“This has been the most important agronomy tool we’ve used to date.”

- Dave Gill, Golden Eagle Farms

Hortau for Hops

How monitoring soil tension can help you better control input costs, keep plants healthy, and promote a high-quality harvest

TRAVIS GOLDMAN, HORTAU
Travis Goldman  
Irrigation Management Advisor  
Hortau  
CCA: 732597  
CAIS: 127075

Alfalfa  
Almonds  
Apples  
Apricots  
Asparagus  
Artichokes  
Apricots  
Blackberries  
Blueberries  
Broccoli  
Brussel Sprouts  
Cannabis/Hemp  
Carrots  
Cauliflower  
Celery  
Cherries  
Corn  
Garlic  
Hops  
Onions  
Peppers  
Tomatoes  
- (Fresh market/solids)  
Onions  
Lettuce -  
(Romaine/Iceberg/Artisan)  
Pistachios  
Raspberries  
Strawberries  
Walnuts  
Wine Grapes  
Zinnias
What are the three pillars of agronomy?
Three Pillars of Agronomy

• Each discipline is vital to consistent, reliable crop performance
• Each is advanced or limited by one another
• Consideration of each control variables
Why Irrigation Matters

• Goal is to maximize production, not just get crops to survive

• Water deficit “overrides” all other functions
Why precision irrigation matters

Each season crop stress factors can reduce yield by more than 50%¹

During the season, the crop is exposed to different stress factors that cause yield losses. These losses happen quickly and can never be retrieved. The only way to avoid them is to anticipate and correct the situation before any damage is done.

Gap between potential yield and actual yield at harvest time due to in-season crop stress.

Stomatal Control

• Gas exchange critical to photosynthesis

• Stomata have 3 functions
  • Let CO2 in
  • Let water out
  • Regulate water loss

• When stomata close to save water, CO2 is also limited

• When CO2 is limited, the plant factory is limited.
Stomatal Control

• When water becomes limited, the roots send signal to leaves to begin closing stomata

• Water deficit “overrides” all other functions
Stomatal Control

- Stomata’s function in relation to the whole system
- When water is freely available, water flows through the plant and through the stomata, and CO2 flows freely in to feed the plant’s factory
Nutrient Uptake

- Soil nutrients are dissolved or suspended in soil solution
- Soil solution carries nutrients into roots and through the plant (Mass Flow)
- Nutrient uptake does not occur from soil particle to plant
How? Measure and anticipate what matters most: soil tension

Soil tension is the proven way to measure directly and accurately plant stress. Hortau’s technology allows growers to maximize their crop yield’s potential by getting real-time data.
The Right Measurement

Soil Tension

• How hard to pull water from soil
• Indicates plant needs
• Is the same, no matter the soil
  • No need to calibrate
• Reflects soil physical properties
  • Enables better management decisions
Ensure optimal growing conditions by staying within the comfort zone.

- Wet zone
- Comfort zone
- Dry zone

Soil Tension Curve

0 kPa to 80 kPa

Yields
What does 0 kPa look like?

• All macro and micropores of the soil are full
• No oxygen is present
• Soil cannot sustain this much water and will leach until back to field capacity
• WE’VE MADE MUD
The Comfort Zone
“The Blue Band”

• Good balance of available water and air for the roots

• Improved transpiration rates

• Improved nutritional uptake by the plant

• Improved photosynthesis

• NO DOWN TIME
How Dry is Too Dry?

36” soil horizon

24” soil horizon
Do we wait till we see plant stress?
Ensure optimal growing conditions by staying within the comfort zone.
How Real Time Data is Used

Soil tension Probes

Offset probe placement will give you exact wetting bulb pattern in real time to help leach salt and for optimum fertilizer placement.
Keys to Irrigation Management

What are my soils?

What is my pump capacity?

What is my application rate?

What is my water quality?
-BMP for irrigation maintenance
What are my soils?
What are my soils?

- Plant Available Water (PAW)
  - Brentwood Clay Loam @ 2.22”/ft
  - Yolo Silt Clay Loam @ 2.25”/ft
  - Capay Clay @ 1.55”/ft

- University Approach (% by volume)
  - AWHC(RZ) @ 100% = 6.66”
  - AWHC(RZ) @ 50% = 3.33”
  - AWHC(RZ) @ 25% = 1.667”
What is my application rate?

Irrigation System: 12’ Rows with double line drip
Emitter: 0.53 GPH w/ 24” spacing
-0.008833 GPM every 24”

Application Rate (in/hr) = \( \frac{96.3 \times (0.008833 \text{ GPM}) \times 2}{12’ \times 2’} \) = 0.0708”/hr

GPM/ac = \( \frac{0.00883 \text{ GPM} \times 2 \times 43560 \text{ sq. ft}}{12’ \times 2’ \times 1 \text{ ac}} \) = 32.05 GPM per acre

West Irrigation Set @ 16.75 acres = 536 GPM

Easter Irrigation Set @ 17 acres = 544 GPM

Pump Output estimate: 600 GPM @ 40 psi
What is my pump capacity?
Can my filters keep up in the summer?
Flushing Irrigation Lines

Distribution Uniformity is critical
Water Quality and irrigation efficiency
Early Vegetative Bine Regrowth

- Manage the root zone to optimize nutritional uptake (10 kPa to 20 kPa)
- Eliminate excessive watering to limit anaerobic downtime
- What’s the weather forecast? (Irrigate or hold off)

April-June 2018
Not every year is the same

April-May 2019
Fertigation: Where is my Nitrogen?
My Leaching Fractions

My fertility program
Vegetative (10-25 kPa)
Vegetative Production (10-25 kPa)
Flowers are expensive
Flower Production (10-25 kPa)

Minimize stress as much as possible

- Strig
- Bracteole
- Bract
- Lupulin glands
  - Containing Resins and Essential Oils
Flower Production (10-25 kPa)
Pulse Irrigation through automation
Post Harvest Irrigation Management

- Manage the root zone to optimize carbohydrate sequestration and root flush (10 kPa to 25 kPa)
- Eliminate excessive watering and leaching fractions until dormancy
Post Harvest Irrigation Strategy

ELIMINATE EXCESSIVE WATER
100% soil rehydration @ 7 hours

25% Depletion estimate by grower with ET @ 1.667”
AR @ 0.071”/hr
Wetting Pattern AR @ 0.107”/hr
Total water applied: 16.6 hrs x 0.107”/hr = 1.77” of water
Hortau Projection @ 7 hours = 0.75” of water
Root zone was overwatered by 1” of water
“I had a drastic increase in my yield since I started to manage efficiently my irrigation with Hortau's equipment. Just by looking in my field, I wasn't able to know the water stress on my crop without a good irrigation management tool.”

-Alexandre Bastien at Houblon Bastien Inc.
### SCHEDULE

<table>
<thead>
<tr>
<th>Name</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
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</tbody>
</table>
• Cells are created in meristem and nowhere else

• Most plant growth in size and mass is due to enlargement of existing cells.

• After a fruit passes from the meristem, it contains all of the cells it will ever have.
1st Year Tree Research in Nonpareil Almonds

High Compliance

PEDRERO NEW PLANTING

VS

Low Compliance

FIELD 8S ALMONDS
High Compliance Irrigation in 1st Year Nonpariel

- Circumference (in.)
- Length (in.)
- Volume (in^3)
Low Compliance Irrigation in 1st year Nonpariel
<table>
<thead>
<tr>
<th></th>
<th>Circumference (in.)</th>
<th>Length (in.)</th>
<th>Volume (in^3)</th>
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</thead>
<tbody>
<tr>
<td>High Compliance Ranch (NP)</td>
<td>5.91</td>
<td>27.48</td>
<td>76.61</td>
</tr>
<tr>
<td>Low Compliance Ranch (NP)</td>
<td>4.07</td>
<td>24.90</td>
<td>33.25</td>
</tr>
<tr>
<td>% Increase in High Compliance Ranch</td>
<td>45%</td>
<td>10.40%</td>
<td>130%</td>
</tr>
</tbody>
</table>
12 Months High Compliance

12 Months Low Compliance
<table>
<thead>
<tr>
<th></th>
<th>Circumference (in.)</th>
<th>Length (in.)</th>
<th>Volume (in^3)</th>
</tr>
</thead>
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<tr>
<td><strong>December 2018</strong></td>
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<tr>
<td>High Compliance Ranch (NP)</td>
<td>5.91</td>
<td>27.48</td>
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<td>130%</td>
</tr>
<tr>
<td><strong>December 2019</strong></td>
<td></td>
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</tr>
<tr>
<td>High Compliance Ranch (NP)</td>
<td>12.19</td>
<td>27.47</td>
<td>325.01</td>
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<td>Low Compliance Ranch (NP)</td>
<td>7.71</td>
<td>24.89</td>
<td>119.65</td>
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<tr>
<td>% Increase in High Compliance Ranch</td>
<td>58%</td>
<td>10.3%</td>
<td>172%</td>
</tr>
</tbody>
</table>
Walnuts (1st year advising)

- 44% Increase in edible yield
- 6% Increase in light meat

Optimize root surface area during nut fill
# Oakdale Almonds

## Key metrics (Site averages)

<table>
<thead>
<tr>
<th>Metric</th>
<th>2017</th>
<th>2018</th>
<th>Change</th>
<th>Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Applied/Acre (ac-in)</td>
<td>35</td>
<td>29</td>
<td>-6</td>
<td>-16%</td>
</tr>
<tr>
<td>Site-Wide Water Use (ac-ft)</td>
<td>8382</td>
<td>7021</td>
<td>-1361</td>
<td>-16%</td>
</tr>
<tr>
<td>Water Use Efficiency (lbs/ac-in)</td>
<td>21</td>
<td>53</td>
<td>32</td>
<td>152%</td>
</tr>
<tr>
<td>Leaching (hrs per block)</td>
<td>326</td>
<td>292</td>
<td>-34</td>
<td>-11%</td>
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<tr>
<td>Pumping Energy Costs ($/ac)</td>
<td>$257.03</td>
<td>$215.30</td>
<td>$(41.73)</td>
<td>-16%</td>
</tr>
<tr>
<td>Water Cost ($/ac)</td>
<td>$43.30</td>
<td>$36.27</td>
<td>$(7.03)</td>
<td>-16%</td>
</tr>
<tr>
<td>Yield (lb/ac)</td>
<td>732</td>
<td>1543</td>
<td>811</td>
<td>111%</td>
</tr>
<tr>
<td>Yield value ($/ac)*</td>
<td>$1,904</td>
<td>$4,013</td>
<td>$2,108</td>
<td>111%</td>
</tr>
<tr>
<td>Gross Profit Margin variation ($/ac)</td>
<td>$1,604</td>
<td>$3,761</td>
<td>$2,157</td>
<td>134%</td>
</tr>
</tbody>
</table>

*Priced at $2.60/lb

## Site Totals

<table>
<thead>
<tr>
<th>Metric</th>
<th>2017</th>
<th>2018</th>
<th>Change</th>
<th>Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Water</td>
<td>$872,122</td>
<td>$730,516</td>
<td>$(141,606)</td>
<td>-16%</td>
</tr>
<tr>
<td>Crop Value</td>
<td>$4,688,017.20</td>
<td>$7,702,314.340</td>
<td>$3,014,297</td>
<td>64%</td>
</tr>
</tbody>
</table>

## Gross Profit Increase

- $3,155,903.40

## Your Return on Hortau solutions invested is (ROI)

- 25.7x
# Newman Almonds

## Key metrics (Site averages)

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>Change</th>
<th>Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Applied/Acre (ac-in)</td>
<td>33</td>
<td>37</td>
<td>4</td>
<td>11%</td>
</tr>
<tr>
<td>Site-Wide Water Use (ac-ft)</td>
<td>3875</td>
<td>4293</td>
<td>417</td>
<td>11%</td>
</tr>
<tr>
<td>Water Use Efficiency (lbs/ac-in)</td>
<td>28</td>
<td>33</td>
<td>5</td>
<td>18%</td>
</tr>
<tr>
<td>Leaching (hrs per block)</td>
<td>0</td>
<td>36</td>
<td>36</td>
<td>0%</td>
</tr>
<tr>
<td>Pumping Energy Costs ($/ac)</td>
<td>$247.21</td>
<td>$273.83</td>
<td>$26.62</td>
<td>11%</td>
</tr>
<tr>
<td>Water Cost ($/ac)</td>
<td>$555.21</td>
<td>$614.99</td>
<td>$59.78</td>
<td>11%</td>
</tr>
<tr>
<td>Yield (lb/ac)</td>
<td>933</td>
<td>1217</td>
<td>283</td>
<td>30%</td>
</tr>
<tr>
<td>Yield value ($/ac)*</td>
<td>$2,053</td>
<td>$2,677</td>
<td>$624</td>
<td>30%</td>
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<tr>
<td>Gross Profit Margin variation ($/ac)</td>
<td>$1,251</td>
<td>$1,788</td>
<td>$537</td>
<td>43%</td>
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</table>

* Priced at $2.20/lb

## Site Totals

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>Change</th>
<th>Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Water</td>
<td>$1,120,173</td>
<td>$1,240,792</td>
<td>$120,620</td>
<td>11%</td>
</tr>
<tr>
<td>Crop Value</td>
<td>$2,866,398</td>
<td>$3,736,933</td>
<td>$870,536</td>
<td>30%</td>
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</table>

## Gross Profit Increase

$749,915.92

## Your Return on Hortau solutions invested is (ROI)

6.2x
Bakersfield Almonds

<table>
<thead>
<tr>
<th>Key metrics (Site averages)</th>
<th>2017</th>
<th>2019</th>
<th>Change</th>
<th>Change %</th>
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</thead>
<tbody>
<tr>
<td>Water Applied/Acre (ac-in)</td>
<td>55</td>
<td>49</td>
<td>-6</td>
<td>-12%</td>
</tr>
<tr>
<td>Site-Wide Water Use (ac-ft)</td>
<td>5075</td>
<td>4479</td>
<td>-596</td>
<td>-12%</td>
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<tr>
<td>Water Use Efficiency (lbs/ac-in)</td>
<td>51</td>
<td>61</td>
<td>10</td>
<td>19%</td>
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<tr>
<td>Pumping Energy Costs ($/ac)</td>
<td>$409.68</td>
<td>$361.55</td>
<td>$(48.13)</td>
<td>-12%</td>
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<td>Water Cost ($/ac)</td>
<td>$502.48</td>
<td>$445.47</td>
<td>$(57.00)</td>
<td>-11%</td>
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<tr>
<td>Yield (lb/ac)</td>
<td>2840</td>
<td>2988</td>
<td>148</td>
<td>5%</td>
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<tr>
<td>Yield value ($/ac)*</td>
<td>$7,384</td>
<td>$7,770</td>
<td>$385</td>
<td>5%</td>
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<tr>
<td>Gross Profit Margin variation ($/ac)</td>
<td>$6,472</td>
<td>$6,962</td>
<td>$491</td>
<td>8%</td>
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* Priced at $2.60 /lb

<table>
<thead>
<tr>
<th>Site Totals</th>
<th>2017</th>
<th>2019</th>
<th>Change</th>
<th>Change %</th>
</tr>
</thead>
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<tr>
<td>Cost of Water</td>
<td>$1,006,296</td>
<td>$890,310</td>
<td>$(115,986)</td>
<td>-12%</td>
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<tr>
<td>Crop Value</td>
<td>$8,146,165</td>
<td>$8,571,327</td>
<td>$425,162</td>
<td>5%</td>
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| Gross Profit Increase                             | $541,147.90 |

ROI on Hortau’s system: 6.5X
A team of Ag professionals

Hortau at a glance

- 17 years in the business
- 75 employees
- Offices in San Luis Obispo and Canada
- More than 1,000 farms being serviced
- 6500+ monitoring stations deployed
- Full service irrigation advising

For more on the entire Hortau team, visit hortau.com/staff
In-field sensing, analytics and advising to increase crop and farm input productivity
A look inside the company

Patented technology (11 patents)
- Soil sensing technologies
- Multi-variated crop stress management

Trade secrets on
- Machine learning algorithms
- Sensing ceramics
- Polymers

Internal R&D team
- Wireless solar powered devices
- Sensor development
- Machine learning
- Add design and development

Manufacturing:
- Flexible production capacity
- In-house assembly and quality control
Anticipating and managing crop stress can lead to multiple benefits

Increased crop health
- Better quality
- Better uniformity
- Better yields

Better input efficiency
- Water
- Nutrients
- Pesticides

Better reporting and traceability
- SIGMA
- Repeatability of best results
Taking action: easily turn field data into irrigation schedules
## Services currently offered

<table>
<thead>
<tr>
<th>Irrigation Management</th>
<th>Autonomous Irrigation</th>
<th>Weather</th>
<th>Flowmeter Monitoring</th>
</tr>
</thead>
</table>
| On-demand, tension-based, irrigation management service including  
  - Equipment, Wireless, Data storage, Apps and access  
  - Crop stress anticipation with forecasted schedule a week ahead  
  - Field tech support  
  - Grower support | Autonomous irrigation operation and control service including  
  - Equipment, Wireless, Data storage, Apps and access  
  - Three automation mode: remote start, schedule and fully autonomous  
  - Field tech support  
  - Grower support | Local weather monitoring service including  
  - Equipment, Wireless, Data storage, Apps and access  
  - Access to Hortau weather network (in development)  
  - Field tech support  
  - Grower support | Wireless flowmeter monitoring service including  
  - Equipment, Wireless, Data storage, Apps and access  
  - Remote access to flowmeter data from multiple locations  
  - Field tech support  
  - Grower support |
Soil Tension

• Monitoring soil tension allows us to know when to irrigate long before the plant shows any visible sign of stress

• Keeps Stomata open, CO2 flowing in, Vapor Transpiring out, and nutrients flowing through the plant.

• Health, yield, and growth are optimized

• Critical physiological periods can be understood and controlled
The Right Tech

• More than 15 years experience developing product

• We have gone through the paces to know what works and what does not

• Continuous R&D to further develop hardware and software
The Right Support

• Complete service package
  • We take care of it all
    • Installation
    • Maintenance
    • Updates
    • Training
    • Analysis
    • Troubleshooting
    • Irrigation Schedule
Why Hortau?

Committed partner
- 15 years in Ag business
- More than $10M invested on crop research and technology development
- In-field support specialists
- Service approach
- ROI season after season

Data
- Direct soil tension
- Integrated weather measurement
- Crop stress anticipation
- Real-time, actionable reports
- Accessible by any device
- Complete automation

Expertise
- Team of farm experts and agronomists
- Trusted advisor relationships, built by farmers for farmers
- 24/7 support, data stream reliability
- Grower support
- Tech support
Connecting the dots between Ag and tech

Hortau’s team includes graduates, M.Sc. and Ph.D in:
• Soil science
• Crop science
• Soil physics
• Soil bio-chemistry
• Ag engineering
• Ag business
• Certified Crop Advisors

Team members grew up on a farm and have many years of industry experience.

Agronomic support and training
Direct technical support
Precision farming made easy

Hortau’s team relentlessly help **bridge the gap** between the field and the office.
Creating tangible and sustainable on-farm value

- Reduce water and energy usage by 20 to 35%
- Increase yield by 10 to 50%
- Increase quality and uniformity
- Virtually eliminate fertilizer losses through leaching
- Keep crops healthy, minimizing the impact of pests and diseases
- Reduce pesticide usage
- High ROI – 5X to 30X

**Strawberry Research**
- 17% yield increase
- 35% water savings
- Near-zero fertilizer leaching

**Almond Research**
- 16% yield increase
- 24% water savings

**Cranberry Research**
- 20% to 50% yield increase
- 5X less water consumption

**Lettuce Research**
- 18% yield increase
- 10% - 20% less tip burn
- Profitability $500 to $4,000 per acre
Mites present in orchard

Leaf Drop