HYDRAULIC AND CLOGGING CHARACTERISTICS OF MOISTUBE IRRIGATION

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Outline

• Introduction

• Description of Moistube irrigation

• Methodology

• Results
  - Discharge characteristics
  - Clogging characteristics

• Conclusion and Recommendation
Introduction

• Irrigation technologies aim at minimizing

  1) Evaporation
  2) Surface run-off
  3) Deep percolation

• Percolation losses is still a problem especially in coarse –textured soils
  (cote, et al., 2003)

  Minimized by Subsurface Drip Irrigation (SDI)
Moistube Irrigation

• Moistube irrigation is a new technology which originated in China

• The system uses semi-permeable membrane

• It simulates plant water uptake by supplying water at low flows

• Supplies water at 80 – 90% FC throughout the cropping cycle

(Envirogrower, 2017; Yang, 2016)
Moistube Irrigation...

- The flow from Moistube occur in two ways

1) In absence of external (system) pressure and water flows as a function of soil water potential

2) In the presence of system pressure, water flows as a function of both the soil water potential and the system pressure

Water flow due to soil water potential

\[ \mathcal{C}_{\text{water}} \geq \mathcal{C}_{\text{soil, large volume of water seepage}} \]

\[ \mathcal{C}_{\text{water}} > \mathcal{C}_{\text{soil, less volume of water seepage}} \]

\[ \mathcal{C}_{\text{water}} = \mathcal{C}_{\text{soil, no water seepage}} \]

(Yang, 2016)
Moistube Irrigation...

- High energy savings
- Water savings
- Low operation cost

(Lyu et al., 2016, Envirogrower, 2017, Yang, 2016, )
Crop Performance Under Moistube Irrigation

- Black mustard (*Brassica Nigra*) plants irrigated by Moistube were 33% taller than in conventional irrigation (Yang, 2016)

- WUE for tomatoes grown under Moistube irrigation was 20% higher than drip irrigation (Xie, *et al.*, 2013)
Clogging In Subsurface Irrigation

- Serious problem
- Physical clogging - due to suspended solids (TSS) from silt, clay particles etc
- Chemical clogging – due to precipitation of dissolved solids (TDS)
- Biological clogging – due to agents such as bacteria
- Sources of water
  1) Surface sources contain high TSS
  2) Ground contain high TDS
  3) Treated wastewater contain high TSS, TDS and biological impurities
Objectives

• To determine the discharge characteristics of Moistube irrigation under varying pressures

• To determine the effect of suspended and dissolved solids on the discharge of Moistube irrigation
Methodology

1) Effect of suspended solids (TSS)
   • Soil passing through 125 µm sieve was added to tap water to achieve 25 mg/l, 75 mg/l and 150 mg/l of TSS

2) Effect of dissolved solids (TDS)
   • CaCl₂, MgSO₄ and NaHCO₃ were added to tap water to achieve 1000 mg/l and 2500 mg/l TDS

3) Tap water characteristics
   • pH (7.5 – 8.3), TDS (29 – 33 mg/l)
   • EC (60 – 67 µS/cm), Temperature (13.2 – 21.8 °C)

1 – Moistube tape inside a 50 mm PVC gutter
2 – Collection beakers  3 – Pressure gauge  4 – 20 mm delivery pipe
5 – Control valve  6 – Water tank  7 – Water tank platform
Methodology …

For purposes of determining CV, 20 cm segment of Moistube was assumed to constitute one emitter.

Flow was measured from 5 No. 20 cm segments for 20 – 100 kPa.

Coefficient of variation determination

\[ CV = \frac{S}{\overline{q}} \times 100 \]

Where

- CV = manufacturer’s coefficient of variation (\%)
- \( S \) = standard deviation of discharge (l/hr/m)
- \( \overline{q} \) = mean discharge (l/hr/m)

**Evaluation Criteria for line-source emitters (ASAE Standard EP 405.1)**

<table>
<thead>
<tr>
<th>CV (%)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>Good</td>
</tr>
<tr>
<td>10 – 20</td>
<td>Acceptable</td>
</tr>
<tr>
<td>&gt;20</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

(Teeluck and Sutton, 1998)
1) Discharge characteristics

Pressure – Discharge Relationship

Manufacturer’s coefficient of variation

\[ Q = 0.0187H - 0.1489 \]

\[ R^2 = 0.9765 \]
Discharge Characteristics …

• The flow from Moistube is sensitive to pressure
• CV as a result of manufacturing process varied from 4 to 18% with an average of 12%
• For porous plastic irrigation pipes, Teeluck and Sutton (1998) found CV values of 23.9 – 58% while Liang et al. (2009) found CV of 14.3 – 48.7%
2a) Effect of suspended solids

Results ...

[Graph showing relative discharge (% vs. time (hrs)) for different suspended solids concentrations at 20 kPa and 30 kPa. The graphs illustrate the effect of suspended solids on relative discharge, with distinct lines for 150 mg/l TSS, 75 mg/l TSS, 25 mg/l TSS, and tap water.]
Effect Of Suspended Solids …

There was no significant difference between clogging at 75 mg/l and 150 mg/l at both 20 kPa and 30 kPa (p > 0.05).

In some instances, suspended solids of about 50 mg/l could be considered critical level which contribute to clogging (Capra and Scicolone, 2007).

Discharge decreases linearly over time as a result of clogging of the Moistube pores.

### Reduction in Discharge at the end of experiment (14 days)

<table>
<thead>
<tr>
<th>Concentration (mg/l)</th>
<th>Reduction in Discharge (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 kPa</td>
</tr>
<tr>
<td>25</td>
<td>25.7</td>
</tr>
<tr>
<td>75</td>
<td>38.4</td>
</tr>
<tr>
<td>150</td>
<td>43.3</td>
</tr>
</tbody>
</table>
Results …

2a) Effect of dissolved solids

- **20 kPa**
  - Black line: 2500 mg/l
  - Pink line: 1000 mg/l
  - Blue line: Tap water

- **30 kPa**
  - Black line: 2500 mg/l
  - Pink line: 1000 mg/l
  - Blue line: Tap water
Effect Of Dissolved Solids …

Reduction in Discharge at the end of experiment (14 days)

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<th>Concentration (mg/l)</th>
<th>Reduction in Discharge (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>20 kPa</td>
</tr>
<tr>
<td>1000</td>
<td>19.4</td>
</tr>
<tr>
<td>2500</td>
<td>22.8</td>
</tr>
</tbody>
</table>

- There was no significant difference between clogging at 1000 mg/l and 2500 mg/l at both 20 Kpa and 30 kPa (p > 0.05)
- There was significant difference between clogging for same concentration at 20 kPa and 30 kPa (p < 0.05)
- This imply that pressure has significant effect on clogging of Moistube
- Moistube has relatively higher clogging resistance at 20 kPa than at 30 kPa
Clogging In Moistube Irrigation …

• Physical clogging is severe in Moistube than chemical clogging
• Reduction in discharge in Moistube due to clogging (19 – 53%) compare well with other irrigation emitters

Past studies on clogging of drip emitters

<table>
<thead>
<tr>
<th>Author</th>
<th>clogging element</th>
<th>Reduction in discharge (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lili, et al., (2016)</td>
<td>Saline water (EC = 3560 µS/cm)</td>
<td>21.4 – 53.7 after 126 hours</td>
</tr>
<tr>
<td>Liu, et al., (2015)</td>
<td>Hard water (hardness 250 – 500 mg/l)</td>
<td>49.9 – 84.6 after 35 days</td>
</tr>
<tr>
<td>Niu, et al., (2012)</td>
<td>Water with soil particles (1.25 g/l – 1.5 g/l)</td>
<td>7 – 22 after 52 hours</td>
</tr>
<tr>
<td>Li, et al., (2012)</td>
<td>Reclaimed wastewater (TSS 24 – 78 mg/l, Ca^{2+}68 mg/l , etc )</td>
<td>30 – 50 % after 450 hours</td>
</tr>
</tbody>
</table>
Conclusions

- Moistube irrigation is a low flow and low pressure irrigation technology
- The flow is sensitive to pressure variation
- Clogging due to suspended and dissolved solids increases linearly with time
- Physical clogging is severe than chemical clogging
- Moistube is relatively resistant to clogging (relative discharge > 75%) at 20 kPa under moderate and high concentration of dissolved solids
- Therefore, it is suitable for application in areas where saline water is abundant
Recommendations

• Further research need to be carried out on clogging under a variety of pressures up to 100 kPa

• Cleaning of clogged Moistube (through flushing) need to be investigated
Thank You