The Alfalfa Yield Gap: What’s Holding Us Back?

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Outline

Yield trends

Five issues affecting yield

Breeding opportunities

Management opportunities
California Alfalfa Yield – USDA Ag Statistics

Yield (tons/acre)

1993
1. What’s breeding done for yield?
UC Variety Trials
First Year Yield of Top Entry in Each Trial

**Tulelake**

- Yield: 7 to 14 tons/acre
- R² = 0.31757

**El Centro**

- Yield: 9 to 16 tons/acre
- R² = 0.2865

**Davis**

- Yield: 9 to 13 tons/acre
- R² = 0.08108

**% of Vernal**

- 1990: 110%
- 1995: 120%
- 2000: 130%
- 2005: 140%
- 2010: 130%
- 2015: 120%
- 2020: 110%
- R² = 0.21328

**% of CUF101**

- 1990: 90%
- 1995: 100%
- 2000: 110%
- 2005: 120%
- 2010: 130%
- 2015: 140%
- 2020: 150%
- R² = 0.40921

**% of CUF101**

- 1990: 100%
- 1995: 110%
- 2000: 120%
- 2005: 130%
- 2010: 140%
- 2015: 150%
- 2020: 160%
- R² = 0.00848
Yield vs. Year of Cultivar Release

- **2010 Tulelake - 2013 Yields**
  - $R^2 = 0.04$

- **2011 Davis Trial - 2013 Yields**
  - $R^2 = 0.001$

- **2011 Modesto - 2013 Yield**
  - $R^2 = 0.02$

- **2012 Imperial - 2013 Yields**
  - $R^2 = 0.00013$
Do new varieties partition yield differently across harvests?
First full production year yield

<table>
<thead>
<tr>
<th></th>
<th>El Centro</th>
<th>Tulelake – 2013 Trial</th>
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<tbody>
<tr>
<td></td>
<td>% Yield Before July 1</td>
<td>% Yield</td>
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<tr>
<td></td>
<td>1998</td>
<td>2012</td>
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<tr>
<td>Top Entry</td>
<td>64</td>
<td>69</td>
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<tr>
<td>Bottom Entry</td>
<td>65</td>
<td>69</td>
</tr>
<tr>
<td>CUF101</td>
<td>65</td>
<td>69</td>
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<tr>
<td>Minimum</td>
<td>62</td>
<td>66</td>
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<tr>
<td>Maximum</td>
<td>67</td>
<td>71</td>
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Very little variation among cultivars
All FD 8-10

Larger variation among cultivars
Due to higher FD pushing more fall yield
The Yield/Quality Tradeoff

\[ y = 0.0402x + 1.25 \quad R^2 = 0.6451 \]

\[ y = -0.2262x + 55.442 \quad R^2 = 0.5715 \]

2. Cutting Schedule Affects Yield

The yield – quality tradeoff

Yolo County

Days of regrowth

Yield

TDN

40

45

50

55

60

65

70
Alfalfa Hay Quality Has Improved

Reflects earlier harvesting ... and lower yield

Avg. all cuttings, data from Petaluma Labs, CA
(thousands of samples, mostly from intermountain areas of N. California)

\[ R^2 = 0.76056 \]
High temperatures = Rapid quality decline
Need short harvest interval
3. Fall Dormancy: Yield vs. Quality, Part II
Less dormancy associated with higher yield
faster regrowth rate
higher fiber (lower quality)
earlier flowering time

Davis, CA yield trials

Putnam & Orloff, 2003, 33rd CA Alfalfa Symposium
4. Traffic Decreases Yields...
Variety Trial in Davis
Planted 9/30/2002
2003 Yields

Two Treatments
No traffic
1 pass of 4 ton tractor 5-6 days after harvest

Range in yield loss
12-26%
1.4 to 3.6 tons/acre!

Average loss:
2.5 tons/acre (20%)!
5. Irrigation Scheduling Affects Yield
Subsurface Drip Irrigation
(also new sprinkler technologies)

SDI
20-35% yield improvement

Better able to meet ET demand
More uniformity across the field
Flexibility before and after harvest

Yield with conventional irrigation (t/a)

Yield with SDI (t/a)

Grower fields

$Y_{SDI} = 0.98Y_{flood} + 3.00$
$R^2 = 0.74$

Cumulative water (in.)

Day of the Year

Alfalfa SDI Trial- 2015 Davis

Cut 2
Cut 3
Cut 4
Cut 5
Cut 6
Cut 7
Breeding Goals

Decouple yield and quality
Low-lignin varieties? Modified flowering? Delayed senescence?

Decouple dormancy and quality
Higher yielding non-dormants with better quality and persistence

Better breeding methods
Drone-based phenotyping

Measure height, ground cover, disease, others
Predict yield (and quality?)
Genomic selection for forage yield & quality

Develop predictive model
“If a plant has these genetic markers, then it will produce this yield”

Better phenotype data from drones?

Select plants based on markers to turn cycles rapidly

Evaluation in Tulelake planted this spring
Management Goals

“Hay in a Day”
Minimize time windrow covers regrowing shoots
Minimize traffic on regrowth
Maximize irrigation flexibility through SDI or drop sprinklers
Choose best varieties for harvest schedule flexibility
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