LESA System Provides Uncertain Efficiency Improvements for Alfalfa Irrigation, Sierra Valley,

Sierra Valley Irrigation Tests, 2018 – 2019

Bachand & Associates
In collaboration with U.C. Cooperative Extension
June 2020

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Contributors, Collaborators and Cooperators

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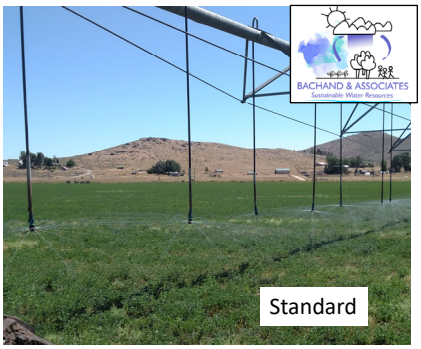
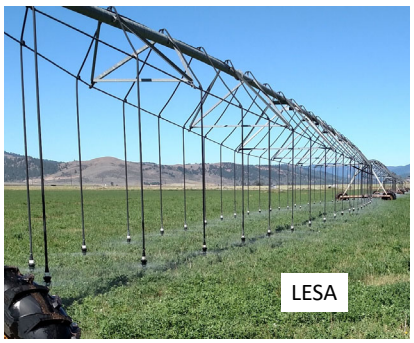
Outline

- Pivot Systems – LESA vs Standard
- Methods and Results
  - Applied Irrigation Water as Measured by Flow Meters
  - Irrigation Efficiency
  - Soil Moisture
  - Plant Effects
- Summary

Goal = Provide Defensible, non-biased assessment of pivot technology





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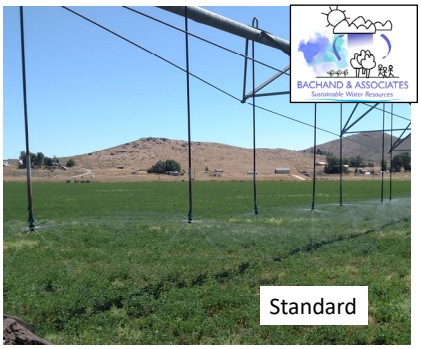
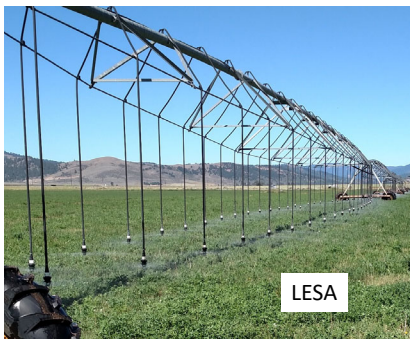
Center-Pivot Systems

Standard (MESA) – Mid-Elevation Spray Application

LESA – Low Elevation Spray Application

- Nozzle height and spacing roughly half of Standard
- Designed to:
  - Reduce water loss
  - Increase irrigation uniformity





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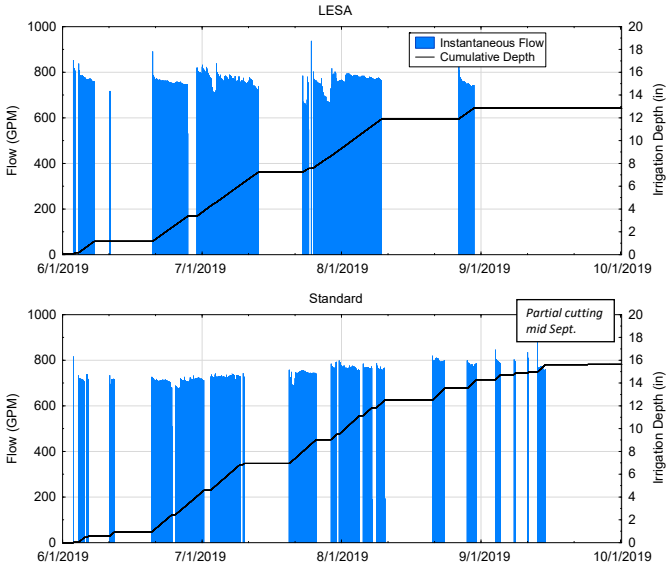
Flow Meter Totals

- Installed on center tower
- Measures and records instantaneous & total flow
  - Telemetric / cloud-based data storage:
    - Protected and secure
    - Real-time
    - Enables quality control measures and actions for robust data collection
- Total irrigation to Field
- Standardized to Field Area



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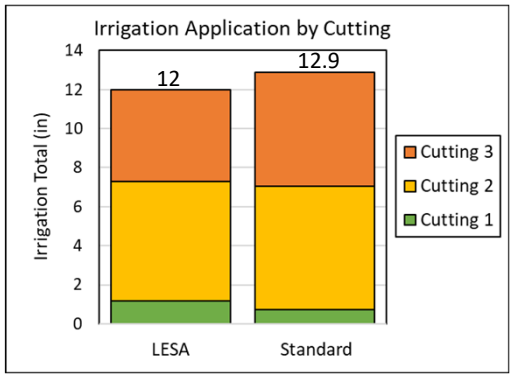
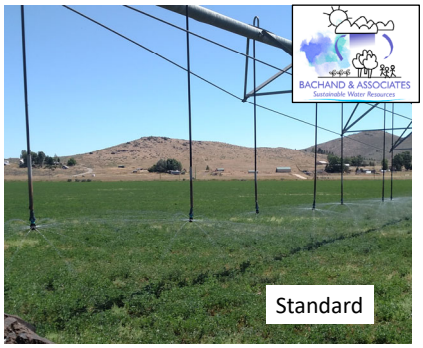
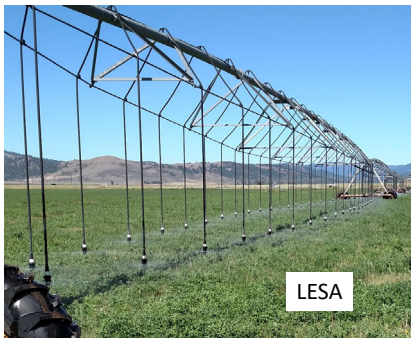
Applied Water (Inches) For First Three Cuttings: Flow Meter Totals



Cutting Dates
1. 6/13/19
2. 7/14/19
3. 8/13/19

$$\frac{LESA}{Std} = \frac{12\ inches}{12.9\ inches} = 93\%$$





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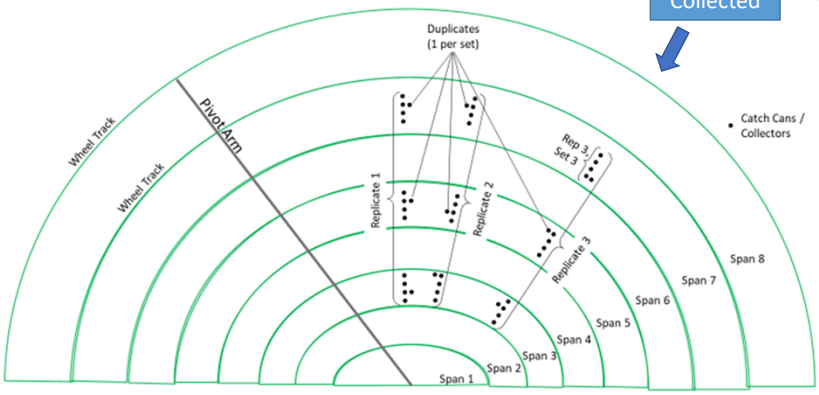
Irrigation Efficiency Tests

- Performed Three replicates on each field for June and July sampling events
  - Inches Collected: Catch Can Tests
  - Inches Applied: Nozzle Flow Tests

Inches Collected



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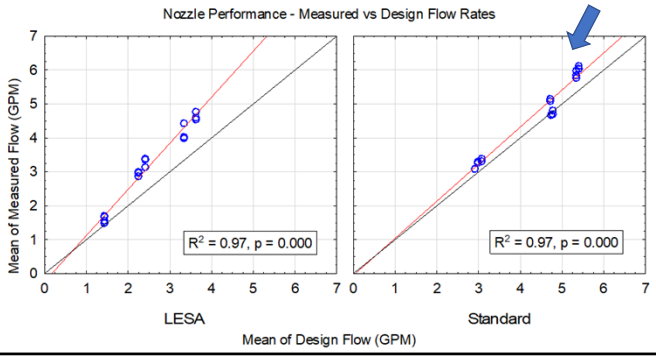
Nozzle-applied Depth

- Design Characteristics
  - Different nozzles for LESA & Standard Systems
  - Design flows increase further from center by span
- Valve Characteristics: Measured vs Design Flows
  - LESA: Measured typically 15 – 30% above Design
  - Standard: Measured typically 5 – 13% above Design

Inches Applied



Measured time to fill 1 gallon, 4 tests per nozzle at 3 places in each span

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Irrigation Application Efficiency (IAE)

$$\text{Irrigation Application Efficiency} = \frac{\text{Inches Collected}}{\text{Inches Applied}} = \frac{\text{Catch Can Depth}}{\text{Nozzle Application Depth}}$$

Treatment	Mean	SD	N	p<0.05
LESA	0.583	0.267	329	Yes
Standard	0.761	0.459	327	Yes

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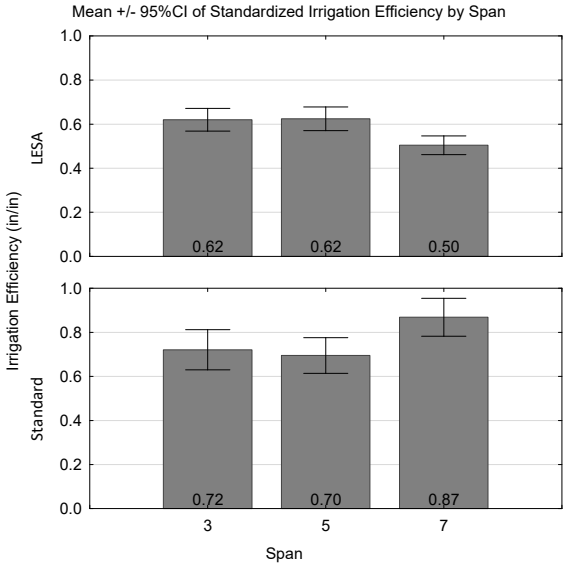
Irrigation Application Efficiency Summary

- Lots of variance but…
- IAE relatively similar
  - Across spans (i.e., 3, 5, 7)
  - Across speeds (i.e, 20, 33, 35, 86)
  - Across months (i.e., June, July)
- Mean IAE statistically higher for Standard vs LESA (0.76 vs. 0.58)



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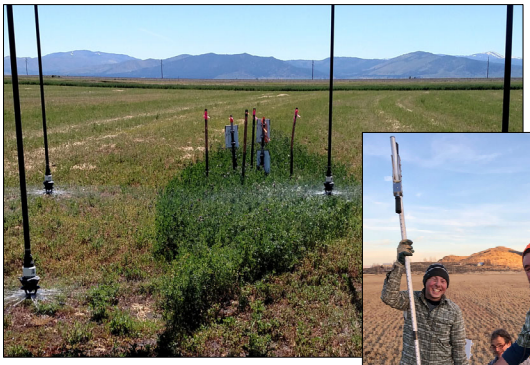
Soil Moisture Probes at Test Fields

- 3 Moisture Probe Sets Per Treatment
- Each Set
  - Replicates
  - Six probes at six soil depths:
    - 6”
    - 12”
    - 18”
    - 24”
    - 36”
    - 48”
- EC, moisture, temperature
- Telemetric



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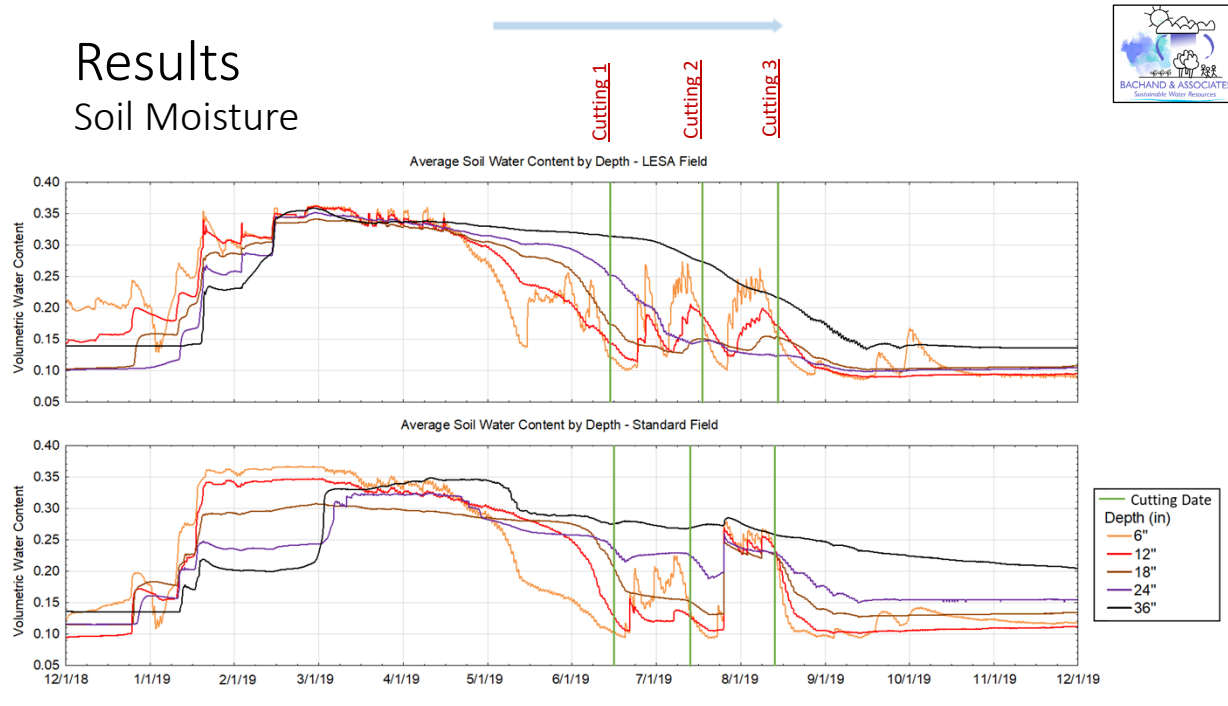
Results

Soil Moisture



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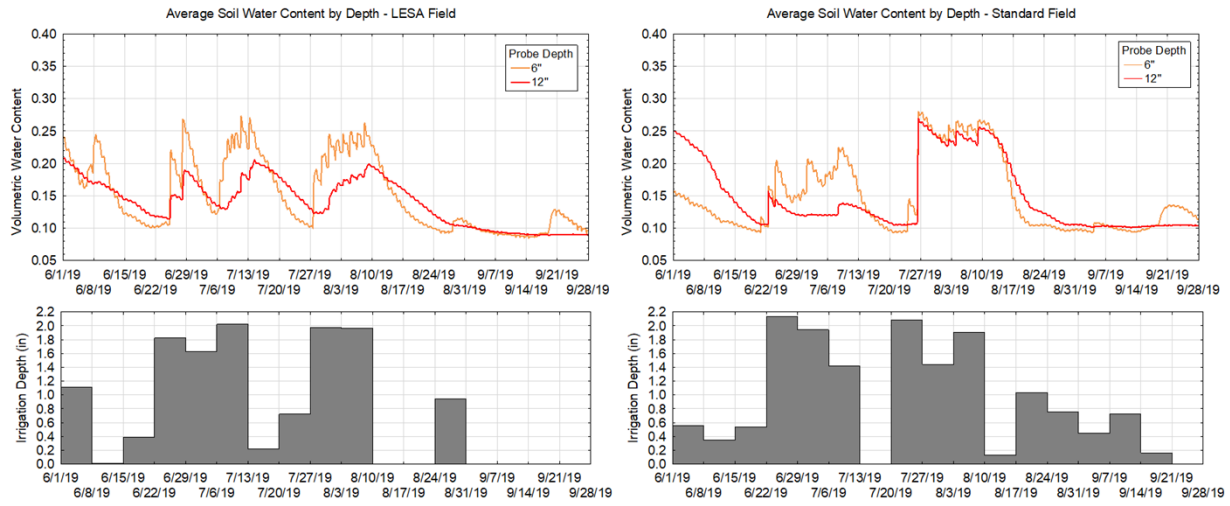
Results

Soil Moisture – Upper Root Zone

- Maximum weekly irrigation approx. 2 inches for each system
- Top soil layers increase moisture in response



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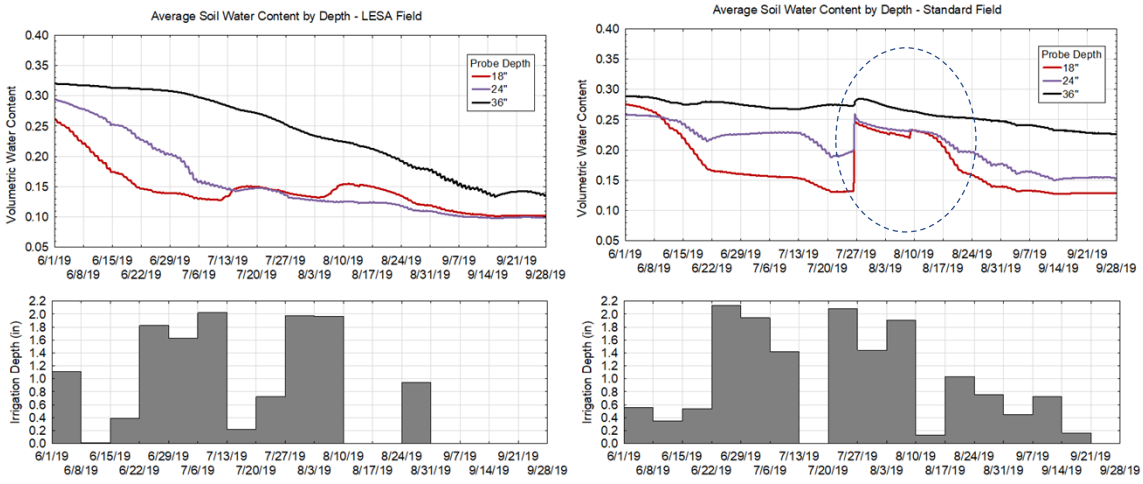
Results

Soil Moisture – Deeper Root Zone

- Lower soil layers showing less obvious affect to irrigation…
- Though LESA field is in greater general decline than Standard field….
  - Less likely to recover soil moisture and ….
- Suggesting more flow to deeper depths under Standard irrigation



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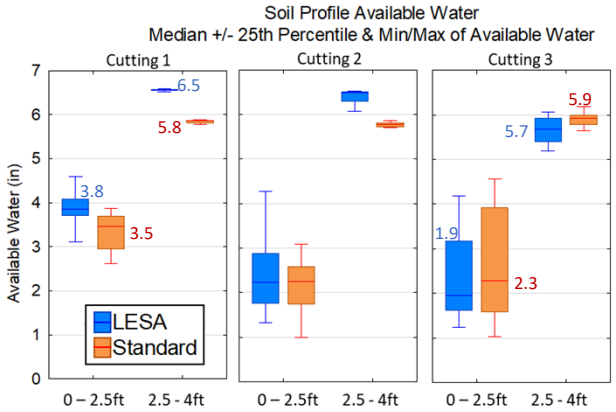
Available Water in the Root Zone through Cuttings 1 – 3
Similarities between LESA and Standard

- Available Water, Average
  - Similar at deeper depths
  - Decreases through the year
  - Similar end value at end of season
- Available Water, Variance (Distribution)
  - Increases through season
  - Higher at shallow depths
  - Similar for both systems



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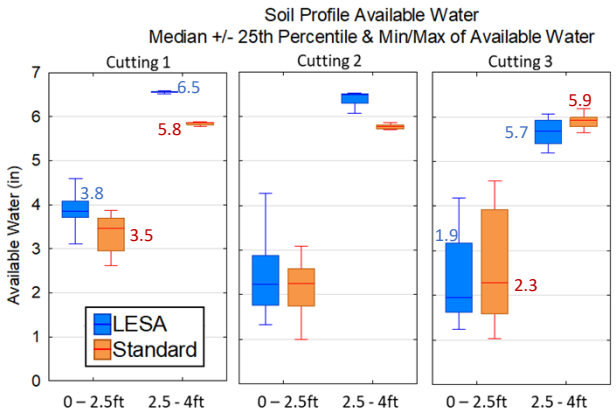
Available Water in the Root Zone through Cuttings 1 – 3
Differences between LESA and Standard

- Available Water decreased more across LESA system during the season
  - Change in Mean Available Water Decrease at 0 – 2.5 ft
    - LESA = -1.9 inches
    - Standard = -1.2 inches
  - Change in Mean Available Water Decrease at 2.5 – 4 ft
    - LESA = -0.8
    - Standard = 0.1



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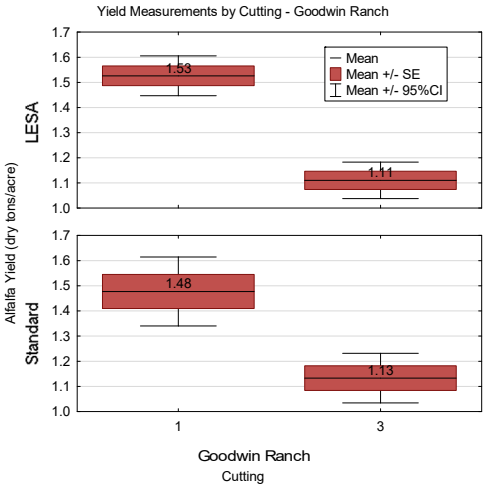
Crop Yield – Goodwin Ranch

- Yield decreases throughout season
- No significant differences between LESA and Standard for each cutting



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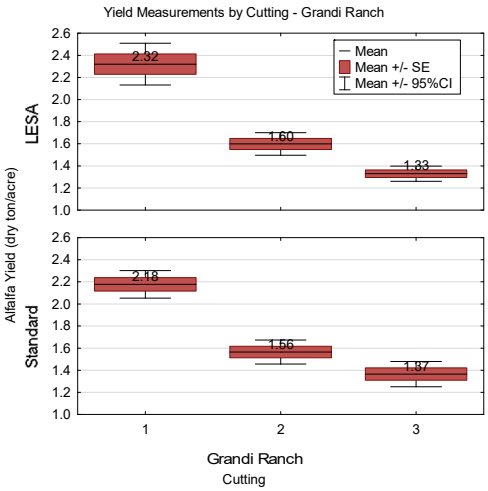
Crop Yield – Grandi Ranch

- Yield decreases throughout season
- No significant differences between LESA and Standard for each cutting



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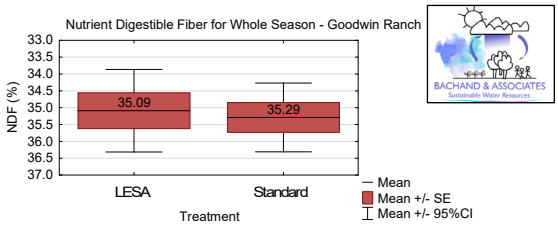
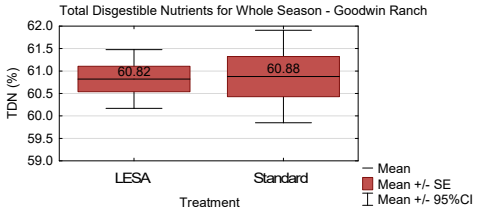
Hay Quality – Goodwin Ranch

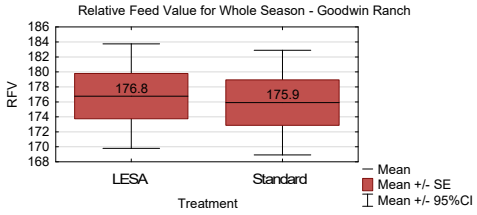
- Higher quality hay for both LESA and Standard systems
  - Low NDF
  - High TDN
  - High RFV
- No significant differences between systems

Irrigation	N	Overall Quality[1]
LESA	9	Premium
Standard	9	Premium

[1]USDA Hay Quality Categorization







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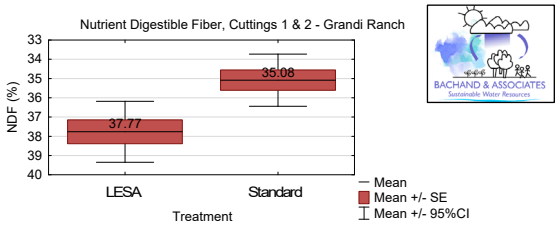
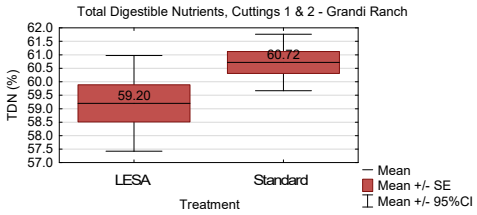
Hay Quality – Grandi Ranch

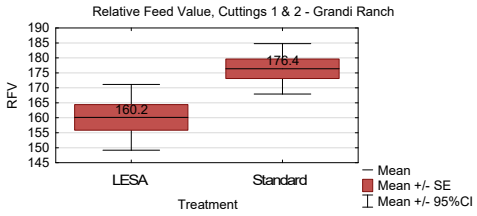
- Higher quality hay for Standard vs. LESA system
  - Low NDF
  - High TDN
  - High RFV
- Standard significantly higher quality

Irrigation	N	Overall Quality[1]
LESA	6	Good
Standard	6	Premium

[1]USDA Hay Quality Categorization







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Summary comparison of metrics under LESA and Standard Pivot Systems

Metric		LESA [3]	Standard [3]	Notes
Irrigation	Irrigation Inches [1]	12	12.9	LESA used 7% less water
	Irrigation Efficiency	58%	76%	Std had higher IE but greater variance
Soil Moisture	Average	Greater annual decline	Lower annual decline	Similar overall responses to irrigation upper and lower profiles but greater seasonal decrease for LESA
	Variance	Similar range	Similar range	Similar variability across time and across locations
	Operational Flexibilty	Lower	Higher	Std had greater ability to catch up on water deficit but may have greater likelihood of over watering
Yield	Goodwin	Similar [2]	Similar [2]	Statistically similar averages, variance and trends across cuttings [2]
	Grandi	Similar [2]	Similar [2]	Statistically similar averages, variance and trends across cuttings [2]
Hay Quality	Goodwin	Similar [2]	Similar [2]	Statistically similar averages, variance and trends across cuttings [2]
	Grandi	Lower	Higher	Not statistically different but generally lower quality across all measures

Notes

1. 7% less water under LESA.
2. Statistically different for p<0.05

3	Best	Similar	Worse	, Ranking.

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Summary – Confounding Factors

- Operational
  - Goodwin fields flooded in 2017 and haven't fully recovered
  - Pivot speeds were adjusted throughout the study
  - Full circle systems keep turning (as on LESA field) whereas half circle needs to be manually reversed (as on Standard field)
    - Affects water distribution, particularly at the end of a run
- Environmental
  - Soil types differed between fields
  - Shallow groundwater may have affected soil moisture (capillary pressure)
- Experimental
  - One year, one farm

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Summary: Standard vs. LESA

Standard

- Used slightly more water (7%)
- Soil moisture declined less throughout the season
- Appeared to have more operational flexibility (can catch up)
- Yields were similar
- Hay yield quality tended towards, premium at both fields

LESA

- Used slightly less (7%) water
- Soil moisture declined more throughout the season
- Appeared to have less operational flexibility (more difficult to catch up)
- Yields were similar
- Hay quality tended towards lower, though still good to premium

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Operational Observations

- System maintenance important for irrigation efficiency
  - Nozzle emitters clog easily, can severely affect irrigation uniformity
- Pump rates decrease during irrigation and throughout season in response to local groundwater level declines
- Pivot operation affects water distribution and irrigation uniformity
  - Higher pivot speeds likely lead to greater ET losses (could not be measured here)
  - Changing pivot speeds affects irrigation uniformity
  - On half- and quarter-field pivot systems, pivots stop at the end of the run but continue pumping
    - Affects irrigation uniformity
    - Automatic pump switch would increase uniformity and water use efficiency

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Conclusion and Recommendations

- LESA systems –
  - may provide slight decrease in irrigation water use
  - can reduce crop quality
  - may be more likely to lead to greater soil moisture declines throughout the growing season
  - may be less effective in overcoming soil moisture deficits due to higher design efficiencies
  - valves are more likely to stray from design specifications
- Groundwater levels (short-term and long-term) affect pumping rates
- Effective pivot system maintenance is required for optimum irrigation system performance
  - Anecdotal information suggests LESA systems require greater maintenance
- Pivot systems design and operation affect their performance
  - Slower pivot speeds more likely to reduce transpiration losses
  - Slower pivot speeds could lead to greater water losses past the root zone
  - Alfalfa is considered deep rooted crop so may be able to recover deeper water if trained
  - Changes in operation (e.g., pivot speed, clogging) affect water distribution and likely irrigation use efficiencies
- Improvements in irrigation water use
  - may be achievable with improved pivot operation and appropriate soil moisture monitoring (including to depth)
  - May be more cost effective than transitioning from Standard irrigation systems to LESA systems

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