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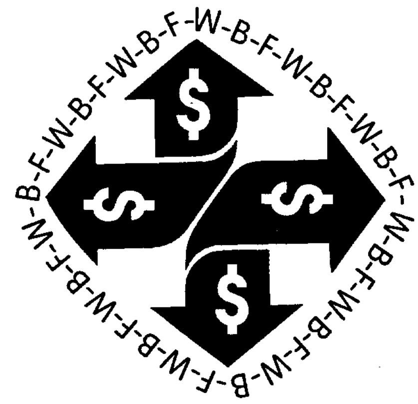
Crop Rotations for Profit in North Dakota



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How to best sequence crops to develop a profitable rotation requires a lot of thought, an understanding of the interactions among your many management decisions and a willingness to look at a longer time frame.

A good rotation for the soil or for disease and weed control is not sustainable unless it is profitable enough for the family to stay on the farm.

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Rotation — What is it?

Crop rotation is a planned order of crop sequence on the same piece of land over time. The purpose of a rotation is to increase the average profit from the land by selecting a cropping sequence that has more additive than non-additive effects. To accomplish this, crops used in any rotation must **(1)** be adapted to the local climate and soils, **(2)** be compatible with the producers management, **(3)** have a potential market and **(4)** be aesthetically and culturally acceptable.

North Dakota farmers practice crop rotation on most fields with little continuous cropping. However, they may not be planning and using rotations that will maximize benefits. Some farmers have well planned and organized crop rotations they follow year after year. A few operators pay little or no attention to rotations, preferring to take a chance on trying to hit the market jackpot with no regular plan in mind; many producers just follow rotations to comply with government farm programs.

Farmers who are inclined to pay little or no attention to rotations say the seasons are too variable and the choice of crops is too limited. While climate, soils and market value do limit our choice of crops, benefits can still be gained from well planned rotations.

A closer look at some of the factors that limit choice of crops will help determine the boundaries that must be followed when selecting crops to grow in a rotation.

Climate imposes several limitations on choice of crops.

- **Growing season.** In North Dakota it is comparatively short and varies from year to year. The normal frost free period varies from 100 days in the north central part of North Dakota to 140 days in the southeast. The relatively short frost free period increases the risk for grain corn and other long season crops in much of the state as compared to further south.
- **Precipitation**. It is variable and usually limited. Fortunately, nearly one-half of the seasonal precipitation occurs during the growing months of May, June and July. However, the average annual precipitation is many times not adequate for maximum crop yield, and the lack of rainfall often causes drought stress periods during the growing season. This pattern of maximum precipitation early in the growing season favors early- maturing cool-season crops.
- **Temperatures**. Both air and soil temperatures have their effect on crop choices. Air temperatures through June are generally favorable for early-maturing cool-season crops such as small grain and grass but usually become too high in late July and during August. Later-maturing crops such as corn, soybean and sunflower do well in warm years when adequate moisture is available in August. Soils are frozen from November through March. Winter injury to fall sown cereal crops, except winter rye, is common. Spring seeded crops must be able to germinate and start growth in relatively cold soil and with cool air temperatures.

Problem Soils can also limit crop choices. Saline or alkaline conditions, drouthy soils or areas subject to flooding all limit the choice of crops available and, therefore, the possibilities or rotations involving such fields.

Market Value of crops grown in a rotation must be profitable. They must either have a profitable value as a cash crop or as a feed crop, or they must benefit succeeding crops in the rotation. A crop may be adapted and even yield well, but it is of no value to the producer without a profitable market outlet.

Farm Programs that limit the acreage that can be planted to a crop may encourage rotations by farmers who participate.

The length of growing season, precipitation, temperatures, problem soil areas, profitable market demands and federal farm programs all combine to limit the choice of crops to be included in rotations in North Dakota. Even with a limited choice of crops and cropping practices, crop rotation has value and should be carefully planned and followed for maximum farm profit. Rotations are especially helpful in maximizing water use; controlling erosion, weeds, plant diseases and insects; and distributing labor and machinery requirements, but they require more planning and management from the producer.

Advantages of a Rotation in North Dakota

While several factors may limit the choice of crops that can be used in profitable rotations, many benefits can still be gained from rotations adapted to North Dakota conditions.

These benefits include:

Maximum water use, which is very important in North Dakota. Crop yield is influenced by the moisture left by the preceding crop or practice. Summerfallow, for example, leaves some accumulated moisture for next year's crop. Early maturing crops allow moisture accumulation after harvest while late maturing, deep rooted crops may leave very little moisture reserve for the next crop. A sod crop or alfalfa for several years usually depletes the subsoil moisture reserve. Residue (amount and type) can be important as a snow catching system.

Weed control is a serious problem in producing spring sown small grains. Summerfallow in the rotation tends to encourage weed seed germination and allows excellent weed control, which prevents weed seed production. However, some weed seed survive for more than a year and weeds that emerge the following year will respond to fallow as well as, or more than, the planted crop.

Row crops are good for weed control if they are kept free of weeds, either with herbicides or with cultivation. The practice of delayed seeding is often used to permit weed emergence and tillage or chemical burndown for weed control before the crop is sown. Fall rye included in the rotation, especially on summerfallow, is an effective control practice for wild oat and other weeds due to the extreme competitive ability of rye. Perennial grasses and legumes grown for several years and pastured or cut for hay or silage are also good weed control crops. Crop rotation can be a critical component in reducing build-up in herbicide resistant weeds. Rotate crops, particularly those with different life cycles (winter annual such as winter wheat, summer annuals such as corn, sunflower and spring wheat, and perennials such as alfalfa). At the same time, remember not to use herbicides with the same mode of action on these different crops against the same weed unless other effective control practices are also included in the management system.

Soil Productivity must be maintained for continued high yield. Including grasses and legumes in the rotation helps keep soil in good physical condition, maintains organic matter and provides a change in rooting patterns. The extensive root system of grass and legumes improves soil tilth and structure. Light sandy soils are given structure and water holding capacity and heavier loam and clay soils are loosened up so water will infiltrate more rapidly. The organic matter supplied by these crops also adds raw food material for soil microorganisms and improved tilth. All annual crop residue should also be incorporated or left on the soil surface.

Legume crops such as alfalfa and sweet clover generally improve the fertility level of the soil because of their nitrogen fixation. Sod crops, however, are heavy users of moisture and may reduce the yield of following crops until soil moisture reserves are replenished. Alfalfa may dry the soil 8 to 12 feet deep, sweet clover 5 to 8 feet, and perennial grass 4 to 6 feet deep. Annual legumes such as soybean, dry edible bean and field pea do not deplete soil moisture as deeply and, where adapted, are beneficial in a rotation.

While crop rotation may be beneficial from a fertility standpoint, it should not be relied upon entirely. The intelligent use of commercial fertilizer or farm manure is needed to increase the productive capacity of most soils. Soil testing will give the information needed to blend and match these management components.

Wind and water erosion can be reduced by practices such as strip cropping, contour farming and terraces. Rotations can also help when added to these practices. Cropping practices and tillage methods are probably more important than rotations for erosion control. Where water erosion is serious, the field or area should be seeded to a permanent sod. Where wind erosion is serious, plant residues and vegetative barriers are tools to use.

Diseases may remain in the soil from season to season living on plant residue or as resting spore bodies. Crop rotation can be helpful in controlling disease caused by fungi and bacteria. The biological cycle of the plant pathogens is broken and they cannot survive for extended periods in the absence of their host plants.

Insects which have feeding habits restricted to certain crops can be controlled or at least reduced by rotations. Susceptible crops should not follow each other in rotation. Wheat stem sawfly, for example, attacks wheat and spring rye, while wireworms attack wheat, spring rye, corn, potatoes and sunflower, but oat, barley, sweet clover and alfalfa are less susceptible.

Labor Distribution and **Machinery Requirements** are helped considerably by rotations that distribute the load over a longer season. Rotations that include perennial grasses and legumes, fall-seeded cereal crops such as rye, late-seeded spring crops such as corn, millet, sudangrass, buckwheat and flax, and late-maturing crops such as corn, sugarbeet and potatoes all help spread the work load during their seeding and harvest seasons.

In summary, many benefits can be gained from selection of crop rotation management strategies best suited for individual field situations.

Influence of the Previous Crop

The **influence of the previous crop** can have a profound effect on the response of a crop in a rotation sequence. The following summary statements can be made based on long time research results of the NDSU Research Centers at Dickinson, Minot and Fargo as well as farmer experience.

Corn yield generally is not affected by different cereal crops. Yield is similar following small grain or following corn. Corn does not respond nearly as well to fallow as small grains. This is of value in planning a rotation because **(1)** small grains yield better following corn than following small grain and **(2)** small grains respond to fallow much better than corn. Corn on fallow is worthwhile only if a drought year occurs.

Wheat performs best planted on fallow, second best after soybean, and then after corn. Wheat does better following oat than other cool season cereal grains. In a rotation, wheat should follow summerfallow, row crops or oat where possible and continuous wheat should be avoided.

Oat apparently can go any place in the rotation except following oat.

Barley yields best on fallow and next best after row crops and poorest after barley. A common rotation in parts of North Dakota is fallow-wheat-barley. The federal farm program has been a factor in popularizing this rotation. Barley also does well after flax when the flax stubble is left to trap snow.

Flax should follow a small grain. If seeded late, it should be followed by corn or fallow.

Rye uses a lot of moisture and needs to follow an early harvested crop or be planted on fallow. Volunteer rye is a potential problem, so rye should be followed by a row crop where grasses can be chemically controlled or controlled by late spring tillage. Rye should not be followed by winter wheat, spring wheat, barley or oat.

Sunflower and **Safflower** are late maturing, drought resistant crops which root deep and dry the subsoil. Sunflower and safflower should follow small grain. In dry years, sunflower and safflower ground should be fallowed if soil moisture recharge is limited.

Dry edible beans can take the place of any row crop in the rotation. They should not follow sunflower or potato due to shared diseases.

Soybean should follow corn or small grains and be followed by the same.

Field pea, tame mustard and canola are early maturing crops and can be followed by many other crops with wheat and barley most often the grain of choice. Sunflower and dry edible beans should be avoided.

Rotational restrictions from the use of certain herbicides must be acknowledged as rotational plans are developed. Likewise, taking advantage of herbicide carryover should be considered. Residual herbicide activity can be a plus as well as a negative.

Green manure crops including field pea, rye and sweet clover have increased small grain and corn yields when moisture conditions are above average. Small grains or corn should follow an early-plowed green manure fallow rather than a late-plowed green manure.

Perennial grasses and legumes generally should not be included in short rotations on good crop land. The exception may be on heavy clay soils where soil condition needs improvement.

While rotations have considerable agronomic and environmental value and can help increase farm income, they have some **undesirable features.** Adding new crops may require additional capital investment in the farming operation. For example, a row crop such as corn requires special planting, cultivating and harvesting equipment and may require an investment in livestock if the corn is harvested as silage. Grass and legume crops may require investments in harvesting equipment and livestock. Sugarbeet and potato are examples of crops that require extra investment for specialized equipment. New crops may add to labor requirements and marketing problems. In some cases, additional on-farm storage structures may be necessary.

Role of Green Manure Crops and Animal Manure

Green manure crops add organic matter to the soil, improve soil structure and may also increase the nitrogen supply and make certain other minerals more readily available. They are, therefore, used to improve soil tilth as well as the general fertility level of the field.

Generally, only one-half to two-thirds of the nitrogen contained in legume biomass is obtained from the atmosphere. The remainder of the nitrogen in legume tops and roots is obtained from the soil and does not represent a net gain in N.

Data from various experiment stations indicate that the tops and roots of sweet clover in the fall of the year seeded may contain nearly 150 pounds of nitrogen per acre while the tops and roots of alfalfa, red clover, soybean, and field pea contain about one-half that amount. These data are from areas where fall growing conditions in most years may be more favorable than in much of North Dakota. However, the data indicate the fast buildup of nitrogen in sweet clover compared to other legume crops. Sweetclover does not continue rapid accumulation of N, and when plowed under the second year at flowering still contains no more than 150 pounds of nitrogen per acre. Second-year plowed alfalfa and red clover was equal to sweetclover and may also contain up to 150 pounds of N per acre in the tops and roots combined. Research evidence also indicates that nitrogen in legume residues is more slowly available to a small grain crop than commercial fertilizer nitrogen.

NDSU research at Fargo has shown that sweetclover plowed under for green manure increased available nitrate nitrogen in the soil profile, but this beneficial effect was offset by the extra removal of soil moisture. Sweetclover allowed to grow two hay crops or a hay crop and a seed crop resulted in lower wheat yields the next year than wheat after regular fallow, presumably because of the extra moisture used by the sweetclover crop. At NDSU research centers in North Dakota, regular summerfallow has produced greater crop yields than green manure-fallow the only exception being in years of above average precipitation where yields were similar or slightly higher following green manure.

Crops commonly used for green manure in North Dakota include sweetclover, field pea, buckwheat, rye, sorghum/sudan and alfalfa. If used in a rotation, they should be plowed under early in the season to limit moisture use or the yield of the following year's crop may be reduced instead of benefited in most of North Dakota. Green manure crops have considerable value in improving the physical condition of heavy clay soils and are considered beneficial to these soils.

Considering the cost of seed and the risk of yield reduction, statewide use of green manure is not strongly recommended as a general practice. In the heavy and poorly drained soil areas of the Red River Valley, increased yields of crops following green manures are more often obtained. In this area, legume green manures are recommended for general use.

Barnyard manure varies in nutrient content depending on species of animal, kind and quality of feed and care of manure after it is produced. A ton of average mixed farm manure contains fertilizer nutrients about equal to 100 pounds of 10-5-10 commercial fertilizer. Fresh manure does not decompose completely the season it is applied; therefore, only 30 to 40% of the nitrogen and phosphorus is considered available from fresh farm manure the first season. When manure is partly decayed, as from a feed lot and cattle sheds, 60 to 70% of the N and P are considered available the first season. The potassium is considered 100% available for plant growth.

Manure fertility losses may occur by leaching with poor storage, by volatilization of ammonia nitrogen if spread and allowed to dry before plowing under, and by surface run-off if spread on snow or frozen soil. These losses reduce the value of manure.

Barnyard manure contains a considerable amount of organic matter. Applied manure may cause a temporary biological soil nitrogen tie up and may also cause dryness of surface soil if plowed. Small grain yields, therefore, are often lower when manure is incorporated directly ahead of planting. Fields planted to corn or fallowed provide manure more time and warmer soil temperatures in which to decay and release nutrients than if the manured field is planted to small grains. Generally, soils with thin top soils or those low in organic matter will give greatest crop responses to manure applications.

In North Dakota, manure should be applied to land that will be planted to corn or is to be fallowed. These application strategies are considered best for several reasons. Preparation of land for corn or fallow fit better in the spring

season with time that can be devoted to loading and spreading manure from feed lots or winter storage. Corn yields are usually not decreased from heavy manure applications. Tillage for corn and fallow can better control increased weediness often associated with manure applications. Spreading manure in these two places in the rotation also eliminates the temporary nitrogen shortage and surface soil drouthiness that may lower small grain yields.

Farmers testify that application of livestock manure to eroded hill-tops has enabled them to increase yields of both small grains and row crops on hilly land. The manure should be incorporated by tillage after spreading to reduce movement of nutrients down the slope by water erosion. Never apply manure to hill-tops or slopes when soil is frozen.

Recently, debates over the value of manure have been ongoing with some questioning whether or not manure is really worth the expense and labor of hauling onto the field. Manure, however, has to be removed from feed lots and sheds, and it takes very little extra effort to spread it on the land. Proper handling of manure can provide valuable plant nutrients and reduce fertilizer costs.

A downside cost of manure is addition of weed seed to the land. Depending on the manure handling system, the amount of weed seed in the feed bedding and the length and type of storage, a large number of weed seed could be returned to cultivated fields. Some seeds lose their viability going through the animals digestive system, some die from the heat generated in storage, but a large number of weed species seed remain viable even after all of this. Additional management will be needed to handle this problem in subsequent crops.

Problem Soils

Problem soil areas such as sandy soils, drouthy soils and soils subject to erosion or flooding present special rotation problems on some farms or parts of farms.

Saline Soils

Profitable production of annual crops on saline soils is difficult. They are often best suited for use as grazing land. If native vegetation has been destroyed by attempts to crop salty ground, then reseeding to the most salt tolerant perennial grasses is advisable.

Soils that are moderately saline can usually be cropped at least part time but need special consideration of crops selected for the rotations and cropping practices. Suggested strategies of handling saline soils are:

- Do not use fallow in a rotation on soils with a high water table. Surface evaporation will leave salts concentrated on or near the surface. Saline soils with high water tables should be cropped as intensely as possible to increase water use thus reducing surface evaporation.
- Grow alfalfa, sweetclover and sunflower or safflower at intervals in the rotation. These deep-rooted high-water-requirement crops will reduce surface soil evaporation and may even lower the water table, allowing rain and snow moisture to move salts downward as soil moisture is replenished.
- Addition of organic matter such as barnyard manure, green manure crops and returning all possible straw and stubble to the soil can be helpful. Organic materials aid water infiltration and provide surface cover to reduce evaporation.
- Plan to grow only those crops that are most tolerant to saline soil conditions. Sugarbeets are quite tolerant after emergence while potatoes have poor tolerance. Small grains have moderate tolerance with barley being more tolerant than oats or wheat and they, in turn, are more tolerant than soybean, corn, dry edible bean and flax. Perennial grasses such as tall wheatgrass, slender wheatgrass and western wheatgrass are very tolerant of salt conditions. Sweetclover is quite salt tolerant and so are alfalfa and sunflower once past the seedling stage.

Sandy soils

Fields having light sandy or gravelly subsoil tend to be drouthy. Fallow is of little or no value in conserving moisture on such soils because the total water-holding capacity is low. The best adapted annual crops include short-season, early-maturing small grains that can be grown during the cool and favorable rainfall months of early summer.

Erodible soils

Soils subject to wind erosion need special handling and cropping practices. If they are to be cropped on an annual basis, special emphasis must be placed on erosion control practices such as strip cropping, grass barriers and field windbreaks, in addition to reduced tillage and management practices that leave protective crop residue on the surface during most of the year. Where soils with chronic wind erosion problems make up a small part of the farm, the best use is planting them to a suitable grass and legume mixture for hay or pasture use. This solves the erosion hazard as well as saving the cost of annual cropping.

Grasses Legumes

Research in North Dakota and other Northern Great Plains states has shown that grasses grown for several years may increase soil organic matter and accumulate mineralized soil nitrogen. They also improve soil structure, which increases water uptake and reduces erosion. The beneficial effects of grass appear to be rather short lived. Research data at Mandan indicate that 75 to 95% of the grass roots in the surface 6 inches of soil had decomposed 2½ years after plowing.

This research data also show that alfalfa grown for several years usually increases soil nitrogen and organic matter, but the effect of legumes on physical soil condition appears to be minor except on heavy clay types. The improved physical conditions from grass/legume in the rotation has seldom increased crop yields in the Northern Great Plains, indicating that physical soil condition is generally not a limiting factor in annual crop production.

Grasses and forage legumes grown for several years in a rotation tend to deplete subsoil moisture and reduce yield of the crop that follows. Alfalfa may dry the soil 8 to 12 feet deep, sweet clover 5 to 8 feet and perennial grass 4 to 6 feet. Yield reductions of crops following grass and forage legumes are commonly associated with depleted subsoil moisture reserves. Even if the land is fallowed before planting the next crop, yields are frequently not increased over those with ordinary fallow.

In eastern North Dakota, where annual precipitation is greater, legumes in rotation can increase yields of corn and small grain in years of average or above average precipitation. Increased yields are usually attributed to the addition of nitrogen from the legume; however, legumes in a rotation also provide a break in host plants for several disease and insect problems. From the standpoint of increasing yields of sequential crops, available data indicate little justification for growing forage legumes and grasses in rotation on good crop land elsewhere in the state.

Recent data from the USDA-ARS Great Plains Research Center at Mandan indicates that the longer North Dakota soils are cropped, the more likely soil fertility is to become a limiting crop production factor, especially where cropping systems have not included legumes in the rotation. Grass has not benefitted the rotation as much as legumes from a fertility standpoint. This fertility problem is brought about by a gradual decrease in soil nitrogen and phosphorus as organic matter is lost. The application of commercial fertilizer is the cheapest way of correcting this problem, but other fertilizer sources can be used.

When land has been left in sod crops three years or longer, special attention needs to be given to the cropping and fertilizer program to follow. Moisture is probably the primary concern following sod. Without good recharge of subsoil moisture in broken out sod, the chances are poor for a profitable crop return from an investment in fertilizer. In order to replenish subsoil moisture, fallowing or chemical fallow, started as early as possible the year before cropping is advisable, especially if small grain crops are to be seeded. Crops like wheat, barley, and oat need moisture early in the growing season.

If newly tilled sod land is not fallowed, corn is a better choice than small grains because it is planted later with moisture demand coming later in the growing season, allowing more time for soil moisture accumulation. If the sod was alfalfa or an alfalfa-grass mixture and fallow operations were started early in the season, no supplemental nitrogen fertilizer would be required. If, however, the fallow operation was started July 1 or later, a nitrogen application at about one-half the rate for regular nonfallow stubble land should be adequate. If the sod was grass only, some nitrogen might be beneficial, especially if the fallow operation was started about June 1. If the fallow operation of grass sod was delayed until July 1 or later, nitrogen applications similar to those on nonfallow stubble land are suggested.

In North Dakota, the use of grass and legumes in long rotations (five or more years) is suggested for the less desirable crop land areas on the farm. Grasses and legumes are not recommended for short rotations on good crop land except in the heavy soils in the eastern part of the state where they can be expected to have beneficial effects on soil structure and crop yields.

Your Rotation — Your Plan

To develop a rotation plan for your farm, it may be necessary to refer to all of the preceding sections.

Crop rotations, of course, are not confined to only cash crop land on the farm. Land that may have been cropped but has been seeded to sod crops for hay or pasture would need its specific rotation plan. Sod crops on such land may need to be cropped temporarily to prepare for reseeding. A rotation of eight years grass — two years small grains would be an example. Sod land would be brought back into the regular crop rotation plan only if permanent shifts in the farming operation converts it back to crop land. This may occur when crop commodity price relationships or government programs change.

Most farms in North Dakota are too large to consider one rotation for the entire farm. **Step one** in planning rotations is to divide the crop land into areas based on similarity of several factors.

Some of the more important factors that will influence division of the farm into rotation areas and determine rotations are these:

- Type of soil, water-holding capacity, and salinity as it may affect yield and possible erosion problems.
- Field topography especially if it contains steep slopes, large potholes or flats subject to flooding.
- Physical shape and condition of fields as influenced by streams, ditches, roads, rocks, easements, etc.
- Size and type of farm: grain, livestock or mixed.
- Distance of field from the farmstead. Fences, well location or water accessibility, presence of corral, pens, livestock and equipment loading facilities also need to be considered.
- Kind and size of machinery to be used.
- Weed control problems: annual and perennial species.
- Labor distribution needs.
- Participation in federal farm program.
- Management skills of the operator.
- Family labor availability.
- Ability to accept risk.

Step two is to classify the farm, field by field, with respect to cash crop potential into **(1)** most desirable crop land, **(2)** less desirable crop land and **(3)** undesirable crop land areas.

Step three is to plan the specific rotation for each field. On the most desirable land, include the leading cash crops and the shortest, least flexible rotations. On the less desirable land, plan longer and more flexible rotations, and for the undesirable crop land area, plan to establish permanent grasses as quickly as possible because continued cropping may not be profitable.

After the rotations are planned on paper, do some calculations using expected yields and prices to see if some changes may increase potential farm income.

While the choice of crops in much of North Dakota is limited, benefits can be gained from well planned rotations. Careful attention to this phase of farm management will help keep a positive net return on the farm. Long term rotations may require some adjustments based on changes in demand for certain commodities. Many times producers say that "requirements in the federal farm program" prevent them from establishing better rotations with a desired level of profitability.

A good rotation for the soil or for disease and weed control is not sustainable unless it is profitable enough for the family to stay on the farm.

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