Subsurface Drip Irrigation of Alfalfa

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Subsurface drip irrigation (SDI) is a low-pressure, low-volume irrigation system that uses various types of drip tubes buried below the soil surface. The applied water moves by soil matrix suction, eliminating ponding and the effects of surface infiltration. Benefits of SDI over more conventional surface drip or sprinkler/spray irrigation methods may include improved crop yield and quality, maintenance of a dry soil surface to reduce weed growth, moisture loss and disease infestations, and a broad lateral spread of water throughout the soil profile that maximizes the wetted root volume and minimizes percolation losses.

SDI is being increasingly used for irrigating alfalfa, cotton, corn, sugarcane, and sorghum in the southern United States. It compares favorably to sprinkler irrigation in terms of crop yields, crop water use, water savings, a drier canopy (better crop quality), and fewer weeds.

A 1977 demonstration near Lethbridge, Alberta, evaluated the suitability of using SDI for irrigating fruit trees, with promising results. However, evaluation of SDI on forage/alfalfa crop yields and crop quality has never been done in Alberta. Data is also not available on the use of laterals with built-in pressure compensating emitters, varying lateral spacing, and distribution uniformity within the rooting zone in the province.

The primary purpose of this project was to demonstrate the use of SDI on alfalfa in southern Alberta and evaluate its impact on irrigation water distribution, water savings, and crop production.

The specific study objectives were to determine:

1. Whether SDI on alfalfa consumes less water than conventional irrigation methods and whether yield and forage quality can be maintained or increased with the lower water use.
2. Soil wetting patterns and salinity changes resulting from SDI.
3. Whether the use of SDI on alfalfa requires special management strategies for local soil and climatic conditions.
4. The overall applicability and economical viability of SDI to agriculture in Alberta.
Method

A subsurface drip system of four 0.2 ha zones was designed to fit into the non-irrigated part of a pivot irrigated field on the CACDI Irrigation Demonstration Farm. Two types of emitter tubing, Aquatraxx Drip tape and Geoflow polytubing, were installed in June 2001. The 16mm diameter drip tape was installed at 1.5 and 1.0 m lateral spacing in zones 1 and 2, respectively. The tape is characterized by 30 cm emitter spacing, 15-millimeter wall thickness and a nominal emitter discharge of 1.1 L/hr at 69 kiloPascals (kPa). The polytubing was also installed at 1.5 and 1.0 m lateral spacing in zones 3 and 4 respectively. The tubing is characterized by 60 cm emitter spacing, 43-millimeter wall thickness and an emitter discharge of 1.6 L/hr at 69 kPa. The polytubing had Rootguard bio-barrier to discourage root intrusion.

All laterals were placed at 45 cm depth. Class 160 PVC supply pipe at 60 cm depth was designed to deliver water to the supply header midpoints, using 40 mm diameter pipe for zones 1, 3, and 4, and 50 mm pipe for zone 2. Supply headers were 30 mm PVC for zones 1, 2 and 3; 40 mm for zone 4. All flushing headers were 25 mm in diameter with a 40 mm gate valve and 25 mm air/vacuum valve at the pipe midpoint. All headers were installed with automatic drains at low points. The system head flow was supplied from an existing 345 kPa sprinkler supply line by PVC pipeline. The supply infrastructure consisted of a check valve, venturi injector, and ARKAL automatic backflush 200 mesh disc filter. Each zone turnoff consisted of a gate valve, totalizing flow meter, 24 volt Irritrol Ultraflow valve with adjustable pressure regulator and gauge, and a 25 mm air/vacuum valve.

Zone 5 was irrigated by a hand move spray/sprinkler irrigation system. The irrigation amounts for this zone were determined using several rain gauges installed within the area.

In 2001, laterals were plowed into a pre-seeded oat field, using a deep shank and tube guide. The laterals were attached to the header line, which was installed at a set elevation in an excavated supply header trench. The flushing header trench was excavated after the laterals were installed. PVC tees and API Tape Loc and compression fittings were used to connect the laterals to the headers. Connections between the supply header and drip tape were made with 50-mm lengths of 18-mm outside-diameter polyethylene tubing to prevent damage to the tape when backfilling the header trench. A 24-volt battery operated controller was installed at the site to regulate the solenoid valves.

In late May 2002, the site was seeded with AC Longview alfalfa at a rate of 12 lbs/ac and ammonium phosphate fertilizer was applied. Three replicated plots (6m x 6m) were established on each of the five treatment zones and neutron probe access tubes were installed to monitor moisture for scheduling irrigations. The sprinkler system on zone 5 was set up but was not used in 2002 since the soil was sufficiently moist.
Results

The high average precipitation in 2002 made data collection difficult. Investigation of water distribution around the emitters was to be done in intervals of 5-, 10- and 15-hours of irrigation, but activities were hindered by the wet soil conditions. This task was accomplished in the summer of 2003.

Prior to the first cut in 2003, the crop received 88 mm of rainfall and no irrigation water. After the first harvest, the soil was left to dry to allow for the measurements of wetting patterns or fronts. After measuring the wetting patterns, the crop received 76 mm of irrigation and 10 mm of rainfall before the second harvest. Between the second and third harvest, normal irrigation management was practiced and a total of 100 mm of irrigation water was applied. All zones, including the sprinkler area, received the same amount of water during the growing season.

The pit method, which involves the excavation of a soil pit around a drip emitter, was used to monitor the wetting fronts/patterns on each of the SDI zones after 5-hour, 10-hour, and 18-hour irrigation events. A tape measure was used to measure the vertical and horizontal dimensions of the wetting fronts. The near soil surface wetting fronts were again measured after 20 hours of irrigation and showed no changes from those measured after 18 hours of irrigation. Gravitational force was controlling the movement of water, resulting in an increase in deep percolation.

After 5 hours of irrigation, the wetting fronts around the emitter on the Drip Tape were 30 cm wide and 33 cm high, with a 30 cm dry zone above them, whereas the tubing front's were 30 cm wide and 43 cm high with 30 cm of dry soil between them and the soil surface. The wetting front below the emitter on the Geoflow Tubing lateral had advanced 10 cm deeper than that of the emitter on the Drip Tape.

When irrigation was extended to 10 hours, the Drip Tape's wetting fronts advanced to 46 cm wide and 51 cm high, with 20 cm of dry soil above them, while the Geoflow's wetting fronts advanced to 61 cm wide and 61 cm high coupled with an 18 cm dry zone.
above them. The Geoflow’s bottom wetting front was still advancing 10 cm faster than that of the Drip Tape. Water reached a depth of 1-meter below the soil surface after 18 hours of continuous irrigation.

The wetting fronts were again measured after irrigating for 18 hours. It was observed that the wetting patterns around the emitter on the Drip Tape were 66 cm wide and 89 cm high with a 13 cm dry soil above it; the emitter on the Geoflow Tubing wetted 76 cm wide and 89 cm high, leaving a 10 cm dry zone of the soil surface. In both cases, the moisture came within 10 cm to 13 cm of the soil surface.

The wetting front dimensions described above indicate that the SDI system, as installed, is not able to move water to the soil surface and the wetting fronts between laterals do not overlap or even join. Based on the 2003 observations and data, we can recommend that SDI is not suitable for alfalfa establishment and production under the conditions tested.

The lateral spacing of 1.5 m was not suited to maximum alfalfa hay production and even a 1 m lateral spacing was found insufficient in uniformly applying water across the landscape and within the entire root zone. An appropriate lateral spacing was estimated to be 65 cm for Drip Tape and 75 cm for Geoflow. To achieve soil surface wetting, depth of installation would have to be a maximum of 35 cm.

### Alfalfa dry matter yields for three cuts harvested in 2003

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Dry Matter Yield (kg/ha)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>First Cut</td>
</tr>
<tr>
<td>Drip Tape 1.5m spacing (zone 1)</td>
<td>2.7</td>
</tr>
<tr>
<td>Drip Tape 1m spacing (zone 2)</td>
<td>2.5</td>
</tr>
<tr>
<td>Geoflow 1.5m spacing (zone 3)</td>
<td>2.6</td>
</tr>
<tr>
<td>Geoflow 1m spacing (zone 4)</td>
<td>2.7</td>
</tr>
<tr>
<td>Sprinkler irrigation (zone 5)</td>
<td>3.2</td>
</tr>
<tr>
<td>Water Received:</td>
<td>88</td>
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</tbody>
</table>

The available soil moisture within the alfalfa’s root zone at the end of April 2003 was estimated to be 170 mm. The wet spring plus the May and June rainfalls, totaling 88 mm, kept the soil moisture above the irrigation trigger point until after the first cut. Since no irrigation event was applied prior to the first cut, the first yields for all zones were similar. The results for the second and third cuts showed the sprinkler irrigation zone yielding significantly higher than the SDI zones. The total dry matter yields for the SDI zones were statistically equal. The total plant available moisture, stored in soil and applied, was approximately 444 mm.
In addition, there were several maintenance problems encountered with the SDI system in 2003:

1. The filtration system was not well drained of water prior to freeze up, and therefore was damaged by ice during the winter.

2. As has been observed previously, rodents damaged the Drip Tape during the early spring in several areas. Wet soil along the lateral was a good indication of this problem. To repair the damaged line, a hole was dug and the line spliced. Drip tape is most prone to mechanical or rodent damage due to its reduced wall thickness and the reduced structural strength of the tubing wall.

3. The Drip Tape laterals were disconnected three times where they joined with the sub-main lines. This problem could have been caused by the pressurization of the system. Wet soil along the sub-main line was a good indication of this problem. To repair the damaged joint, a hole was dug and a line reconnected to the sub-main line.

4. During system flushing, it was noticed that the Drip Tape laterals produced water with more soil particles than seen from the Geoflow laterals. The collapsing of the Drip Tape when depressurized may have had something to do with this problem.

Based on the number of repairs needed during the 2003-growing season, Geoflow lateral material worked well for SDI irrigation compared to Drip tape. No repair was needed on the Geoflow lines while the Drip tape was damaged and repaired frequently.

Total cost of materials and installation (based on 2001 prices) for the Subsurface Drip Irrigation system for this project was $25,023. When the design was expanded to a corner of a quarter section with center pivot, the total calculated cost of materials and installation ranged from $24,350 to $27,300 or $6835/ha to $7662/ha, depending on the number of zones used.

For more information, or to obtain a copy of the research report, contact Alan Efetha – Telephone 403-223-7910 or email: alan.efetha@gov.ab.ca