KERNZA® PERENNIAL GRAIN AND WHEAT-FALLOW BUDGETS: COMPARING A PERENNIAL AND ANNUAL CROPPING SYSTEM IN SOUTHEASTERN WYOMING

Hannah Rodgers
Research Scientist, University of Wyoming Department of Agricultural and Applied Economics (formerly with the USDA Northern Plains Climate Hub)

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University of Wyoming | College of Agriculture, Life Sciences and Natural Resources

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Editor: Maya Gilmore, University of Wyoming Extension
Designer: Jeremy Cain, University of Wyoming Extension

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Figure 1. Wheat (left) and Kernza (right) plants excavated from fields near Chugwater, Wyoming. Kernza grows a larger, deeper root system than wheat.

INTRODUCTION

Annual plants, such as wheat, corn, and rice, make up most of the food grown by farmers around the world. In contrast, native ecosystems contain mostly perennial plants, like the grasses in prairies or the trees in forests. Not only can perennials live for many years, but they tend to grow bigger, deeper root systems (Fig. 1) and can be more resilient to climate stressors like drought (Glover et al., 2010; Sprunger et al., 2024). Perennial crops require less soil disturbance than annuals and keep the soil covered year-round, which reduces erosion, helps the soil absorb and store water, builds soil fertility, and supports soil microbial communities (de Vries et al., 2012; DuPont et al., 2014). These soil health benefits can improve crop yields over time and provide some economic benefit to farmers.

A newly developed perennial grain crop could provide some of these benefits to vulnerable croplands in the U.S. Kernza® is the trademark name for the grain harvested from varieties of intermediate wheatgrass (*Thinopyrum intermedium*), originally developed by The Land Institute. To create these varieties, plant breeders crossed thousands of intermediate wheatgrass (IWG) plants over many generations and selected those with desirable traits like bigger seeds. The resulting crop can be harvested for forage or for grain, which can be used in products like bread, cereal, and beer.

However, these varieties of IWG have been bred for grain production for only about 35 years (compared to more than 10,000 years for wheat) and so produce lower yields than most other grain crops. The Land Institute and other plant breeders are continuing to develop new varieties of IWG bred for grain production. Nonetheless, these early stages are a great opportunity for researchers and farmers to work together to find the best ways to grow, harvest, and market this new grain crop.

Figure 2. A field tour of a Kernza field intercropped with alfalfa near Albin, Wyoming.

Name	Description
TLI - 3471	Long, slender seeds, higher percentage of naked seed compared with TLI C5.
TLI - 701	Decent performance in drought conditions.
TLI - 703	Higher number of rhizomes compared with TLI - 704, decent performance in drought conditions.
TLI - 704	Drought sensitive. Recommended for wet or irrigated conditions only. Few tillers.
TLI - 801	Higher percentage of naked seeds, consistent despite drought conditions.
MN - Clearwater	Higher percentage of naked seeds, selected under cold, wet spring soils and higher precipitation.

Table 1. Kernza varieties available on the seed market in 2023. Taken from Tautges et al. (2023)

Varieties of IWG bred for grain production were planted for the first time in Wyoming in 2021 as part of a Western Sustainable Agriculture Research and Education (SARE) project through the University of Wyoming (Western SARE, 2024). Researchers worked with three dryland farmers in southeastern Wyoming (located in Albin, Chugwater, and Slater) to trial these varieties on their farms (Fig. 2). The most common cropping system in this region is wheat-fallow, where farmers keep the land bare for a full year between wheat crops to build up soil moisture. The wheat-fallow system is not always profitable in this region (Lee et al., 2018) and is increasingly vulnerable to climate stressors such as drought (Asseng et al., 2015), prompting farmers and researchers to search for alternatives. Since IWG bred for grain production can be used for hay in a drier year or grain in a wetter year, it can provide flexibility for farmers dealing with uncertain weather.

To better understand what yields and market prices are needed to make Kernza grain a competitive crop for this region, this bulletin compares cash crop budgets for a wheat-fallow system and a hypothetical Kernza system, both under dryland, conventional (non-organic) practices. With fewer than 200 farms growing IWG for grain production across the country, this crop budget can only give an estimate until more cost and revenue data are collected in the coming years.

CASH BUDGET FOR CONVENTIONAL DRYLAND KERNZA®

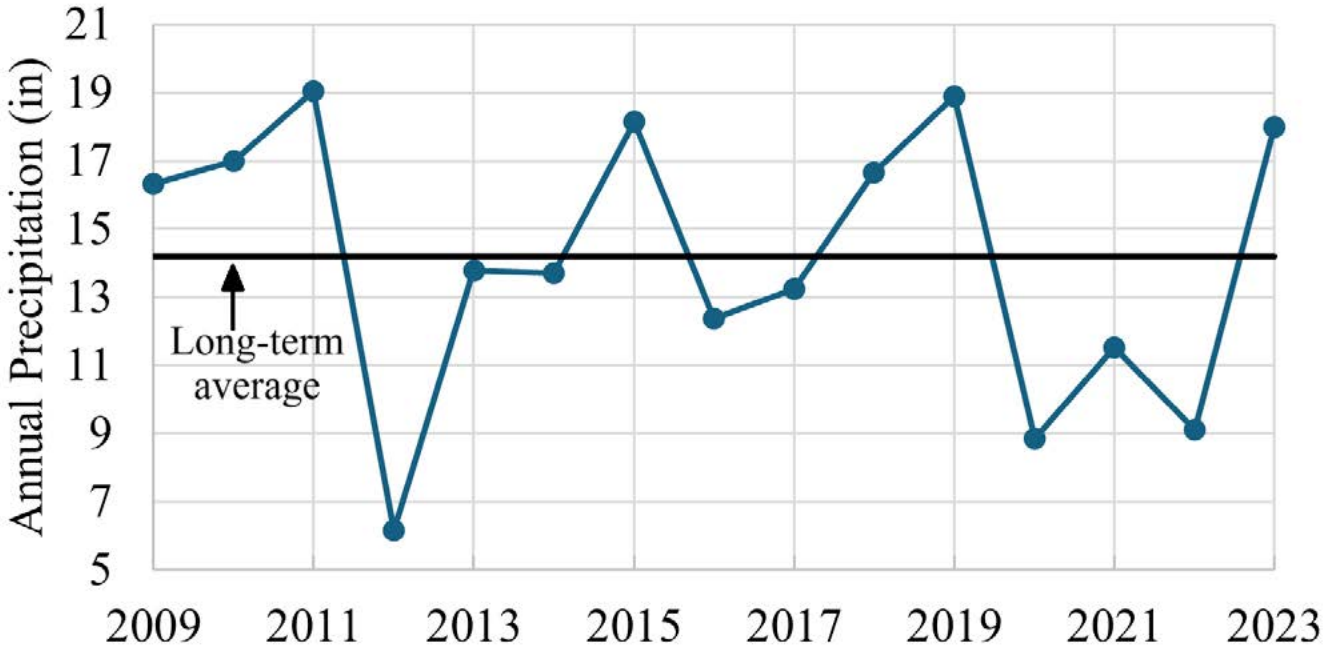
This cash budget models a conventional, dryland Kernza perennial grain operation in southeast Wyoming over five years. A stand of IWG bred for grain production typically lasts three to five years before grain yields decline notably, at which time the IWG is rotated out of production and can be followed by another crop. This budget provides costs on a per-acre basis, beginning with a fall planting of IWG and the first grain crop the following summer. The seed cost and grain price listed in the budget represent our best estimates, while operation and management costs are taken from multiple sources, including discussions with farmers involved in the USDA Western SARE Professional-Producer Grant (Western SARE, 2024); a Kernza crop budget from the University of Minnesota (Jungers, 2020); crop budgets from the University of Nebraska (Klein et al., 2017; McClure and Jansen, 2024); and machinery cost estimates from the University of Minnesota (Lazarus, 2015). See Appendix 1 for a more detailed version of the budget.

Kernza Varieties of Intermediate Wheatgrass and Yield Estimates

The IWG varieties assessed in this study are actively being bred for larger seed size, ease of harvesting, and increased yields, with several varieties currently available commercially (Table 1; Tautges et al., 2023). The most common varieties grown in the Central Great Plains, Colorado, and Wyoming are TLI 701, TLI 703, and TLI 801, which tolerate drought well. In order to market Kernza grain, farmers must apply to The Land Institute for a commercial Kernza grower license.

Precipitation is highly variable in southeastern Wyoming. Yearly rainfall has ranged from 6–19 inches per year over the last 15 years (Fig. 3; WRDS, 2024), so crop failure is common. We assume that

Figure 3. Annual precipitation in southeastern Wyoming (Lingle). The black line represents the 30-year average (WRDS, 2024). Due to the high variability, producers might harvest Kernza grain only in wetter-than-average years and otherwise use Kernza for hay or forage in drier-than-average years.



in wetter-than-average years, producers in environments like this might get a grain crop from Kernza varieties of IWG. In dry years, producers might instead use the IWG for hay or forage. Therefore, this budget assumes two primary products from a typical Kernza stand: grain in years two and four, and hay in years three and five.

All listed yields represent cleaned and dehulled grain. Currently, Kernza grain yields from TLI 801 can be as high as 700 lb/ac (pounds per acre) in a research setting; however, on-farm yields in the Great Plains and High Plains tend to be much lower. Aggregated yield data for 2023 in the U.S. Great Plains averaged 140 lb/ac (Fancher, 2023), while yields from the Western SARE project in southeastern Wyoming of variety C5 (no longer available) were around 200 lb/ac in a wetter-than-average year, with minimal yields in a drought year (Rodgers, 2024). This budget assumes grain yields of 150 lb/ac and hay yields of 1 ton/ac.

Field Operations

This budget is based on a five-year period with planting in the spring. Similar to wheat, the Kernza budget includes two fertilizer applications: 80-0-26 applied at planting and 40-0-0 (dry urea) applied the following spring. For more precise applications, growers are highly encouraged to perform a soil test prior to planting, though the impact of fertilizer on Kernza grain yields in southeastern Wyoming is still largely unknown.

Though producers in wetter regions generally plant varieties of IWG bred for grain production in the fall, dryland producers in the High Plains region often plant in the spring due to more reliable spring moisture and to leave more time for establishment before winter. Spring planting typically occurs before April 15, and fall planting typically occurs between September 15 and October 30 (Tautges et al., 2023). Termination usually occurs in the fall after the final harvest, using either a herbicide or tillage.

Land, Machinery, and Labor

The budget includes cash costs for both owned and rented land. Rented land in southeastern Wyoming is estimated to cost $39/ac (USDA NASS, 2024), whereas owned land costs $12/ac, which is the estimated cash cost of overhead and taxes. The budget assumes labor is provided by the landowner at a rate of $25/hour for all field operations, except the custom application of fertilizer, which is assumed to cost $10.78/ac (McClure and Jansen, 2024). All machinery costs were estimated using Nebraska Farm Custom Rates (McClure and Jansen, 2024), which include labor needed to operate farm machinery (chisel plow, fertilizer custom application, field cultivator, press wheel drill, rotary mower, hay rake, RD baler, 15-foot SP harvester, 30-foot combine rigid platform). Transportation was estimated for hay using Nebraska Farm Custom Rates (McClure and Jansen, 2024) and for grain using grain shipping costs from previous studies.

Capital and Government Programs

The interest on operating capital is estimated at 4.75% based on 2024 Farm Service Agency (FSA) loan interest rates (FSA, 2024). This percentage is charged on all cash operating expenses for a six-month time period. Operating loan interest is included in the administration and overhead budget estimate. Currently, a crop insurance product does not exist for Kernza; therefore, the budget does

not include a crop insurance expense. However, in 2022, the Natural Resources Conservation Service (NRCS) adopted the perennial grain conservation rotation enhancement (E328O) to reduce the risk of a move toward perennial grain cropping systems. Currently, enhancement payments are available for Kernza grain producers through the Conservation Stewardship Program (CSP) and Environmental Quality Incentives Program (EQIP), with a typical annual payment of $160/ac for the duration of the CSP contract (NRCS, 2024). If interested, farmers must enroll in E328O prior to planting. Revenues from E328O are not included in this budget.

Additional Considerations and Caveats

Growing and marketing an experimental crop like IWG bred for grain production involves risk in a quickly changing commercial environment. While hay and forage markets are well-established and reliable, the Kernza grain market is still quite young. Though organic and regenerative organic certified Kernza grain currently has stronger market demand, it can be difficult for conventional Kernza growers to find grain buyers. Therefore, growers are not recommended to harvest grain unless they have a sales contract in place. Current Kernza varieties are not free-threshing, so farmers need to ship the grain to processing facilities that can handle small grains such as grass seed, buckwheat, spelt, emmer, or einkorn. **Due to these uncertainties and to minimal yield data available for Kernza grain in the western U.S., a yield-price comparison table (Table 2) for several potential market values and yields is provided below. The goal of this budget is not to provide information for specific farms but instead to understand the ecological, agronomic, and economic conditions in which Kernza might be a viable crop for this region.**

CONCLUSIONS

Currently, the profit margin for conventional, dryland wheat-fallow in southeast Wyoming is very narrow (and in fact negative when averaged across years), which may push farmers to look for alternative crops. While IWG bred for grain production shows some potential, there are many unknowns about the conditions under which this new crop might be a viable alternative. Given average market prices and owned land costs for conventional systems, even low Kernza yields could provide similar net returns as wheat, assuming the producer is able to find a processor and buyer for their Kernza grain (Table 2). Beyond monetary returns, farmers plant perennials for a variety of reasons, including conservation payments, risk tolerance, soil health benefits, and forage, all of which should be considered when making cropping decisions. Because IWG bred for grain production can help improve marginal lands and provide flexibility during drought, it may be a viable alternative for areas no longer suitable for annual grain cropping due to changes in growing conditions or markets. **Although there is still a large amount of uncertainty in grain production, this budget suggests that in conventional, dryland systems, Kernza may outcompete wheat-fallow economically under some scenarios.**

	Low Yield (100 lb/ac)	Average Yield (150 lb/ac)	High Yield (200 lb/ac)
Low Price ($1.00/lb)	-$72.19	-$22.19	$27.81
Average Price ($2.00/lb)	$27.81	$127.81	$227.81
High Price ($3.00/lb)	$127.81	$277.81	$427.81

Table 2. Net returns ($/ac) for 1 year of Kernza grain harvest under different yields* and market prices.**
Just considering net returns in one year of grain harvest, Kernza has the potential to provide higher returns than wheat under some yield and market scenarios, assuming that farmers are able to find processors and buyers for their Kernza grain. These net returns are taken from the budgets for conventional, dryland grain production shown on the tables that follow.
*Yields are clean, dehulled estimates.
**Returns are for owned land. Rented land costs $27.95/ac more than owned land.

CONVENTIONAL DRYLAND KERNZA CROP BUDGET (FIVE-YEAR STAND WITH SPRING PLANTING)

	Year 1 Spring planting	**Year 2** Grain	**Year 3** Hay	**Year 4** Grain	**Year 5** Hay
REVENUE (per acre)					
Cleaned, de-hulled grain yield (lb)	0	150	0	150	0
Grain price ($/lb)	$2.00	$2.00	$2.00	$2.00	$2.00
Hay yield (ton)	0	0	1	0	1
Hay price ($/ton)	$100.00	$100.00	$100.00	$100.00	$100.00
Total revenue	**$0.00**	**$300.00**	**$100.00**	**$300.00**	**$100.00**
COSTS (per acre)					
Seed	$120.00	$0.00	$0.00	$0.00	$0.00
Fertilizer	$13.91	$9.48	$0.00	$0.00	$0.00
Crop chemicals	$58.45	$2.00	$0.00	$0.00	$0.00
Machinery (including labor)	$98.09	$66.30	$38.53	$66.30	$38.53
Transportation	$0.00	$4.39	$3.06	$4.39	$3.06
Grain cleaning and processing	$0.00	$78.00	$0.00	$78.00	$0.00
Administration and overhead For rented land For owned land	 $39.98 $12.03	 $39.98 $12.03	 $39.98 $12.03	 $39.98 $12.03	 $39.98 $12.03
Total costs (rented)	**$330.43**	**$200.15**	**$81.57**	**$188.67**	**$81.57**
Total costs (owned)	**$302.48**	**$172.20**	**$53.62**	**$160.72**	**$53.62**
NET RETURNS (rented)*	**-$330.43**	**$99.85**	**$18.43**	**$111.33**	**$18.43**
NET RETURNS (owned)*	**-$302.48**	**$127.80**	**$46.38**	**$139.28**	**$46.38**

*Annualized net returns over five years are -$16.48/ac/year (rented) and $11.47/ac/year (owned)

CONVENTIONAL DRYLAND WHEAT-FALLOW CROP BUDGET (TWO YEARS)

The wheat-fallow budget below combines wheat-fallow revenue estimates with updated field and operational costs based on a 2018 budget for conventional dryland winter wheat-fallow for Goshen County, Wyoming (Lee et al., 2018). Prices are based on U.S. Wheat Associates (2023) and yield estimates are based on average yields for Wyoming from 2017-2024 (30 bushels/ac) (USDA NASS, 2024).

	Year 1 Grain	**Year 2** Fallow
REVENUE (per acre)		
Grain yield (lb)	1,800.00	0.00
Grain price ($/lb)	$0.10	$0.10
Straw yield (ton)	0.90	0.00
Straw price ($/ton)	$100.00	$100.00
Total revenue	**$275.40**	**$0.00**
COSTS (per acre)		
Seed	$36.00	$0.00
Fertilizer	$20.56	$0.00
Crop chemicals	$58.45	$9.30
Machinery (including labor)	$133.00	$45.24
Transportation	$5.51	$0.00
Administration and overhead For rented land For owned land	 $39.98 $12.03	 $39.98 $12.03
Total costs (rented)	**$293.50**	**$94.52**
Total costs (owned)	**$265.55**	**$66.57**
NET RETURNS (rented)*	**-$18.10**	**-$94.52**
NET RETURNS (owned)*	**$9.85**	**-$66.57**

*Annualized net returns over two years are $-56.31/ac/year (rented) and -$28.36/ac/year (owned)

APPENDIX 1: WYOMING KERNZA CROP BUDGET DETAILS: PRICES AND PRODUCTION COST

Assumptions:

This cash / partial budget includes no opportunity cost, very little contracting, and no custom combining. It assumes two grain harvests and two hay harvests out of a four year stand.

Sources:

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APPENDIX 1: WYOMING KERNZA CROP BUDGET DETAILS: PRICES AND PRODUCTION COSTS (CONTINUED)

	Annual Operations			$ Estimate	Application Rates and Unit Prices					
Prices and production costs (per acre)	Establishment	Grain	Hay	$/ac	ApplicationRates	Unit	Unit Price	Unit	Date Updated	
Market prices										
Hulled harvested grain					300	lb				
Cleaned, de-hulled grain		$300.00		$300.00	150	lb	$2.00	lb	Dec. 2024	1
Hay		$100.00	$100.00	$100.00	1	ton	$100.00	ton	Sept. 2023	
Production input costs										
Seed	$120.00	$0.00	$0.00	$120.00	12	lb/ac	$10.00	lb	Sept. 2023	
Fertilizer costs										
NH3				$0.00		ton	$532.00	ton	Sept. 2023	
Urea	$9.48	$9.48		$9.48	0.04	ton	$237.00	ton	Dec. 2024	2
P2O5	$0.00			$0.00	0	ton	$529.00	ton	Dec. 2024	3
K2O	$4.43			$4.43	0.013	ton	$341.00	ton	Dec. 2024	4
Total fertilizer cost	$13.91	$9.48	$0.00							
Chemical costs										
2, 4 D herbicide (1.5 gal/ac)	$38.40			$38.40	1.5	gal	$25.60	gal	Sept. 2023	
S-metolachlor (1 pt/ac)	$10.75	$2.00		$10.75	0.125	gal	$86.00	gal	Sept. 2023	
Pre-establishment glyphosate (1qt/ac)	$9.30			$9.30	0.25	gal	$37.20	gal	Sept. 2023	
Total chemical costs	$58.45	$2.00	$0.00							
Machinery, operation, and labor costs										
37-foot chisel plow	$17.67			$17.67	1	ac	17.67	ac	Sept. 2023	
Fertilizer, liquid constant rate application	$28.59	$9.53		$9.53	1	ac	$9.53	ac	Sept. 2023	5
60-foot field cultivator	$30.16			$15.08	1	ac	$15.08	ac	Sept. 2023	6
30-foot presswheel drill	$21.67			$21.67	1	ac	$21.67	ac	Sept. 2023	
12-foot rotary mower/conditioner			$16.67	$16.67	1	ac	$16.67	ac	Sept. 2023	
30-foot hay rake (Wheel, 2-16')		$6.54	$6.54	$6.54	1	ac	$6.54	ac	Sept. 2023	
20-foot round baler/wrap 5x6		$15.32	$15.32	$15.32	1	ac	$15.32	ac	Sept. 2023	
30-foot combine rigid platform		$34.91		$34.91	1	ac	$34.91	ac	Sept. 2023	
Total machinery and labor cost	$98.09	$66.30	$38.53							
Transportation costs										
Loading and hauling round bales (1000 lb each)		$3.06	$3.06	$3.06	1	each	$3.06	each	Sept. 2023	
Hauling grain to de-huller (40 lb bushels)		$0.80		$0.80	5	bu/ac	$0.16	bu	Sept. 2023	
Hauling grain from de-huller (60 lb bushels)		$0.53		$0.53	3.3	bu	$0.16	bu	Sept. 2023	
Total transportation costs	$0.00	$82.39	$3.06							
Cleaning and de-hulling costs (per lb)		$78.00		$78.00	1	lb	$0.52	lb	Dec. 2024	7
Administration and overhead										
Accounting and management administrative services	$2.26	$2.26	$2.26	$2.26	Per acre estimate				Sept. 2023	
Interest on operating loan (over six months)	$0.72	$0.72	$0.72	$0.72	4.77%	Percent			Dec. 2024	8
Land rent	$37.00	$37.00	$37.00	$37.00	1	ac	$37.00	0	Dec. 2024	9
Administation and overhead (rented)	$39.98	$39.98	$39.98							
Sub-total costs (rented) excluding administration and overhead	$290.45	$160.16	$41.59							
Total cost (rented):	$330.43	$200.14	$81.57							
									Sept. 2023	10
Administation and overhead (owned)	$12.03	$12.03	$12.03							
Sub-total costs (owned) excluding administration and overhead	$290.45	$160.17	$41.59							
Total cost (owned):	$302.48	$172.20	$53.62							

1. 50% loss from cleaning and de-hulling
2. Total urea applied is equivalent to 80 pounds
3. Phosphorous is not typically applied
4. Total K20 applied is equivalent to 26 pounds
5. Three passes, one for each herbicide
6. Two passes
7. Cleaning rate is charged per clean de-hulled pound of grain. Assume 150 pounds clean grain yield
8. Based on $30,000 loan, current interest rate, and 1,000 acre farm
9. 2023 Northwest Nebraska dryland cropland rental rate
10. 2023 Western Nebraska dryland cropland value

- Adapted from original 2020 budget by Jake Junger.
- Modified and updated for southeast Wyoming by Thomas Foulke in October 2023.
- Modified for Kernza yield and price data and field inputs by Hana Fancher in December 2024

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