Effect of Controlled Drainage and Subirrigation on Corn Evapotranspiration

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Abstract

The effect of controlled drainage and subirrigation (CDS) on crop evapotranspiration (ET_c) was assessed by measuring the energy flux components with an eddy covariance system over six years for corn (4 yrs.), soybean (1 yr) and sugarbeets (1 yr). The results illustrated that CDS treatment had significant effect ($P<0.05$) on ET_c during the high crop water demand period. The CDS treatment increased the soil water content and resulted in a better yield. Utilizing CDS practice provided better distribution of moisture in times without sufficient rain events.

Materials and Methods

The study site (44 ha) is located in Clay County, MN (Fig. 1). The data were collected during the growing season (May-October). The site is a poorly drained silty clay loam soil (30 to 38% of clay) and nearly flat with shallow water table. Pairs of soil moisture sensors and pressure transducers were used to monitor soil moisture, and water table fluctuation above and between tile drainage locations (Fig. 2).

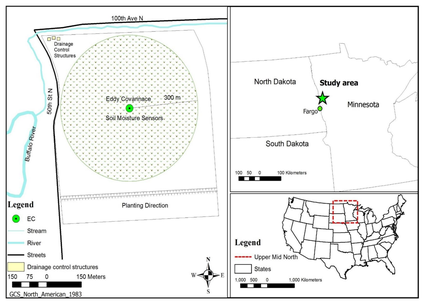

Figure 1. Study area location

Eddy covariance system was used to measure energy flux components with 10 Hz frequency and stored data as an average of 30-minute value to calculate the ET_c.

$\theta_{FC} = 0.42$ cm³/cm³

$\theta_{PWP} = 0.17$ cm³/cm³

ρ_b=1.2 to 1.45 g/cm³

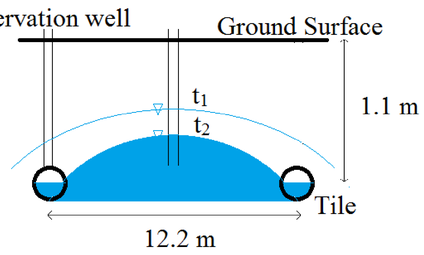

Figure 2. Subsurface drainage and observation wells information

Results

CDS had significant impact on the overall water balance. CDS treatments increased ET_c and reduced the soil deficit during the critical stage of growing period (Fig 3), and prevent crop from yield reduction (Tan et al, 2012). Keeping the water in the field as a result of control drainage reduced drainage outflow especially for wet years in which crops utilized from available moisture during the critical stages of water requirement.

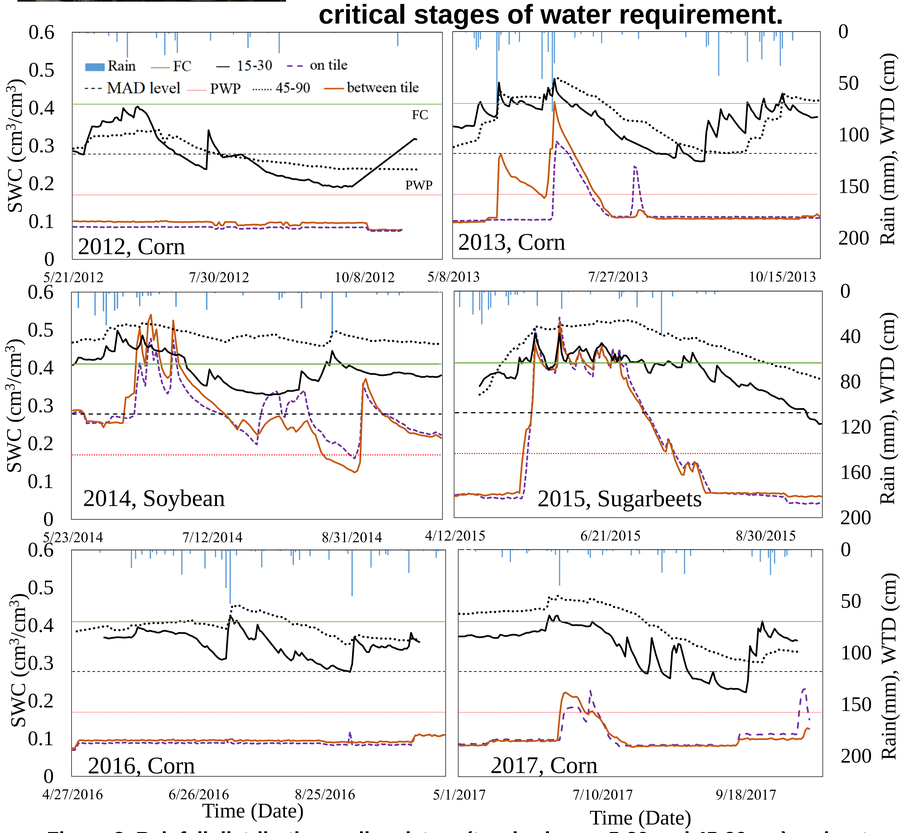

Figure 3. Rainfall distribution, soil moisture (two horizons: 5-30 and 45-90 cm) and water table depth (WTD) between and on tile drainage on Clay County, MN.

Table 1. Summary of measured and calculated data

Year	Crop	Rainfall (mm)	Sub-irrigation dates	Sub-Irrigation (in)	Seasonal Avg. ET_o (mm/day)	Seasonal Avg. ET_c (mm/day)	Yield (Kg/ha)
2012	Corn	167	-	0.31	4.7	2.8	7,783
2013	Corn	594	03 Aug.	0.16	3.8	2.6	10,922
2014	Soybean	261	29 Jul. to 01 Aug. 04 Aug. to 12 Aug.	1.79	4.1	3.1	3,308
2015	Sugarbeets	444	-	-	4.2	3.8	57,344
2016	Corn	426	2 & 6 Sep.	0.18	3.9	3.0	11,430
2017	Corn	255	30 Jun. & 1 Nov.	0.75	4.1	2.5	11,110

As a result of subirrigation event, soil moisture in lower profile increased which caused to increase crop uptake and transpiration. Due to the increase in transpiration, measured latent heat flux by eddy covariance which define ET_c increased and showed highest level especially during the crop critical stage (Fig 4). Preventing the crop yield reduction in years with low rainfall amount (except 2012 which no CDS applied) was obtained as a result of CDS treatment.

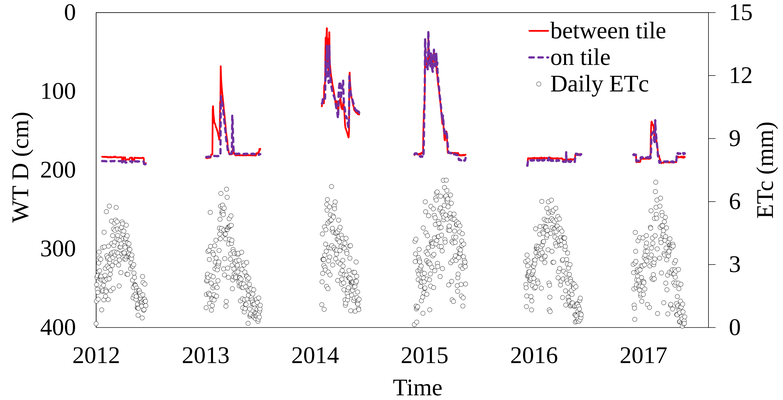

Figure 4. Measured ET_c by eddy covariance and water table fluctuation between and on tile drainage for six years of study

Conclusion

High-quality measurements of ET_c using eddy covariance were obtained for six years. The comparison of years with the same crop showed that despite the weather condition, controlled drainage and subirrigation (CDS) can increase the ET_c and crop yield. Due to non-uniform distribution of rainfall among the growing season, controlled drainage provide an ability of using soil storage capacity and keeping soil moisture for a longer time. Using one time subirrigation during critical stage of growing season can satisfy crop water requirement, increase crop transpiration to the highest level and can prevent crop from yield reduction.

Acknowledgments

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References

Tan. C.S., Drury, C.F., Gaynor, J.D., Welacky, T.W., Reynolds, W.D. (2002). "Effect of tillage and water table control on evapotranspiration, surface runoff, tile drainage and soil water content under maize on a clay loam soil. *Ag. Wat. Mng.* 54: 173-188.

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