SOIL MOISTURE MONITORING FOR EFFICIENT IRRIGATION OF ALFALFA

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IRRIGATION MANAGEMENT IN ALFALFA IS CHALLENGING!

- ET-based scheduling is complicated by the periodic cutting & re-growth cycles
- Irrigations are cut back a few days prior to cutting, and during hay curing
- At least 6- to 20-day periods during which fields cannot be irrigated
- Irrigation decisions are driven and constrained by the cutting schedule
WHAT HAPPENS DOWN THERE IN THE SOIL?

Water stress (deficit or excess)? How much, and for how long?

Is there any deep soil water storage (buffer)?

6-20 DAYS

Irrigation Threshold

F.C. W.P. DAYS

Water stress Threshold

6-20 DAYS

DAYS
Lots of uncertainties

- Homogeneous soil profile or layered?
- Any confining/hard layer that constrain roots growth?
- How deep is soil for roots growth?
- Do roots keep growing along the crop cycle?
- How deep they end up growing?

Period of potential vegetative growth
1) Determinant crops; 2) Indeterminant crops
More uncertainties

✓ How are roots distributed along the soil profile?

✓ What is the real pattern of water uptake by roots, under different conditions

**NO TIME TO FIND OUT ANSWERS!**

Well watered and **No Constraints** => ERZ is around 4 feet (end of 1\(^{st}\) year)

- 70% uptake from the first 2 feet
- 90% uptake from the first 3 feet

Not well watered field => deeper roots (6-12 feet) by the 3\(^{rd}\) year and beyond
Still uncertainties?

✓ How uniform is our soil within the field?

✓ How uniform is water application by our irrigation system?
✓ How much water is retained by the soil after an irrigation (WHC)?

ARE WE WASTING MONEY? (water + energy)

✓ Are we infiltrating sufficient, too much water (leaching beyond the root zone), or too less?

✓ Are we building up a good deep soil water reserve?
Inproper irrigation is the No. 1 factor limiting Alfalfa yields

Alfalfa gets stressed around cutting times and when the new growth is coming:

MOST SENSITIVE STAGE !!

ALFALFA IS VERY FORGIVING BUT ALSO VERY SENSITIVE !
IRRIGATION SCHEDULING DECISIONS BASED ON?

**Past practices & experience** => not easy to adjust to weather variations

**Weather (ET) based:**
- Keep track of daily crop water use: $\text{ET}_c = \text{ET}_0 \times K_c$
- Irrigate when max 50% of the AW has been depleted from the soil
- Difficult calculations and adjustments to crop stage
- Difficulty to schedule around harvests

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>AVAILABLE WATER (IN./FT)</th>
<th>ALLOWABLE DEPLETION (IN./FT)</th>
<th>AVAILABLE WATER IN 4FT ROOT ZONE (IN.)</th>
<th>ALLOWABLE DEPLETION IN 4FT ROOT ZONE (IN.)</th>
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<tbody>
<tr>
<td>COARSE SAND</td>
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<td>1.00</td>
<td>8.0</td>
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**TABLE 2.** Typical quantities of available water and allowable depletion.
## Daily ETc Values for Different Growing Locations in California

<table>
<thead>
<tr>
<th></th>
<th>Shafter</th>
<th>Five Points</th>
<th>Parlier</th>
<th>Davis</th>
<th>Nicolaus</th>
<th>Durham</th>
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<td>0.15</td>
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<td>0.03</td>
<td>0.07</td>
</tr>
</tbody>
</table>
ADVANTAGES OF SOIL MOISTURE MONITORING

keep track of what is happening in the soil root zone with regard to:

1. Water that infiltrates during and after irrigations
2. Water that gets depleted (up-taken by plants) between irrigations
3. Overall soil water conditions for plants production

Matching irrigation applications with actual crop water use to target optimal soil water conditions
ANSWERING THE FOLLOWING QUESTIONS

✓ When to start irrigation?

✓ Has enough water infiltrated the soil during an irrigation?

✓ Are we applying enough, insufficient, or excessive water?

✓ Is there sufficient deep soil water reserve for crop water uptake during periods of no irrigation, or when growth season starts?
HOW TO EXPRESS SOIL MOISTURE LEVEL?

**SOIL MOISTURE CONTENT**

% **weight** = \( \frac{\text{weight of water}}{\text{weight of dry soil}} \times 100 \)

% **volume** = \( \frac{\text{volume of water}}{\text{volume of soil}} \times 100 \)

**Depth** = \( \frac{\text{inches of water}}{\text{foot of soil}} \)

**SOIL MOISTURE TENSION** (centibars)

How strongly water is held by soil particles

The higher the tension, the drier the soil and the more difficult it is for plants to extract water.
**Recommended values of soil moisture tension at which irrigation should occur (50% of PAW)**

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Soil Moisture Tension (centibars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand or loamy sand</td>
<td>40-50</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>50-70</td>
</tr>
<tr>
<td>Loam</td>
<td>60-90</td>
</tr>
<tr>
<td>Clay loam or clay</td>
<td>90-120</td>
</tr>
</tbody>
</table>

**Recommended values of soil moisture content at which irrigation should occur (@ 50% of PAW depleted)**

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Soil Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>7</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>12</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>15</td>
</tr>
<tr>
<td>Loam</td>
<td>20</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>23</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>28</td>
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<tr>
<td>Clay Loam</td>
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</tr>
<tr>
<td>Sandy Clay Loam</td>
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</tr>
<tr>
<td>Sandy Clay</td>
<td>22</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>30</td>
</tr>
<tr>
<td>Clay</td>
<td>31</td>
</tr>
</tbody>
</table>
WHAT TYPE OF SOIL MOISTURE SENSOR TO USE?

NEUTRON PROBE (content)
- Larger soil volume sampled
- Measurements at multiple depths
- Not good at shallow depths (< 6 in.)
- Need training & licensing
- Radioactive source
- Need soil-specific calibration

GYPSUM BLOCKS (tension)
- Very cheap & Maintenance free
- Can last 1-3 years (soil moisture)
- Sensitive to soil temperature
- Corrosion of electrodes
WATERMARK (tension)

- Read from 0 to 200 centibars
  - Low soil moisture tension indicates moist soil
  - High soil moisture tension indicates dry soil
- Saturated soil after irrigation or rainfall
  - Reading < 5-10
- With evaporation and transpiration, readings gradually increase until irrigation is necessary

DIELECTRIC (EM) SENSORS (content)

- Measure volumetric soil moisture
  - Sense soil dielectric constant (function of soil moisture)
  - Dry soil = 3-5; air = 1; water = 80
  - Can be Capacitance, TDR and TDT
  - Need calibration bw dielectric constant and soil moisture (manufacturer)
  - Zone of influence 1-4 inches from the sensor
Recommended installation of Watermarks

- 90% depth
- 1 ft.
- 2 ft.
- 4 ft.
Irrigation Scheduling Example: LOAMY SOIL

The graph illustrates the monitoring of soil moisture levels over time. The sensor readings (in centibars) are indicated along the vertical axis, with 'DRY' at the bottom and 'WET' at the top. The horizontal axis represents dates from April 15 to July 1.

The graph shows three key points labeled 'Irrigation' with arrows pointing to the sensor readings at points B, C, and D, indicating times when irrigation is necessary to maintain adequate moisture levels. The yellow arrow labeled 'Harvest' indicates the timing of the harvest event.

Lines A, B, C, D, E, and F represent different irrigation schedules or different depths, with line colors indicating different depths: 1 Ft, 2 Ft, and 4 Ft.
Over-Irrigation Example
BEST IRRIGATION SCHEDULING APPROACH?
Combination of soil moisture monitoring & ETc

1. Irrigation start timing from Soil Moisture (Tension of Content)

2. Irrigation amount (inches) from ETc since last irrigations

3. Ground-truthing from Soil Moisture Sensors
Main constraints and limitations
FINAL CONSIDERATIONS

WHERE SHOULD WE PLACE THE SENSORS?
WHERE TO PLACE THE SENSORS & HOW MANY SITES?

ZONING + Accurate evaluation of soil differences ($40-60/Ac)

Textural classes include gravelly loam, silt loam, and silty-clay loam soils.
CONCLUSIONS

SMM provides real and cost-effective advantages to growers

✓ Understanding what is going on in the soil profile
✓ Ground-truth irrigation decisions
✓ Avoid costly irrigation mistakes
✓ Create deep soil water reserve to buffer for potential mistakes/outages
✓ Avoid spending too much in water & energy
✓ Fine-tune current irrigation practices
THANK YOU!