Determining Profitable Annual Forage Rotations

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Summary

Producers are interested in growing forages, yet the southwest region of Kansas lacks proven recommended crop rotations such as those for grain crops. Forage production is important to the region's livestock and dairy industries and is becoming increasingly important as irrigation well capacity declines. Forages require less water than grain crops and may allow for increased cropping intensity and opportunistic cropping. A study was initiated in 2013 comparing several 1-, 3-, and 4-year forage rotations with no-till and minimum-till (min-till). Data presented are from 2013 through 2014. Winter triticale yields were not affected by tillage in 2013 but were increased by tillage in 2014. Double-crop forage sorghum yielded 30% of full-season forage sorghum in 2013, which was a drought year, but across years yielded 70% of full-season sorghum. Oats failed to make a crop during the drought year and do not appear to be as drought tolerant as spring triticale or forage sorghum. Subsequent years will be used to compare forage rotations and profitability.

Introduction

To stabilize crop yields, dryland rotations in the southwest Kansas region have typically included fallow to accumulate moisture in the soil profile. Fallow is relatively inefficient at storing and utilizing precipitation when compared to storage and utilization of precipitation received during crop growth. Fallow periods increase soil erosion and organic matter loss (Blanco and Holman, 2012), representing a large economic cost to dryland producers.

Forage production may be considered to reduce the frequency of fallow in the region, increase precipitation use efficiency, improve soil quality, and increase profitability. Several annual forage rotations were identified as being potentially acceptable by producers, based on recent forage research and grower feedback. This study tests several forage rotations for water use efficiency (WUE), forage quality, and profitability.

Annual forage crops are grown for a shorter time and require less moisture than traditional grain crops. Including annual forages in the cropping system might enable cropping intensity and increase opportunistic cropping. "Opportunistic cropping" or "flex cropping" is the planting of a crop when conditions (soil water and precipitation outlook) are favorable and fallowing when unfavorable. Forage producers in the region commonly grow continuous winter triticale (T), triticale or summer crop silage, or forage sorghum or sorghum/sudan hay (S), but they lack a proven rotation concept for forages such as that developed for grain crops (e.g. winter wheat-summer crop-fallow). Producers are interested in forage crop rotations that enable increased pest management control options, spread equipment and labor resources over the year, and reduce weather risk. Growing forages throughout the year greatly reduces the risk of crop failure.

Double crop yields of WT and FS were 70% of annual cropping at Garden City, Kansas ($P \leq 0.05$), between 2007 and 2010. Double cropping resulted in about 44% more forage yield than annual cropping. However, crop establishment was more challenging, and crop growth was highly dependent on growing season precipitation in the double-crop rotation compared to annual cropping. An intermediate cropping intensity of three crops grown in two years or four crops in three years might be successful crop rotations in western Kansas. Wheat yields following spring annual forages were similar to wheat yield following fallow in a wheat-fallow rotation in non-drought years, and wheat yields were only reduced in drought years (Holman et al., 2012). Forages are valuable feedstuff to the cow/calf, stocker, cattle feeding, and dairy industries throughout the region (Hinkle et al., 2010).

Recently in western Kansas, glyphosate-resistant kochia was identified, and several other grasses (e.g. tumble windmill grass and red three-awn) are already tolerant of glyphosate. Although continuous no-till was shown to provide better water conservation and crop yields, this result is contingent upon being able to control all weeds with herbicides during fallow. Limited information is available on the impact of occasional tillage on forage yield. Yield of forage crops following tillage might not be impacted as much as in grain crops, since forages require less water.

Study Objectives

- Improve precipitation use and fallow efficiency of dryland cropping systems by reducing fallow through the use of forage crops.
- Test a number of forage crop rotations and tillage practices (no-till and min-till) to identify sustainable forage cropping systems.
- Disseminate results to growers, crop advisors, and local extension agents through meetings and publications.

Procedures

An annual forage rotation experiment was initiated in 2012 at the Southwest Research-Extension Center in Garden City, Kansas. All crop phases were in place by 2013, with the exception of winter triticale-forage sorghum-spring oat/triticale (T-S-O), which had all crop phases in place by 2015. The study design was a randomized complete block design with four replications. Treatment was crop phase (with all crop phases present every year) and tillage (no-till or min-till). Plots were 30 ft wide and 30 ft long. Crop rotation was 1-, 3-, and 4-year rotations (see treatment list below). Crops grown were winter triticale (×*Triticosecale* Wittm.), forage sorghum (*Sorghum bicolor* L.), and spring oat (*Avena sativa* L.). Spring triticale was grown in place of spring oat beginning in 2015. Tillage was implemented after spring oat/triticale was harvested in treatments

3 and 5, using a single tillage with a sweep plow with 6-ft blades and trailing rolling pickers.

Treatments included:

1. Continuous forage sorghum (no-till): (S-S)
2. Year 1: winter triticale/double-crop forage sorghum; Year 2: forage sorghum; Year 3: spring oat/triticale (no-till): (T/S-S-O no-till)
3. Year 1: winter triticale/double-crop forage sorghum; Year 2: forage sorghum; Year 3: spring oat/triticale (single tillage after spring oat, min-till): (T/S-S-O min-till)
4. Year 1: winter triticale/double-crop forage sorghum; Year 2: forage sorghum; Year 3: forage sorghum; Year 4: spring oat/triticale (no-till): (T/S-S-S-O no-till)
5. Year 1: winter triticale/double-crop forage sorghum; Year 2: forage sorghum; Year 3: forage sorghum; Year 4: spring oat/triticale (single tillage after spring oat, min-till): (T/S-S-S-O min-till)
6. Year 1: winter triticale; Year 2: forage sorghum; Year 3: spring oat/triticale (no-till): (T-S-O)

Winter triticale was planted the end of September, spring oat/triticale was planted the beginning of March, and forage sorghum was planted the beginning of June. Crops were harvested at early heading to optimize forage yield and quality (Haun scale 9.5). Winter triticale was harvested approximately May 15, spring oat/triticale was harvested approximately June 1, and forage sorghum was harvested approximately the end of August. Forage yields were determined from a 3-ft × 30-ft area cut 3 inches high using a small plot Carter forage harvester from each plot. Forage yield and quality (protein, fiber, and digestibility) were measured at each harvest. Gravimetric soil moisture was measured at planting and harvest to a depth of 6 ft using 1-ft increments. Precipitation storage efficiency (% of precipitation stored during the fallow period) was quantified for each fallow period, and crop water use efficiency (forage yield divided by soil water used plus precipitation) was determined for each crop harvest. Crop yield response to plant available water at planting is being used to estimate yield and develop a yield-prediction model based on historical or expected weather conditions. Most producers use a soil probe rather than gravimetric sampling to determine soil moisture status, so soil penetration with a Paul Brown soil probe was used four times per plot at planting to estimate soil water availability. Previous studies found a soil moisture probe provided an accurate and easy way to determine soil moisture level and crop yield potential.

Data produced by this study will be used to evaluate the economics of forage rotations and tillage. Production cost and returns will be calculated using typical values for the region. The implications of using forages on crop insurance dynamics and risk exposure is a critical component of a producer's decision-making process and will be evaluated at the conclusion of this study.

Results and Discussion

Rotation Yield

Annual rotation yield was determined by measuring total yield for the rotation within a year and dividing by the number of years in the rotation. This method allows for comparing rotations of different years to each other annually (Table 1). A very dry year was recorded in 2013, resulting in low crop yields and no spring oat yield. In 2013, S-S produced the highest annual yield. In 2014, annualized yield was comparable across treatments except for T/S-S-O (no-till), which had lower yield than T/S-S-S-O (min-till) and was comparable to all other treatments. The crop rotation of T-S-O was not in phase until 2015, so no comparison was made to that rotation. Tillage did not affect rotation yield in 2013, but tillage increased yield in 2014.

Forage yield per crop harvest was determined since planting and harvest expenses are the major expenses to growing a crop. Crop rotations with higher yield per harvest are likely more profitable compared to rotations with low yield per harvest, since the expense per unit of yield is less. However, although oat and triticale yield less than sorghum, they are also higher in crude protein and digestibility and are worth more per unit than forage sorghum. A full economic analysis of rotations will be completed at the conclusion of this study. In 2013, S-S had the highest yield per harvest, and all other rotations had similar yields per harvest (Table 1). In 2014, T/S-S-O (no-till) had lower average harvest yields than S-S or T/S-S-S-O (min-till) but was similar to T/S-S-O (min-till) and T/S-S-S-O (no-till). Sorghum has the highest yield potential of the three crops investigated, but S-S does not allow for crop diversification, improved weed management, higher forage quality (oats and triticale), or the ability to reduce weather risk by growing a crop during different times of the year.

Crop Yield

In 2013, winter triticale yield was not different across rotation treatments, averaging 434 lb/a with a water use efficiency (WUE) of 29 lb/a per inch soil water. However in 2014 — and averaged across years — tillage increased yield of triticale (Figure 1). Averaged across years, tillage increased triticale yield between 250 and 600%. This increase in yield was attributed in part to increased WUE (Figure 2).

Full season sorghum yields — either grown after T/S or S — were similar across rotations (Figure 1). In 2013, sorghum grown double crop after triticale yielded about 30% (1,130 lb/a) of full season sorghum (3,870 lb/a). Averaged across years, double-crop sorghum yielded 70% (4,060 lb/acre) of full season sorghum (5,790 lb/a). Sorghum grown after triticale has less available soil water, and in the dry year of 2013 it was severely drought stressed. Moisture came late in 2014, and there was little yield difference between double-crop and full season sorghum. Previous research found in normal to above-normal precipitation years, double-crop sorghum yield following triticale was 70% compared to full season sorghum (Holman, unpublished data). Sorghum yield was not affected by tillage. Sorghum WUE was correlated to forage yield, with full season sorghum having greater water use efficiency (457 lb/a per inch soil water) than double-crop sorghum (371 lb/a per inch soil water) (Figure 2).

Oats failed to make a crop in 2013 due to drought conditions, and yields were similar among rotations in 2014 (400 lb/a).

References

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Table 1. Rotation yields across years between 2013 and 2014.

Crop rotation	Total Yield		
	2013	2014	Average†
	DM lb/acre		
S-S	4262	7426	5844
T/S-S-O (no-till)	3451	13322	8387
T/S-S-O (min-till)	4020	20130	12075
T/S-S-S-O (no-till)	7702	27260	17481
T/S-S-S-O (min-till)	8896	30266	19581
T-S-O	*	*	*
	Annualized Yield		
S-S	4262	7426	5844
T/S-S-O (no-till)	1150	4441	2796
T/S-S-O (min-till)	1340	6710	4025
T/S-S-S-O (no-till)	1926	6815	4370
T/S-S-S-O (min-till)	2224	7566	4895
T-S-O	*	*	*
$LSD_{0.05}$‡	1508	3038	
	Yield per Harvest		
S-S	4262	7426	5844
T/S-S-O (no-till)	863	3331	2097
T/S-S-O (min-till)	1005	5032	3019
T/S-S-S-O (no-till)	1540	5452	3496
T/S-S-S-O (min-till)	1779	6053	3916
T-S-O	*	*	*
$LSD_{0.05}$‡	1323	2566	

† Average of years 2013–2014.
‡ Means in columns followed by different letters are statistically different at $P \leq 0.05$.

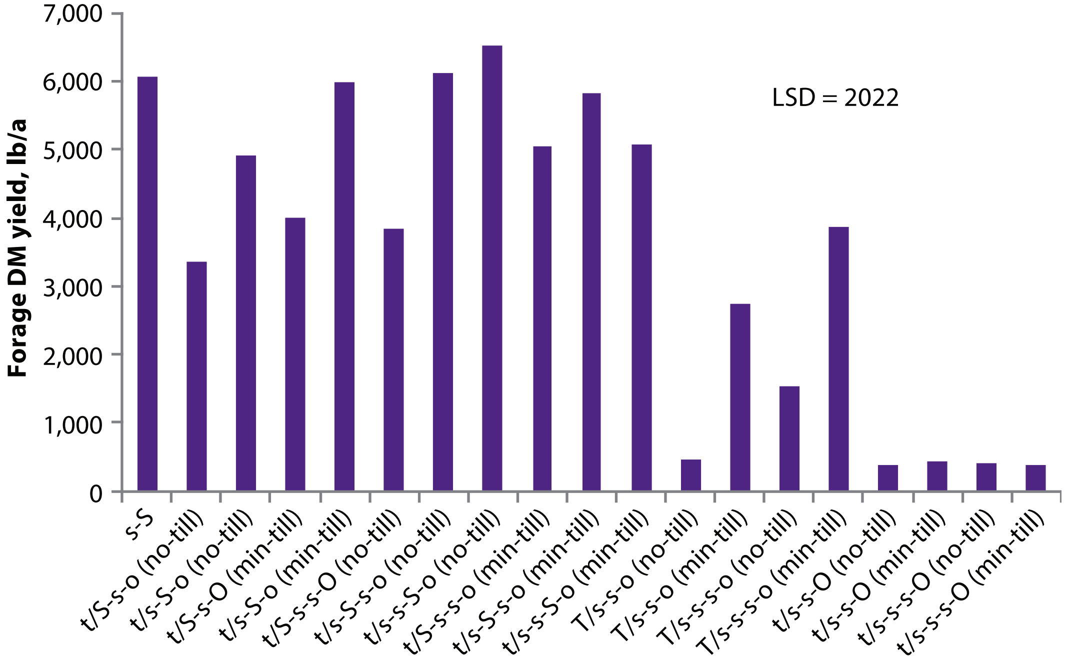

Figure 1. Forage dry matter yield in all crop rotations and phases averaged across 2013 and 2014. Crop is identified by capitalization in X axis. LSD= 2022 lb/A.

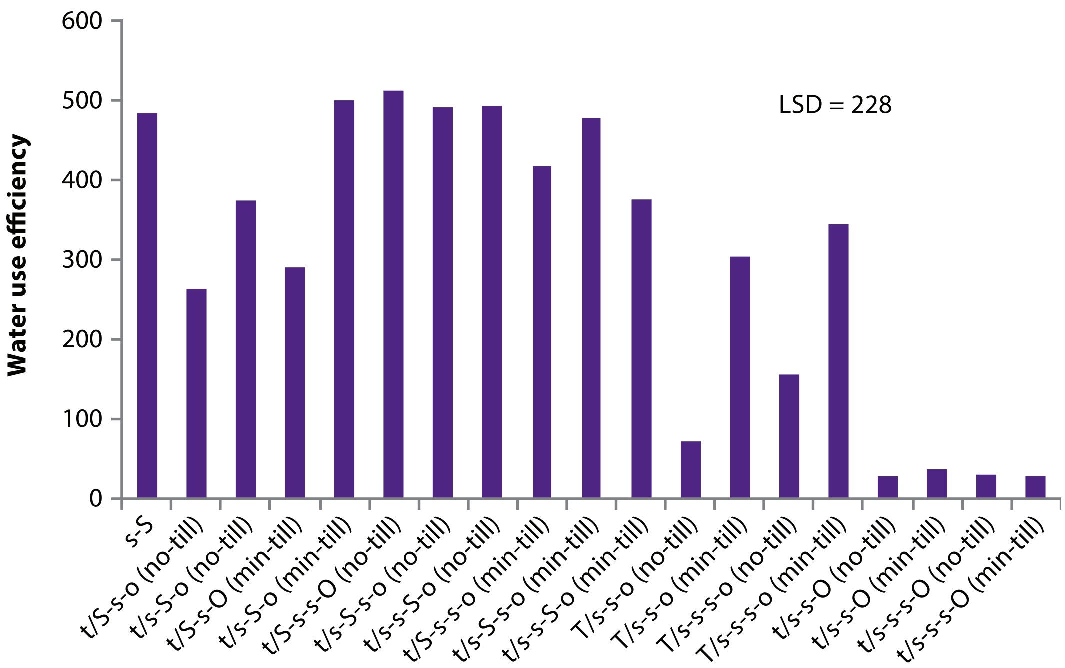

Figure 2. Water use efficiency (WUE) [forage dry matter yield/(ending-beginning soil water content) + growing season precipitation] for all crop rotations and phases averaged across 2013 and 2014. Crop is identified by capitalization in X axis. LSD= 228 lb/a per inch soil water.