Analyzing Topographic Wetness Index Values With Soil Moisture Throughout the 2013 Growing Season

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Introduction

Variable Rate Irrigation (VRI) allows for site specific watering depths that provide the potential to optimize water use. There are numerous factors that impact effectiveness of irrigation, including soil properties, topography, runoff, run-on, tillage practices, crop condition, and previous weather events. Topographic wetness index utilizes elevation data to estimate locations that have potential to be wetter than other regions based solely upon terrain. Wetness index was analyzed using GIS to investigate any existing relationships with recorded soil moisture values. The objective of this study was to analyze wetness index values with watermark data and compare consistencies between the two.

Materials and Methods

- Watermark sensors (Fig 1.) were installed into an irrigated cornfield in Hamilton county at six different locations.
- Depths of 0.5, 1.5, 2.5, 3.5 and 4.5 ft were installed and connected to a data logger which took readings every 10 minutes.
- Watermark sensors are an accurate and affordable way to monitor soil moisture status at multiple locations combined with wireless transmitters which are relatively low maintenance.
- Soil samples were also collected and test results used to convert watermark data to volumetric water content.

Fig. 1: Irrometer Watermark Sensor

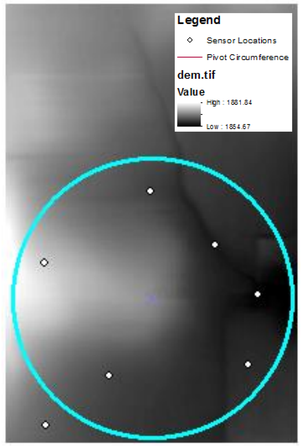

Fig. 2: 3 m^2 DEM of study site

- ArcGIS was used to calculate wetness index values.
- RTK GPS data were used to create a digital elevation map (DEM) by interpolation (Fig. 2)
- TauDEM (Terrain Analysis Using Digital Elevation Models) was used to analyze the elevation data to determine the specific catchment and slope of each cell.
- Cell sizes of 3 m^2 and 10 m^2 were used.

- Wetness Index (WI) describes the propensity for a site to become saturated as a result of its contributing area and local slope characteristics.
- WI is calculated as:

$$WI = Ln\left(\frac{SCA}{\tan(Slope)}\right)$$

Where:
SCA is Specific Catchment Area
Slope is local field slope (degrees)

Watermark Results

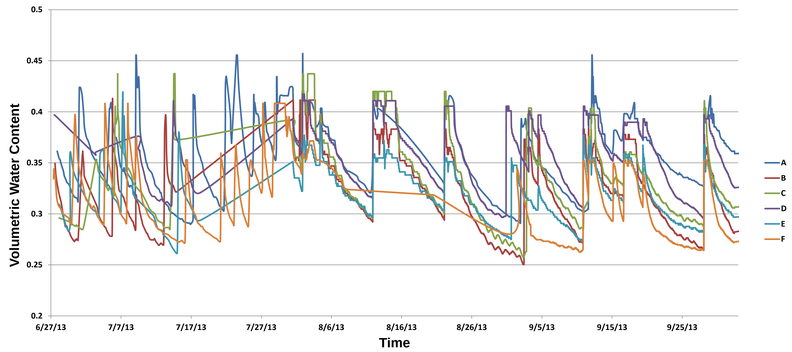

Fig. 3: Soil Moisture Data at 0.5 ft Depth (locations A-F)

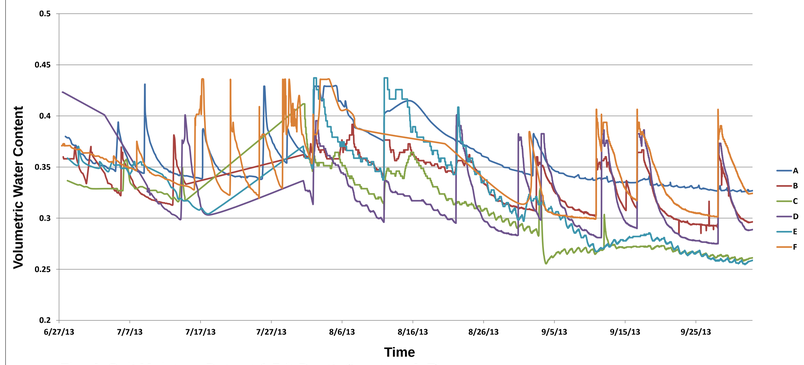

Fig. 4: Soil Moisture Data at 1.5 ft Depth (location A-F)

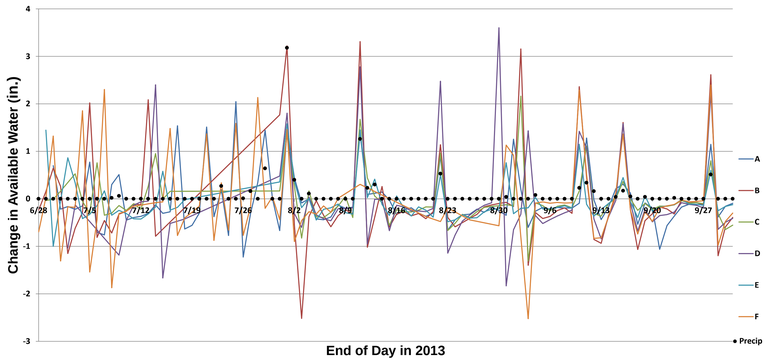

Fig. 5: Daily Increase/Decrease in Soil Moisture Throughout 5 ft Root Zone (locations A-F)

- The above graphs (Fig. 3-5) were collected throughout the 2013 irrigation season. A total of six locations (A-F) were collected and analyzed. Figures 3 and 4 display volumetric water content throughout the season in 1 ft and 2 ft profiles. Figure 5 displays the change in available water (AW) in a five foot profile at each location, along with depths of natural rain events as measured by a weather station located at the site.
- Additional graphs generated and studied combined the 1 ft and 2 ft volumetric water contents, 1' AW, 2' AW, and 1' through 5' AW.

Wetness Index Results

- ArcGIS was used to calculate WI throughout the field based upon RTK GPS data which was interpolated and transferred to a surface. For sensors A through F (with the exception of C), the index values of the 3 m^2 cell and 10 m^2 cell were used as the WI for that sensor location. Location C fell close to a boundary which resulted in a significant difference between adjacent cells so this was taken into consideration.
- The range of WI values of the study field was 3.2 to 24 with most locations having a value of greater than 9; results are in table 1.

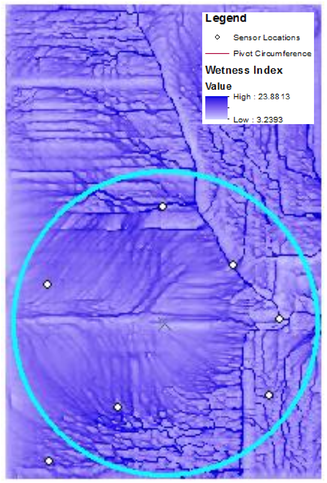

Fig. 6: 3m^2 WI

Table 1: Wetness Index Results

WETNESS INDEX		
	Resolution	
Sensor Location	10 m	3 m
A	13	13
B	22	17
C*	6, 22	9, 15
D	9.5	8.3
E	9.6	9.8
F	7.4	7.5

* Location C includes additional adjacent cell value

Conclusions

For the study field, higher WI values did not result in a wetter profile over an extended period. When observing rain events it was concluded that the 1' AW indicated greater variability in AW when compared to 2' AW. The 1' AW estimates showed the greatest correlation with WI. These results suggest that precipitation exceeded infiltration rates which resulted in runoff. As a result, locations with higher WI values may have received run-on which caused higher AW values at 1' depths. Less correlation between WI and AW at 2 ft depths may have resulted from different subsoils or other underlying factors.

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