Growing Season Soil Moisture Monitoring 2019: A Case Study from Portage la Prairie, MB

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Background

Soil moisture is one of the main drivers of crop yield potential and variability within landscapes (Aspinall, 1997). Differences in available soil moisture vary spatially, with depth, and temporally, and these differences are dramatically influenced by weather and crop management practices.

The advent of in-field weather stations providing data in real-time allows for timely crop management decisions, but proper interpretation and validation of soil moisture values is crucial for end-users to address the following objectives:

1. Identify the influence of crop type and growth stage on soil moisture
2. Determination of critical values of soil moisture
3. Quantify the impact of tillage and compaction on water movement through the soil profile.

Methods

Site description of AAFC-Portage la Prairie:

- Soil: Neuhorst silty clay loam (imperfectly drained, Gleyed Rego Black Chernozem, with an Agriculture Capability Class 2W and an average particle size analysis of 4% sand, 64% silt and 32% clay (Michalyna and Smith, 1972). Soil Organic Matter approx. 6.0% (2019 soil test, AgVise Laboratories).
- Book values for wilting point (WP) and field capacity (FC) were obtained through soil survey reports where data was available for comparable soil series.
- Values for each horizon depth were averaged to give a single approximate value for a 120 cm (4 ft) profile depth.
- 2019 weather data (% of normal rainfall by month):

Growing Season 410 mm (121%); May 56%; June 67%; July 169%; Aug 36%; Sept 314%.

- Two types of soil moisture sensors installed at two different locations at AAFC-Portage:

a) Weather station: CS655 (Campbell Sci. Inc.) at depths of 5, 10, 20, 50 and 100 cm, under grass;

b) Tillage trial: ECH_2O EC-5 (Decagon Devices Inc.) at depths of 12, 20 and 50 cm, under canola (seeded May 31) under four tillage treatments (chisel plow (CT), subsoiler (DT), vertical tillage (VT) and raised bed (RB)).

- Site-specific calibration improves the accuracy of soil moisture sensors (Ojo et al., 2015). However, all measurements are presented using factory calibration, which is valid for the range of soil moisture observations in this study.

Observation 1 – ID effect of crop water use

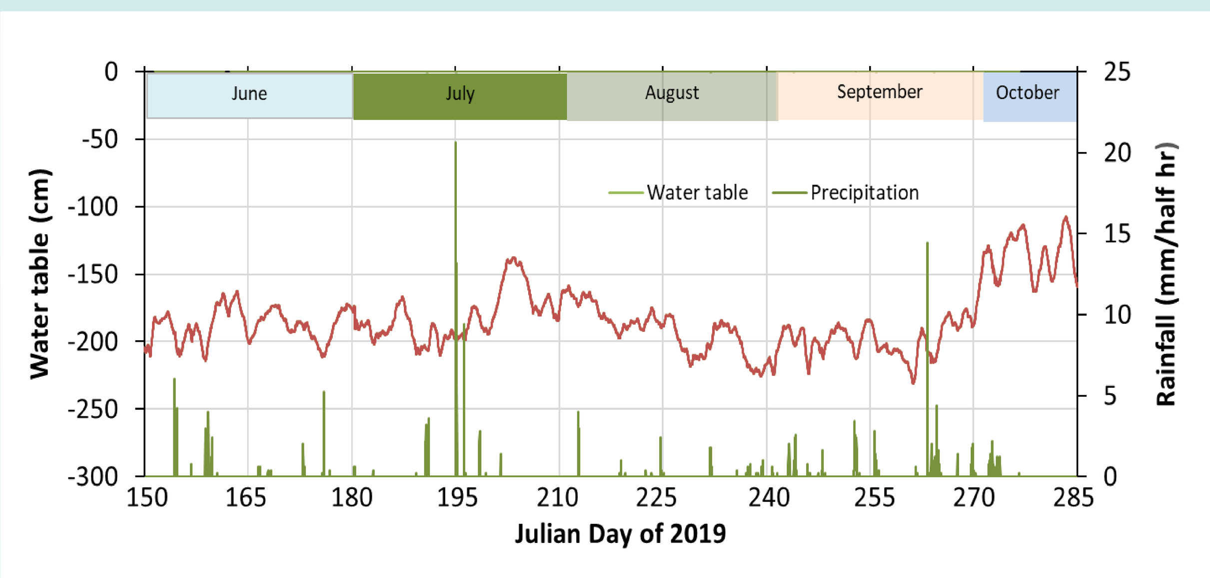

Figure 1. Depth to water table at observation well (BH4) and 2019 growing season precipitation.

- Water table responds to precipitation more dramatically when crop uptake ceases (Fig. 1).
- Crop growth began to use soil moisture by mid-late June, as indicated at the 5 and 10 cm depths, early July at the 20 cm depth and mid-July at the 50 cm depth (Fig. 2).
- Crop water use can be up to 8 mm/day, depending on the crop, growth stage and growing conditions (McKenzie and Woods); yield potential of various crops are based on available soil water (Manitoba Agriculture).

Observation 2 – ID critical soil moisture values

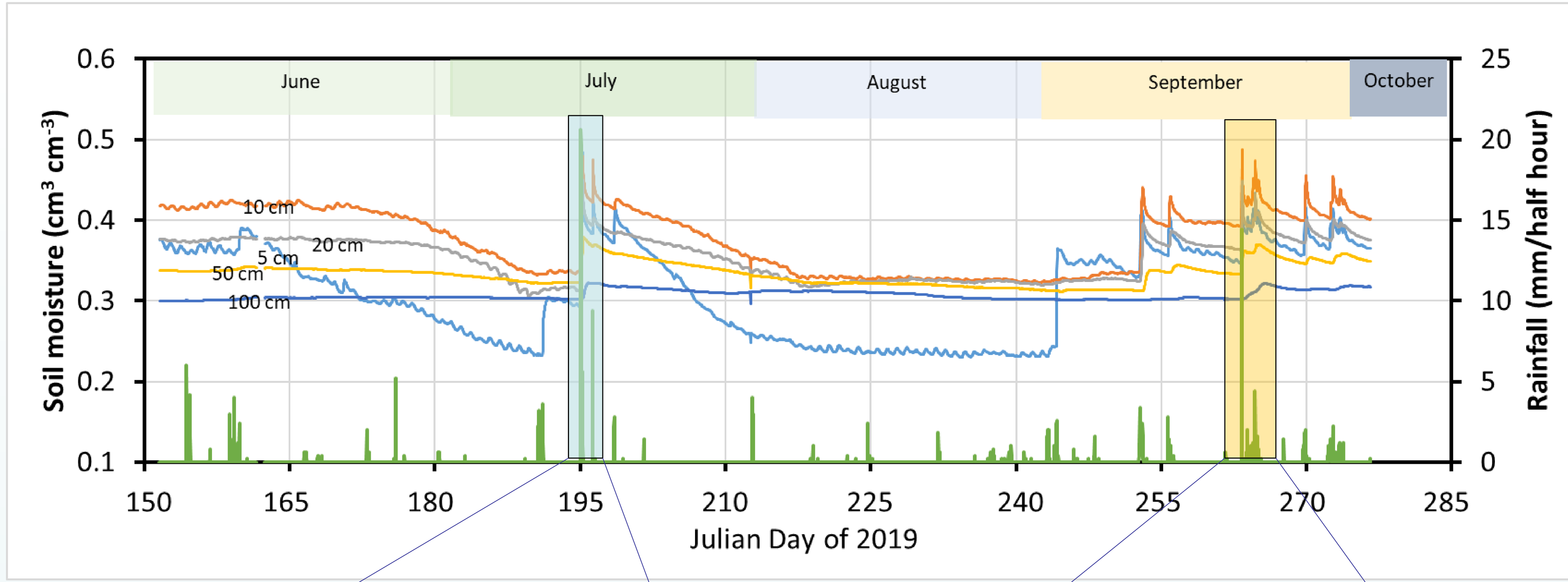

Figure 2. Soil moisture by depth and rainfall at AAFC-Portage weather station.

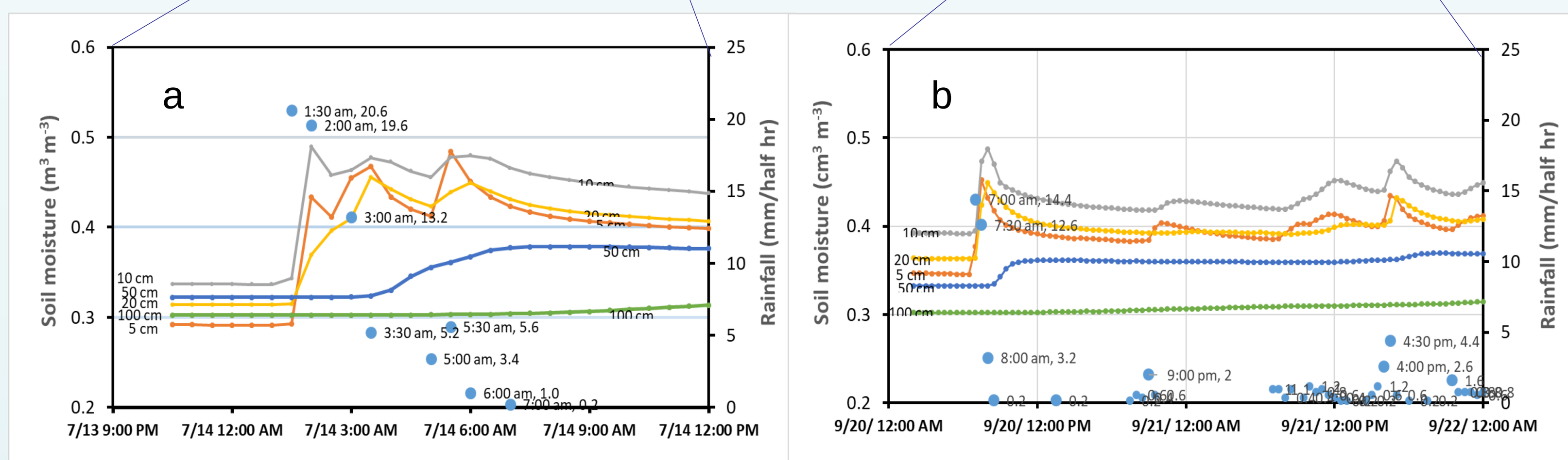

Figure 3. Changes in soil moisture by depth after two significant rainfalls:
a) July 14, at maximum crop growth (70 mm over 15 hours);
b) September 20, after crop growth has ceased (58 mm over 48 hours).

- Maximum soil moisture (saturation) immediately after a significant rainfall (July 14) = **0.48** m^3/m^3 at 5 and 10 cm depths (Fig. 2).
- Records indicate fields were not accessible by traffic for **up to 5** days, suggesting a plastic limit of **0.38** m^3/m^3 at 5 cm (Fig. 2) This was compared with the "thread rolling" method which gave a moisture content of **0.40** m^3/m^3, depending on the bulk density of the soil.
- Field capacity as estimated by 10 cm moisture sensor in mid-September = **0.40** m^3/m^3 (Fig. 2)
- Infiltrating moisture from surface depths began to increase soil moisture at 20 cm at 1 hour and 50 cm at 3 hours (Fig 3a), suggesting an unsaturated infiltration rate of approx.**17** cm/hour (**6.6** inches/hour).

Observation 3 – Quantify the impact of tillage

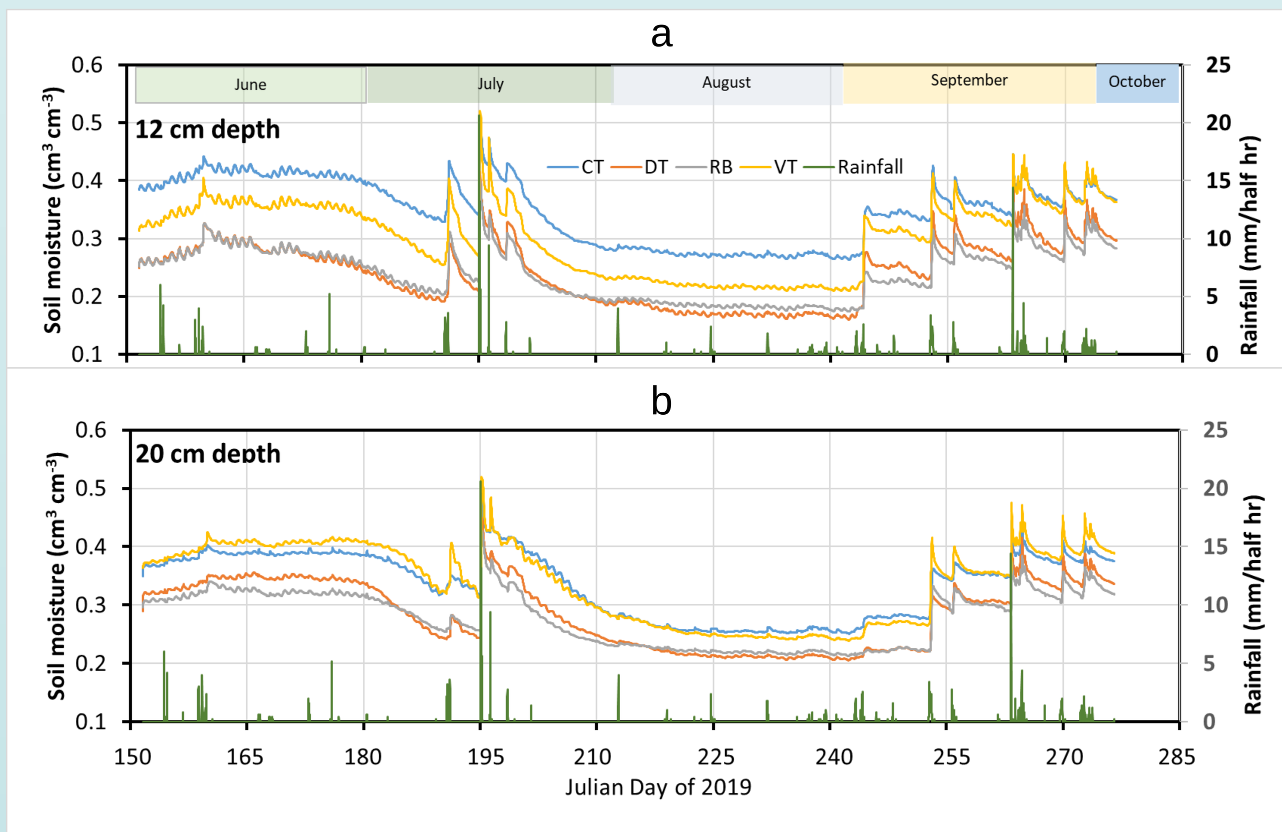

Figure 4. Soil Moisture under four different tillage methods at: a) 12 cm depth; and b) 20 cm depth.

- CT and VT are shallow types of tillage (< 10 cm); DT and RB include subsoiling to a depth of 40 cm; this greater depth of tillage has resulted in drier soil moistures likely due to increased infiltration.
- Soil moisture at 12 cm is higher for the CT treatment than VT, but this is opposite at 20 cm, suggesting more moisture is stored deeper in the profile with the VT treatment.

Discussion

- Critical moisture values from various sources are reported in Table 1. Compare these book values with % Saturation = % Water-Filled Pore Space (FC = 69%; WP = 21%).

Table 1. Comparison of critical soil moisture values for Neuhorst series.

Moisture Parameter (Volumetric basis (m3/m3))	Book Value (Soil Survey Report)	Lab Values	Field Sensors Estimates from Figures 2-4	mm (inches) per 1.2 m (4 ft) of soil profile
Saturation	-	-	0.48	N/A
Field Capacity (FC)	0.33	0.39	0.40	396-480 (15.6-18.9)
Wilting Point (WP)	0.10	0.27 (?)	0.15	120-324 (4.7-12.8)
Available Water (AW)	0.23	0.12 (?)	0.25	144-300 (5.7-11.8)
Plastic Limit (PL)	-	0.42 X 0.96 = 0.40	0.38	N/A

- Results appear to be reasonable but should be verified and refined with in-field bulk density values and account for variability among soil layers within the profile.
- The effect of crop water use on soil moisture is expressed in the delay in infiltration during the July rainfall event vs Sept event (Fig. 2) , as well as the faster increase in subsoil moisture at the 50 and 100 cm depths in September vs July (Fig. 3a and 3b).
- The influence of deep tillage treatments (raised beds and subsoiling) decreased soil moisture and resulted in a negative impact on crop yield when growing season moisture was limited. These treatments tended to reduce soil compaction slightly and could improve crop yields during conditions of excess moisture (Cavers, 2018).

Summary

Enhanced knowledge of soil moisture parameters will improve agriculture's ability to:

a) More accurately determine crop yield potential throughout the growing season;
b) Apply crop inputs more efficiently based on field accessibility and other moisture-related factors;
c) Identify the early onset of soil health risks, such as soil compaction and salinity, due to prolonged excess moisture conditions, so that appropriate and timely management decisions can be made.

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