FARM IRRIGATION SYSTEMS AND THEIR COMPLEXITIES

TYPES OF IRRIGATION METHODS AND DESIGN OF A FARM IRRIGATION SYSTEM

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WATER RESOURCES AND IRRIGATION METHODS

(FAO, UNEP, WHO; 1988)

www.tehrantimes.com <FAO NEWS story>

Flood Irrigation  Sprinkle Irrigation  Drip Irrigation
SOIL WATER AND PLANT

Plant canopy

Main axis
1st order lateral
2nd order lateral

Irrigation

Root zone
THE INTERACTION

Water

GHG

Food

Energy
DATA REQUIREMENT FOR THE DESIGN OF A FARM IRRIGATION SYSTEM

Plant physiology:
RZD, Growing period, Kc, salt tolerance etc.

Climatic Data for ETo
DATA REQUIREMENT FOR THE DESIGN OF A FARM IRRIGATION SYSTEM

Soil

- Saturation (SAT)
- Field capacity (FC) (-10 to -33 kPa)
- Optimum Yield Threshold (OYT)
- Wilting Point (WP) (-1500 kPa)
- Permanent Wilting Point (PWP) (< -1500 kPa)

RAW = FC - OYT
TAW = FC - OYT
MAD (% TAW)
<table>
<thead>
<tr>
<th>SAT vol%</th>
<th>FC vol%</th>
<th>WP vol%</th>
<th>tau</th>
<th>Ksat mm/day</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>13</td>
<td>6</td>
<td>1.00</td>
<td>1500</td>
<td>Sand</td>
</tr>
<tr>
<td>38</td>
<td>16</td>
<td>8</td>
<td>0.95</td>
<td>800</td>
<td>Loamy sand</td>
</tr>
<tr>
<td>41</td>
<td>22</td>
<td>10</td>
<td>0.75</td>
<td>500</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>46</td>
<td>31</td>
<td>15</td>
<td>0.60</td>
<td>250</td>
<td>Loam</td>
</tr>
<tr>
<td>46</td>
<td>33</td>
<td>13</td>
<td>0.50</td>
<td>150</td>
<td>Silt loam</td>
</tr>
<tr>
<td>43</td>
<td>33</td>
<td>9</td>
<td>0.35</td>
<td>50</td>
<td>Silt</td>
</tr>
<tr>
<td>47</td>
<td>32</td>
<td>20</td>
<td>0.45</td>
<td>125</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>50</td>
<td>39</td>
<td>23</td>
<td>0.40</td>
<td>70</td>
<td>Clay loam</td>
</tr>
<tr>
<td>52</td>
<td>44</td>
<td>23</td>
<td>0.30</td>
<td>20</td>
<td>Silty clay loam</td>
</tr>
<tr>
<td>50</td>
<td>39</td>
<td>27</td>
<td>0.42</td>
<td>75</td>
<td>Sandy clay</td>
</tr>
<tr>
<td>54</td>
<td>50</td>
<td>32</td>
<td>0.20</td>
<td>15</td>
<td>Silty clay</td>
</tr>
<tr>
<td>55</td>
<td>54</td>
<td>39</td>
<td>0.10</td>
<td>2</td>
<td>Clay</td>
</tr>
</tbody>
</table>

The characteristics of the soil layer are the following hydraulic properties:

- **SAT**: soil water content [vol%] at saturation;
- **FC**: soil water content [vol%] at field capacity;
- **WP**: soil water content [vol%] at wilting point;
- **tau**: drainage characteristic (value between 1 and 0);
- **Ksat**: infiltration rate [mm/day] at saturation.
IRRIGATION APPLICATION FREQUENCY

- Low Frequency irrigation
- High Frequency Irrigation

2.5 liter by flooding
- Depth of water = 2.5 mm
- Wetted area = 1 sq m

1 m

Depth of water = 2.5 mm
Wetted area = 0.4 sq m

one liter by drip irrigation

1 m
## COMPLEXITIES AFFECTING THE CHOICE OF IRRIGATION METHOD

### Irrigation Preference Matrix

<table>
<thead>
<tr>
<th>Complexity factor</th>
<th>Flood Irrigation</th>
<th>Drip Irrigation</th>
<th>Sprinkle Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop type</td>
<td>Field crops, wheat, barley etc.</td>
<td>Row crops, vegetable and trees</td>
<td>Field crops and trees</td>
</tr>
<tr>
<td>Soil Type</td>
<td>Clay loam, clayey soils</td>
<td>Sandy soil</td>
<td>Sandy soil</td>
</tr>
<tr>
<td>Field Slope</td>
<td>Level fields, paddies</td>
<td>All types of land slopes</td>
<td>All type of land slopes with sandy soil</td>
</tr>
<tr>
<td>Climate</td>
<td>Areas with high winds</td>
<td>Under large number of climates</td>
<td>Area with up to mild winds</td>
</tr>
<tr>
<td>Water Availability</td>
<td>Water abundant areas (low efficiency)</td>
<td>Water stressed areas (with very high efficiency)</td>
<td>Water stressed areas with higher efficiency</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Water with high sediments</td>
<td>Water with dissolved salts</td>
<td>Water with dissolved salts</td>
</tr>
</tbody>
</table>
DESIGNING A FARM IRRIGATION SYSTEM

Data
Set of 4 fields
Crop = vegetables, tomatoes, pepper
$D_{rz} = 0.9 \text{ m}$
Field slope = 2% (in N-S direction)
$ET_c (\text{max}) = 5.1 \text{ mm/day}$
Soil type: Sandy loam (FC=22%)

Drip Specs for vegetables:
Vegetable >>
Single line drip lateral
4 lit per day in peak season
2-3 hours daily operation

Orchard trees >>
Double line drip
High Q emitter
DESIGNING A FARM IRRIGATION SYSTEM

Field #1
- Emitters
- Submain line

Field #2
- L=30 m

Field #3
- Main line

Field #4
- 10.5 m
- Drip laterals

Drip Specs for vegetables:
- Emitter to Emitter distance, E = 0.3 m
- Row to Row distance, R = 0.5 m
- Emitter discharge, \( q_e = 2 \) LPH
- Emitter operating head, \( H_a = 1 \) bar = 10 m
- No of emitter/row, \( N_E = \frac{L}{E} = \frac{30}{0.3} = 100 \)
- No of rows/field, \( N_R = \frac{10.5}{0.5} = 21 \)

Discharge Calculation:
- Lateral discharge = \( q_l = q_e \times N_E = 200 \) LPH
- Submain discharge, \( q_s = q_l \times N_R = 4200 \) LPH
- Main line discharge = \( Q = 4 \times q_s = 4 \times 4200 = 16800 \) LPH
**DESIGNING A FARM IRRIGATION SYSTEM**

**Head loss (Pressure loss) calculation:**
- Total dynamic head = suction head + delivery head + head loss in fitting + head loss in Main + head loss in sub main + head loss in laterals + operating head of emitter

**Calculation:**
Head loss calculation for laterals, submain and main line needs to be calculated individually using Hazen-Williams equation

(Click here to get Excel sheet calculator for head loss calculation)

**Pressure Management criteria (FAO, 2007):**
- \( Ha = 1.00 \)
- \( Ho = 0.95Ha \)
- \( Hn = 1.15Ha \)
- \( Hm = 1.35Ha \)

Velocity in all pipes <1.17 m/s

**Rule of thumb:** On level fields,
Head loss from “Hm” to “Ho” should not be greater than 20 % of TDH
Total Dynamic Head, TDH = 20 m
Total discharge when 4 fields irrigate simultaneously,
\[ Q = 4 \times 4200 = 16,800 \text{ LPS} = 16.8 \text{ m}^3/\text{s} \]
Irrigation pump Power = ?
Efficiency of Solar power pump set, \( E = 50\% \)

\[
P = \frac{Q \times H \times SG}{367.2 \times E}
\]

\[
P = \frac{16.8 \times 13.6 \times 0.997}{367.2 \times 0.5}
\]

\[ P = 1.82 \text{ Kwatt} \]

Handover to Solar Engineer
THANK YOU FOR YOUR ATTENTION