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CORN

BEST MANAGEMENT PRACTICES

CHAPTER 9

Crop Rotations Can Increase Corn Profitability and Reduce Pests

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This chapter provides a brief overview on how rotations can increase long-term sustainability and resilience against climate variability for South Dakota producers. Crop rotation is a complex subject where biological factors, farm management resources, and market forces all interact to influence rotation effectiveness.

Introduction

Crop rotations are long-term plans that improve sustainability and profitability. A producer considering crop rotation should examine:

- Profitability, equipment, and labor availability.
- Climate and market variability.
- Soil health.
- Short-term gains vs. long-term sustainability.
- The impact on weed, insect, and disease problems.
- Pest resistance to various control mechanisms.
- Matching crop production requirements with available resources.

Crop rotations are a foundational element of sustainability and long-term profitability. For example, the introduction of the "Norfolk Rotation" (Barley-Clover/ryegrass-Wheat-Turnips) by Sir Charles Townshend in England played a large role in nearly tripling England's agriculture output in the 1700s in a sustainable manner. This technology improvement provided food and the labor required for England's Industrial Revolution. Opposite results can occur if the production systems adopt extractive rather than sustainable techniques. For example, it is thought that the ancient inhabitants of Easter Island deforested their island leading to soil erosion, a loss of productivity, and societal collapse. Although in a different environment, similar loss of soil resources occurred in the Mediterranean 1500 years ago (Thirgood, 1981).

One way to consider sustainable production systems is to look at natural systems as a model to mimic. Natural systems tend to maximize resource capture and biomass production while minimizing nutrient loss. Natural systems keep the soil covered and protect the soil from erosion. As natural systems develop, they follow a "succession" process where one set of species modifies the environment to the benefit of the next set of species. In a similar manner, a good rotation program should be productive, minimize nutrient loss, cover the soil, provide resilience against pests and stress, and each crop should benefit of the next crop.

Designing a Rotation

Rotations should be adaptable to local conditions and challenges. There are many factors that must be considered when designing a rotation. Producers need to look at rotations as one tool for optimizing long-term profitability and reducing risk. Achieving these goals is complicated, as one management practice may have negative implications on other practices. For example, reducing tillage intensity without use of a sustainable rotation can increase the risk of plant diseases (Table 9.1).

Table 9.1 Some corn diseases that can be influenced by rotations.

Disease	Pathogen and Environment	Inoculum source
Goss's wilt	*Clavibacter michiganensis* (bacteria); associated with injury from violent weather (e.g., wind and hail); favored by moderate temperatures, and can overwinter on some weeds.	Overwinters on residue; also some grassy weeds act as alternate hosts; moves with rain.
Gray Leaf Spot	*Cercospora zeae-maydis* (fungi); favored by moderate to warm temperatures and high humidity.	Overwinters on residue; moves with wind and rain.
Anthracnose leaf blight and stalk rot	*Colletotrichum graminicola* (fungi); favored by warm termperatures and long periods of cloudy, humid weather.	Overwinters on residue; moves with wind and rain.
Eyespot	*Kabatiella zeae* (fungi); favored by cool, wet weather.	Overwinters on residue; moves with wind and rain.
Northern Corn Leaf Blight	*Exserohilum turcicum* (fungi); favored by moderate temperatures and humid weather.	Overwinters on residue; moves with wind.

Rotations and Plant Diseases

Rotation is a very valuable tool for breaking disease cycles, particularly in no-till and conservation tillage systems. Crop residue acts as an inoculum source for many important diseases in corn (Table 9.1). Hence, rotations that use nonhost crops or resistant hybrids/varieties provide an opportunity for the residues to decompose, which should decrease pest risks.

Because certain pests persist in the soil, there are some diseases, such as seedling damping off (*Pythium* spp) and root rots (*Rhizoctonia solani* and *Fusarium* spp), that can be managed only by combining the rotation with other techniques. Additional methods might include using appropriate seed treatments, delaying seeding, and installing tile drainage.

Rotations and Weed Management

Rotation can have large impacts on weed pressure. Rotations provide the opportunity to rotate the herbicide mode of action, which should reduce the risk of creating herbicide-resistant weeds. A "stacked" rotation can be effective in reducing this risk. In a stacked rotation, the same or very similar crops are grown two years in a row and then skipped for four or more years (e.g., corn-corn-soybean-soybean-wheat-wheat), allowing for the use of herbicides with long residuals in the first year of each crop while maintaining a long period (four years) where the land is rotated to other crops (Beck, 2003). Alfalfa can also be used for this purpose.

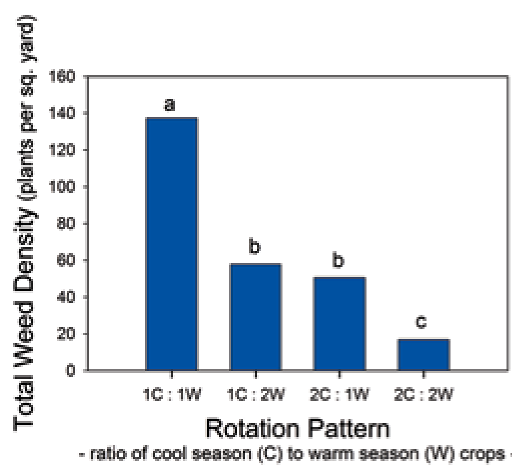

Figure 9.1 Average weed density after 10 years of different sequences of warm-season (w) and cool-season (c) crops from three trials. The lowest weed density was found where the warm- and cool-season crops were each grown in two-year blocks – two years of cool-season crops followed by two years of warm-season crops (e.g., oats-wheat-corn-soybeans; or wheat-canola-sorghum-sunflower). (Modified from Anderson, 2008)

Similarly, an advantage can be gained by a rotation between warm- and cool-season crops, where each cycle is held for two seasons (two warm-season crops followed by two cool-season crops) (Anderson, 2008). Holding the given pattern for two years disrupts weed life cycles such that the weed seeds have to survive for three years before they get the opportunity to grow and multiply (Fig. 9.1).

Rotation, Residue, and Nutrient Availability

Corn produces more residue than either soybeans or small grains. For example, a 150 bu/acre corn crop will produce about 8400 lbs reside/acre, whereas a 45 bu/acre soybean crop generates about 2500 lbs residue/acre, much of this being leaves which quickly decompose. A 60 bu/acre wheat crop will produce about 3600 lbs residue/acre. The large amount of residue from corn is an asset in building soil organic matter and protecting the soil from erosion. If current climate projections, i.e., more intense storms, hold true (Seeley, 2012), then the value of the residue becomes increasingly important. However, large amounts of residue can also pose challenges in creating a "good" seedbed, controlling pests, and recycling nutrients. The high level of corn residue is a concern for wheat because it acts as a host for the fungi Fusarium graminearum, which causes wheat head scab. For this reason, it is not a good idea to follow a corn crop with a wheat crop.

Soybeans tend to tolerate high-residue situations better than many other crops. The persistence of corn residue may slow nutrient recycling and the release of N from decaying stover. Following corn with a legume crop such as soybeans can be used to overcome this problem.

The use of cover crops before and following corn is a topic that needs additional investigation. Research at the SDSU Southeast Research Farm suggests that corn yields are higher following fall-planted, cool-season broadleaves (brassicas and legumes such as radish and peas) than grass-dominated cover crops (Sexton et al., 2012, 2014). Benefits of cover crops on corn yields is attributed to improved nutrient recycling and increased plant diversity (Sexton et al., 2009).

Impacts on Yield in a Corn-Soybean System

Studies in South Dakota, Minnesota, Wisconsin, and Nebraska have reported a 10% to 22% yield benefit for corn grown in rotation with soybeans versus a continuous corn cropping pattern (Porter et al., 1997; Reidell et al., 2009; Stanger and Lauer, 2008; Wilhelm and Wortmann, 2004) (Fig. 9.2). Similar results were observed for soybeans where there was an 8% to 10% yield advantage when grown in rotation with corn rather than a continuous soybean rotation (Porter et al., 1997; Pederson and Lauer, 2004; Wilhelm and Wortmann, 2004). The rotational effect is attributed to many factors including enhanced root growth (Nickel et al., 1995).

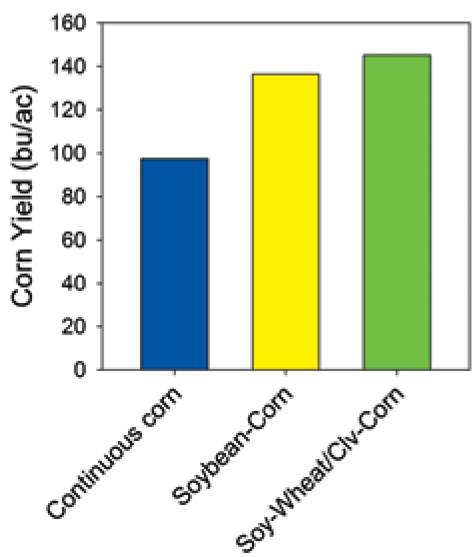

Figure 9.2 Average corn yields, at the end of six years, in three rotational sequences. (Katsvairo and Cox, 2000) Even after just two cycles, yield differences were apparent. Data shown are averages across three tillage regimes from the final year of the study. These plots received 145 lbs/acre of N.

Crop rotations can impact profitability. A 15-year Wisconsin study compared the corn-soybean rotation with continuous corn and rotations that contained oats and alfalfa (Stanger et al., 2008). This study reported that the corn-soybean rotation was more profitable than continuous corn and rotations that include oats and alfalfa.

While a corn-soybean rotation has been shown to be superior to continuous corn, it is still not a very diverse system. In many fields, there is a corn yield decrease of about 5% to 15% for second-year corn relative to first-year corn. The greatest yield reductions are typically measured between first- and second-year corn but can also be high when weather is unfavorable. Yield reductions generally stabilize after the third-year corn. Soybeans have similar responses and generally yield 5% to 8% more when following two or more years of corn. Crookston et al. (1991) conducted a 9-year study looking at corn and soybean yields in southwestern Minnesota. They concluded that "a superior cropping sequence … would include at least three crops and possibly more." Additional benefits from diverse rotations include reduced development of pest resistance, improved ability to manage variable weather conditions, and increased economic diversification.

Rotations and Water Use

Rotations can be used to improve water management. For example, rotations provide protection from summer droughts by distributing the critical water-use periods across the growing season. Research conducted by the author shows that corn, wheat, and soybeans have different critical periods for water stress. Wheat partially avoids drought-stress by flowering and completing its lifecycle earlier in the growing season than either corn or soybeans (Fig. 9.3). Soybean flowering is spread over several weeks so that it can better avoid the effects of drought. The corn crop, on the other hand, flowers and sets seed at one point in time and does this during the warmest part of the year, when evaporative demand (water use) is at its peak. High temperatures and drought stress can reduce corn kernel set by decreasing pollen viability and delaying silking. By seeding hybrids of different maturities, the length of the pollination period for the farm can be expanded.

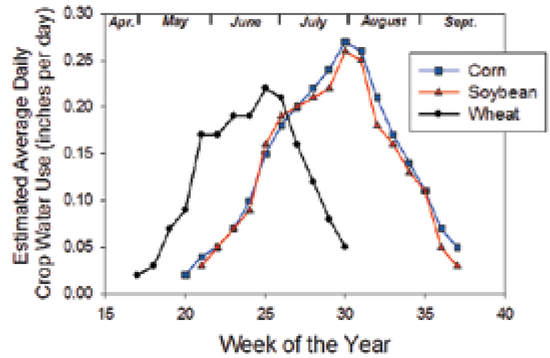

Figure 9.3 Estimated crop water used by spring wheat, corn, and soybeans grown over a season at Huron, S.D. Based on data from the University of Minnesota Extension, www.extension.umn.edu, and South Dakota climate archives, www.climate.sdstate.edu. Note: Drought stress is reduced by shifting wheat water use earlier in the season.

A worksheet for calculating agricultural intensity for different rotations is available at the South Dakota Lakes website. This calculator can be used to determine water harvesting from the different crops in a rotation. Along with water-use timing, crop rooting depth should be considered. Crops with deep extensive root systems that grow late into the season (e.g., sunflower and alfalfa) are likely to leave less reserve moisture than shallower-rooted, earlier maturing crops (e.g., peas, flax, and lentils). Cropping more frequently with high water-use crops increases the cropping system intensity. Barley, winter wheat, field peas, and canola are low water-use crops, whereas corn, soybean, and alfalfa are high water-use crops.

Crop Diversity

When considering diversity, crop rotations can increase diversity and reduce problems with labor, equipment, disease, weeds, and insects. Diversity assessments should consider the type of plant. In South Dakota, commonly grown crops can be classified as:

1. Cool-season grass: spring wheat, winter wheat, barley, durum wheat, oat, and winter rye.
2. Warm-season grass: corn, sorghum, sudangrass, and millet.
3. Warm- and cool-season broadleaf plants such as field pea, lentil, canola, mustard, crambe, flax, safflower, chickpea, sugar beet, sunflower, dry edible bean, soybean, and alfalfa.

When selecting a crop rotation it is important to avoid potential conflicts between the seeding and harvest times of different crops (i.e., trying to seed one crop when harvesting another, or harvesting more than one crop at a time).

Rules of Thumb for Increasing Diversity in Semi-arid Regions

1. Use soil survey information to evaluate soil water storage. Determine the appropriate cropping intensity based on this information.
2. Manage crop residues to facilitate soil water storage.
3. Manage crop nutrients to optimize yields while minimizing competition with weeds.
4. Utilize legume crops and animal manure to increase energy efficiency and improve soil quality.

5. Adopt techniques that minimize wind and water erosion.
6. Anticipate equipment and/or labor requirements for growing new crops.
7. Use cover crops to increase crop rotation intensity and diversity.
8. Consider a perennial crop, such as grass or alfalfa. They provide excellent weed suppression in a rotation, particularly if the crop following perennial plant is planted with minimal soil disturbance.
9. Consider the marketability of the commodity prior to planting a crop.
10. Avoid using crops with the same pests after each other. For example, soybeans should not follow field peas.

Importance of Linking Tillage and Crop Rotations

Crop rotation and tillage should be considered simultaneously. Designing appropriate crop rotations is a mix of art and science. For any given situation, there will be a range of rotations that are appropriate. Within this range, there are rotations and tillage practices that reduce or increase risks. Additional information on tillage systems is available in Chapter 11.

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