Flexible Summer Fallow: A Dynamic Cropping Systems Concept for 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, summer fallow jeopardizes the long-term sustainability of dryland systems by degrading the soil resource and limiting profitability. We argue that a dynamic system involving flexible 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

Summer fallow, the practice of controlling all weed growth during the non-crop season, is commonly used to stabilize winter wheat production in the Great Plains. 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). Data from 1993-2001 at Akron, CO (Nielsen et al., 2002) indicated that winter wheat yields were strongly influenced by amount of soil water available at wheat planting. They also showed that 2- and 3-yr cropping systems that included no-till summer fallow before wheat planting nearly always had enough soil water at planting to ensure at least 2500 kg ha^{-1} wheat grain yield. On the other hand, a 3-yr no-till system without summer fallow had enough soil water at planting to ensure at least 2500 kg ha^{-1} in only 28% of the years.

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) and effectively control winter annual grass weeds in winter wheat (Daugovish et al., 1999).

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

Investigating the Elimination of Summer Fallow

A study was initiated at the High Plains Agricultural Laboratory located near Sidney, NE in the spring of 1999 to investigate the impact of eliminating summer fallow as a means of transition from a summer crop to winter wheat. Spring-planted crops (oat/pea for forage, spring canola, proso millet, dry bean, and corn) were no-till seeded into sunflower residue in 1999, 2000, and 2001. A no-till summer fallow treatment was included for comparison purposes. The spring-planted crops served as whole plot treatments (15.2 x 15.2 m plots) in a randomized complete block design and five fall-applied N fertilizer rates (0, 22, 45, 67, and 90 kg N ha^{-1}) in winter wheat served as the split-plot treatments (2.4 x 15.2 m plots). Treatment combinations were replicated five times in each of three seasons beginning with the 1999-2000 season. Gravimetric soil water contents were collected to a depth of 1.2 m, in 0.3 m increments, immediately prior to seeding winter wheat. Soil water content in the surface 1.2 m was always greatest after summer fallow. The 3-yr mean soil water content at winter wheat planting was 36 to 68% greater following summer fallow than following any other crop treatment. Additionally, soil water was more evenly distributed throughout the surface 1.2 m of soil after summer fallow than after other crop treatments, where the surface 0.3 m of soil was much wetter than at deeper depths. Gross returns were calculated based on five-year average prices for the region, excluding any government payments. Cost of production budgets were developed for each spring-planted crop using common production practices and the University of Nebraska budget generator. These values were used to determine the return to land and management for each observation with an annualized return developed for the two-year spring-planted crop–winter wheat system.

Precipitation during the wheat growing season was less than the 30-yr mean in two of the three years of the study. During the wheat grain filling period (June), precipitation was 63, 51, and 62% below the 30-yr mean in 2000, 2001, and 2002, respectively. Averaged across all three years, oat/pea for forage and proso millet provided greater financial returns than summer fallow. Winter wheat grain yields and returns, averaged across all three years, were greatest after summer fallow, with wheat after oat and pea for forage providing the next greatest yields and returns. Annualized returns to land and management suggests that systems involving oat/pea for forage and proso 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 other systems over the three years of study. Corn and canola were not economically viable as transition crops in these systems, although regionally adapted canola germplasm could change this scenario.

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 1). System improvement could come from improving transition crop yields or decreasing the negative effects of the transition crop on subsequent wheat yields.

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 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.

Table 1. 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)	16.90	13.56	14.19	8.58

Discerning When to Use Summer Fallow

In a previous study (Lyon et al., 1995) conducted near Sidney, NE, the grain yields of two short duration crops (pinto bean and proso millet) consistently responded positively to increasing soil water at planting (Table 2). In contrast, grain yields of long-duration crops (corn, grain sorghum, and sunflower) did not consistently respond to increasing soil water at planting, although there was a significant positive correlation between soil water at planting and dry weight of the crop at 12 wk after planting. The correlation of grain yield to soil water at planting appeared to decrease as the days from planting to harvest increased. There might be a substantial amount of initial soil water available at flowering for short-duration crops, but not for long-duration crops, because they use this initial water for vegetative production, leaving little for grain development.

Table 2. Correlation coefficients (r) showing the relationship between soil water at planting and dry weight accumulation 12 wk after planting, grain yield, and water use.

Crop	Dry weight	Grain yield	Water use
		r	
Proso millet	0.87***	0.89**	0.55*
Pinto bean (1992)	0.72*	0.81*	0.77**
Pinto bean (1993)	0.93***	0.87**	0.89**
Sunflower	–	0.65**	0.85**
Corn	0.93***	-0.64**	0.85**
Grain sorghum	0.80***	-0.51*	0.81**

*, **, *** Indicates significance at 0.05, 0.01, and 0.001 levels, respectively.

Discussion

Taken together, these studies suggest that short duration crops, particularly short duration crops that are harvested by mid-summer (such as oat/pea for forage), are critical for the success of the winter wheat-summer crop-flexible fallow system. Some potential crops to investigate include the pulse crops such as dry pea and chickpea, and forage crops such as triticale, oat, and forage pea. Nielsen (2001) found chickpea, field pea, and lentil to have agronomic potential as dryland crops planted before winter wheat in the Central Great Plains. The market potential for the summer crops selected will play a critical role as well. Price expectations at planting, cost of production, and the ability to forward price the expected production will be necessary elements of the decision making process. It will be necessary to design studies that will allow the development of decision algorithms to determine when to plant and when to fallow.

Growers should begin to limit the role of summer fallow in their cropping systems. Summer fallow needs to change from a strategic practice to a tactical practice that is only used during drier phases of the climate cycle, when soil water levels and forecast precipitation are low.

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