1998-E

Designing Rotations for a Semiarid Region

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Rotation Design Highlights

1. Determine cropping potential with precipitation use
   Continuous cropping: 80%
   Rotations with fallow: 65%

2. Plan a cycle of 4 years with summer and winter crops to favor the rotation effect and pest management

3. Diversify crops to maximize yield

With improved residue and water conservation techniques, more intensive cropping is now possible in the central Great Plains (16). The USDA-ARS Research Station at Akron, CO initiated a study in 1990 to evaluate several rotations as alternatives to winter wheat-fallow. The study is located on a Weld silt loam, with winter wheat (W), corn (C), proso millet (M), sunflower (S), and fallow (F) combined in various sequences. With all rotations, we use minimal tillage. The site's long-term precipitation average is 16.5 inches per year. Our results demonstrate that this region has a greater cropping potential than W-F, as annualized yield (yield expressed on a land area basis, with fallow included) increased 67% with a W-C-M rotation compared to W-F.

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corn yields only 12 bu/ac whereas sunflower yields 480 lbs/ac in this rotation, reflecting the shortage of water.

Therefore, producers can use a value of 80% to estimate their system's water supply for continuous cropping. In a 16-inch precipitation zone, producers will have approximately 13 inches of water available for crop use each year. Table 1 also includes the yield change per inch of water used by the crop, thus, producers can plan rotations with potential yield goals for their location.

Table 1. Water use of wheat, corn, sunflower, and proso at Akron (15).

Crop	Average yield	Water use (inches)	Yield/ additional inch
Wheat	45 bu/ac	14	7 bu/ac
Corn	60 bu/ac	15	10 bu/ac
Sunflower	1200 lb/ac	13	160 lb/ac
Proso	2050 lb/ac	12	240 lb/ac

If fallow is included in the rotation, a target SPU for minimal-till systems would be 65%. Successful rotations like W-C-S-F or W-C-M-F both have a SPU near 65%. Rotations such as W-C-F or W-M-F have SPUs of 53 to 59%, which suggests that these rotations may be wasting yield potential because available water is not being used. The target SPU is lower for rotations with fallow because long fallow periods are inefficient in storing precipitation in soil (16).

Thus, increasing the time interval between wheat crops in combination with crop diversity (broadleaf crops) maximizes the rotational effect on wheat yield, especially in wet years. Similar time interval and crop diversity effects have been found with corn (18) and proso (2). This rotation effect on yield also increases with time. Since 1994, yield of both wheat and proso have increased 5% per year in W-C-M compared to W-M, reflecting the longer time interval between crops and greater crop diversity.

Rotations: Length

Another consideration related to rotation design is pest management, as producers can minimize pest populations with appropriate crop combinations. With weeds, seeds in the soil are the source for plants establishing in the crop. However, number of live seeds in soil decline at a characteristic rate, due to germination, predation, or death. Green foxtail and field sandbur seed population declines rapidly, with 30% or less of seeds remaining after 1 year (Table 2). After 2 years, less than 10% of seeds of either species are alive. Populations of winter annual grass seed decrease similarly over time, except that jointed goatgrass persists longer than the other species.

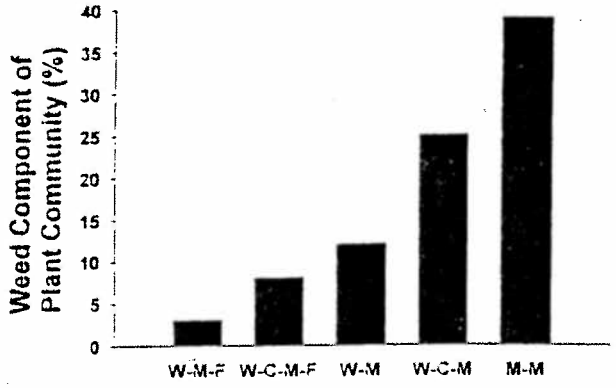
Table 2. Longevity of seed survival in soil of four weeds (1, 2, 4, 5, 8).

Years in soil	Green Foxtail	Field Sandbur	Downy Brome	Jointed Goatgrass
	% live seed remaining			
1	18	30	20	60
2	5	8	5	25
3	2	3	2	8

with W-C-M-F, weeds were only 12% of the total biomass, whereas in W-M-F, with only 1 summer crop in 3 years, less than 3% of the biomass was weeds.

In the central Great Plains where winter wheat is the most prevalent and valuable crop, producers may want to maintain a high percentage of their land base in wheat. Thus, a producer may grow 2 years of winter wheat in a row, a practice that may reduce grain yield in the second year (19).

Figure 3. Weed infestation in proso of various rotations, after 8 years.

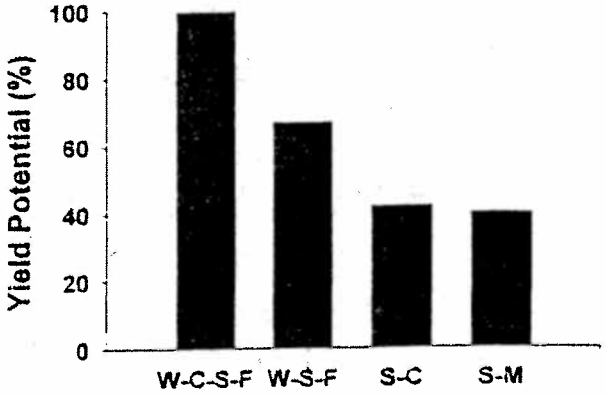


However, this yield loss, caused by root diseases (6), also is related to time needed for population growth of the root pathogen. Yield loss in the 2nd year of continuous wheat averages 8%, ranging from 0 to 19% (11, 13, 14, 19). The variation in yield loss is caused by differences in growing season precipitation, with more yield loss in wet years (14). Yield losses continue to increase with time as root pathogen populations increase, as 3 years of continuous wheat lead to 20% yield loss. Thus, if a producer follows a crop cycle of 4 with winter and summer crops, yield loss due to root diseases can be minimized by growing wheat only 2 years in a row.

Producers may prefer 2-year rotation cycles in place of 4 years. However, we tested eight 2-year rotations of various combinations of corn, proso, sunflower, and wheat at Akron. Only W-M was successful, with the other seven rotations failing due to either low yields or excessive weed problems. Also, the rotation effect related to time between crops is minimized in 2-year rotations.

Sunflower: Sunflower yield was highest in the W-C-S-F rotation (Figure 6). Sunflower yielded 60% less in the 2-year rotations, C-S and M-S. Similarly to proso, sunflower yielded 29% less in the 3-year rotation, W-S-F, than with the 4-year rotation W-C-S-F.

Figure 6. Sunflower yield as affected by crop sequence.



The yield reduction of sunflower in W-S-F and the 2-year rotations was caused partially by phoma. This soil-borne fungus infests the stem, interferes with plant translocation, and weakens the stem (10), which can cause plant lodging. In 1996, over 40% of the sunflower stand in the W-S-F and 2-year rotations lodged, while no lodging occurred in the W-C-S-F rotation. To control phoma and other related root diseases such as sclerotinia, sunflowers should be grown only once every 4 years (10).

Sunflower can impact yield of following crops, even after a fallow period. Wheat yields were 28% less in the W-S-F rotation compared to either W-C-S-F or W-F. We are unable to explain why, but we speculate that sunflower stems weakened by phoma lodge earlier during the non-crop period, thus minimizing the amount of snow catch during winter in the W-S-F rotation.

Both proso and sunflower yielded well when grown after corn in 4-year rotations. Furthermore, both crops yielded more in 4-year rotations than in 3-year rotations with wheat and fallow (Figure 5 and 6). This suggests that sunflower and proso may respond to the time interval between crops, similarly to winter wheat, or that corn has a synergistic effect on following crops.

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