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Estimating Annual Forage Yields with Plant Available Water and Growing Season Precipitation

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Abstract

Forage production is important for western Kansas region's livestock and dairy industries and has become increasingly important as irrigation-well capacity declines. Forages require less water than grain crops and may allow for increased cropping intensity and opportunistic cropping. Being able to estimate forage production is important for determining forage availability versus forage needs. Data from several studies were used to quantify annual forage yield response to plant available water (PAW) at planting and growing season precipitation (GSP). In addition, water use efficiency was quantified. Forages evaluated included winter triticale, spring triticale, and forage sorghum.

Keywords

annual forage yields, plant available water, forage yield, western Kansas

Authors

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Summary

Forage production is important for western Kansas region's livestock and dairy industries and has become increasingly important as irrigation-well capacity declines. Forages require less water than grain crops and may allow for increased cropping intensity and opportunistic cropping. Being able to estimate forage production is important for determining forage availability versus forage needs. Data from several studies were used to quantify annual forage yield response to plant available water (PAW) at planting and growing season precipitation (GSP). In addition, water use efficiency was quantified. Forages evaluated included winter triticale, spring triticale, and forage sorghum.

Introduction

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 increased cropping intensity and 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 winter triticale, forage sorghum, or spring triticale/oat. Producers are interested in forage crop rotations that enable increased pest management control options, spread out equipment and labor resources over the year, reduce weather risk, and increase profitability. Growing forages throughout the year greatly reduces the risk of crop failure. Understanding the yield relationship to PAW and GSP would help producers better meet their forage needs.

Study Objectives

1. Quantify yield relationship of winter, spring, and summer forages with PAW and GSP.
2. Determine water use efficiency of winter, spring, and summer forages.

Experimental Procedures

Annual forages were grown as part of several different rotation experiments near Garden City, KS. Plant available water, growing season precipitation, and forage yield were measured annually. Data for winter triticale and forage sorghum were available from 2008 through 2017, and spring triticale from 2012 through 2017.

Annually, winter triticale was planted at the end of September, spring triticale was planted at the beginning of March, and forage sorghum was planted at the beginning of June. Crops were harvested at early heading to optimize forage yield and quality (Feekes 10.1) (Large 1954). Annually, winter triticale was harvested approximately May 15, spring oat was harvested approximately June 1, and forage sorghum was harvested approximately the end of August. Forage yields were determined from a 3- × 30-ft area cut 3 in. high using a small plot Carter forage harvester for each plot. Forage yield was measured at each harvest. Gravimetric soil moisture content was measured at planting and harvest to a depth of 6 ft using 1-ft increments. Precipitation storage efficiency (percent 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 was regressed to estimate yield. These yield data will eventually be used to develop a yield prediction model based on historical or expected weather conditions when sufficient years of data are obtained.

Data produced by this study will be used to evaluate the economics of forage rotations and tillage. Production costs and returns will be calculated using typical values for the region. The implication 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

Winter Triticale

Winter triticale forage yield was correlated to PAW and GSP, although yield response was highly variable. Plant available water explained approximately 13% and GSP explained 5% of the variability in forage yield (Figures 1 and 2). Together, PAW and GSP explained 48% of the variability in forage yield (Figure 3). For every inch of water used (soil water plus GSP), yield was increased 640 lb/a. Averaged across the study period, yield was 3,500 lb/a.

Spring Triticale

Spring triticale forage yield was significantly correlated to PAW and GSP, but yield response was highly variable. Plant available water and GSP both explained approximately 5% of the variability in forage yield independently (Figures 4 and 5). Combining PAW and GSP explained only 10% of the yield variability; suggesting something other than moisture, most likely temperature greatly impacts yield (Figure 6). For every inch of water used (soil water plus GSP), yield was increased 187 lb/a. Averaged across the study period, yield was 1,450 lb/a.

Forage Sorghum

Forage sorghum forage yield was correlated to PAW but not GSP, and yield response was variable. Plant available water explained approximately 22% and GSP explained 3% of the variability in forage yield (Figures 7 and 8). Together, PAW and GSP explained 23% of the variability in forage yield (Figure 9). For every inch of water used (soil water plus GSP), yield was increased 410 lb/a. Averaged across the study period, yield was 5,400 lb/a.

References

Large, E.C. 1954. Growth stages in cereals illustration of the Feekes scale. Plant Pathology. 3 (4): 128–129. doi:10.1111/j.1365-3059.1954.tb00716.x

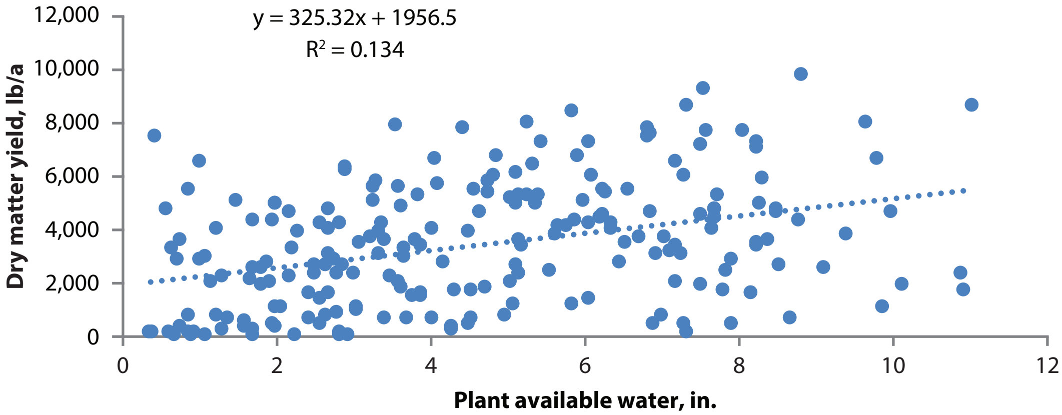

Figure 1. Winter triticale yield response to plant available water at planting.

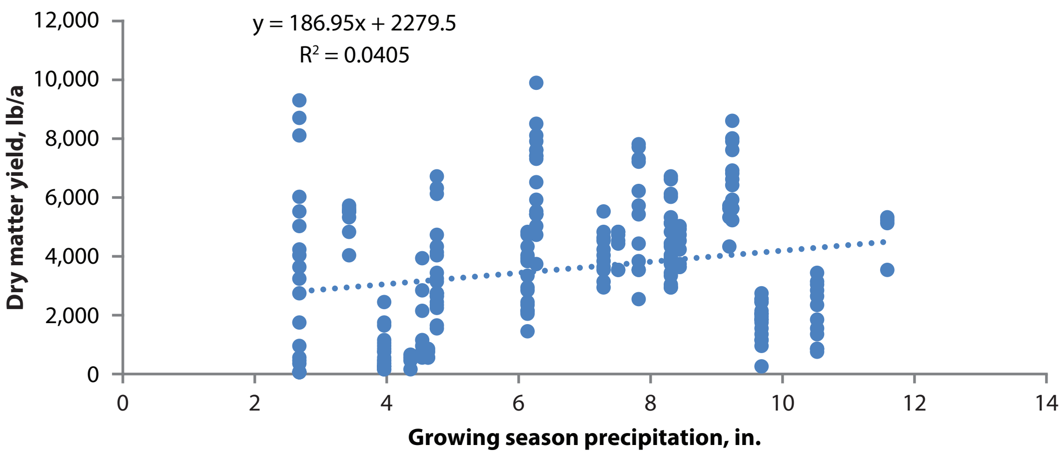

Figure 2. Winter triticale yield response to growing season precipitation.

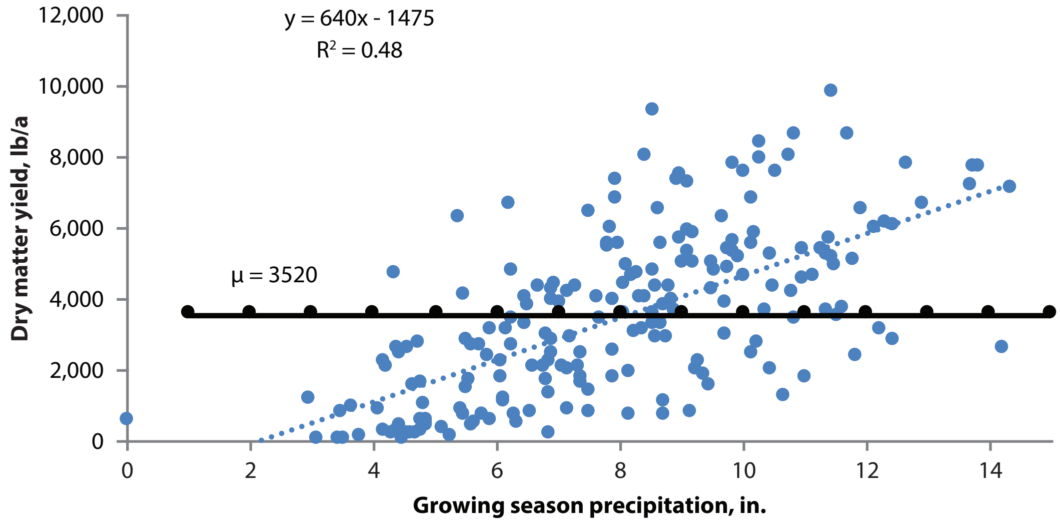

Figure 3. Winter triticale yield response to water use (soil water plus growing season precipitation) and average yield (bold line) across the study period.

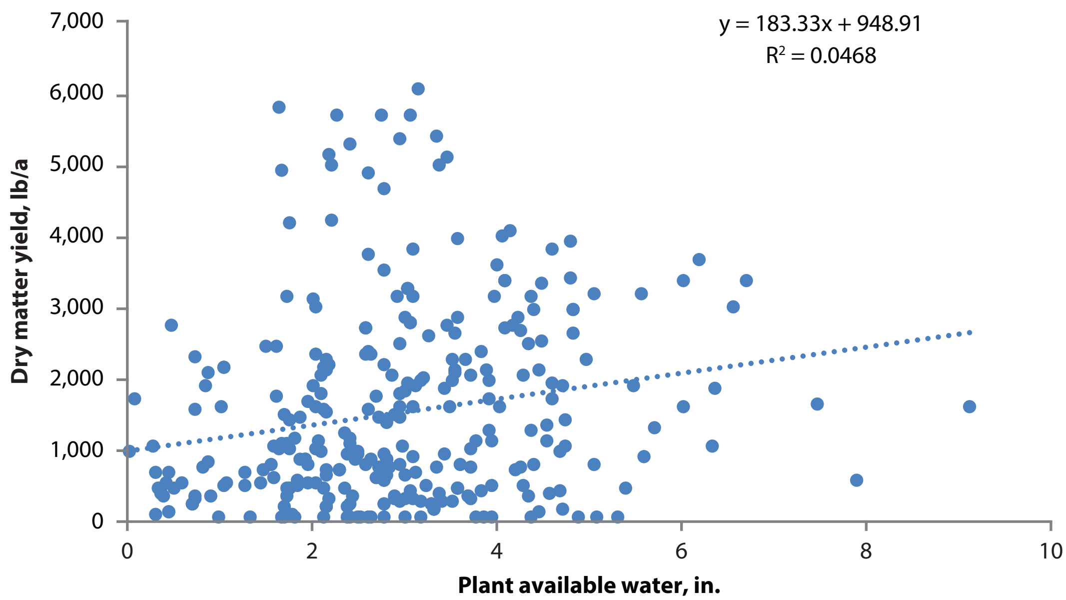

Figure 4. Spring triticale yield response to plant available water at planting.

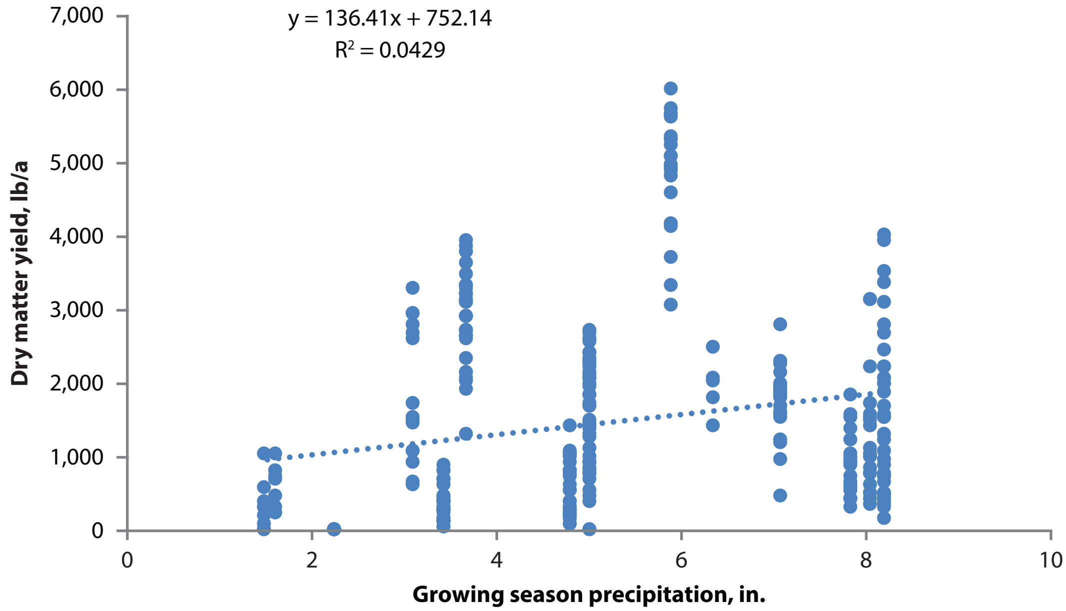

Figure 5. Spring triticale yield response to growing season precipitation.

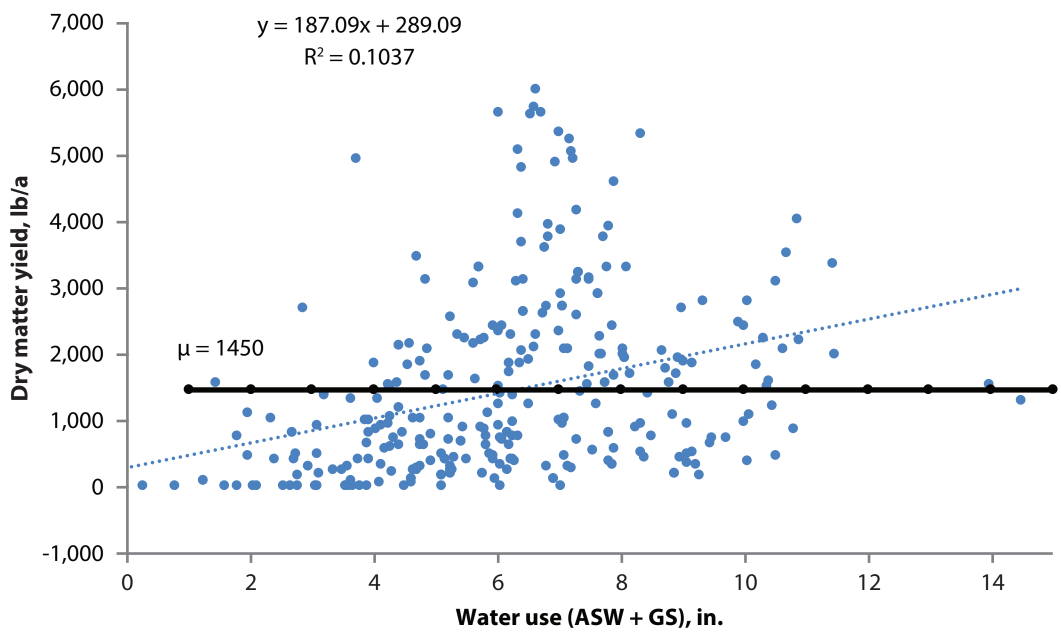

Figure 6. Spring triticale yield response to water use (soil water plus growing season precipitation) and average yield (bold line) across the study period.

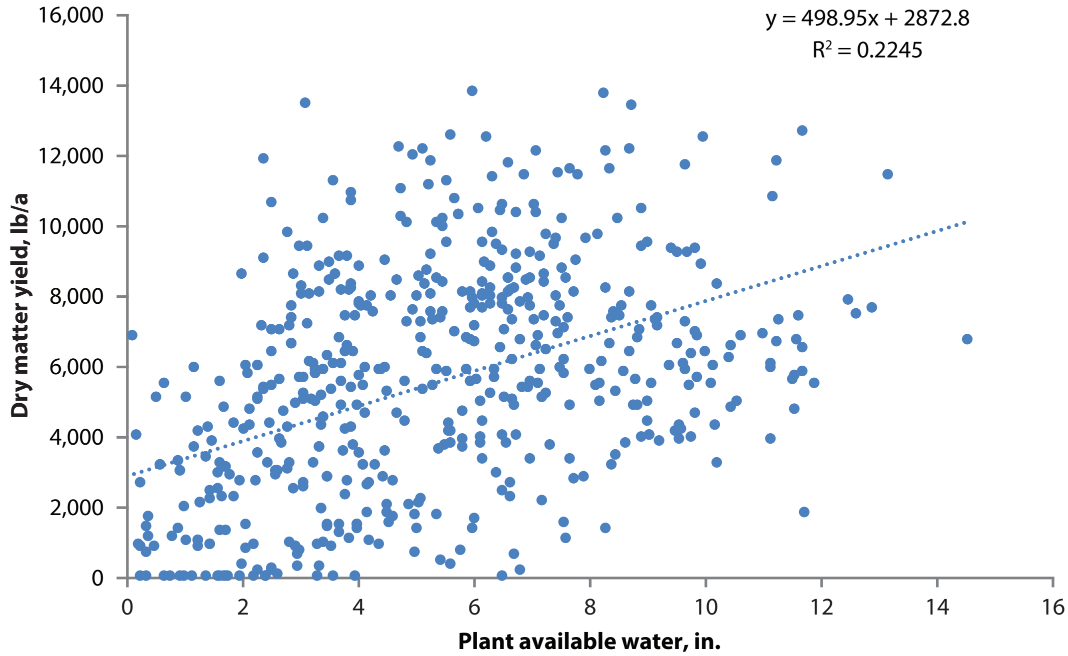

Figure 7. Forage sorghum yield response to plant available water at planting.

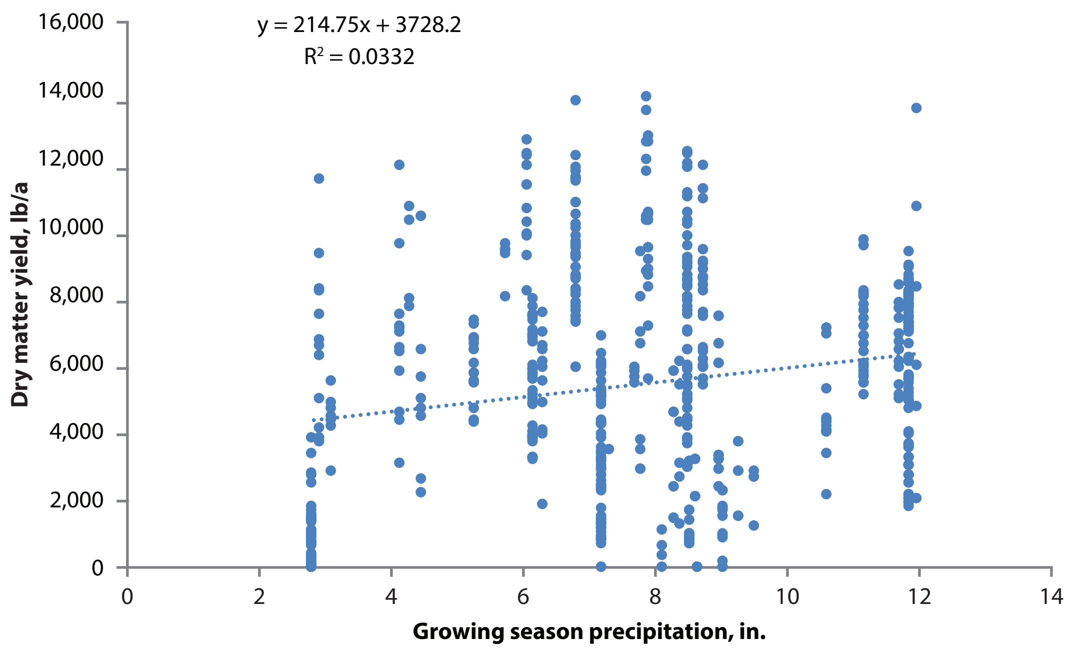

Figure 8. Forage sorghum yield response to growing season precipitation.

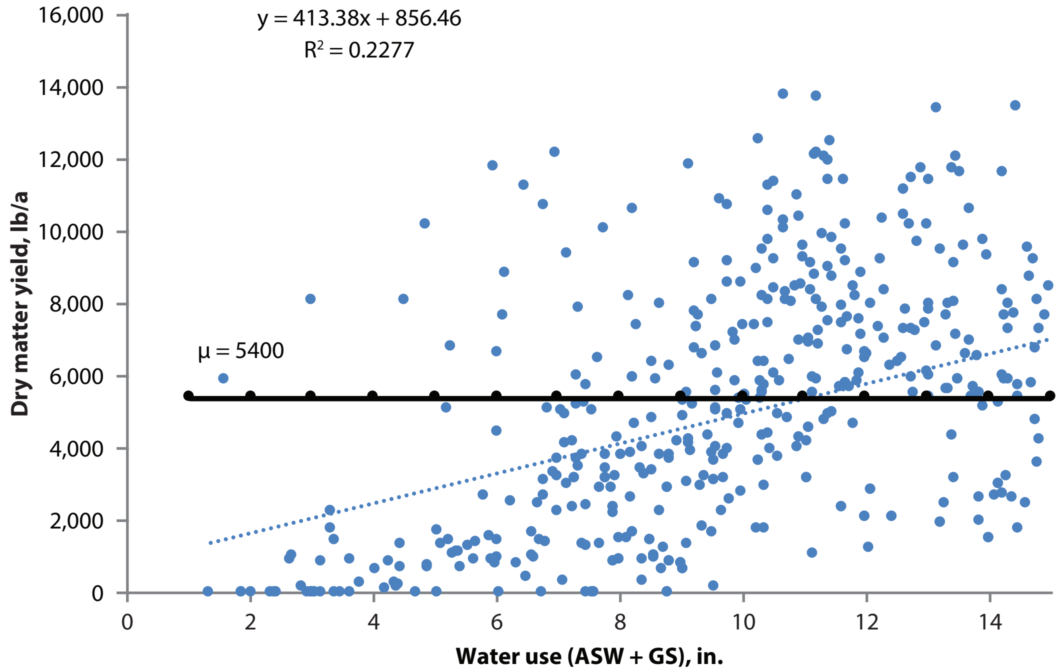

Figure 9. Forage sorghum yield response to water use (soil water plus growing season precipitation) and average yield (bold line) across the study period.