Impact of Precipitation Timing and Soil Water on Wheat and Corn Yields in the Central Great Plains

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INTRODUCTION

•No-till management allows for adoption of intensive cropping systems due to the increased water use efficiency.

•Surface residue and the lack of tillage reduces evaporative losses and increases infiltration rates.

•Wheat- summer fallow cropping systems were adopted in the 1950's to stabilize yields in semi-arid environments as 2 years of precipitation was needed to produce 1 wheat crop consistently in this region.

•Intensification to a 3 year no-till winter wheat-corn/sorghum – summer fallow has become more common in the Central Great Plains.

•Producers and researchers have observed that wheat yields are depend on soil water at planting and corn yields are depend on reproductive period rainfall.

OBJECTIVES

•Evaluate the strength of the relationship between wheat/corn grain yields as a function of soil water at planting, fallow rainfall, vegetative rainfall, and reproductive rainfall.

•Determine if the strength of the relationship is the same for spring and fall planted crops.

METHODS

Rainfall Period Defined

Wheat crop fallow rain = November-August (10 Months).

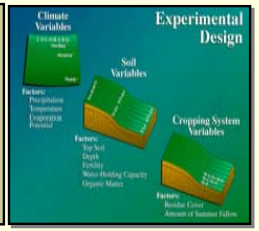
Wheat Vegetative rain = September-April (8 Months).

Wheat reproductive rain = May-June (2 Months).

Corn fallow rain = July-April (10 Months).

Corn vegetative rain = May-June (2 Months).

Corn reproductive rain = July-August (2 Months).



METHODS

▪ Long-term dryland rotation experiment initiated in 1985 with 3 potential evapotranspiration (PET) sites. These sites represent an increasing PET gradient from north to south, but all have a long-term mean annual precipitation of 420 mm.

▪ Topographic variable was represented by slope positions of summit, side, and toeslope along a catenary sequence.

▪ Cropping systems were placed across the soil sequences at each site in strips that are 6.1 m wide by 185 to 300 m long, depending on site. All phases of each cropping system are present each year.

▪ Three-year rotation of wheat-corn-fallow (WCF) at the low (Sterling) and medium (Stratton) PET sites and the wheat-sorghum-fallow (WSF) rotation at the high PET site (Walsh) were evaluated.

▪ Profile soil water content was measured at planting in all crops and soils using a neutron probe.

▪ Precipitation data was collected from the weather stations at each site location.

▪ Multivariate regression analysis was performed using SAS mixed GLM. Wheat and corn yields by site and slope for 22 years were regressed against soil water at planting, fallow rainfall, vegetative rainfall, and reproductive rainfall.

▪ Level of significance (p-value) and correlation coefficient (r) are presented.

RESULTS

Wheat Grain Yields – LOW PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial Soil water	0.0234	0.2411	0.5718
Fallow rain	0.0794	0.0011	0.0011
Vegetative Rain	0.4061	0.4018	0.1835
Reproductive Rain	0.6418	0.7986	0.1642
Prob. > r	0.7182	0.7659	0.7712
p-value	0.0005	0.0003	0.0012

Wheat Grain Yields – Medium PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial Soil water	0.0155	0.0017	0.6142
Fallow rain	0.0200	0.1738	0.1142
Vegetative Rain	0.6874	0.7931	0.1523
Reproductive Rain	0.1810	0.3536	0.0723
Prob. > r	0.6271	0.7796	0.7459
p-value	0.0093	0.0062	0.0089

Wheat Grain Yields – High PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial Soil water	0.1977	0.1236	0.5011
Fallow rain	0.0469	0.0244	0.0460
Vegetative Rain	0.0386	0.1873	0.2149
Reproductive Rain	0.2161	0.3725	0.2060
Prob. > r	0.8039	0.7709	0.7259
p-value	0.0095	0.0012	0.0033

▪ Wheat grain yields regressed against soil water at planting, fallow rain, vegetative rain, and reproductive rain all had significant correlations across all sites and soils.

▪ Fallow period rainfall was significant across all soils at both the Low PET and High PET sites with only the summit soil being significant at the medium PET site. Soil water at planting was statistically significant at the summit soil within the Low PET site and at the summit and side at the Medium PET site.

▪ It is of note that reproductive rainfall was not significant in wheat grain yields at 8 out of the 9 soils analyzed.

Corn Grain Yields – LOW PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial soil water	0.4332	0.5190	0.7594
Fallow rain	0.8007	0.9773	0.9491
Vegetative Rain	0.0201	0.5232	0.1060
Reproductive rain	<.0001	0.0016	0.0011
Prob > r	0.8233	0.7656	0.7871
p-value	<.0001	0.0002	0.0001

Corn Grain Yields – Medium PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial soil water	0.2616	0.3636	0.8090
Fallow rain	0.3589	0.1946	0.2544
Vegetative Rain	0.5099	0.5514	0.1036
Reproductive rain	0.0010	0.0065	0.0004
Prob > r	0.8565	0.7778	0.8669
p-value	<.0001	0.0060	<.0001

Sorghum Grain Yields –Walsh PET And By Soil (*p*-value)

	Summit	Side	Toe
Initial soil water	0.1096	0.8341	0.0174
Fallow rain	0.4527	0.5159	0.1942
Vegetative Rain	0.3894	0.6975	0.2462
Reproductive rain	0.1377	0.1801	0.0010
Prob > r	0.1164	0.4891	0.7358
p-value	0.6919	0.0643	0.0018

▪ Corn grain yields regressed against soil water at planting, fallow rain, vegetative rain, and reproductive rain showed significant and strong correlations for 7 out of the 9 soil slope and site combinations with only the summit and side slope soils at the High PET site not having a statistical relationship.

▪ Reproductive rainfall in spring crops has been shown to be significant in most of the PET site by soil slope positions analyzed.

▪ The High PET site near Walsh, Colorado has the largest deficient moisture of the 3 locations and the coarsest textured soils, especially on the summit and side slope soils.

22 Year Average Precipitation

▪ Monthly precipitation 22 year average was 424mm, 405 and 404 for the Low, Medium and High PET site with the lowest relative standard deviation % (RSD) found in May.

▪ The highest precipitation month was July for Low and Medium PET sites and August for the High PET site, concurrent with the spring planted corn/sorghum crops.

▪ July and August precipitation accounts for 33% of the annual precipitation in this region. 22 Year mean precipitation is 72 mm with a SD of 49 mm in July. August mean precipitation is 64 mm with SD of 40 mm.

▪ Winter wheat has the same fallow length prior to planting as corn/sorghum but has 86% of the precipitation during this fallow whereas the fallow prior to corn has 72% on average.

▪ The fallow period is reduced to 10 months in a 3 year WCF system vs. a WF system which has 14 months of fallow.

CONCLUSIONS

•There is a strong relationship between fallow rain and wheat yields and reproductive rainfall for corn/sorghum yields. The variability of rainfall in the spring for wheat reproductive period and corn/sorghum planting is low whereas the variability of rain during the reproductive period of spring crops is higher.

•Changing to a more diverse cropping system with less fallow duration and frequency optimizes the rainfall that is received in this semi-arid environment. This system divides the risk across each phase within the system and validates what researchers and producers have observed with this 3 year cropping system.

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