | Lb./ac. | | Lb./ac. | | % | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Field pea | 2510 | 2330 | 2180 | 2080 | 87 | 89 |
| Lentil | 1340 | 1270 | 1090 | 1060 | 81 | 83 |
| Mustard | 1520 | 1270 | 960 | 800 | 63 | 63 |
| Safflower | 790 | 1250 | 780 | 1130 | 99 | 91 |
| Sunflower | 790 | 790 | 750 | 700 | 95 | 88 |
| CWRS wheat | 2410 | 2280 | 1660 | 1680 | 69 | 74 |

*Source: adapted from Miller et al., 1997*

**Good farming practices**
Farming practices affect the ability of the crop to capitalize on available water. For example, the water consumed by a 35 bu./ac. wheat crop is very close to that of a wheat crop that has been reduced to 30 bu./ac. due to poor management. Adequate fertilization and control of yield limiting factors such as diseases, insects and weeds, allows the crop to capitalize on available water and realize its yield potential. Inappropriate seeding date, seeding depth, variety selection, and other factors also affect yield and should be considered.

## Optimizing Crop Use of Nutrients

Most Saskatchewan soils are low in nitrogen and phosphorus, many are low in sulphur for high sulphur using crops such as canola, mustard and alfalfa, and some are low in potassium and a few fields may be deficient in micronutrients. Soil testing is the best way to optimize cropproduction by correcting deficiencies. A number of ways of optimizing or improving crop nutrient use are discussed in the following FarmFacts: *Nitrogen fertilization in crop production, Phosphorus fertilization in crop production, Potassium and Chloride fertilization in crop production, Sulphur fertilization in crop production and Micronutrients in crop production*.

With regard to crop rotations, optimizing crop nutrient use falls under two general headings:

- selecting crops that reduce the need for application of fertilizer; and,
- managing residual soil nutrient levels.

**Crop selection**
Perhaps the easiest way to improve crop nutrient use is to reduce the need for nitrogen (N) fertilizer application by growing a pulse crop in the rotation. Pulse crops obtain between 50 and 90 per cent of their total N requirement through biological fixation of N, a significant saving in fertilizer expenditure in the year the pulse is grown (Table 4).

**Table 4**. Nitrogen Fixation in Inoculated Pulses Grown Under Irrigation in Southern Alb.erta

| Pulse | Plant-N Derived from Atmosphere (%) | N Fixed Symbiotically (lb./ac) | N Fertilizer Equivalent @ $0.45 / lb. actual N ($/ac) |
|---|---|---|---|
| Fababean | 90 | 267 | 120 |
| Field pea | 80 | 178 | 80 |

| | | | |
|---|---|---|---|
| Lentil | 80 | 134 | 60 |
| Chickpea | 70 | 108 | 49 |
| Dry bean | 50 | 62 | 28 |

*Source: adapted from R.J. Rennie, formerly at Agriculture Canada Research Station, Lethbridge, Alberta*

Crop(s) following the pulse crop also require less N fertilizer. The high N content of pulse residue (straw, chaff, root material) breaks down faster than cereal residue, returning N to the soil sooner. Note in Figure 3 that barley yield is higher on pulse stubble than on barley stubble when N was not applied.

Figure 3 also shows that the benefit of a pulse crop to the following crop is due to more than just N. In this example, the barley on pulse stubble continues to significantly out yield the barley on barley stubble up to 180 lb./ac of applied N. The non-N benefit to succeeding crops may sometimes be greater than the N benefit of growing pulses.

**Figure 3.** Average Yield Response of Barley to N Fertilizer When Grown on Barley, Fababean, Field Pea and Lentil Residues in Northeastern Saskatchewan
*Source: adapted from Wright, 1990*

Complementary cropping is one way of improving crop nutrient use that has not received a lot of attention, except among organic producers. Different crops have a differing need for, or sensitivity to, the deficiency of particular nutrients (Tables 5). One practice under complementary cropping is to rotate between high and low nutrient demand crops in order to slow the development of a nutrient deficiency.

Table 5. Approximate nutrient uptake by selected crops

| | Yield (bu./ac.) | Straw/Grain Ratio | Nitrogen (N) | Phosphorus (P2O5) | Potassium (K2O) | Sulphur (S) |
|---|---|---|---|---|---|---|
| | | | lb.. of nutrient removed (by grain+straw) per bu. grain | | | |
| Barley | 80 | 1 | 1.3 | 0.53 | 1.2 | 0.15 |
| Canola | 35 | 2 | 3.2 | 1.49 | 2.3 | 0.54 |
| Fall rye | 55 | 2 | 1.7 | 0.84 | 2.4 | 0.29 |
| Field pea | 50 | 1 | 3.1 | 0.84 | 2.7 | 0.26 |
| Flax | 24 | 1.4 | 2.7 | 0.79 | 1.5 | 0.54 |
| Lentil | 30 | 1.7 | 3.1 | 0.80 | 2.5 | 0.30 |
| Oat | 100 | 2 | 1.1 | 0.40 | 1.5 | 0.13 |
| Spring wheat | 40 | 1.6 | 2.2 | 0.80 | 1.8 | 0.23 |
| Sunflower | 50 | 1.5 | 1.5 | 0.52 | 0.7 | 0.16 |
| Winter wheat | 50 | 1.2 | 1.3 | 0.60 | 1.4 | 0.20 |

**Note:** Nutrient uptake is an indication of nutrient requirement, but not a recommendation for fertilizer application soil test. Recommended application rates of fertilizer also consider fertilizer use efficiency, availability of nutrients in the soil, etc.
*Source: Adapted from Nutrient Uptake and Removal by Field Crops in Western Canada, by the Fertilizer Canada.*

Another example would be to avoid growing pulse crops on fields with high soil N levels. Pulse nodule formation will be progressively inhibited as soil nitrate-N levels rise above (about) 35 lb./ac (to the 12 inch depth) and little fixation will occur as levels rise above (about) 50 lb./ac. This is because legumes preferentially use most of the available soil N before they begin to fix atmospheric N.

### Managing soil nutrient levels

Just as consideration should be given to selecting the appropriate crop according to soil residual nutrient levels, consideration should be given to managing soil residual nutrient levels to optimize crop nutrient use. For example, although flax requires phosphorus (P) and some P fertilizer can safely be applied with the seed, research indicates that the yield response is low unless the P fertilizer is placed in a band 1 inch away from the seed row. Another strategy is to maintain soil residual P levels higher for fields that include flax in the rotation.

Although maintaining higher soil P levels means higher P fertilizer costs, in an number of situations the overall net return is also higher due to increased productivity. Seeding equipment, environmental conditions and soil type often prevent the safe seedplaced application of all the P fertilizer that is needed by the crop; particularly for fertilizer sensitive crops, such as the oilseeds and pulses. Sidebanding or mid-row banding the P (and other) fertilizer, overcomes this problem.

Some forage producers take this practice one step further by applying enough of all the needed non-mobile nutrients (phosphorus, potassium) to last several years, prior to stand establishment. However, with today's banding technology, annual band application of nutrient levels required to correct deficiencies into forage stands has been shown to be effective.

### Diseases of Cereals, Oilseeds and Pulses Introduction

Crop rotation is a tool used to manage population levels of many residue and soil-borne plant disease organisms. Other management tools include resistant cultivars, adequate soil fertility, cultural practices and, where appropriate, chemical application. Although short term economics may influence the crop selection decisions, the long term returns from crop rotation can be significant. The role of crop rotation in disease management may be best summarized as a management tool to reduce certain pathogen populations to a level where they will have little or no economic impact when the crop is grown again.

### Cautions

Not all plant disease pathogen populations can be reduced or managed economically through crop rotation alone. Crop rotation has a limited impact on disease management when:

1. The pathogen is primarily or entirely seed-borne, like the cereal smuts.
2. The disease is spread long distances by air-borne spores, like the cereal rusts.
3. The disease is carried and spread by insects which can move long distances. An example is aster yellows in canola, vectored by leafhoppers.

4. The pathogen has a wide range of hosts. *Sclerotinia sclerotionim,* the causal agent of sclerotinia stem rot, is a pathogen which can cause disease in more than 400 host species, including most of the annual broadleaf crops grown in Saskatchewan.
5. The pathogen can exist in the soil apart from its host. Botrytis gray mold on lentil fits this category.
6. The pathogen has long lived resting spores. The flax wilt fungus can persist for many years in the soil without flax being grown. Fortunately, adequate resistance in new varieties has lessened the impact.

Although crop rotations may have limitations on certain plant diseases, many positive benefits can be realized from the reduction of those pathogen population levels affected by crop rotation. Furthermore, crop rotations can reduce certain plant pathogen populations to a level where other disease control methods will work more effectively.

## Cereal Crops

### The Diseases

Crop rotation has a significant impact on many cereal leaf spot and root rot causing pathogens. Recent adoption of certain crop management practices including reduced tillage, low soil disturbance seeding and shorter rotations, may be contributing to the increase of cereal leaf disease incidence recently observed on the prairies.

The economically important leaf diseases on wheat grown in Saskatchewan are tan spot (*Pyrenophora tritici- repentis*) and septoria leaf blotch (*Septoria nodorum & S. tritici*). Leaf spot diseases usually occur every year but do not always cause economic losses due to unfavourable environmental conditions suitable for infection, disease development and spread. Leaf disease severity and incidence can be expected to increase under conditions of abundant moisture and in the presence of inoculum. Continuous cropping of wheat has the potential to further increase the population levels and inoculum potential of leaf disease pathogens for subsequent wheat crops. Yield losses of 20 per cent caused by tan spot and septoria leaf blotch have been reported in continuous wheat.

Net blotch (*Pyrenophora teres*) and scald (*Rynchosporium secalis*) are the most important leaf diseases found on barley grown in Saskatchewan. As a general rule, two-row barley varieties are more susceptible to leaf disease than six-row varieties. Yield losses caused by these diseases range from 10 to 40 per cent. Low levels of infection can affect seed quality and result in a loss of malting status. Fields where these diseases are found should not be planted back to barley for at least one year, and preferably two.

Common root rot (*Cochliobolus sativus, Fusarium* spp.) and take-all (*Gaeumannomyces graminis*) are the most common root diseases affecting cereals. Common root rot can occur in most cereal crops causing small but consistent losses averaging 10 per cent per year. Most infections are initiated by soil-borne spores or mycelium (inoculum) which can remain viable in the soil for several years. The resting spore of some fungi can survive in soil in the absence of residue from a susceptible crop. The root rots occur in both wet and dry soil, however, the disease tends to be worse under dry conditions where the damaged root system is unable to supply the moisture required by the infected plant. Common root rot is usually more severe in wheat and barley than in oats, rye or triticale. A two to three year rotation with non-cereal crops and fallow can reduce the incidence and severity of the disease, but will not eliminate it. Shallow seeding, balanced fertility, chemical seed treatments and other management practices which result in the vigorous growth of plants, help reduce the severity of root rots and impact on yield.

Take-all occurs mainly on wheat but can also infect barley, triticale, rye, oats, brome grass and bent grass. Disease incidence and severity is worse when wheat is planted on wheat stubble or cropped after the breaking of native or cultivated grasslands. The fungus overwinters on plant debris and plant root contact with the fungus is the main method of disease transmission and spread. Although crop rotation is quite effective in minimizing this disease, losses due to take-all can range from 15-40 per cent. Adequate and balanced fertility also seems to help keep the disease in check.

Common leaf and root diseases may not appear to be as severe on oat compared to wheat or barley, however, oats will carry common root rot and take-all.

Fusarium head blight is becoming increasingly important in Saskatchewan. Yield loss is a result of shrunken infected kernels, but more importantly, infected kernels may contain mycotoxins. Fusarium head blight is caused by a number of *Fusarium* species, the most important one is *Fusarium graminearum*. Crop rotation is one management practice used to prevent inoculum build-up in fields.

**Factors affecting disease**

Table 7 summarizes the biological characteristics of the major cereal pathogens. Environmental factors play a major role in determining the incidence and severity of cereal diseases. The arid climate of the Canadian prairies during the 1980s allowed growers to plant cereals on the same land, or even to practice cereal monoculture, without serious losses from disease. However, in the wetter years of 1993 and 1994, cereal diseases caused larger yield losses. Generally, leaf diseases are more severe in areas with higher rainfall, such as in the dark brown and black soil zones. During years of higher rainfall or in fields under irrigation, severe leaf diseases can also occur in the brown soil zone.

**Table 7.** Biological characteristics of the major pathogens causing disease on wheat and barley in the Canadian prairies

| Disease | Host Specificity | Survival | Spore Type | Dispersal Mechanism | Preferred Environment |
|---|---|---|---|---|---|
| Common root rot | barley, wheat, oats, triticale, rye, canaryseed | soil, residue, seed, conidia, mycelia | pigmented conidia | wind, water, cultivation, seed, residue | hot, dry soil |
| Take-all | wheat and other cereals | mycelia in residue | pigmented runner hyphae | root to root, infested soil | cool, moist soil |
| Tan spot | wheat | residue, mycelia, pseudothecia | conidia, ascospores | wind, residue | humid, wet, cool-warm |
| Septoria leaf blotch | wheat, barley | residue, seed, pseudothecia | conidia, ascospores | rainsplash (conidia), wind (ascospores) | wet canopy, wet-hot |
| Scald | barley | mycelia, seed, residue | conidia | rainsplash | cool,wet |
| Net blotch | barley | mycelia, seed, residue, pseudothecia | conidia, ascospores | wind | warm-hot, wet |

| | | | | | |
|---|---|---|---|---|---|
| Fusarium head blight | wheat, barley, oats, rye, triticale, canary seed | mycelia, perithecia, seed, residue | conidia, ascospores | seed, residue, rain splash | humid, wet, warm during cereal flowering |

*Source: Bailey and Duczek, 1996*

Infected crop residue can act as a source or reservoir for many plant diseases. The rate of residue decomposition determines the length of time and amount of disease inoculum that will carryover from season to season. Practices which increase crop residue decomposition will also reduce the incidence and severity of diseases caused by residue-borne pathogens. Cereal residue decomposition increases with more available water and higher temperatures. Barley residue decomposes more rapidly than wheat. Partially or completely buried residue decomposes more rapidly than left on the soil surface. Crop residue also decomposes more rapidly in soil with higher nitrogen content. Rotating cereals with nitrogen fixing legume crops may help speed up the decomposition of disease infested cereal residue.

Survival of tan spot and septoria leaf blotch is reduced when the stubble infected with these fungi are buried by tillage. Incorporation below the soil surface also prevents the physical release of spores. Buried infested residue also interferes with light requirements for some disease organism life cycles. However, tillage is no longer a recommended practice to control disease because of soil erosion issues and moisture conservation needs.

Rotating cereals with non-cereal crops reduces plant pathogen populations which specifically infect cereals. Continuous cropping of cereals can result in the phenomenon known as disease-suppressive soils. Take-all decline is a good example where the pathogen increases in the initial years of continuous wheat cropping, but then diminishes due to an increase in the population of microorganisms which attack the take-all pathogen. It may take up to seven years before take-all severity is reduced to economical levels and so is not a practical method for disease management. However, identification of the microorganisms responsible for the decline has led to the development of biological control agents for the disease.

**Management strategies affecting disease**

Compared to conventional till systems, reduced tillage will leave more crop residue on the soil surface resulting in cool and moist soils. These changes to the soil environment may cause some diseases to increase in severity while others decrease (Table 8). Fusarium root rot, like take-all, tends to be more severe with higher surface residues, whereas spores of the common root rot organisms are found closer to the soil surface under reduced and zero-tillage management. Since common root rot infection frequently occurs through the sub-crown internode and lower crown below the soil surface, reduced disease incidence and severity has been observed under minimum tillage. Shallow seeding under reduced tillage system also reduces the distribution of inoculum which results in lower common root rot infection. Leaf diseases caused by residue-borne pathogens tend to be more severe under zero till compared to conventional tillage (Table 8).

**Table 8.** Average effects of tillage on leaf spot and root disease severity and the isolation of pathogens from wheat leaves (the number of lesions per unit leaf area) and (per cent infected), 1992-93

| Tillage | Leaf Spot | | | | | Root Rots | | |
|---|---|---|---|---|---|---|---|---|
| | Severity | Septoria Glume Blotch (leaf lesions) | Septoria Leaf Blotch | Tan Spot | Spot Blotch | Severity | Common Root Rot | Fusarium Root Rot |
| Conventional | 1.2a* | 3.0a | 10.0a | 2.1a | 0.7a | 0.74a | 71a | 76a |
| Zero | 3.6b | 3.2a | 12.0b | 4.4b | 0.3b | 0.47b | 42b | 86b |

* Letters that are the same within a column are not significantly different at P=0.05.
*Source: adapted from Bailey, AAFC, 1996.*

Continuous production of the same or similar crop can increase foliar disease incidence and severity regardless of tillage systems. The fungi which cause tan spot and septoria can survive on residue for at least two years after wheat has been grown. Although a one-year break between wheat crops may decrease disease incidence and severity, under favourable conditions, disease levels can be significant. Crop rotations involving non-cereal crops will lower inoculum levels and reduce the risk of cereal diseases caused by many soil and residue borne pathogens. However, the period of time required to reduce pathogen populations prior to planting a subsequent cereal crop will depend on the type of crops used in rotation, soil type, and the environmental conditions experienced between crops.

Cultivars resistant to plant diseases may have less disease and no yield loss, but in some cases the disease organisms can still survive on the plants. Fungicides can be applied on susceptible crops to slow the rate or stop disease development before or after initial infection. Regardless, whether a fungicide or resistant variety is used to reduce the impact of a plant disease, crop rotation is necessary to reduce the residual inoculum of the pathogen.

Maintaining adequate and balanced fertility is very important for effective disease management. Plants have defence mechanisms against pests, including disease. Vigorously growing plants can usually withstand a certain amount of disease. Phosphorus promotes new healthy root growth which will compensate for diseased roots. Excessive use of nitrogen will lead to dense vegetative growth creating a suitable micro-environment for leaf disease infection, colonization and inoculum production. Copper deficiency may result in greater ergot infections in cereal crops. Balanced plant nutrition will not reduce disease under poor crop rotation, however, inadequate fertility usually negates the benefits of good crop rotation.

**"Rules of thumb" for disease management**

Recommendations suggesting burial of crop residue and several years rotation with non-cereal crops may appear to be too general and not practical under current farming regimes. Decisions on crop choice and the length of rotation should be made based on levels of risk, damage thresholds and economics. Previous crop and disease history, including that of neighbouring fields, should be used to determine the level of disease risk in subsequent crops.

A short break of one or two years out of cereals can usually provide adequate management of many leaf spot diseases affecting cereals. However, crop rotation alone will not be sufficient to control disease. Crop rotation must be integrated with other agronomic practices, such as planting disease free seed, using chemical seed treatments, applying fungicides, seeding resistant cultivars, shallow seeding and adequate fertility to manage and reduce the level of disease risk.

Planting a cereal once every two or three years grown in rotation with pulses, oilseeds and forage crops should keep many of the cereal leaf disease levels low. At least one, but preferably two years is required between cereal crops to reduce take-all, however, longer intervals may be required to reduce common root rot. Research studies have shown cereal yields to be higher when grown in rotations with pulses even when nitrogen differences were eliminated. Suppression and breaks in disease cycles could explain at least a portion of these yield enhancements.

Key points to remember include:

- most root and leaf diseases become more severe under continuous cereals
- do not plant cereals more than two years in a row
- do not grow the same type of cereal crop year after year
- use different cereals such as wheat, barely, triticale, oats and rye in the rotation
- wheat and barley have more similar disease problems than oats or rye
- grasses including canaryseed and forage grasses can carry cereal diseases
- growing wheat or barley after grasses or grass mixtures increases the risk of root diseases
- take-all causes more damage in wheat than barley
- most oilseed, pulse and legume crops are not susceptible to the same diseases as cereals
- use cereals as a break crop to interrupt the disease cycles of oilseeds and pulses
- sow disease-free seed and resistant varieties for added protection
- seed treatments can reduce the risk of introducing diseases into non-infested fields
- foliar fungicide application can minimize yield losses caused by leaf diseases under favourable environmental conditions
- use an integrated approach to disease management including cultural, biological, chemical, and physical methods to prevent and reduce disease

### Canaryseed

Septoria leaf mottle (*Septoria triseti*) has caused problems for canaryseed growers. Although identified in 1988, this disease was not recognized as significant until 1993 when large yield losses were attributed to this disease. Septoria leaf mottle is a residue-borne disease. Canaryseed crops sown on or adjacent to canaryseed stubble are considered "high risk". A crop rotation with at least a two-year break from canaryseed is the best way to reduce the level of infestation. A foliar fungicide may also be used if disease risk is deemed economically damaging.

### Oilseed and Pulse Crops

Oilseed and pulse crop acres have increased significantly in the last decade while summer fallow acres have been reduced. Although crop residues from pulses breakdown quicker than canola, both tend to persist and support pathogens longer than cereal crop residues. In general, many diseases of broadleaf crops require longer rotations to reduce the risk of disease.

### Canola

Blackleg (*Leptosphaeria maculans*) and sclerotinia stem rot (*Sclerotinia sclerotiorum*) are two very important and serious diseases of canola grown across the prairies. The canola blackleg fungus can be isolated from canola stubble in soil six years after the last canola crop was grown. The fungus persists on the base of the canola stem which is very slow to decompose. Spore production is greatest on two-year old stubble, but is substantially reduced after four years.

Blackleg can spread by planting infected seed, considered to be a major source of infection in canola, or by spore movement from infested residue in adjacent fields. The presence of a sexual stage capable of ejecting ascospores into air currents results in long distance spread of the disease. Canola should not be grown on the same land more than once every four years, and avoid planting in fields adjacent to land with infested crop during the previous three years. The blackleg fungus cannot infect cereal or pulse crops, but can be carried by tame and wild mustard plants, as well as volunteer canola. Control of these weeds during non-canola years is important in overall disease management.

Sclerotinia stem rot is caused by a fungus which can infect many annual broadleaf crops and weeds. Canola is very susceptible to this disease, resulting in significant yield losses in wet seasons. Sunflower, pea, lentil and flax can also be infected by this fungus and should not be grown more than once every four years in rotation with canola. Sclerotinia development is dependant on moist environmental conditions for disease progression, therefore, disease severity will vary from year to year.

**Flax**
Flax is rarely grown more than once every three years on the same field resulting in few significant disease problems. Some seedling and root rots are common between all broadleaf crops but in most cases are insignificant when cereals are grown between broadleaf crops. Pasmo (*Septoria linicola*) is a fungal disease that has the potential to cause significant crop loss if flax is grown more than once every three years.

**Lentil**
Ascochyta blight (*Ascochyta , lentis*) and anthracnose (*Colletotricum truncatum*) are two diseases which can cause significant yield losses in lentil production. The species causing ascochyta blight in lentil is specific to lentil and will not infect any other broadleaf crop. Ascochyta is widespread and losses of 15 to 50% are not uncommon where infection occurs. The fungal spores overwinter on lentil stubble but can spread to adjacent fields in the spring by rain splashed spores from infested stubble. Planting infected seed can also spread disease to uncontaminated fields. Periods of rain during the growing season favour spore dispersal, infection and colonization by this disease. The risk of getting this disease can be kept low by allowing at least three years between planting a lentil crop in the same or adjacent field. Planting ascochyta resistant varieties and applying foliar fungicides are additional management practices.

Anthracnose is another fungal disease of lentil which has been found in different areas of the prairies. Conditions favouring ascochyta also favour anthracnose. The fungus which causes anthracnose on lentil has also been isolated from soybean and faba bean. The disease is spread by stubble, wind-blown dust, and to a limited extent, by seed. Disease severity is favoured by a dense, warm and moist canopy. It is recommended to use crop rotations that include three to five years between susceptible crops to reduce the level of anthracnose.

Botrytis stem and pod rot (*Botrytis cinerea*) (grey mould) can cause severe crop losses during wet years. The fungus causing these rots can overwinter on the soil surface or in debris, and occasionally can be seed borne. This ubiquitous fungus has a wide range of host plants, and crop rotation would have little impact on disease management.

Root rots and seedling blights are caused by a complex of several soil-borne pathogens which are not host specific. The recent increase in broadleaf acres has resulted in narrower rotations and an increased incidence of root rots. Severe losses are not common, but planting cereal or grass crops in rotation with lentil is necessary to keep losses minimal.

Aphanomyces root rot is a part of the root rot complex. The causal agent, *Aphonomyces euteiches*, produces long-lived soil-borne resting spores. A minimum of six years between susceptible crops (peas and lentils is recommended in fields where the pathogen's presence has been confirmed.

**Peas**
Mycosphaerella blight (*Mycosphaerella pinodes* = *Ascochyta pinodes*) is the most common disease of peas and cannot be easily distinguished from ascochyta foot rot (*Ascochyta pinodella*). Both diseases are seed- borne and can persist for several years on infested stubble or as resting spores in soil. Because of the persistence of this organism, a minimum of four years between planting peas on the same field or adjacent fields is necessary to reduce disease to a manageable level.

Powdery mildew (*Erisyphe pisi*) is a fungal disease which overwinters on plant debris. In summer the disease can quickly spread by air currents and is favoured by warm days and cool nights which lead to dew. Avoid planting pea on or near pea stubble and sow early maturing varieties to avoid severe powdery mildew development.

*Sclerotinia scerotiorum* can infect peas; however, yield losses are usually low, particularly when short erect varieties are grown. The inoculum left over from infected pea residue may cause severe disease and yield loss of subsequent susceptible crops grown in the rotation, especially canola, beans and sunflower. Pea following a susceptible crop infected with white mould may result in greater losses to this disease.

**Chickpea**
A species of ascochyta (*Ascochyta rabiei*) attacks chickpea and can cause significant yield losses in some years. Ascochyta blight is both residue and seed-borne and favoured by frequent rain showers during the summer. A rotation of three to four years between chickpea crops is advised, as well as not planting next to infected chickpea stubble. Management practices also include the use of disease-free seed, varieties with some resistance, and the application of foliar fungicides.

**Alternative Crops**

Planted acres of herbs, spices, medicinal plants and other alternative crops has increased recently. Not all diseases of these crops have been identified and their impact on the more traditional crops is not well documented. The environmental conditions on the prairies is different from other areas where these crops are cultivated which may influence the type, severity and incidence of diseases. Since most of the alternate crops are broadleaf, they should be rotated with cereal or grass crops to reduce the chance of yield loss.

**Assessing Disease Risk**

Crop disease will develop when a pathogenic organism, a susceptible host and a suitable environment are present. Predicting disease epidemics or yield loss due to a particular disease is only as reliable as predicting the weather. The presence of a pathogenic organism in a field does not necessarily result in disease.

However, should environmental conditions suitable for disease development occur in the presence of a susceptible crop and a plant pathogen, the probability of disease increases. Knowledge of the environmental conditions suitable for disease development, the biology of the plant pathogen and the range of hosts susceptible to infection by a pathogen will help farmers plan strategies including crop rotation to minimize disease and yield losses. Although farmers cannot control the weather, they can manipulate cropping practices to alter the micro-environment within a crop to minimize the risk of disease. For example, wider row spacing would allow better air movement and quicker drying within a crop canopy, reducing the probability of severe disease. Growing disease resistant varieties when possible will also reduce losses due to disease.

Crop rotation can significantly reduce the population levels of many soil and residue borne diseases which will not survive long in the absence of suitable host tissue or residue.

By the time some plant diseases are easily seen, it is too late to take effective control measures. For example, *Sclerotinia sclerotorum* ascospores primarily initiate infection by infecting and colonizing the delicate flower petals of susceptible plants. Crop infection occurs when the fungus grows out of the colonized flower petals which have fallen onto leaves and particularly stems of the host crop. Properly timed fungicide application to protect both uninfected flower petals, as well as leaves and stems prior to petal drop, will significantly reduce disease incidence and severity. A petal test to determine infections present at early flowering in canola has been developed which can alert farmers to the potential incidence of this disease in their crop.

Techniques and technology to predict the probability of disease based on local environmental conditions, assuming the pathogen and suitable host are present, have been developed for some diseases of potatoes and tomatoes. Predicting disease and crop losses in the cereal, oilseed and pulse crops can be challenging, however, the risk of disease can be assessed in each field by reviewing length of crop rotation, crop sequence, previous disease history and environmental conditions.

Attempts have been made to determine the risk associated with shortening recommended crop intervals for various diseases. Although the categorization may be somewhat subjective, the information can be useful in assessing risk and making rotation decisions. Table 9 is an example of this risk analysis.

**Table 9.**Risk associated with shortening the recommended crop rotation intervals for some plant diseases

| Disease | Crop Affected | Recommended Rotation | Risk of Shortening Rotation |
|---|---|---|---|
| Common root rot | cereals | 2-3 years | low |
| Take-all | cereals | 1 year | low |
| Leaf spots | cereals | 2-3 years | low-moderate |
| Sclerotinia | most broadleaf crops, not cereals or grasses | >5 years | moderate-high |
| Ascochyta | lentils, peas, chickpeas | 3-5 years | high |
| Blackleg | canola | 4 years | high |
| Fusarium head blight | Cereals, grasses | 2-3 years | moderate |

*Source: Bailey, AAFC Saskatoon*

Assessing disease risk would also assist in analyzing the economics of various rotations. The economics of planting the same crop in a field or shortening the rotation may appear to be justifiable to some growers regardless of the disease risk.

Most rotation studies in Saskatchewan have been conducted in the black soil zone where rotations have traditionally been more diverse. Table 10 shows the results of a rotation study completed at the Melfort Research Station. The data indicates higher yields when a crop is not grown on its own stubble and shows the value of alternating between cereal and non-cereal crops when planning crop rotations and crop sequences.

**Table 10.** Yields of crops grown on their own stubble and stubble from other crops grown in rotation. Melfort Research Station (1990-1992)

| **Crop** | **Yield (kg/ha) Stubble** | | | |
|---|---|---|---|---|
| | **Own** | **Cereal*** | **Oilseed*** | **Field** |
| Field Pea | 1600 | 2000 | 1830 | 1600 |
| Flax | 960 | 1070 | 1050** | 1360 |
| Canola | 560 | 850 | 990** | 1100 |
| Wheat | 1630 | 1590* | 2140 | 2400 |
| Barley | 2630 | 2870* | 3620 | 4010 |

* Average of wheat and barley stubble. Wheat stubble only in barley row; barley stubble only in wheat row.
** Average of flax and canola stubble. Flax stubble only in canola row; Canola stubble only in flax row.

Often the economic returns of a crop in any particular year dictates what a grower will plant, rather than the benefits of crop rotation. However, these individual management decisions should be based not only on short- term business economics, but also long-term crop sustainability. Carefully planned crop rotations based on good crop management decisions will result in both economical and crop production sustainability

Government of Saskatchewan


Wheat sub-crown internodes infected with common root rot.


Take-all infected crowns and lower culm of wheat. The shiny black lesions are characteristic of this disease symptom.


Scald lesions on barley have a very dark margin around a bleached center.


Fusarium head blight of wheat

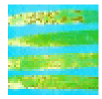

Blackleg lesion on the base of a canola stem.


Sclerotinia infection from a colonized flower petal on canola leaf.


Ascochyta lesions on lentil leaves.

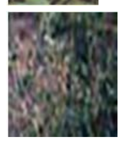

Tan spot lesions on wheat leaf.


Septoria leaf blotch lesions on wheat can be differentiated from tan spot by the lighter lesion margins and small black pimples (pycnidia) in the center of the lesions.


Net blotch on barley can appear as dark irregular spots, small oval spots, or long lesions running parallel to the leaf veins with some occasionally crossing over giving a netted or rail road track appearance.


Mycosphaerella leaf spot on peas.


Powdery mildew on peas


Ascochyta blight on chickpea

## Integrated Weed Management and Crop Sequencing

Integrated weed management (IWM) and crop sequencing are integral components of sustainable agriculture from an agronomic, economic, and environmental perspective. While crop sequencing is generally listed as a part of IWM, crop sequencing is, in fact, the vehicle that systematically implements components of IWM. Good crop sequences can reduce weed densities at the time of crop emergence, thereby minimizing crop yield losses, and can inhibit long-term changes in the weed spectrum towards species that are difficult to control. Varying selection pressure is the ecological principle that accomplishes these goals.

## What is Integrated Weed Management?

Integrated weed management makes use of a combination of different agronomic practices to manage weeds, so that the reliance on any one weed control technique is reduced. Reducing the reliance on one or two specific weed control techniques means that those techniques or tools will be effective for the future use. The object of integrated weed management is to maintain weed densities at manageable levels while preventing shifts in weed populations to more difficult to control weeds. Losses caused by weeds will be minimized without reducing farm income.

Controlling weeds with one or two techniques gives the weeds a chance to adapt to those practices. For example, the use of herbicides with the same mode of action (belonging to the same herbicide group) year after year has resulted in weeds that are resistant to those herbicides. The continuous production of certain types of crops also gives weeds a chance to adapt (downy brome has increased on fields where winter cereals are frequently grown).

Integrated weed management uses a variety of control techniques to keep weeds "off balance". Weeds are less able to adapt to a constantly changing system that uses many different control practices, unlike a program that relies on one or two weed control tools.

**Types of Integrated Weed Management Practices**

There are three main types of agronomic practices that you can use to develop your integrated weed management program:

- practices that limit the introduction and spread of weeds (prevent weed problems before they start)
- practices that help the crop compete with weeds (help "choke out" weeds)
- practices that keep weeds "off balance" (make it difficult for weeds to adapt)

Combining a number of practices from each group will allow you to design an integrated weed management program for your farm.

**Give Your Crop the Advantage Over Weeds - Help it Compete**

Fertilizer placement affects the crop's ability to compete with weeds. Placing the fertilizer where the crop has access to it, but the weeds do not, allows the crop to be more competitive with weeds. For example, after banding nitrogen fertilizer for four consecutive years, green foxtail densities were reduced by more than 95 per cent under zero-tillage conditions, and that was before any in crop herbicide was applied.

Similar trends were observed under conventional tillage conditions.

**High Seeding Rates** can help give the crop an edge on weeds. Extra plants allow the crop to shade weeds and make it more difficult for them to access nutrients and water. The additional competition may give your herbicide a boost and improve the job that it does. Try to use the maximum recommended seeding rate for each crop you grow.

**Narrow Row Spacing** (6 to 8 inches) also allows your crop to be more competitive. There may be situations where wide row spacings are necessary (residue clearance in zero tillage systems), and higher seeding rates may offset the effect of going to a wider row spacing.

**Shallow Seeding** (1 inch or less) and **Uniform Seeding** are important for fast crop emergence and good establishment, which allows the crop to be more competitive with weeds (see Table 11). Assuming the seed has been placed in moist soil, the closer it is to the soil surface, the faster the crop will emerge. Weeds that emerge after the crop cause less yield loss than those that emerge before, which is important when determining if it is necessary to spray.

**Table 11.** Seeding Depth Affects Crop Emergence

| Seeding Depth (Wheat) | Days to Emergence | Crop Emergence (%) |
|---|---|---|
| 1 inch | 1.5 days | 90 |

| | | |
|---|---|---|
| 2 inches | 3.5 days | 81 |
| 3 inches | 5.0 days | 84 |

*Source: Yantai Gan, PhD thesis, University of Manitoba, 1994*

Shallow, uniform seeding is important for good crop emergence. Seeding wheat at 1 inch in this case gave the fastest, most even crop emergence. A crop that emerges quickly and establishes well will be more competitive with weeds. **High-Quality Seed** (large, plump seed) produces vigorous seedlings that improve crop emergence, establishment and yield (see Table 12). Certified seed is your best source of high-quality seed.

**Table 12.** High Quality, Certified Seed is Important for Field Sanitation and High Yields

| Crop | Noxious Weed Seeds (per | Other Seeds (per | Yield |
|---|---|---|---|
| Certified Wheat | 0 | 0 | 41.5 |
| Bin-run Wheat | 148 | 671 | 39.7 |
| Certified Barley | 0 | 0 | 70.0 |
| Bin-run Barley | 600 | 3350 | 67.0 |

*Source: Crop Development Center, University of Saskatchewan*

Twelve randomly selected seed samples were taken from Certified and bin-run seed sources to demonstrate the importance of Certified seed. This table clearly shows that Certified seed is your best source of weed-free seed, which is important for good field sanitation. As well, Certified seed is of high quality, and produces healthy, vigorous seedlings which are important for weed competition and maximum yield potential. This is demonstrated by the higher yields achieved with the certified seed sources. How you **prepare your seedbed** can affect crop and weed growth. Ensuring that the crop seed is placed in an ideal growing environment, and the weeds are not, is another way to give your crop the edge. On-row packing leaves the soil in the row firm, but loose in between the rows. Zero-tillage systems leave crop residue in between the rows, which shades the soil and keeps it cool. Fewer weeds germinate under zero-tillage because of the reduction in soil disturbance. For example, green foxtail problems are reduced in zero-till systems because weeds are less able to germinate and grow in the zero-till soil environment.

Certain **crop varieties** can be more competitive than others. Semi-dwarf wheat varieties are generally less competitive than regular varieties. Taller varieties close their crop canopies more completely than shorter types, which help shade out weeds. This is also true of pea varieties. Research shows that yield losses caused by grassy weeds in tall pea varieties are less than half those suffered by shorter varieties. You may still need to spray the taller varieties, but your weed control will be better because of the added crop competition.

*Yield losses are dramatically less in taller pea varieties. The variety you choose can affect how competitive your crop will be.*

**Keep Weeds "Off Balance" - Don't Let Them Adapt**

Crops can be chosen so that **seeding date** is varied from year to year. Wheat and peas are generally sown as early as possible, while crops like canola are planted later to avoid spring frosts. Seeding early gives the crop a jump on weeds that emerge after the crop, while late seeding allows for a pre-seed herbicide application or a tillage operation to control early-germinating weeds. Weeds that prefer cooler conditions (wild oats, wild mustard) may be more of a concern in early-sown crops, while weeds that prefer warmer conditions (green foxtail, redroot pigweed) could be more of a problem in crops that are planted late. Wild oats can quickly become a serious problem on early-sown fields that are in continuous wheat production. Changing the seeding date from year to year means that specific types of weeds cannot adapt.

Varying **herbicide practices** is important for keeping weeds "off balance". Rotating herbicides with different modes of action (from different herbicide groups) will help delay the development of herbicide.

Herbicide practices can also be varied by taking advantage of the different application "windows" during the year. Post-emergent herbicides can be applied pre-seeding, in-crop, pre-harvest or post-harvest. In-crop herbicide applications may be the most important in early-sown crops, but in later-sown canola, a pre-seeding treatment may be all that is required in certain years. Likewise, pre-harvest applications might fit for crops that are harvested late, while post-harvest herbicide treatments could play a greater role in early-harvested crops (lentils, winter wheat).

Crops differ in their **competitive ability**. Wheat, barley and canola are more competitive than flax or pulse crops. Winter cereals (fall rye, winter wheat) are more competitive than spring cereals if they have overwintered well. Growing crops with different competitive abilities is an important technique for keeping weeds "off-balance".

Varying the **life cycle** of the crops you grow will help prevent weeds from adapting. Annual weeds do well where annual crops are grown frequently (wild oats in wheat); winter annual weeds adapt on fields where winter annual crops are used (downy brome or flixweed in winter wheat); and perennial weeds increase where perennial crops are grown (dandelions in alfalfa). Using crops with different life cycles will help prevent weeds with specific life cycles from adapting and establishing.

**Economic thresholds** can help you decide if it is necessary to spray weeds, allowing you to save money on your herbicide bill. Economic thresholds make use of yield loss equations that allow you to determine how much yield you stand to lose at a given weed density. By estimating the yield and price for your crop, you can decide if the return on spraying is worthwhile.

Skipping a spray operation can also help with weed resistance management. Not spraying in one year means less selection for herbicide-resistant weeds. Skipping a spray operation also gives more flexibility in choosing herbicides with different modes of action, which is important for herbicide rotation. Reduced selection for resistant weeds and better rotation of herbicides mean that weeds are less able to develop resistance to herbicides.

**Crop Rotation** forms the framework that truly allows you to keep weeds "off balance". Crop rotations that make use of a small number of crops do not allow much flexibility for varying seeding dates, altering herbicide practices or using crops with different competitive abilities or life cycles. Diversified rotations that use many different crops provide more opportunities for varying your weed control practices. Figures 6 and 7 demonstrate how weeds are less able to adapt when rotations with a number of different crops are used.

**Prevent Weed Problems Before They Start**

The best way to control weeds is by keeping them out of your fields. **Field sanitation** involves practices that prevent weeds from entering or spreading through your fields.

The use of **clean seed** (certified seed), **clean equipment**, and **tarping grain loads** are examples of good field sanitation techniques. This will reduce your weed pressure and decrease the introduction of new and/or noxious weeds in your fields (see Table 11).

Controlling weeds in **ditches** and at the **edges of fields** or around **sloughs** is an important practice for limiting the spread of weeds like Canada thistle and scentless chamomile.

Patches of new **invading weeds** or **herbicide-resistant weeds** should be controlled to prevent them from spreading. If small patches are detected after the normal spraying time, they should be mowed or treated with an appropriate herbicide (glyphosate) to prevent seed set.

**Removing weeds** before they have a chance to set seed is an important form of field sanitation. Collecting weed seeds by pulling **chaff wagons** behind the combine catches many seeds before they fall to the ground. The use of forage crops (perennial or annual) allows you to **cut weeds** before they set seed, which is an important form of removal. Annual grassy weeds (wild oats, green foxtail) are less of a problem after alfalfa, partly because of weed seed removal.

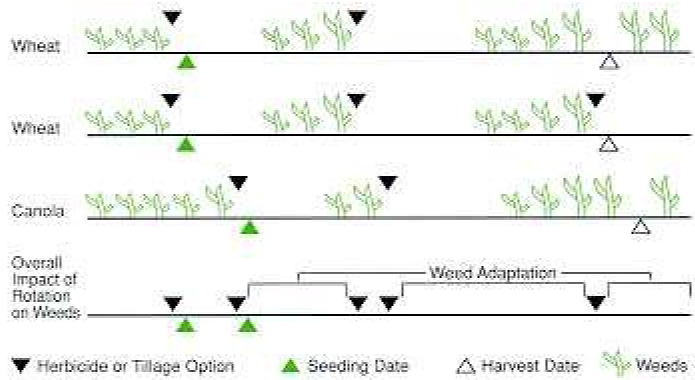
Be aware that spreading fresh manure may return weed seeds that are collected in chaff and forage if they are used for livestock feed. **Composting livestock manure** (one year minimum) will reduce the viability of many weed seeds, although certain weeds can survive longer than others in composted manure.

**Integrated Weed Management - Making it work on Your Farm**

There are a number of different practices and techniques that you can use to develop an integrated weed management program for your farm. It's easiest to start by trying a few new techniques (by changing the way you place your fertilizer, or by growing a crop that you haven't tried before) and then adding more practices as time goes on.

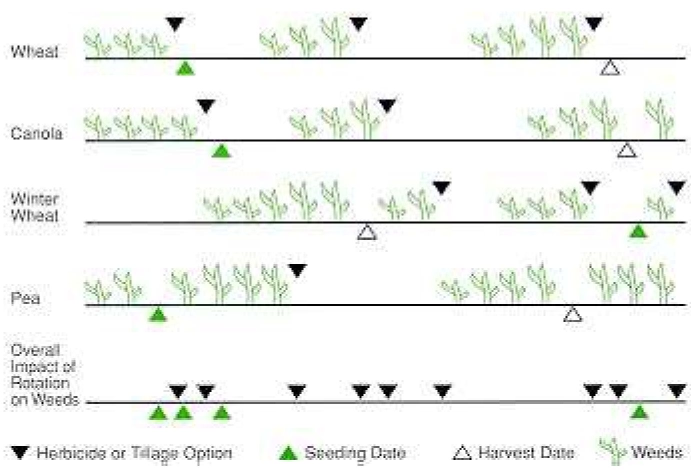
After a few years, you will have developed a system where a number of different management techniques are working together in an integrated control program. The use of a variety of agronomic practices to control weeds reduces the reliance on any one technique or tool, which means that those tools will still be effective for future years. The use of a number of different weed control tools keeps weeds off-balance and prevents them from adapting to your integrated weed management strategy.

**Figure 6.** Non-Diversified Rotations Allow Weeds to Adapt




*The small number of crops in this rotation means there is little variation in seding dates or herbicide practices and little use of different crop competitive abilities or life cycles. This system gives weeds a chance to adapt.*

**Figure 7.** Diversified Rotations are Better at Keeping Weeds "Off-Balance"




*Diversified rotations that use a number of different crops allow you to manage weeds at many different times over the growing season. The overall effect of the various practices at different times keeps weeds "off-balance".*

**Your Management Journal**

Government of Saskatchewan

Here's an example of what your weed management journal might look like as you begin to develop an integrated weed management program:

| | |
|---|---|
| April 15 | Picked up the last of the seed today. Going to try a new variety of peas. It's taller than the other varieties I've tried, so it will hopefully choke out the weeds a little better. |
| May 3 | Decided to try knifing in the nitrogen as anhydrous instead of broadcasting granular fertilizer. The green foxtail seems to do better where I've broadcasted - banding should give the crop a bit more of a boost. |
| May 15 | Seeded the last of the wheat. The air seeder seems to be doing a good job. The soil in- between the rows is loose, which should make it tough for weeds to germinate. |
| June 18 | Decided not to spray the canola for grasses this year. It was the last crop in the ground, and not many weeds came after seeding. Did some rough weed counts, and the numbers just didn't seem to justify spraying. |
| July 15 | Saw some chamomile showing up down by the slough. I think I'll mow it out before it sets seed. Also saw an odd looking patch of wild oats - might spray it with Roundup if it looks resistant. |
| August 8 | Going to apply pre-harvest Roundup this year on some of the wheat. Want to clean up the thistle a bit since it may go into lentils next year. |
| August 25 | The new truck tarps don't take much time to roll out, and I don't have to worry as much about spilling grain - or weed seeds! |
| September 10 | Just finished seeding the winter wheat. It should help clean up some of the wild oats and green foxtail on that field. Will check later for winter annual weeds. |
| October 15 | Sprayed a couple of pea fields for stinkweed and sheperd's purse today. Less residue from the peas should let me direct-seed those fields next year. Winter annuals seem tougher to kill after they bolt - should do a better job by spraying this fall. |

**Summary**

Crop rotation (sequence) affects, and is affected by, water and nutrient use, disease, weeds, and seeding systems. The challenge faced by the producer is to use the information contained in this bulletin and from other sources to continually re-determine the 'best' crop rotation (sequence) for each field according to problems, circumstances and commodity prices. Also, rotating herbicides and maintaining accurate herbicide use records are critical in planning crop rotations.

For more information contact Agriculture Knowledge Centre at 1-866-457-377

Government of Saskatchewan