Surface Irrigation Strategies on Alfalfa for Groundwater Recharge
Alfalfa and Forage Virtual Field Day
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University of California
Agriculture and Natural Resources
Cooperative Extension
Irrigation: Controlled amount of water is applied to plants at specific intervals

Irrigation Methods in California:

1- Surface irrigation (flood or gravity):
   - Border strip (flat) irrigation (slope 0.1-0.2%)
   - Furrow irrigation (slope)
   - Basin irrigation (zero slope)

2- Sprinkler Irrigation (various types)

3- Low volume/Drip Irrigation (various types)
   - Surface drip and Subsurface drip
SGMA Groundwater Management

On September 16, 2014, Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). For the first time in its history, California has a framework for sustainable, groundwater management - “management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.”

SGMA requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. For critically over-drafted basins, that will be 2040. For the remaining high and medium priority basins, 2042 is the deadline.

Source: California Department of Water Resources
Top field crops in California

### Field and Seed Crops Total Value

<table>
<thead>
<tr>
<th>Commodity</th>
<th>U.S. Rank</th>
<th>CA Share of U.S. Receipts</th>
<th>Area Harvested</th>
<th>Production</th>
<th>Total Value $1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>3</td>
<td>7.6</td>
<td>302.0</td>
<td>216.5</td>
<td>548,816</td>
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<tr>
<td>Cotton Seed</td>
<td>2</td>
<td>8.8</td>
<td>NA</td>
<td>339.0</td>
<td>78,725</td>
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<tr>
<td>Grain, Corn</td>
<td>3</td>
<td>0.1</td>
<td>65.0</td>
<td>314.9</td>
<td>52,570</td>
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<tr>
<td>Peppermint</td>
<td>NA</td>
<td>NA</td>
<td>1.6</td>
<td>7.6</td>
<td>3,739</td>
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<tr>
<td>Hay, Alfalfa and Other</td>
<td>1</td>
<td>11.1</td>
<td>980.0</td>
<td>5,682.0</td>
<td>769,826</td>
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<tr>
<td>Oats</td>
<td>19</td>
<td>1.6</td>
<td>6.0</td>
<td>6.7</td>
<td>1,448</td>
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<tr>
<td>Potatoes (Excl. Sweet)</td>
<td>4</td>
<td>7.0</td>
<td>38.3</td>
<td>772.9</td>
<td>258,625</td>
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<tr>
<td>Potatoes, Sweet</td>
<td>2</td>
<td>30.4</td>
<td>21.0</td>
<td>435.1</td>
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<tr>
<td>Rice</td>
<td>2</td>
<td>30.0</td>
<td>504.0</td>
<td>2,431.8</td>
<td>755,763</td>
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<tr>
<td>Sugar Beets</td>
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<td>3.4</td>
<td>24.6</td>
<td>1,092.0</td>
<td>52,761</td>
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<tr>
<td>Wheat, All</td>
<td>21</td>
<td>0.8</td>
<td>143.0</td>
<td>348.2</td>
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<tr>
<td>Oil Crops</td>
<td>30</td>
<td>0.1</td>
<td>117.5</td>
<td>121.5</td>
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<tr>
<td>Other Seed Crops</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Other Field Crops</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>Floriculture</td>
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<td>25.5</td>
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<td>NA</td>
<td>1,215,997</td>
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<td>Miscellaneous Crops</td>
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<td>22.5</td>
<td>NA</td>
<td>NA</td>
<td>4,725,764</td>
</tr>
</tbody>
</table>

Alfalfa
1,020,000 acres in 2009
670,000 acres in 2018
About 34% decline

TRENDS IN CALIFORNIA IRRIGATED AGRICULTURE

California Agriculture Challenges

Regulations, water, labor, high production costs, etc

Approximately 30% decline in field crops between 2009 and 2018 and increase in permanent crops

Source: Irrigation Survey 2018, (DWR-UCD)
Typical 80-160 acre alfalfa field in CA

- Flow rate, Q: 4-20 cfs (1 cfs ~ 449 gpm)
- Border length: 1,200-2,500 ft
- **Border width:** 60-300 ft
- Slope: ~ 1-2 ft/1000 ft
- Average depth applied per irrigation 3-6 in

- **Goal with surface irrigation:** refill soil profile
- **Minimize losses** (runoff and deep percolation)
Surface Irrigation Efficiency

Applied water = Root zone storage + runoff + deep percolation

Root zone storage (A)

Surface runoff (B)

Deep percolation (C)

Application Efficiency (AE) = A/(A+B+C)

To achieve higher efficiency, reduce B and/or C
Subsurface

Intermittent Groundwater Recharge on Alfalfa

One low flow (Q) and long (T) surface irrigation event per week (Jan- April)

Applied water = Root zone storage + runoff + deep percolation

Root zone storage (A) ~ ETo

(between recharging events)

Surface runoff (B) = 0

Subsurface

Deep percolation (C)

Groundwater Recharge Efficiency = C/(A+B+C)

To achieve high GW recharge efficiency, eliminate B and minimize A
Intermittent Groundwater Recharge on Alfalfa
UC Kearney Agricultural Research and Extension Center, Parlier, CA

2019 feasibility study on selected borders
3rd year alfalfa stand

2020 replicated study on 24 borders
2nd year alfalfa stand

Soil: Hanford sandy loam

Drainage class: Well drained
Capacity of the most limiting layer to transmit water
\( K_{\text{sat}}: \) High (1.98 to 5.95 in/hr)
Surface Irrigation and Groundwater Recharge on alfalfa (2019 - 3\textsuperscript{rd} year stand)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 16”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- \(\text{O}_2\) levels in rootzone above the critical 5\% needed to maintain healthy root system

Data from UC Kearney Research and Extension Center (2019; \~53 inches of recharge in 6 irrigation events)
Surface Irrigation and Groundwater Recharge on alfalfa (2020-2nd year stand)

- Irrigation treatments during the growing season (April-November):
  - Full irrigation and Deficit irrigation after August cutting
  - GW recharge treatment: Intermittent winter flooding and no flooding
  - Replicated three times (yield, O₂ level in soil, moisture content, ETa, etc)
Surface Irrigation and Groundwater Recharge on alfalfa (2020-2\textsuperscript{nd} year stand)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 14”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- Data from UC Kearney Research and Extension Center (2020; ~80 inches of recharge in 10 irrigation events)

![2020 KARE Alfalfa Flooding Events](image)

**Applied water (in)**
Surface Irrigation and Groundwater Recharge on alfalfa (2020 - 2\textsuperscript{nd} year stand)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 14”/week recharge with intermittent flooding with no significant impact on alfalfa yield.
- O\textsubscript{2} levels in rootzone above the critical 5% needed to maintain healthy root system.

Data from UC Kearney Research and Extension Center (2020: \textit{~80 inches} of recharge in 10 irrigation events)
Surface Irrigation and Groundwater Recharge on alfalfa (2020 - 2\textsuperscript{nd} year stand)

- Continuous flooding: reached 5\% O\textsubscript{2} level in 5-7 days

%O\textsubscript{2} level continuous flooding

%O\textsubscript{2} level control (no flooding)
Surface Irrigation and Groundwater Recharge on alfalfa (2020 - 2nd year stand)

Deficit irrigation on selected borders after Aug. 2019 cutting

Flooding events on selected borders
Practical options for groundwater recharge (alfalfa)

- Deficit irrigation on alfalfa to address water shortages is feasible (Water transfer, drought, SGMA, and limited water supplies, etc) with minimal impact on alfalfa stand KARE

- Great potential for utilizing existing surface irrigation infrastructure for groundwater recharge (to address SGMA) on alfalfa

- Alfalfa fields with the proper soil type (medium to high infiltration rates) are ideal locations for GW recharge in California (less potential issues with nitrate leaching as compared to other crops)

- Very little modification is needed to the existing surface irrigation system and no need for dual irrigation systems (for irrigation and surface system for GW recharge)

- Modernization of irrigation districts or flood water delivery to farms is needed (SSJID-Pressurized, Turlock ID- Active control, Oakdale ID- Storage and automated control, CVWD- GW recharge)
Thank You