Benefits and Impacts of Partial Season Irrigation on Alfalfa Production

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Issue

• Limited water supply
• Increasing demand
• Colorado River Compact - 7 states
  • Upper Basin: Colorado, Wyoming, Utah, New Mexico
  • Lower Basin: Arizona, California, Nevada
  • If flows fall below 75 MAF in any rolling 10-year period (annual average of 7.5 MAF), water curtailments will be imposed on upper basin states
• Primary water use - irrigated agriculture
Western Slope Water Bank

• Owners of pre-compact water rights temporarily lease water
• Irrigators *compensated* to reduce water use
• Saved water is available to the water bank
  • Meet compact obligations
  • Municipal, industrial, or other agricultural uses
• Minimize economic & environmental impacts
  • Short-term
  • Done on a rotational basis
  • Crop selection
Acres of Major Irrigated Crops on the Western Slope of Colorado

- Forage crops may be ideal for inclusion in a water banking system
  - Availability
    - Over 90% of irrigated crops
  - Primary user of water
    - Grass CU = 1,069,759 AF/yr
    - Alfalfa CU = 178,750 AF/yr
  - Tolerance to reduced irrigation
Alfalfa

• Good candidate for partial season irrigation:
  • High Water Consumption
    • Large Potential for Water Savings
  • Drought Tolerance
    • Deep Root System & Dormancy Characteristics
  • Management Flexibility
    • Harvest & Irrigation Timing
    • Quality Incentives
Objectives

• Assess the agronomic feasibility of using partial season irrigation of alfalfa as a method to free up water
  • In support of a Western Slope Water Bank
    • Meet lower basin state compact obligations
    • Transfer to other uses such as municipal, industrial, or higher value agricultural
  • Are there alternatives to the buy-and-dry approach?

• Provide adequate information for hay producers as well as proponents of water banking to confirm if this approach is worth pursing as a method to free up water

• Determine the impacts of reduced irrigation to forage yield and quality and associated recovery period of alfalfa hayfields in different regions of Colorado
NCWCD Study – Berthoud, CO

• 4 Irrigation Treatments
  • Irrigate to fully meet ET requirements (Full Irrigation)
  • One irrigation after 1\textsuperscript{st} cutting and resume after 3\textsuperscript{rd} cutting (Spring and Fall Irr.)
  • Stop irrigation after 2\textsuperscript{nd} cutting (Stop Irr. After 2\textsuperscript{nd})
  • Stop irrigation after 1\textsuperscript{st} cutting (Stop Irr. After 1\textsuperscript{st})
### 2006 Average Alfalfa Yields by Cutting

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>24.0”</th>
<th>12.0”</th>
<th>11.5”</th>
<th>3.6”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Yield</td>
<td>8.2 tons/ac</td>
<td>6.4 tons/ac</td>
<td>5.9 tons/ac</td>
<td>3.6 tons/ac</td>
</tr>
</tbody>
</table>

#### Dry Matter Yield (tons/ac)

- **Full Irrigation**
  - 1st Cutting: 2.3 tons/ac
  - 2nd Cutting: 2.0 tons/ac
  - 3rd Cutting: 1.9 tons/ac
  - 4th Cutting: 1.2 tons/ac

- **Stop Irr. After 2nd Spring and Fall Irr.**
  - 1st Cutting: 1.5 tons/ac
  - 2nd Cutting: 2.5 tons/ac
  - 3rd Cutting: 0.9 tons/ac
  - 4th Cutting: 0.5 tons/ac

- **Stop Irr. After 1st Irr.**
  - 1st Cutting: 1.9 tons/ac
  - 2nd Cutting: 1.3 tons/ac
  - 3rd Cutting: 0.2 tons/ac
  - 4th Cutting: 0.3 tons/ac
## 2007 Average Alfalfa Yields by Cutting

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>21.3”</th>
<th>9.5”</th>
<th>10.4”</th>
<th>2.7”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Yield</td>
<td>8.5 tons/ac</td>
<td>7.9 tons/ac</td>
<td>7.7 tons/ac</td>
<td>6.9 tons/ac</td>
</tr>
<tr>
<td>Dry Matter Yield (tons/ac)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st Cutting</td>
<td>2nd Cutting</td>
<td>3rd Cutting</td>
<td>4th Cutting</td>
</tr>
<tr>
<td>Full Irrigation</td>
<td>3.0</td>
<td>1.4</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Stop Irr. After 2nd</td>
<td>3.2</td>
<td>1.4</td>
<td>2.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Spring and Fall Irr.</td>
<td>3.4</td>
<td>1.3</td>
<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Stop Irr. After 1st</td>
<td>3.3</td>
<td>0.9</td>
<td>1.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

4.5” vs 10.5” precip.
2007 Relative Feed Value (RFV) by Cutting

<table>
<thead>
<tr>
<th>Cutting</th>
<th>RFV 1st</th>
<th>RFV 2nd</th>
<th>RFV 3rd</th>
<th>RFV 4th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Irrigation</td>
<td>143</td>
<td>116</td>
<td>128</td>
<td>145</td>
</tr>
<tr>
<td>Stop Irr. After 2nd</td>
<td>137</td>
<td>114</td>
<td>155</td>
<td>188</td>
</tr>
<tr>
<td>Spring and Fall Irr.</td>
<td>149</td>
<td>131</td>
<td>151</td>
<td>156</td>
</tr>
<tr>
<td>Stop Irr. After 1st</td>
<td>133</td>
<td>146</td>
<td>157</td>
<td>216</td>
</tr>
</tbody>
</table>

Legend:
- 1st Cutting
- 2nd Cutting
- 3rd Cutting
- 4th Cutting
<table>
<thead>
<tr>
<th></th>
<th>1st Cutting</th>
<th>2nd Cutting</th>
<th>3rd Cutting</th>
<th>4th Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Irrigation</strong></td>
<td>10.6</td>
<td>15.3</td>
<td>19.4</td>
<td>17.9</td>
</tr>
<tr>
<td><strong>Stop Irr. After 2nd</strong></td>
<td>10.0</td>
<td>16.2</td>
<td>22.2</td>
<td>22.0</td>
</tr>
<tr>
<td><strong>Spring and Fall Irr.</strong></td>
<td>10.4</td>
<td>15.7</td>
<td>22.6</td>
<td>18.9</td>
</tr>
<tr>
<td><strong>Stop Irr. After 1st</strong></td>
<td>11.8</td>
<td>17.3</td>
<td>22.6</td>
<td>22.0</td>
</tr>
</tbody>
</table>
2007 Average Crown Density

<table>
<thead>
<tr>
<th>Irrigation Treatments</th>
<th>Crowns/sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Irrigation</td>
<td>10.4</td>
</tr>
<tr>
<td>Stop Irr. After 2nd</td>
<td>12.5</td>
</tr>
<tr>
<td>Spring and Irr.</td>
<td>9.6</td>
</tr>
<tr>
<td>Fall</td>
<td>14.2</td>
</tr>
<tr>
<td>Stop Irr. After 1st</td>
<td></td>
</tr>
</tbody>
</table>
Alfalfa Hayfields

• Eckert, CO
  • Kehmeier Farm
  • Lower Gunnison

• Fruita, CO
  • Western CO Research Center
  • Lower Colorado

• Yellow Jacket, CO
  • Southwestern CO Research Center
  • San Juan/Dolores

http://water.state.co.us/DivisionsOffices/Pages/default.aspx
Treatments and Measurements

- Fully Irrigated (Control)
- Stop irrigation after 1\textsuperscript{st} cutting (S1)
- Stop irrigation after 2\textsuperscript{nd} cutting (S2)

Measurements
- Yield
- Quality
  - Crude protein (CP), neutral detergent fiber (NDF), and \textit{in-vitro} true digestibility (IVTD)
Alfalfa Dry Matter Yield

*Means with the lowercase letter(s) are not significantly different within treatments at the P=0.15 level.
*Means with the same uppercase letter(s) are not significantly different within cuttings at the P=0.15 level.
### Alfalfa Forage Quality

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CP (%)</th>
<th>NDF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Control</td>
<td>27.4(^a)*</td>
<td>34.6(^a)</td>
</tr>
<tr>
<td>Stop after 2(^{nd}) (S2)</td>
<td>26.6(^a)</td>
<td>31.1(^{ab})</td>
</tr>
<tr>
<td>Stop after 1(^{st}) (S1)</td>
<td>27.2(^a)</td>
<td>28.2(^b)</td>
</tr>
<tr>
<td>Cutting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>27.0(^a)</td>
<td>29.9(^b)</td>
</tr>
<tr>
<td>2</td>
<td>23.9(^b)</td>
<td>34.2(^a)</td>
</tr>
<tr>
<td>3</td>
<td>25.8(^b)</td>
<td>29.9(^b)</td>
</tr>
</tbody>
</table>

*Means followed by the same letter within a column for either treatment or cutting are not significantly different at the P=0.15 level.
## Digestibility

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fully Irrigated</th>
<th>Stop after 2(^{nd})</th>
<th>Stop after 1(^{st})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting 1</td>
<td>79.0(^{Aa*})</td>
<td>82.0(^{Aa})</td>
<td>79.8(^{Aa})</td>
</tr>
<tr>
<td>Cutting 2</td>
<td>74.3(^{Bb})</td>
<td>74.4(^{Bb})</td>
<td>80.4(^{Aa})</td>
</tr>
<tr>
<td>Cutting 3</td>
<td>76.7(^{Bab})</td>
<td>80.4(^{Aa})</td>
<td>80.4(^{Aa})</td>
</tr>
</tbody>
</table>

*Means followed by the same lowercase letter(s) in a column or uppercase letter(s) within a row do not differ significantly at the P=0.15 level.*
Impact of 2 Years of Treatment and 1 Year of Recovery on Alfalfa Yield – Eckert, CO
Impact of 2 Years of Treatment and 1 Year of Recovery on Alfalfa Yield – Fruita, CO Area
Conclusions

• Partial season irrigation of alfalfa appears to be a viable option for freeing up water to meet compact obligations or for other uses
  • Alfalfa is very resilient and adapted to water stress
  • Yields are significantly reduced and producers will need to be fairly compensated for the water saved
• Stopping irrigation after the 2\textsuperscript{nd} harvest is lower risk but recovery and stand health were excellent when irrigation was stopped after the 1\textsuperscript{st} harvest
  • When all treatments were fully irrigated in year 3, partial season trts yielded the same or more than the control
  • Potential reasons include: reduced pressure from alfalfa stem nematodes, reduced disease pressure, and less weed competition (i.e. a healthier, more vigorous stand) which translates to higher plant density
    • Stand longevity is as long or longer due to implementation of partial season irrigation
    • Also, potential for deeper root penetration and higher levels of nitrogen mineralization
• Forage quality increases when plants are water stressed
  • Potential for quality incentives on cuttings with reduced yields