Evapotranspiration in Winter Wheat Under Different Grazing and Tillage Practices in the Southern Great Plains

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Abstract

Better understanding of evapotranspiration (ET) dynamics in dryland agricultural ecosystems is vital to sustainable crop and animal production in the Southern Great Plains (SGP). The main objective of this study is to document and compare evapotranspiration (ET) dynamics over a 2016-17 growing season in graze-out, graze-grain, and grain-only winter wheat (*Triticum aestivum L.*) within a 4-year winter wheat-canola (*Brassica napus L.*) crop rotation system with conventional and no-till practices. This study is part of the larger SGP Long-Term Agroecosystem Research (LTAR) and GRL-FLUXNET (a cluster of 17 eddy covariance systems) projects at the USDA-ARS Grazinglands Research Laboratory (GRL), El Reno, OK. Biometric measurements (e.g., biomass, leaf area index, percent cover, and canopy height) and ET were measured during the 2016-17 winter wheat growing season. Seasonal rainfall during the winter wheat growing season was 567 mm. Biomass, LAI, and ET rates were higher in the grain-only wheat than graze-grain and graze-out treatments. Daily maximum ET rates ranged from 3.45 (graze-grain) to 5.04 mm (grain-only). Similarly, growing season ET ranged from 396 mm (graze-grain) to 488 mm (grain-only). Long-term year-round measurements from clustered and paired eddy flux towers are needed to provide more insights into the effects of tillage and grazing practices on water budgets of typical wheat cropping systems in the SGP.

Introduction

Precipitation in the Southern Great Plains (SGP) is highly variable both spatially and temporally with recurring periods of severe drought. Different combinations of winter wheat (*Triticum aestivum L.*) – summer fallow system with conventional tillage are the principal dryland cropping system in this region for both grazing and grain. Not surprisingly, winter wheat is a drought avoidance species as it takes advantage of soil moisture that accumulates during summer fallow and matures prior to the hot and dry conditions that prevail during summer. Although summer fallow minimizes risk of crop failure, there are numerous sustainability issues such as poor precipitation-use efficiency, increased soil erosion, and decreased soil organic carbon and nitrogen. No-till systems can help alleviate these problems, but limited adoption is observed in the SGP.

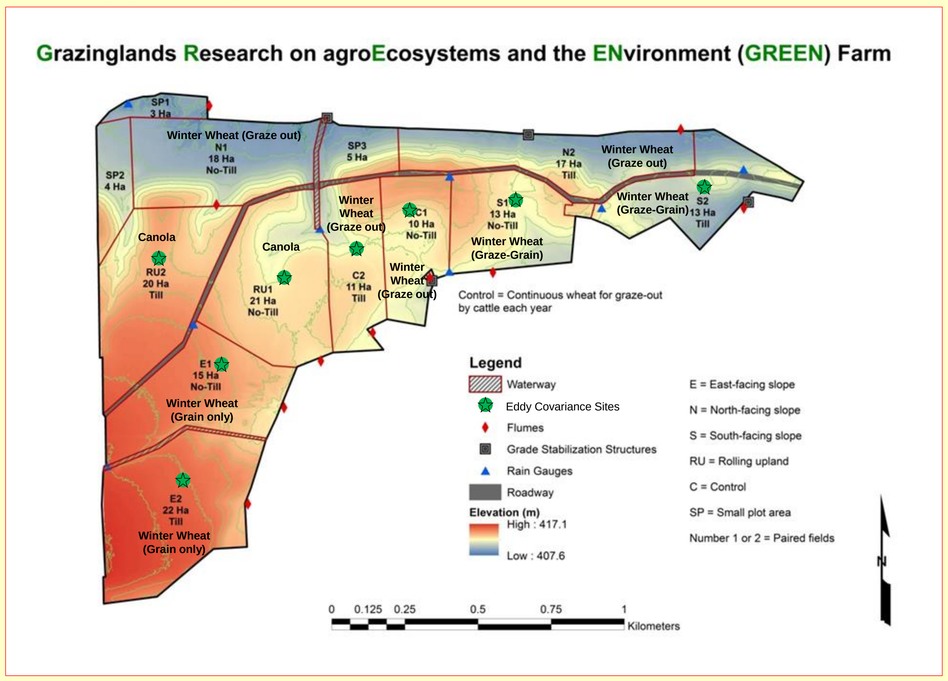
The eddy covariance (EC) technique is recognized as the standard method to study exchange of energy, evapotranspiration (ET), and carbon dioxide (CO_2) between terrestrial ecosystems and the atmosphere. This information is essential for understanding ET dynamics in different agricultural ecosystems, and for developing, testing, and improving crop models, satellite-based production efficiency models, and ET models on a large-scale. In addition, such information will lead to better understanding of the potential of agroecosystems to affect atmospheric CO_2 and other greenhouse gases concentrations and mitigate climate change.

Objective

Monitor and evaluate evapotranspiration (ET) dynamics over the 2016-17 growing season in graze-out, graze-grain, and grain-only winter wheat within a 4-year wheat-canola crop rotation system with conventional and no-till practices.

Study Area

- Southern Great Plains Long-Term Agriecosystem Research (LTAR) site (GREEN Farm) in the USDA-ARS Grazinglands Research Laboratory (GRL), El Reno, OK.
- Total Area – 178 ha (10 fields); Soil Characteristics – Deep, well-drained, loamy soils with clayey or loamy subsoil.

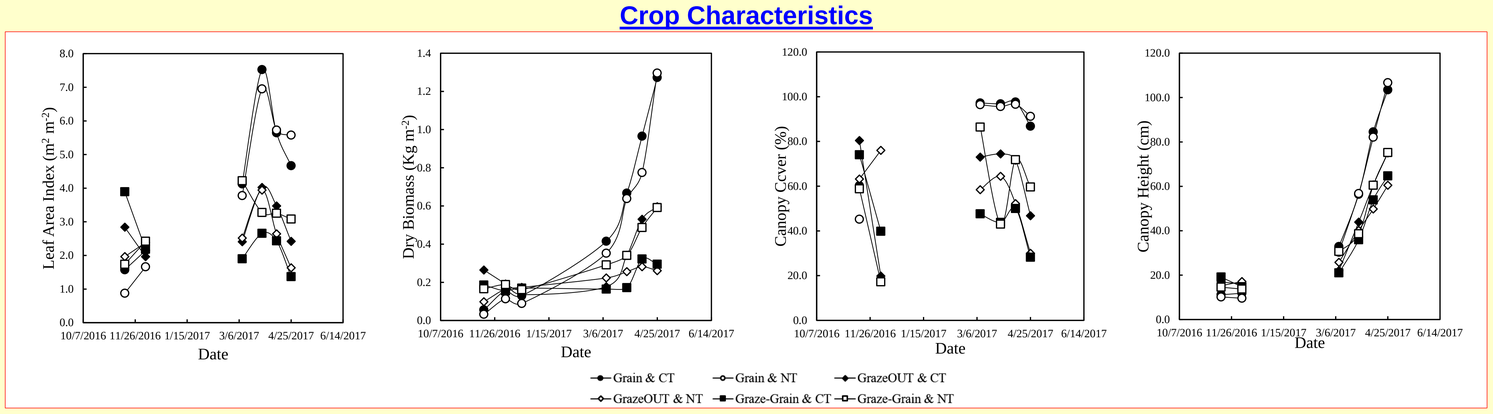


Materials and Methods

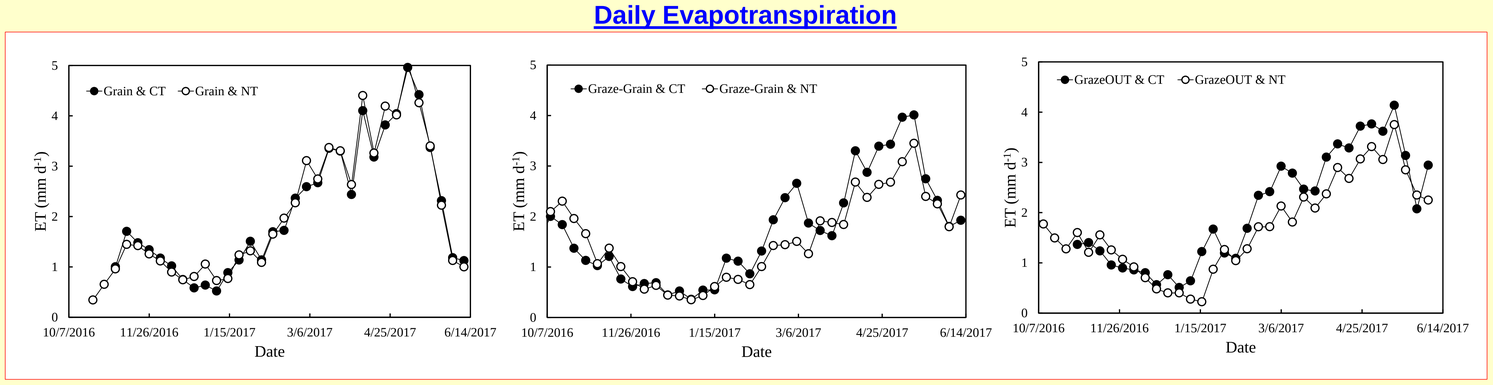
- Data from six EC systems used in this study are part of the GRL-FLUXNET for monitoring ET, CO_2, and surface energy fluxes over a diverse range of terrestrial ecosystems at the USDA-ARS-GRL.
- Crop rotation system: 4 Year; Winter wheat (grain only) – Winter Wheat (graze & grain) – Winter wheat (graze out) – Canola (grain).
- Fertilizer application – 25-30 lbs. N (DAP) per acre at planting. Additional 50-75 lbs. N (UAN) per acre in spring. Based on soil test.
- Growing season: October 2016 – May 2017.
- Stocking rate for grazing – 2 ac per stocker in the fall and 1 acre per stocker in the spring.
- Tillage management practices: No-Till (NT) and Conventional Till (CT).
- Biometerological variables measured: Leaf area index, canopy height, dry biomass, and % canopy cover (bi-weekly).
- EddyPro software version 6.2.0 (LI-COR Inc., Lincoln, Nebraska, USA) was used to compute 30-min fluxes.
- Fluxes with quality flag 2, unreliable fluxes, and statistical outliers (i.e., beyond ±3.5 standard deviation) based on two weeks running window were excluded (Wagle et al., 2015).
- Sensible (H) and latent heat (LE) fluxes were further screened to retain values in the range in of -200 to 500 W m^{-2} and -200 and 800 W m^{-2} (Sun et al., 2010; Wagle et al., 2016), respectively.

Results and Discussion

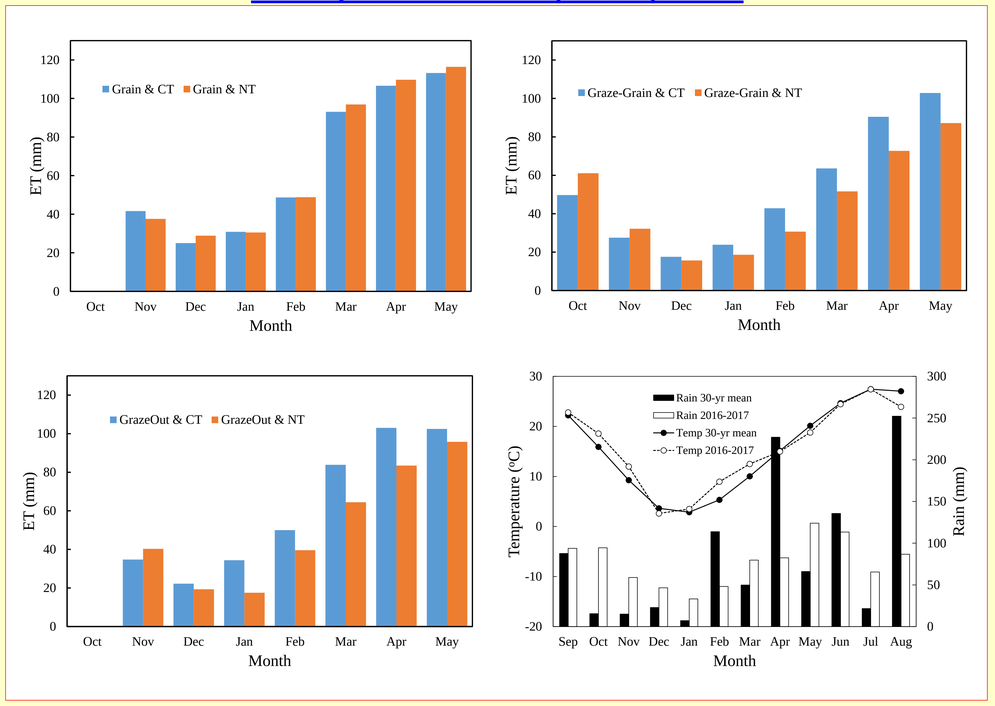
Crop Characteristics



Daily Evapotranspiration



Monthly Rainfall and Evapotranspiration



ET Summary

Treatment	Grain Only		Graze-Grain		Graze-OUT	
	CT	NT	CT	NT	CT	NT
Daily Maximum ET (mm)	4.96	5.04	4.01	3.45	4.14	3.75
Growing Season ET (mm)	473	488	444	396	473	442
GS Length (DOY)	222 days (306-163)		255 days (273-163)		227 days (301-163)	
October 2016 – May 2017 Rainfall (mm)					567	

Summary

- Growing season (October 2016 – May 2017) total rainfall (567 mm) was slightly higher than 30-year average (517 mm).
- Maximum daily ET rates were observed in grain-only fields and it was mainly due to presence of more biomass.
- Comparison of average daily ET rates within the growing season indicated ET by winter wheat in grain-only field was highest followed by graze-out and graze-grain fields irrespective of tillage system.
- ET was observed to be driven mainly by plant characteristics than any other factors.

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