Agricultural Irrigation on the High Plains: Technology & Management

Dana O. Porter, PhD, PE
Research and Extension Agricultural Engineer
Texas A&M University Agricultural Research & Extension Center
Lubbock, Texas
ADVANCES IN IRRIGATION TECHNOLOGY

Have made it possible to achieve

* higher application efficiency
* higher distribution uniformity
* better crop response to inputs
ADVANCES IN IRRIGATION TECHNOLOGY

Equipment
Design
Knowledge
Management Tools
Gravity Systems (including furrow irrigation) – improvements in efficiency through land grading & leveling, tailwater reuse, surge irrigation, alternate furrow irrigation, high flow turnouts, gated pipe, ditch lining…

Under the right conditions (soil, topography, etc.) gravity systems can be managed efficiently.

In much of the High Plains, gravity systems have been replaced by pressurized systems that offer greater potential for high water use efficiency, labor savings and other advantages.
ADVANCES IN IRRIGATION EQUIPMENT

Pressurized Systems

Sprinklers – Center Pivot and Linear Systems
  Low Energy Precision Application (LEPA)
  Low Elevation Spray Application (LESA)
  Mid Elevation Spray Application (MESA)
  Low Pressure In-Canopy (LPIC)

MicrolIrrigation –
  Subsurface Drip Irrigation (SDI),
  Surface Drip, Microspray
LEPA & LESA

Low Energy Precision Application

Low Elevation Spray Application
MicroIrrigation

Microspray

Surface Drip

Subsurface Drip
ADVANCES IN IRRIGATION DESIGN

Developments in irrigation components
- pressure-compensating SDI emitters
- large-droplet, low-drift spray nozzles
- chemical injection components
- corrosion-resistant materials

New tools, knowledge, and education support improved system design to make irrigation
- more efficient
- more uniform
- more user-friendly
- better adapted for site-specific conditions
ADVANCES IN IRRIGATION KNOWLEDGE

Irrigation research programs

Commodity-based and technology-based programs within Texas Agricultural Experiment Station, USDA-Agricultural Research Service, and universities address diverse applied water management research needs.

- SDI, LEPA & LESA: optimization, management, maintenance
- Salinity management
- Utilization of waste waters
- Crop-specific irrigation optimization

USDA-ARS Ogallala Aquifer Initiative:
A multi-state, multi-agency effort
LEPA Irrigation

LEPA drag hose / socks
(note furrow dikes in wet furrows)

Senninger Quad-Spray™*
(Bubbler mode)

*Product names are provided for informational purposes only; this is not intended as an endorsement.
LEPA Irrigation

LEPA is a package deal.

Water is applied at the soil surface at low pressure.

Water is applied to limited surface area – most often in alternate furrows. (Wet furrows for irrigation; dry furrows for traffic.)

Crop rows oriented in the same direction as the path of the irrigation system (circular rows for center pivot; straight rows for linear systems.)

Furrow dikes hold water in place until it can enter the soil through infiltration.
LES A and MESA Irrigation

Low Drift, Low Pressure, Low Elevation Spray (Senninger LDN™)

Large droplets reduce evaporation losses (Senninger I-Wob™)

*Product names are provided for informational purposes only; this is not intended as an endorsement.
LESA (& MESA) & LEPA Irrigation

LESA and LEPA each offer advantages:

With good management, either can be highly efficient. LEPA minimizes evaporation losses, but may pose a risk of runoff. LESA is easier to manage on tight soils and sloping fields. It balances risk of runoff (from LEPA) and evaporation (which is high with high-pressure sprinkler methods.)

Leaf wetting: LESA expands chemigation options; LEPA helps prevent foliar disease and salt damage.

*We can use both LESA and LEPA in the same field.*
Subsurface Drip Irrigation

Subsurface Drip Irrigation has gained a lot of ground in the High Plains – particularly in cotton production systems.

SDI is highly efficient, with little or no risk of runoff or surface evaporation (although as with any irrigation method, excessive irrigation applications can be lost through deep percolation.)

Management and maintenance are key.
Water Source

Volume of water available

Reliability of water source

Water quality

Alternative sources

Pumping & transmission requirements
Contaminants

Water contaminants that may require special consideration for drip irrigation systems:

**Physical Contaminants**
(sand, sediment)

**Biological Contaminants**
(algae, bacteria)

**Chemical Contaminants**
(salinity, calcium carbonate)
Filtration

- Disc filter
- Hydrocyclone
- Sand Separator
- Bank of media filters
Chemical Injection

Chemical injection is necessary with row crop drip irrigation systems.

- prevent emitter plugging
- fertilization of a limited root zone
- limited IPM applications
Considerations

Start with a good design
- Work with a qualified designer (CID, PE, etc.)
- Design for realistic well capacities
- Compare “apples to apples” on designs (cheaper may not be better)
  * Adequate pressure & vacuum relief
  * Flexibility
  * Ease of maintenance
  * Appropriately sized pipelines
  * Adequate filtration and other maintenance, (acid injection, fertigation, etc, as needed)

Install the system correctly: follow design specs

Use pressure gauges & flow meters to simplify troubleshooting
SDI Irrigation System Management

Management of SDI irrigation differs from management of other irrigation methods.

Producers with new drip irrigation systems often refer to the “learning curve” of the first 1-3 years of operation.

- irrigation scheduling
- technical support
SDI vs. Center Pivot

Photo courtesy: Jim Bordovsky, TAES
SDI vs. Center Pivot

SDI cotton and peanuts, Gaines County, 2001
SDI peanuts with cotton in the background, Gaines County, 2002. Also pictured: Scot Towner, TAES student worker.
Subsurface Drip Irrigation
Advantages and Disadvantages

Advantages offered by SDI

+ improved water use efficiency
+ energy savings
+ improved nutrient management (spoon feeding)
+ improved crop yield and/or quality
+ decreased labor requirements
+ system may be automated

Disadvantages of SDI

- high initial cost
- no deep tillage for control of disease and pests
- some designs offered limited flexibility
- potential germination problems (in coarse soils)
- increased management & maintenance requirements
- potential damage due to rodents and other influences
IRRIGATION TECHNOLOGY

Keys to successful implementation

Design
Layout
Installation
Maintenance
Management
IRRIGATION MANAGEMENT

Plant requirements –
what the plant wants
(growth stage, plant density,
leaf character, canopy cover,
stress conditions, etc.)

Climate factors –
temperature, humidity,
solar radiation, wind…

Soil properties –
permeability, water storage capacity

Irrigation system capabilities –
well capacity, flows, delivery rates

Evapotranspiration
ET
Crop water demand
What a Plant Wants

Sufficient soil moisture to prevent drought stress, but not so much that it is waterlogged.

Early season: roots will grow into MOIST soil – not dry soil, not saturated soil.

Important Crop-Specific Information

Critical growth stage(s) during which drought stress will have most impact on the crop.

Peak consumptive water use rate.
How a Plant Uses Water

Early in the season, the plant develops its root system. **Roots grow into moist soil**; they don’t “go hunting” for moisture and nutrients.

The effective root zone of many crops can be as deep as 5-6 feet, if soil conditions allow. Generally speaking most of the water used will be extracted from the top 2-3 feet of soil. Soil features (caliche layers, plow pans, ...) may limit root zone.

**With SDI systems, the effective wetted root zone may be substantially reduced.**

**Nutrients are taken up with water** — broadcast applications of fertilizers may not be intercepted by the SDI-wetted portion of the root zone. Banding of P fertilizer may be recommended. N, S, and some micronutrients may be applied through the SDI system.
Soil Moisture Management
Available Water Storage by Soil Type

- **Grav. H₂O**
- **Avail. H₂O**
- **Hygroscopic H₂O**

**Fine sandy soils**
- 0.6 - 1.25 inch H₂O per ft. soil depth

**Loam soils**
- 1.2 - 1.9 inch H₂O per ft. soil depth

**Clay loam soils**
- 1.5 - 2.3 inch H₂O per ft. soil depth
Soil Moisture Monitoring

Tensiometers and granular matrix blocks are inexpensive and practical.

Installing soil moisture sensors resembles collection of samples for gravimetric soil moisture determination.

Neutron probes are standard in research.

Estimating soil moisture by feel and appearance.

<table>
<thead>
<tr>
<th>Moisture Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25% moisture</td>
<td></td>
</tr>
<tr>
<td>25-50% moisture</td>
<td></td>
</tr>
<tr>
<td>50-75% moisture</td>
<td></td>
</tr>
<tr>
<td>75-100% moisture</td>
<td></td>
</tr>
</tbody>
</table>
Crop Water Use Curve for Cotton
Texas South Plains Area
ADVANCES IN MANAGEMENT TOOLS

Evapotranspiration Networks
Texas North Plains: amarillo2.tamu.edu
Texas South Plains: lubbock.tamu.edu
South/Central Texas: texaset.tamu.edu

Replacing sensors on an ET Network weather station.
South Plains Weather Stations

• Lubbock (text | daily summary | daily fax)
• Halfway (text | daily summary | daily fax)
• Lamesa (text | daily summary | daily fax)

Archived Data: 1994 - 2001
Texas North Plains PET Network
Other Texas Stations

User Information, Explanations, and Help

return to irrigation/water conservation homepage
Date: 7/13/2002  Time: 4:00:08 AM

**Temperatures (F)**

<table>
<thead>
<tr>
<th>Date</th>
<th>ET0</th>
<th>---Air---</th>
<th>Soil Min</th>
<th>Prec.</th>
<th>Growing Degree Days (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>Max</td>
<td>Min</td>
<td>2in.</td>
<td>6in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Crn  Srg  Pnt  Cot  Soy</td>
</tr>
<tr>
<td>07/09/2002</td>
<td>0.24</td>
<td>90</td>
<td>67</td>
<td>72</td>
<td>74</td>
</tr>
<tr>
<td>07/10/2002</td>
<td>0.29</td>
<td>92</td>
<td>69</td>
<td>75</td>
<td>77</td>
</tr>
<tr>
<td>07/11/2002</td>
<td>0.24</td>
<td>91</td>
<td>68</td>
<td>76</td>
<td>79</td>
</tr>
<tr>
<td>10-day avg soil temp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75  77</td>
</tr>
</tbody>
</table>
| Wind 6.4 mph from 133 deg.

**CORN**

<table>
<thead>
<tr>
<th>Seed</th>
<th>Acc</th>
<th>Growth</th>
<th>Day 3</th>
<th>day 7</th>
<th>day Seas.</th>
<th>Long Season Var. Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>GDD</td>
<td>Stage</td>
<td>-----in/d-----</td>
<td>in.</td>
<td>Stage</td>
<td>-----in/d-----</td>
</tr>
<tr>
<td>04/01</td>
<td>2034</td>
<td>Dough</td>
<td>0.29 0.31 0.25 23.6</td>
<td></td>
<td>Blister</td>
<td>0.31 0.34 0.27 23.6</td>
</tr>
<tr>
<td>04/15</td>
<td>1889</td>
<td>Dough</td>
<td>0.29 0.33 0.27 21.0</td>
<td></td>
<td>Blister</td>
<td>0.31 0.34 0.27 20.8</td>
</tr>
<tr>
<td>05/01</td>
<td>1609</td>
<td>Blister</td>
<td>0.31 0.34 0.27 15.9</td>
<td></td>
<td>Blister</td>
<td>0.31 0.33 0.26 15.7</td>
</tr>
<tr>
<td>05/15</td>
<td>1354</td>
<td>Blister</td>
<td>0.31 0.34 0.26 11.4</td>
<td>14-leaf</td>
<td>0.30 0.33 0.25 11.3</td>
<td></td>
</tr>
</tbody>
</table>

**SORGHUM**

<table>
<thead>
<tr>
<th>Seed</th>
<th>Acc</th>
<th>Growth</th>
<th>Day 3</th>
<th>day 7</th>
<th>day Seas.</th>
<th>Long Season Var. Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>GDD</td>
<td>Stage</td>
<td>-----in/d-----</td>
<td>in.</td>
<td>Stage</td>
<td>-----in/d-----</td>
</tr>
<tr>
<td>05/01</td>
<td>1754</td>
<td>Heading</td>
<td>0.27 0.29 0.21 13.5</td>
<td></td>
<td>Boot</td>
<td>0.27 0.26 0.20 12.4</td>
</tr>
<tr>
<td>05/15</td>
<td>1480</td>
<td>Flag</td>
<td>0.23 0.25 0.20 10.1</td>
<td></td>
<td>Flag</td>
<td>0.23 0.22 0.17 9.3</td>
</tr>
<tr>
<td>06/01</td>
<td>1125</td>
<td>GPD</td>
<td>0.19 0.21 0.17 6.4</td>
<td>5-leaf</td>
<td>0.17 0.18 0.14 6.0</td>
<td></td>
</tr>
<tr>
<td>06/15</td>
<td>748</td>
<td>5-leaf</td>
<td>0.17 0.18 0.14 3.4</td>
<td>4-leaf</td>
<td>0.15 0.16 0.12 3.4</td>
<td></td>
</tr>
</tbody>
</table>

**COTTON**

<table>
<thead>
<tr>
<th>Seed</th>
<th>North Plains Area Water Use</th>
<th>South Plains Area Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>GDD</td>
<td>Stage</td>
</tr>
<tr>
<td>05/01</td>
<td>1021</td>
<td>1st Sqr</td>
</tr>
<tr>
<td>05/15</td>
<td>896</td>
<td>1st Sqr</td>
</tr>
<tr>
<td>06/01</td>
<td>715</td>
<td>Emerged</td>
</tr>
<tr>
<td>06/15</td>
<td>478</td>
<td>Emerged</td>
</tr>
</tbody>
</table>

**PEANUTS**

<table>
<thead>
<tr>
<th>Seed</th>
<th>Short Season Var. Water Use</th>
<th>Full Season Var. Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>GDD</td>
<td>Stage</td>
</tr>
<tr>
<td>04/15</td>
<td>1651</td>
<td>Full Pod</td>
</tr>
<tr>
<td>05/01</td>
<td>1419</td>
<td>Beg Pod</td>
</tr>
<tr>
<td>05/15</td>
<td>1199</td>
<td>Beg Pod</td>
</tr>
<tr>
<td>06/01</td>
<td>916</td>
<td>Beg Peg</td>
</tr>
</tbody>
</table>

Fescue/Bluegrass lawn water use 0.24 inch
Bermuda grass lawn water use 0.16 inch
Buffalo grass lawn water use 0.11 inch
<table>
<thead>
<tr>
<th>Date</th>
<th>ETo</th>
<th>----Air----</th>
<th>Soil Min</th>
<th>Prec.</th>
<th>Growing Degrees Days (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>Max Min</td>
<td>2in. 6in.</td>
<td>in.</td>
<td>Crn Srg Pnt Cot Soy Wh</td>
</tr>
<tr>
<td>07/15/2003</td>
<td>.34</td>
<td>101 66</td>
<td>76 80</td>
<td>0.00</td>
<td>26 33 25 23 30 0</td>
</tr>
<tr>
<td>07/16/2003</td>
<td>.32</td>
<td>93 59</td>
<td>75 80</td>
<td>0.00</td>
<td>22 26 21 16 26 0</td>
</tr>
<tr>
<td>07/17/2003</td>
<td>.29</td>
<td>91 60</td>
<td>75 80</td>
<td>0.00</td>
<td>23 26 21 16 27 0</td>
</tr>
<tr>
<td>10-day avg min soil temp</td>
<td></td>
<td>74 79</td>
<td>Wind 6.8 mph from 181 deg.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CORN**

<table>
<thead>
<tr>
<th>Seed Acc Growth</th>
<th>Day 3day 7day Seas. Growth</th>
<th>Day 3day 7day Seas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date GDD</td>
<td>Stage in/d in.</td>
<td>Stage in/d in.</td>
</tr>
<tr>
<td>04/01 1922</td>
<td>Dough .35 .39 .45 24.0</td>
<td>Blister .38 .41 .46 23.8</td>
</tr>
<tr>
<td>04/15 1770</td>
<td>Milk .38 .41 .46 20.8</td>
<td>Silk .38 .41 .46 20.6</td>
</tr>
<tr>
<td>05/01 1559</td>
<td>Blister .38 .41 .46 16.7</td>
<td>Tassel .36 .40 .44 16.4</td>
</tr>
<tr>
<td>05/15 1330</td>
<td>Silk .38 .41 .44 12.6</td>
<td>14-leaf .36 .39 .43 12.5</td>
</tr>
</tbody>
</table>

**SORGHUM**

<table>
<thead>
<tr>
<th>Seed Acc Growth</th>
<th>Day 3day 7day Seas. Growth</th>
<th>Day 3day 7day Seas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date GDD</td>
<td>Stage in/d in.</td>
<td>Stage in/d in.</td>
</tr>
<tr>
<td>05/01 1667</td>
<td>Flag .27 .30 .34 13.8</td>
<td>Flag .27 .30 .33 12.8</td>
</tr>
<tr>
<td>05/15 1445</td>
<td>Flag .27 .30 .32 10.8</td>
<td>GPD .23 .24 .26 9.8</td>
</tr>
<tr>
<td>06/01 1118</td>
<td>GPD .23 .25 .28 7.2</td>
<td>5-leaf .20 .22 .25 6.8</td>
</tr>
<tr>
<td>06/15 843</td>
<td>5-leaf .20 .22 .24 4.7</td>
<td>4-leaf .17 .19 .21 4.5</td>
</tr>
</tbody>
</table>
Efficient & Effective Irrigation Management

Take advantage of equipment and technology developments.

Maintain the system for optimum performance.

Manage soil moisture and water resources for optimum return – Crop Water Use Efficiency.
Dana Porter, Texas Agricultural Experiment Station/Texas Cooperative Extension

Dana Porter, Ph.D., P.E., is an assistant professor and Extension agricultural engineering specialist, has developed an applied research program evaluating irrigation technologies and management strategies to optimize use of modern efficient irrigation technologies. Her collaborative interdisciplinary research activities include irrigation and related soil moisture and climate monitoring for studies involving agronomic and IPM aspects of cotton, peanut, and sorghum production. Dr. Porter's Extension program addresses a wide range of water management, irrigation, and water quality issues; her focus is in promoting use of best management practices to improve water use efficiency. She is the manager of the South Plains Evapotranspiration Network.