Agricultural Water Management 169 (2016) 115–128

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Estimating preseason irrigation losses by characterizing evaporation of effective precipitation under bare soil conditions using large weighing lysimeters

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ARTICLE INFO

Article history:
Received 4 January 2016
Received in revised form 19 February 2016
Accepted 20 February 2016
Available online 1 March 2016

Keywords:
Effective precipitation
Irrigation
Evaporation
Semi-arid regions
Weighing lysimeters

ABSTRACT

Irrigation from the Ogallala aquifer is used to supplement insufficient precipitation for agricultural crop production in the semi-arid Texas High Plains. Decreased pumping capacity has compelled many producers to "pre-water" fields to field capacity prior to planting to hedge against pumping limitations later in the season. However, the direct measurement of evaporative losses from preseason irrigation of bare soil is not commonly studied. The quantification of evaporative losses from effective precipitation, or the net amount of water that infiltrates into the soil following a precipitation event, can be used as a surrogate for estimating losses from preseason irrigation. We identified 35 precipitation events that occurred over lysimeter fields under fallow conditions in 2002, 2005, and 2009. Events were categorized into four bins of precipitation magnitude ranging from 3 mm to 35 mm. Subsequent evaporation was measured for a period of up to seven days following rainfall events using large weighing lysimeters at the USDA-ARS Conservation and Production Research Laboratory in Bushland, TX. An exponential decay function was used to characterize bare soil evaporation using maximum cumulative measured evaporation (E_{Cmax}), soil water transfer constant (k), and cumulative grass reference evapotranspiration (ET_{Cos}). The wide range of E_{Cmax} values and k values demonstrated the sensitivity of evaporative losses to both antecedent soil water content and evaporative demand. We also present measured average daily evaporation values for a range of evaporative demand regimes for each precipitation bin. From data analyzed in this study, nearly all of the water from precipitation events of 10 mm and less were lost to evaporation within the following day under moderate to high grass reference evapotranspiration (ET_{os}) conditions. Nearly all water from precipitation events between 20 and 30 mm was lost to evaporation between three to four days following the event under similar evaporative demand. The considerable potential evaporative losses from preseason irrigation call into the question the prudence of the preseason irrigation, particularly for regions with limited groundwater resources.

Published by Elsevier B.V.

1. Introduction

Irrigation from the Ogallala aquifer is used to supplement insufficient precipitation for agricultural crop production in the semi-arid Texas High Plains. Decades of pumping combined with low recharge have decreased the saturated thickness of the aquifer resulting in decreased well yields. Decreased pumping capacity compels affected agricultural producers to maximize crop yield while minimizing irrigation inputs (Pittman et al., 2007). This may be achieved by increasing water use efficiency (WUE) through the use of more efficient irrigation systems, and by implementing more effective irrigation management and alternate cropping strategies. Many producers, however, are unable or unwilling to invest in new irrigation infrastructure given the downward trend in well capacities in some areas. They are more likely to focus on and continue to adopt improved irrigation scheduling and alternate cropping systems. Research on management strategies that shift a

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http://dx.doi.org/10.1016/j.agwat.2016.02.024
0378-3774/Published by Elsevier B.V.

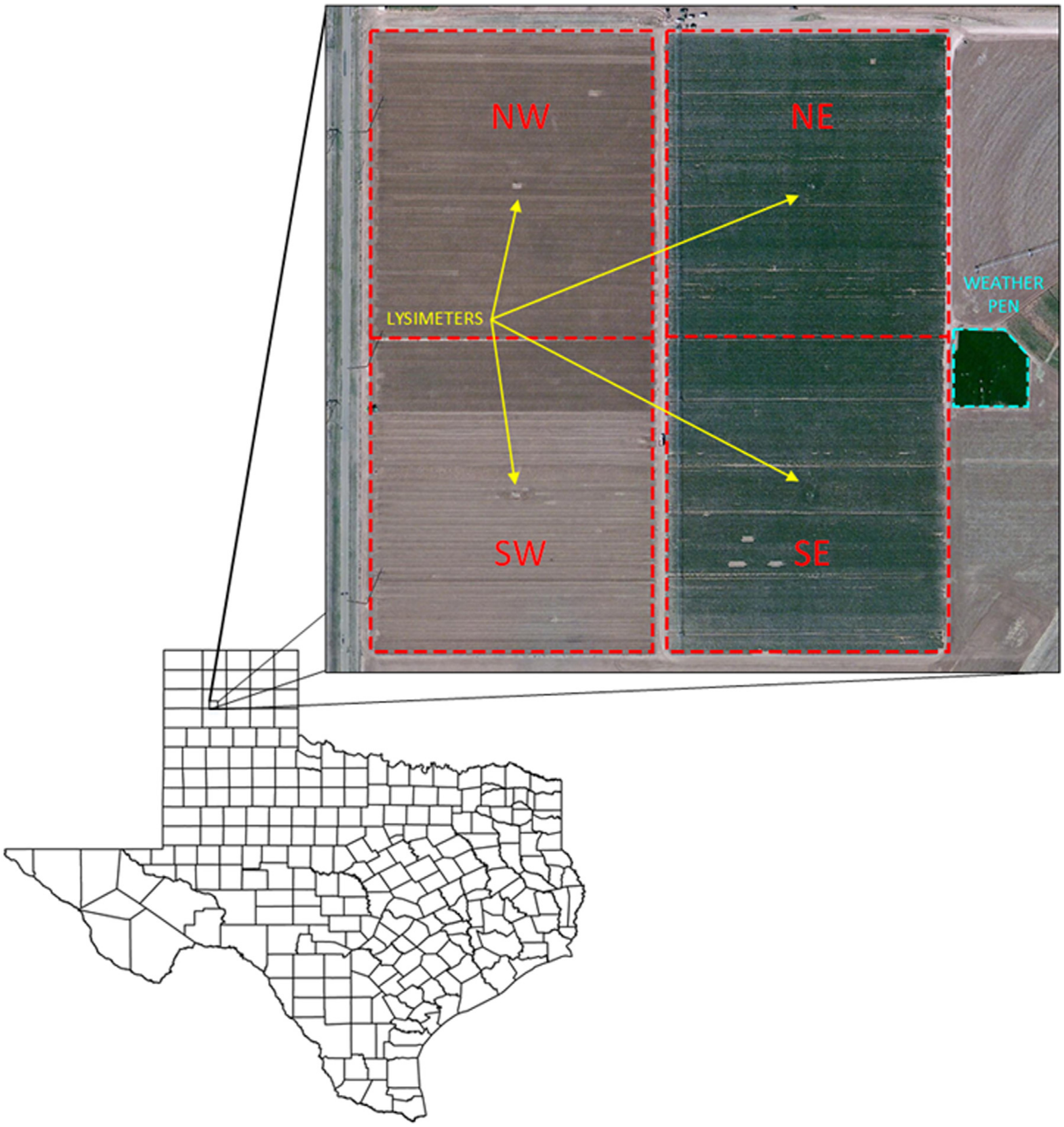

Fig. 1. Location and orientation of four weighing lysimeters fields and the weather pen at USDA-ARS CPRL in Bushland, TX.

Table 1
Selected soil parameters and values for Pullman clay loam soils at Bushland, TX.

Depth (mm)	0–180	180–860	860–1800	1800–2300
Bulk density ($g\,cm^{-3}$)	1.23	1.46	1.48	1.41
Available water capacity (mm H_2O per mm soil)	0.15	0.15	0.15	0.14
Saturated hydraulic conductivity ($mm\,h^{-1}$)	5.72	2.16	2.16	5.16
Clay content	30.3	37.4	38.4	37.4
Silt content	49.3	45.0	41.2	42.1
Sand content (% soil mass)	20.4	17.6	20.4	20.5

Table 2
Precipitation event statistics measured from the NW and SW lysimeters in 2002, 2005, and 2009.

Precipitation (P) magnitude (mm)	Number of measurements	Minimum precip. (mm)	Maximum precip. (mm)	Mean precip. (mm)	Median precip. (mm)	Std. deviation (mm)
$3 < P < 10$	19	3.7	9.8	8.2	9.1	1.9
$10 \leq P < 20$	28	10.1	17.9	13.5	13.0	2.7
$20 \leq P < 30$	11	23.1	29.3	26.2	26.0	2.1
$P \geq 30$	8	31.5	37.3	33.6	33.7	2.0

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