# FLEXIBLE SUMMER FALLOW IN THE CENTRAL GREAT PLAINS

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## ABSTRACT

Summer fallow has played a significant role in dryland cropping systems in the Central Great Plains for many years. Although it helps to stabilize crop yields, frequent use of summer fallow jeopardizes the long-term sustainability of dryland systems by degrading the soil resource and reducing profitability. We argue that a dynamic system involving flexible summer fallow, whereby a grower's decision to transition from a summer crop to winter wheat with a short-duration spring crop or summer fallow is based on several dynamic factors including soil water and economics, would be preferable to a static system incapable of responding to the highly variable climatic and economic scenarios indicative of the region.

## INTRODUCTION

Water is the most limiting resource for dryland crop growth in the semiarid areas of the U.S. Great Plains (Smika, 1970). Summer fallow, the practice of controlling all plant growth during the non-crop season, is commonly used to stabilize winter wheat production in this region of high environmental variability. Wheat-fallow is the predominate cropping system in the Great Plains, but water storage efficiency during fallow is frequently less than 25% with conventional tillage (McGee et al., 1997). The advent of reduced- and no-till systems have generally enhanced the ability to capture and retain precipitation in the soil during non-crop periods of the cropping cycle, making it more feasible to reduce the frequency of fallow and intensify cropping systems relative to wheat-fallow (Peterson et al., 1996).

In the Great Plains, annual precipitation is concentrated during the warm season from April to September. Hence, inclusion of a summer crop, e.g., corn or grain sorghum, in a 3-yr system of wheat-summer crop-fallow increased the efficient use of precipitation by reducing the frequency of summer fallow and using more water for crop transpiration (Farahani et al., 1998). In addition to increased precipitation use efficiency and grain yield, more intensified dryland cropping systems increase potentially active surface soil organic C and N (Peterson et al., 1998), effectively control winter annual grass weeds in winter wheat (Daugovish et al., 1999), and increase net return and reduce financial risk (Dhuyvetter et al., 1996).

In the 1970s, Montana and North Dakota initiated "Flexible Cropping" to use precipitation more effectively to increase spring small grain yields and help prevent and control saline seeps (Brown et al., 1981). A dynamic programming approach determined that using soil water at wheat planting time would give an expected return per year of about \$7.50 ha$^{-1}$ more than continuous wheat and about \$15.00 ha$^{-1}$ more than winter wheat-fallow (Burt and Allison, 1963).

millet are economically competitive with systems using summer fallow. The system involving dry bean had the largest range in returns and was slightly less competitive than the previous systems over the three years of study. Corn and canola are not economically viable as transition crops in these systems, although regionally adapted canola germplasm could change this.

Wheat yield following proso millet responded positively to the first increment of applied N in 2000 and 2001, but no other yield responses to N were observed. Grain protein was not affected by N application (data not shown). In all three years, the most severe root disease was observed on plants in plots previously cropped with proso millet, dry bean, and summer fallow, while the oat/pea for forage, spring canola, and corn treatments resulted in significantly lower disease severity ratings (data not shown).

The cost of summer fallow was \$91.90 ha$^{-1}$. A combination of returns to the transition crop (fallow replacement crop) + relative wheat returns indicates that systems without summer fallow are feasible (Table 2). System improvement may come from improving transition crop yields or decreasing the negative effects of the transition crop on wheat yields.

Table 2. Annualized net return for the spring crop and subsequent winter wheat crop at Sidney, NE.

| Preceding spring crop | 1999-2000 | 2000-2001 | 2001-2002 | 3-yr mean |
|---|---|---|---|---|
| | \$ ha$^{-1}$ | | | |
| Summer fallow | -6.33 | 41.56 | -57.88 | -7.55 |
| Oat/pea forage | 91.05 | -22.43 | -56.03 | 4.20 |
| Spring canola | -50.29 | -106.49 | -127.85 | -94.88 |
| Proso millet | 6.21 | -25.45 | -1.50 | -6.91 |
| Dry bean | 101.63 | -127.60 | -63.01 | -29.66 |
| Corn | -34.15 | -115.56 | -93.78 | -81.17 |
| LSD (0.05) | 17.42 | 13.65 | 14.09 | 19.38 |

This suggests that it may be feasible to eliminate summer fallow in the Central Great Plains. However, the risk of persistent drought is great in this region. A partially fixed, partially flexible cropping system might be of value to balance the benefits of more intense cropping systems with the environmental uncertainties of dryland agriculture in semiarid western Nebraska. A winter wheat-summer crop-flexible fallow system, whereby the decision to replace summer fallow with a spring-planted crop is partially based on soil water in the spring and the price relationships of potential crops, might allow growers to continuously crop during periods of above normal precipitation, but fall back to a more conservative rotation during times of below normal precipitation.

variation, average daily temperatures for the April to August growing season were near normal at both locations in 2004 and 2005.

Triticale forage yield increased by 229 kg $ha^{-1}$ for each cm of soil water available at planting in 2004 (Table 4). Foxtail millet forage yield and grain yield of proso millet increased by 399 kg $ha^{-1}$ $cm^{-1}$ and 148 kg $ha^{-1}$ $cm^{-1}$, respectively, at Akron in 2004. Spring triticale, foxtail millet, and proso millet did not respond to soil water at planting in 2005, when precipitation was above the long-term average. Dry pea did not demonstrate a consistent positive response to soil water availability at planting.

Table 4. Regression equations for plant available soil water at planting (cm)–yield (kg $ha^{-1}$) functions for four short-duration crops.

| Crop | Location | Year | Equation | $r^2$ |
|---|---|---|---|---|
| Spring triticale | Akron & Sidney | 2004 | $y = 568 + 229x$ | 0.76 |
| | | 2005 | $y = 56\,400 + 36x$ | 0.03 |
| | | 04 & 05 | $y = 855 + 293x$ | 0.56 |
| Dry pea | Akron & Sidney | 2004 | $y = 936 + 79x$ | 0.49 |
| | | 2005 | $y = 1270 + 7.6x$ | 0.01 |
| | | 04 & 05 | $y = 1310 + 17.8x$ | 0.04 |
| Foxtail millet | Akron | 2004 | $y = 1480 + 398x$ | 0.62 |
| | Sidney | 2005 | $y = 10\,200 - 118x$ | 0.08 |
| Proso millet | Akron | 2004 | $y = 33 + 83x$ | 0.58 |
| | Sidney | 2005 | $y = 2970 + 65.5x$ | 0.22 |

Results of this study indicate that the amount of plant available soil water at planting may be a suitable indicator of yield potential for selected short-season spring-planted crops. The forage crops in the study, spring triticale and foxtail millet, demonstrated a linear relationship of dry matter accumulation to soil water availability at planting. Proso millet also showed potential as a grain crop for use in a flexible summer fallow cropping system based on soil water at planting. Dry pea did not appear to be suited for such a system. Dry pea yields are unstable and sensitive to temperature and water stress near flowering.

The relationship of soil water at planting to yield is strongest during water-limited years such as 2004. A decision system based on plant available water at planting may underestimate yield when above normal growing season precipitation is received, but the risk of unacceptable yields will be decreased. Additional research will be necessary to further quantify the relationship of plant available water at planting to yield for the crops demonstrating potential for use in a flexible summer fallow system. It may then be possible to develop a decision support tool to determine when to use a short-season spring-planted crop and when to fallow.

Studies are currently underway to determine the impact of these crops and water treatments on yield of the subsequent winter wheat crop.