Ten-Year Comparisons of Irrigation Use from the Ogallala Aquifer in the Texas South Plains

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Introduction

The Southern High Plains of Texas are part of the largest, contiguously irrigated cropland in the USA, drawing water from the Ogallala Aquifer (Fig. 1). The water level has declined by 30 cm/yr., seriously threatening the sustainability of the $9.7 billion ag industry. Advances in irrigation delivery that minimize evaporation losses and the use of irrigation scheduling tools that factor in soil water availability and crop needs for evapotranspiration (ET) are keys to improving whole-system water use efficiency.

The Texas Alliance for Water Conservation (TAWC) is an on-farm demonstration project consisting of a local producer board and a management team of scientists and resource managers. It was formed in 2004 at Texas Tech University to extend information on techniques to conserve irrigation water.

We present a 10-yr summary of data collected from commercial farms on the efficiency of water use.

Objectives

- Demonstrate how to reduce total water use
- Demonstrate how to maintain or enhance profitability
- Identify effective crop and irrigation systems
- Impact producer decision-making

Methods

Monitoring sites were established on 29-33 commercial farms (varied across years) in Hale and Floyd Counties, 50-80 km north of Lubbock, TX. Ten sites were added in six more counties in 2014 (Fig. 2).

Each field-year combination represented an agricultural production system.

Systems included:

- Crop monoculture – one crop in an entire field, usually cotton or corn
- Multi-crop – one field partitioned into different crops, receiving different managements
- Integrated crop/livestock – part of a system was cropped and part grazed
- Beef cow/calf – grazed field, some hay
- Seed/hay production – native grasses

Data collection included (short list):

- Irrigation applied
- Evapotranspiration
- Crop and livestock yields and profits

Improved irrigation managements, such as monitoring soil water content and crop water use were demonstrating at field days.

Fig. 1. Texas High Plains in relation to Ogallala Aquifer

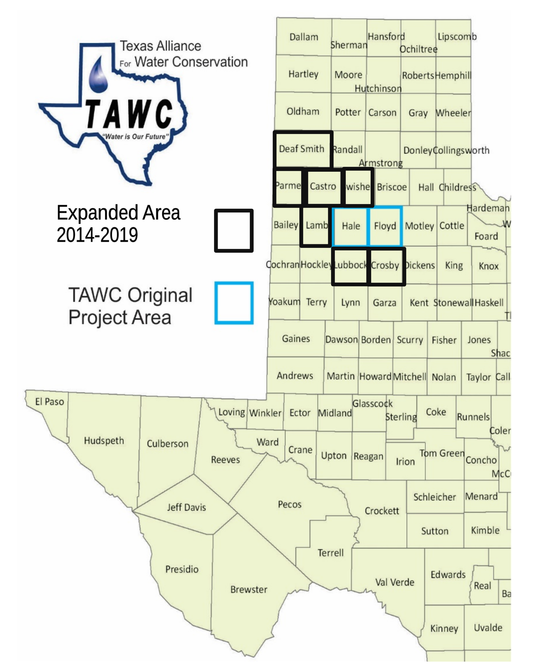

Fig. 2. County locations of the demonstration sites

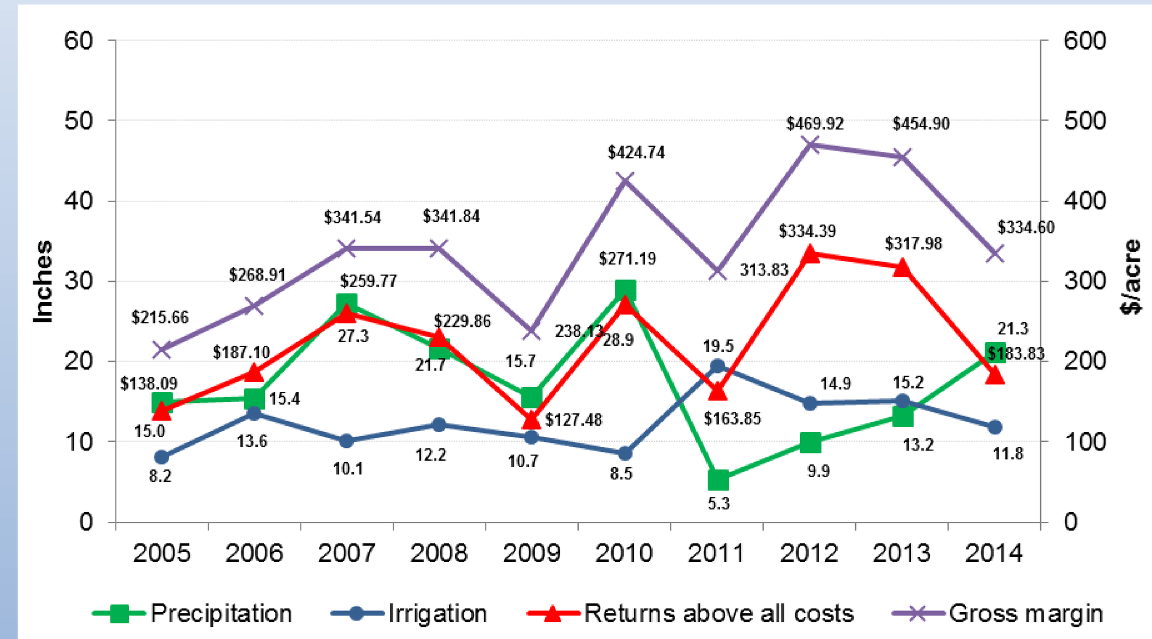

Fig. 3. 10-year trends in water received and profits across sites.

Amounts of water received as precipitation and irrigation fluctuated over 10 yr (Fig. 3). Mean precipitation was 18 inches. Note severe drought in 2011, when irrigation was generally inadequate to meet crop needs.

Trends in net returns and gross margins per acre mainly reflect commodity prices, except in 2011, when drought limited profits.

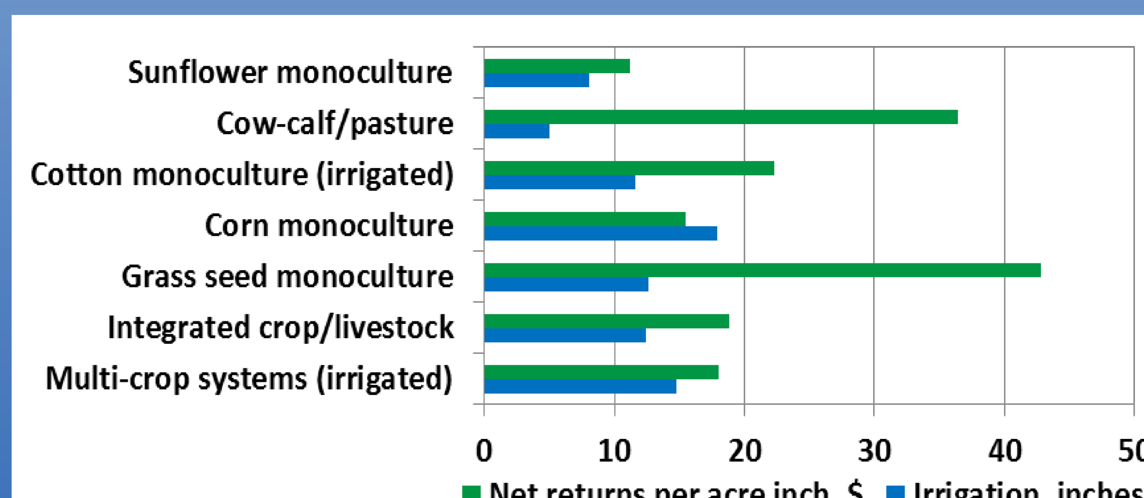

Fig. 4. 10-year means of net returns and irrigation by crop system.

High seed prices drove the high net return/acre in native grass seed (Fig. 4). Net return/acre was high in cow-calf due to low inputs. Drought in 2011 reduced cow herds.

Irrigated cotton was more profitable than corn per unit of irrigation input, and required less irrigation. Integrated crop-livestock and multi-crop systems were intermediate in irrigation and net returns.

Crop	Yield	Unit	Irrigation applied	Irrigation efficiency	Gross margin	Return on water
	Production per acre		Inches	Production per acre-inch	$/acre	$/acre-inch
Corn-Grain	10,418	lbs	18.3	637	425	23.20
Corn-Silage	27.0	tons	22.2	1.4	425	19.14
Gr. Sorghum-Grain	6,694	lbs	12.3	679	230	18.71
Gr. Sorghum-Silage	21.9	tons	13.1	1.8	297	22.67
Sorghum-Sudan Hay	3.0	tons	10.7	0.33	209	19.51
Wheat-Grain	2435	lbs	6.3	513	136	21.43
Cotton-Lint	1,277	lbs	13.4	112	379	28.30

Fig. 5. Mean irrigation efficiency and net return on irrigation by crop.

Irrigation applied was greatest in corn grain and silage and least in wheat (Fig. 5). Irrigation efficiency was greater in corn crops than in grain sorghum crops; however, corn was more profitable than sorghum.

Economic return per acre-inch of irrigation was greatest for cotton owing largely to lower irrigation needs for cotton.

Irrigation technique	Number of site-years	Irrigation applied	Total water	Lint yield	Irrigation efficiency	Total water efficiency
	no.	-------- inches	--------	lbs/acre	---- lbs/acre-inch	----
SDI †	32	15.9	24.5	1,642	125	69
LEPA §	37	15.4	23.7	1,415	109	61
Spray #	79	12.8	20.1	1,268	122	66
Furrow	27	14.4	23.1	1,059	96	47

Fig. 6. Mean irrigation efficiency and total water (irrig. + rain) by irrigation system for cotton. † Subsurface drip § Low energy precision application # Low elevation spray application

SDI irrigation (Fig. 6) yielded the most lint and tended to have the greatest efficiency of irrigation and total water use. Furrow irrigation was the least efficient.

	LEPA	LESA
Cotton lint yield lb/acre	1074	934
Total costs $/acre	958	937
Net returns $/acre	181	57
Water applied inches	19.5	19.5
WUE lbs/acre-inch	55	48

Fig. 7. Comparison of two sprinkler techniques for economic and water use efficiency (WUE) over 2 years at a single site.

Cotton lint yield, net returns, and water use efficiency (WUE) were greater for LEPA than for LESA (spray) irrigation technique (Fig. 7) in a controlled comparison.

(Yates and Pate, 2014. Beltwide Cotton Conference)

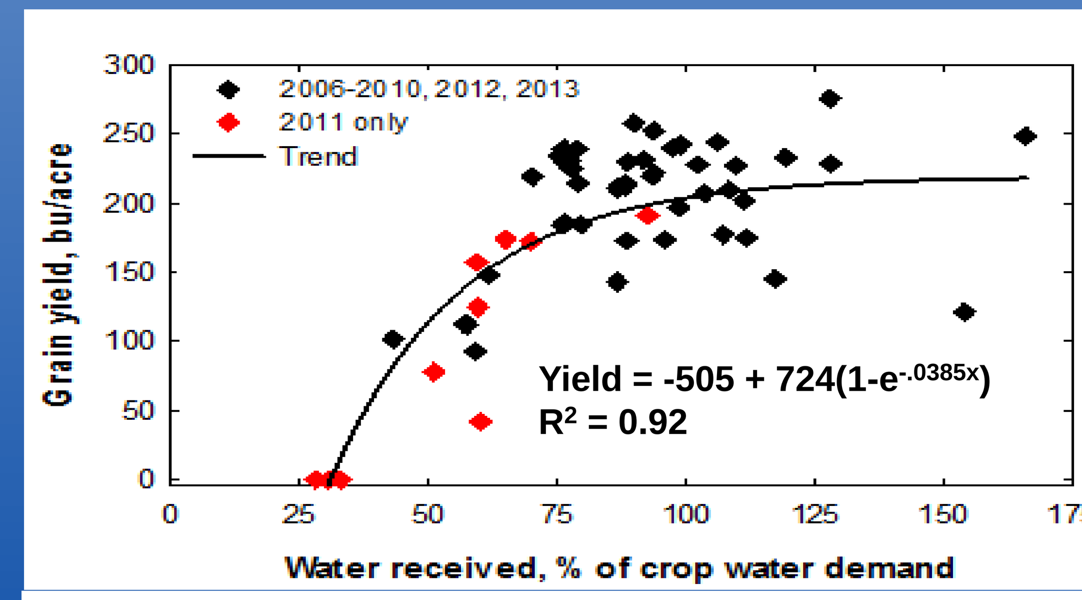

Fig. 8. Corn grain yield response to irrigation (% of potential ET) over 8 years. The drought of 2011 resulted in 3 crop failures. There was no significant response at >75% of ET.

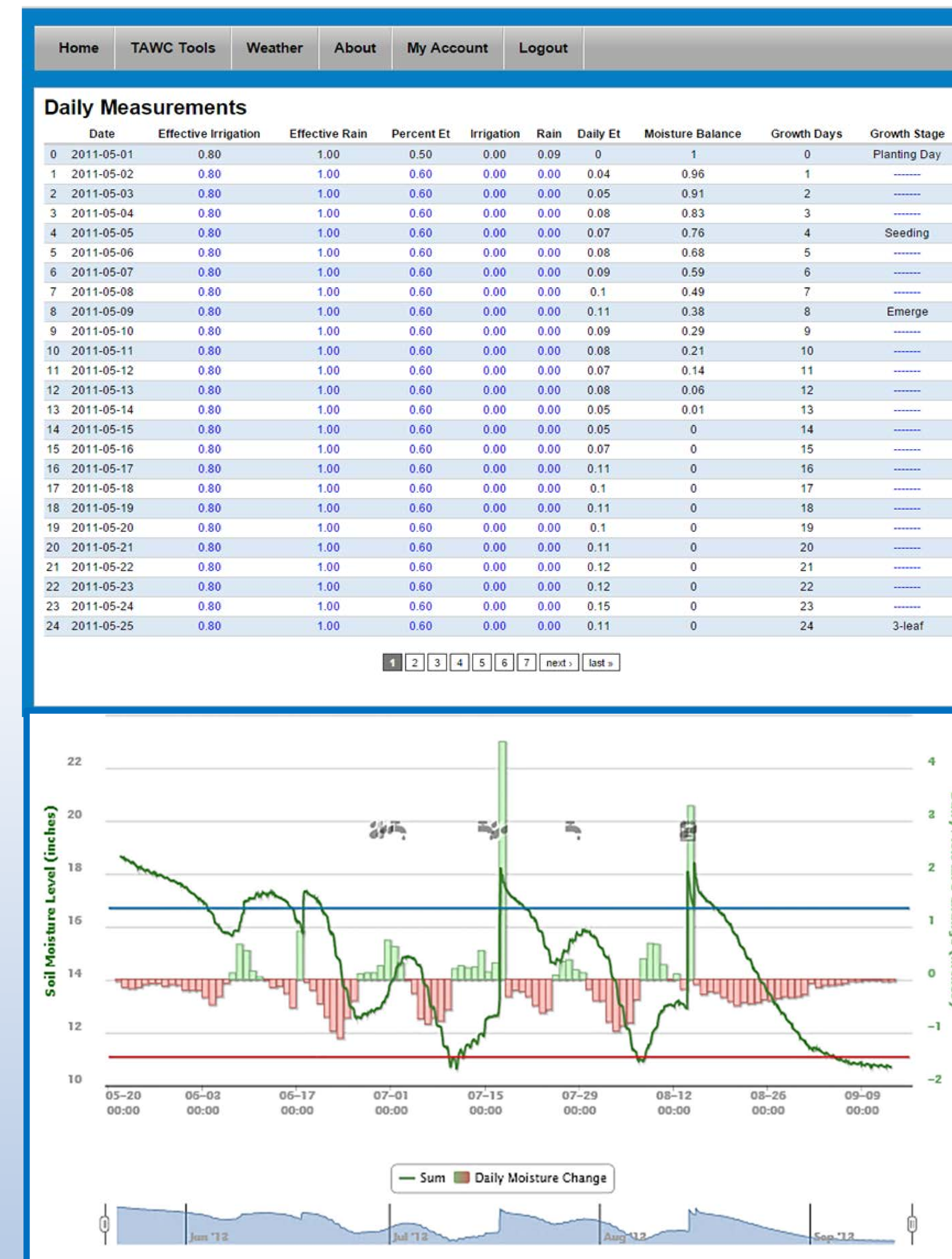

Fig. 9. Examples of tools to improve efficiency of irrigation. Top: TAWC irrigation scheduling tool www.tawcSolutions.org. Bottom: FieldConnect™ soil moisture monitor graph.

Education on ways to maximize efficiency of irrigation is a major TAWC activity. Fig. 9 top shows the free, online TAWC irrigation scheduling tool. It uses nearest weather data and crop coefficients to calculate evapotranspiration losses and soil water balance, as a guideline for when to irrigate.

We demonstrate the use of soil-moisture (Fig. 9 bottom) and crop canopy-temperature monitors to determine when and how much to irrigate.

Conclusions

We demonstrate in workshops, field days, and fact sheets how to optimize water use and reduce the risk of economic losses through the following approaches:

- Use of soil and canopy monitoring and the online scheduling tool to prevent excessive irrigation.
- Demonstrate improved irrigation techniques to increase crop water-use efficiency, such as subsurface drip irrigation.
- Compare crop species and cropping systems to show options that improve overall water use and economic returns.

TAWC project provides a model for other water-limited environments to promote farmer adoption of water-conserving technologies.

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All reports and data are available at www.TAWC.us.