PP-705 (Revised)

CROP ROTATIONS
for Managing Plant Disease

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Crop rotation can help minimize plant disease potential by reducing populations of disease organisms surviving in the soil or on crop refuse. Although crop rotation reduces the risk of many row crop and cereal diseases, it does not eliminate them. Crop rotation does not affect disease organisms that survive on or in the seed, such as the cereal smuts. Crop rotation also does not affect disease organisms that blow in from the south, such as the cereal rusts.

"Unfavorable" rotations do not automatically result in serious disease outbreaks, because disease development often is dependent on favorable weather. However, growing successive crops that are susceptible to the same disease organism increases the odds of severe disease losses. When crop rotations are limited or short term, vigorous disease and pest monitoring is essential.

Some plant disease organisms are unique to a particular crop; others attack many crops. The presence of a particular disease within a crop has important implications for the next crop in that field. Common disease problems and rotations to help avoid them will be discussed.

Cereals

Rotation between cereal crops and broad-leaved crops results in the least risk from plant diseases. Disease organisms that attack cereal crops usually do not attack broad-leaved crops, and vice versa.

Leafspot Diseases. Rotations among different small grains and corn result in less buildup of leafspot diseases than continuous cropping of the same crop. Planting wheat on wheat or barley on barley may result in buildup of several leafspot disease organisms such as tan spot of wheat and net blotch of barley (Table 1). One of the *Septoria* leafspots and the spot blotch fungus also build up when wheat and barley are rotated.

However, with a wheat/barley rotation there is much less likelihood of buildup of tan spot, the most serious wheat leafspot disease. This is because tan spot will not develop and survive on barley. The tan spot fungus will survive on wheat residue for several years. Hence, a two-year period between wheat crops will provide greater reduction in tan spot potential than only a one-year rotation.

Rotation of oats with wheat or barley substantially reduces the risk of leafspot disease, because most organisms that cause leaf diseases of oats do not attack wheat or barley. An oat-wheat or oat-barley rotation results only in a possible buildup of *Fusarium* root rot, which is not a serious problem in North Dakota.

If short rotation intervals or **no** rotation intervals between wheat or barley are practiced, many leafspot diseases can be reduced through tillage and fungicide applications. The potential for early season leafspots can be reduced by complete incorporation of small grain crop residue into the soil several weeks before planting, which buries most leafspot disease organisms. Later in the season, leaf spotting can develop from spores blown in from neighboring fields. Placement of crop residue on the soil surface allows some reduction or decomposition of residue and some reduction of leafspot potential, but not to the extent seen with complete incorporation. Rotational crops such as flax, oats, millet, mustard or canola may provide residue free of cereal leafspot pathogens for minimum or no-till production of wheat or barley.

Fungicide applications for leafspot control may be beneficial if rotations are not ideal and crop residue is not buried (*e.g.* minimum till or no-till). Fungicides may be planned as part of the production costs. However, sprays can be cancelled later if yield potentials at early flag leaf do not warrant the cost of fungicide application, or if the environment has not been suitable for disease development.

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Bacterial diseases, such as bacterial blight, also survive in the stubble and straw of wheat, barley and oats. They are favored by continuous cropping, reduced tillage, sprinkler irrigation or long periods of wet weather. No fungicides are available for their control.

Common Root Rot. Wheat and barley are susceptible to the common root rot fungus, *Helminthosporium sativum.* This fungus survives and multiplies in soil planted to wheat or barley. Planting non-host crops in the rotation reduces the level of this disease organism. Non-host crops include oats and all broad-leaved crops. Fallow also will reduce the common root rot fungus population. Long term (three to four years) rotations will provide the best control. Deep tillage does **not** reduce the level of common root rot. Some reduction of common root rot severity has been seen under minimum and no-tillage practices. Good rotation is the best method for management of common root rot. Other management steps for common root rot include variety choice and fungicide seed treatment.

Ergot. Rotation between wheat and rye is not advisable — both crops are susceptible to ergot. Wheat following rye may result in possible high levels of ergot in the wheat crop. Rye and/or *Triticale* also should not follow each other because of the danger of ergot. Many grasses, such as

Table 1. Some important disease organisms that are affected by crop rotation, and the crops they attack.[a]

CROP	Disease Organism															
	Bacterial Blight of Dry Beans	Bacterial Blight of Soybeans	Black Chaff, Bacterial Leaf Blight of Wheat/Barley	Common Root Rot/Spot Blotch of Cereals	Ergot	Net Blotch	Rhizoctonia			Septoria Leaf Blotch	Septoria Glume Blotch	Stalk Rot/Corn, and Scab/Cereals	Sclerotinia/White Mold	Tan Spot	Verticillium	Wheat Streak
							AG-2-2	AG-3	AG-4							
Cereals																
Barley			++	+++	+	+++				++	(+)	+				+
Corn												+++				++
Millet																++
Oats			+		+						+				+	
Rye			+	+	+++					(+)	+		+		+	
Sorghum												+				
Wheat[d]			+++	++	++					++	++	+++		+++		+++
Wheat Grass			+	++	++							+		++		
Non-Cereals																
Alfalfa							+		+				+			
Beans, Dry Edible	+++						+++		++				+++			
Beans, Soy		++					++		++				++			
Buckwheat													(+)			
Canola (Rapeseed)							(+)		+				++			
Flax								+[b]	++				+			
Lentils									++				++			
Mustard							(+)		(+)				++			
Peas, Field							+		+				+			
Potatoes							*[c]	++	*[c]				+		+++	
Safflower									?				++		++	
Sugarbeet							+++		++							
Sunflower													+++		++	

[a]Most disease organisms that attack only one crop are not listed here. Relative prevalence and severity is indicated as follows: +++ = common and severe; ++ = moderately common, moderately severe; + = occasional and/or not severe, (+) = published reports indicate that the crop is susceptible, but the disease has not been observed in North Dakota.

[b]Seed rot only; no seedling disease or root rot.

[c]May survive saprophytically or as a low level pathogen on roots and maintain a population.

[d]Wheat includes hard red spring wheat, hard red winter wheat and durum wheat.

Agropyron (wheat grass), should not be rotated with wheat because they also are frequently infected with ergot and because of a possible increase in leafspot diseases (Table 1).

Wheat Streak Mosaic. Wheat should not be planted into wheat stubble unless all volunteer wheat plants in that field are destroyed at least two weeks before planting. Destruction of volunteers reduces the danger of wheat streak mosaic, a disease that became epidemic in southeastern North Dakota in 1985 and 1986, and in southwestern North Dakota in 1988. The wheat volunteers are potential reservoirs of the virus that causes the disease. Seeding wheat into stubble of other crops is preferred because of the reduced risk of volunteers. If possible, also avoid planting next to corn. Corn is commonly infected with wheat streak mosaic in southeastern North Dakota and can be a source of infection to adjacent winter wheat (Table 1). Barley and oats also are susceptible to wheat streak, but infection of these crops is not commonly seen in North Dakota.

Take-all. Growing wheat and barley continuously for several years may result in a buildup of take-all root rot — potentially a very serious disease. The disease is most often found associated with fields under high soil moisture. Although take-all is more traditionally found associated with irrigated fields, the disease has been found in dryland wheat fields in years of high rainfall and wet soils. Levels of take-all disease in a field can be reduced substantially if wheat is not grown for several years. Grassy weeds and volunteer wheat are frequent reservoirs of take-all and should be destroyed.

Scab of small grains and corn stalk and ear rot. Head scab of small grains is caused by several species of the fungus *Fusarium*. The scab fungi survive from year to year in small grain and corn residue. Wheat planted into wheat residue is at higher risk of scab infection than wheat planted into fallow or non-host crop residue. Of the small grains, hard red spring wheat and durum wheat are the most commonly infected. Barley and oats are susceptible but infections are seldom seen in North Dakota.

Corn in rotation with small grains can result in the buildup of *Fusarium* species. These fungi also cause corn root rot and corn stalk and ear rot (Table 1). If corn and small grains are included in a rotation, they should be separated by other crops or fallow, if possible. The most serious scab problem is likely to arise if wheat is planted into corn stubble or cornstalk trash. The scab organism survives in corn residue and is readily available to infect the wheat head if favorable warm and wet conditions occur at the time of pollination. Irrigated wheat planted after corn is a high risk rotation practice, because the continuous wet conditions are very favorable for scab infection. Land under irrigation with corn should be rotated to some other crop periodically.

Non-Cereals

Soil-borne Diseases

Sclerotinia (white mold). This fungus attacks many broad-leaved crops (Table 1). Sunflowers are most susceptible. Dry beans, mustard, canola, lentils and safflower are highly susceptible when grown under irrigation or when the growing season is wet. Soybeans are less commonly attacked than dry beans, but *Sclerotinia* infections are fairly common if soybeans are solid seeded, the season is wet, or the crop is irrigated. Alfalfa, field peas, potatoes and garbanzo beans also are susceptible.

Even low levels of *Sclerotinia* are sufficient to maintain a population of the fungus in the soil and cause problems for the next highly susceptible crop. Ideally, all susceptible crops should be in a four-year or longer rotation, with no other highly susceptible crop in the rotation. This rotation interval is **essential** if there are high levels of *Sclerotinia* in a field. It may be necessary to avoid susceptible crops for five to six years on severely infested land. An example of a severe infestation would be a sunflower field that had over 10 percent Sclerotinia stalk rot. If *Sclerotinia* is not at high levels, a four-year rotation is still desirable to prevent its buildup.

The best rotation crops for *Sclerotinia* control are small grains, grasses, corn, and sorghum, as these are **not** host crops for *Sclerotinia*. Many broadleaf weeds are susceptible, including wild mustard, marsh elder, lambsquarters, pigweed, and Canada thistle; they must be controlled when growing non-host crops. Reports from other states indicate that flax is susceptible, but the disease is rare on flax in North Dakota.

Sclerotinia attacks sunflower in two ways, but usually attacks most other susceptible crops in only one way. Sclerotia (hard, black fungus bodies) survive many years in the soil and may germinate to infect sunflower roots, resulting in a wilt disease which is also called basal stalk rot. Wilt occurs whenever sunflower is planted on *Sclerotinia*-infested land.

When soil moisture is high for one to two weeks, the sclerotia form tiny mushroom-like structures (apothecia) that produce millions of air-borne spores. These spores can infect the senescing flower parts of dry beans, canola, lentils, safflower, soybeans, field peas and garbanzo beans. They also can produce head rot and middle stalk rot in sunflower.

Spores for these infections may come from the same field or a nearby field that has sclerotia on or near the soil surface, regardless of the current crop being grown in that field. Thus, *Sclerotinia*-free fields may become infested as a result of air-borne spore infections of susceptible crops or weeds; in some years this can be a very important means of spread. Favorable weather conditions for spore formation do not occur every year, but they did occur in the fall of 1979, 1980, 1985, and 1986 and 1987, resulting in *Sclerotinia* diseased sunflower heads and upper stalks. Favorable weather in July of 1986 and 1987 resulted in considerable white mold in dry beans and soybeans.

Excellent rotations will not prevent *Sclerotinia* from occurring in a field if the disease organism is introduced into clean fields by planting infested seed. Sclerotia can become mixed with the seed. Planting certified seed reduces but does not eliminate the danger of introducing *Sclerotinia* into clean fields. North Dakota seed laws permit no more than one sclerotium per pound of sunflower seed.

Verticillium. Sunflowers should not be rotated with potatoes, since both crops are suceptible to this disease and both may allow populations of the fungus to increase. *Verticillium*-tolerant sunflower hybrids can support a population increase of *Verticillium* that could affect a subsequent potato crop. Potato varieties differ in their susceptibility to *Verticillium*: Kennebec is very susceptible, Russet Burbank is susceptible and Reddale is resistant. Potato crops should be grown at least three years apart. *Verticillium* also can be tuber-borne on potato, so disease-free seed sources are important. Safflower also is susceptible to *Verticillium*, especially when grown under irrigation.

Downy mildew of sunflower. This disease organism survives up to 14 years in the soil. Crop rotations are not suitable for its control, and currently available hybrids are not resistant to all races. Metalaxyl (Apron) or oxadixyl (Anchor) seed treatment protect against infection.

Rhizoctonia seedling blight and root rot. The *Rhizoctonia* fungus is favored by warm, moist soils and causes seedling blight of sugarbeets, dry beans, soybeans, flax and many other crops (Table 1). Rhizoctonia may also infect seedlings when germination is delayed by cool, wet soils. It also causes a root rot of alfalfa, dry beans, soybeans, sugarbeets and black scurf of potato. However, no one strain of *Rhizoctonia* infects all of these crops. Some common strains in North Dakota are designated AG-2-2, AG-3, and AG-4. AG-2-2 infects sugarbeet and results in root and crown rot, and it also causes a root rot of dry bean and soybean; sometimes it also causes a seedling blight of sugarbeet and canola. AG-3 is primarily a pathogen of potato and causes black scurf. The AG-3 strain that attacks potato is both soil-borne and tuber-borne, so disease-free seed sources and crop rotation are important for potato culture. AG-4 is not so selective; it can cause seed rot, seedling blight and occasionally root rot of sugarbeets, plus similar diseases in alfalfa, dry beans and soybeans. Growers should avoid short rotations between sugarbeets and dry beans or soybeans. Crops susceptible to the same strain or strains of *Rhizoctonia* should not be grown more often than once every three years.

Aphanomyces seedling blight and root rot of sugarbeet. *Aphanomyces* is a severe disease of sugarbeet that occurs on wet or water-logged soils during warm weather. Extremely wet conditions in some areas during the summers of 1986 and 1991 favored *Aphanomyces,* especially in southern Minnesota. The fungus produces spores which survive over 20 years in the soil, making it almost impossible to control by rotation. It also survives on pigweed, kochia and lambsquarters. No registered seed treatment is available for control of *Aphanomyces* (as of 1992). Infested fields may need a better drainage system to avoid severe *Aphanomyces* damage in warm wet years.

Potato scab. The potato scab fungus is soil-borne and survives many years in the soil. Scab is a common problem of garden potato but rather uncommon in commercial potatoes. If potatoes are planted in infested fields, the disease is best controlled by the use of resistant varieties. **Do not** use animal manure on fields where potatoes are grown in the rotation, as animal manure can increase the scab disease potential.

Row Crop Diseases Borne on Crop Residues

Certain row crop disease organisms are borne on crop residues. Examples are dry bean rust, safflower rust, sunflower rust, bacterial blight of dry beans, potato early blight, *Cercospora* leaf spot of sugarbeet, white rust of mustard, blackleg of canola, and *Ascochyta* blight of lentil. A three-year rotation is desirable for most of these crops. A four-year rotation for canola has been shown to provide better management of blackleg.

Susceptible crops should not be planted next to a field that was severely diseased the year before, as those disease organisms that produce spores can be airborne or splash dispersed from crop refuse and volunteer plants. If a susceptible crop must be planted next to a field that was severely diseased the year before, tillage should be used to bury the infected crop residue early, and all volunteers should be destroyed before planting. *Alternaria* blights can be serious diseases of several row crops, including safflower, sunflower and dry beans. Each of these crops is attacked by different species of *Alternaria*. Since the *Alternaria* fungi survive on crop residues, crop rotation may help reduce the severity of these diseases. For *Alternaria* blight of safflower, at least a three-year rotation should be used in eastern North Dakota.

Certain diseases borne on crop residues also are seedborne: safflower rust, bacterial blight of dry beans, blackleg of canola, and *Ascochyta* blights of garbanzo beans and lentils. If diseased seed is used, rotations alone will not control these diseases. Selection of clean seed sources is desirable whenever feasible, and safflower seed treatment is recommended to protect against the seedling phase of safflower rust.

Conclusions

Unrelated crops are excellent in a rotation for disease management. Small grains, corn, sorghum and other members of the grass family should be routinely rotated with broad-leaved row crops. When government programs, marketing problems, or environmental constraints make the best rotations unfeasible, then the least risk rotations should be used. The greatest disease risk is always assumed when **no** rotations are practiced, *i.e.* continuous cropping of the same crop. Good rotations reduce the amount of soil- and residue-borne overwintering pathogens that can start disease epidemics. Crop rotations, which provide many benefits in addition to disease control, always should be considered when cropping decisions are made.

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