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Development and Testing of a Mobile Platform for Measuring Canopy Light Interception and Water Stress in Almond

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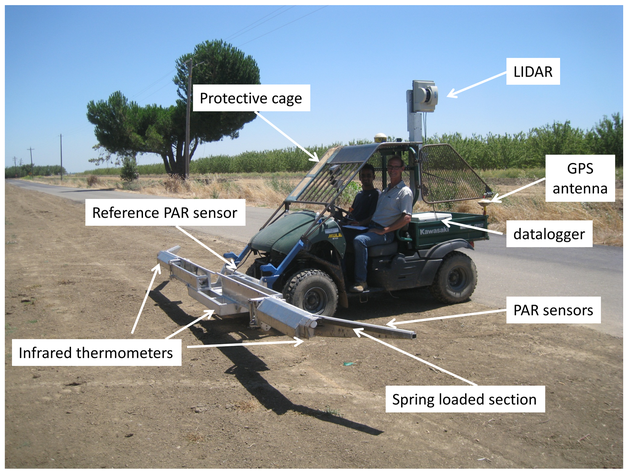

Introduction:

The mobile platform lightbar has now been in use for six years and has proved useful for evaluating productivity in almond. An iPhone app for measuring midday canopy light interception has been developed as an outgrowth of this project and is currently on trial with farm advisors and select growers.

Objectives:

Objective 1- Use the mobile platform mounted lightbar to measure light interception and relate that to yield data from the same area in almond orchards throughout the almond growing area of California. The goal of this is to provide support to other researchers with various irrigation, rootstock, variety, methyl bromide alternatives and other trials as well as to develop our yield/PAR relationship as related to age, spacing, etc.

Objective 2- A mobile sensor suite as well as a continuous leaf monitor were developed and evaluated to predict plant water status by measuring the leaf temperature of almonds. This work is described in Poster #72.

Objective 3- Complete and release a working version of the iPhone app to calculate canopy light interception

Results:

Objective 1. The mobile platform lightbar was utilized in a total of 21 almond orchards in 2015. Data collected has provided a rough upper limit to productivity in almond with the best orchards able to produce about 50 kernel pounds for each 1% of total incoming midday canopy photosynthetically active radiation (PAR) that is intercepted or potentially about 4000 kernel pounds at 80% PAR interception. An example of a high yielding orchard is the site for the McFarland Variety Trial shown in Fig. 2a (described in more detail in Poster #55). The Nonpareil in this trial have averaged well above the optimal line while the pollenizers have been somewhat below the line. These differences are likely due to a combination of genetic variability combined with tree height differences. Figure 2b shows data for pruned versus unpruned Nonpareil trees at a spacing 0' x 22'. Both the pruned and unpruned averaged treatments were just below the optimal line.

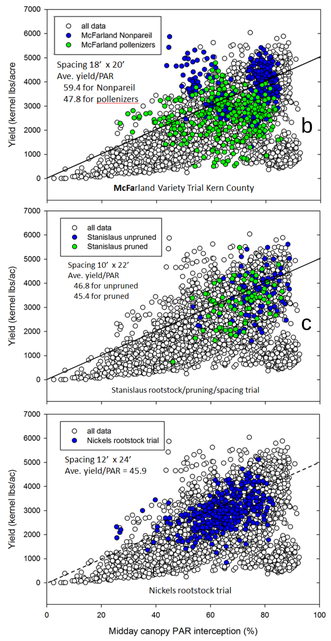

Fig. 1. Midday canopy photosynthetically active radiation (PAR) interception versus yield for (a) McFarland Variety trial Nonpareil versus pollenizers, (b) Stanislaus County unpruned, and (c) Nickels Soil Lab almond rootstock trial.

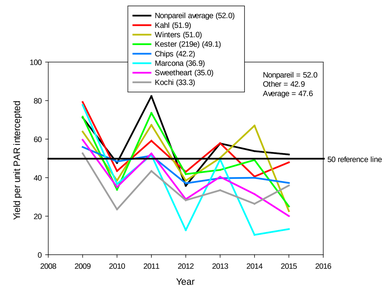

Fig. 2. Yield per unit PAR intercepted by treatment and variety or selection for 2009-2015 seasons at the McFarland variety trial.

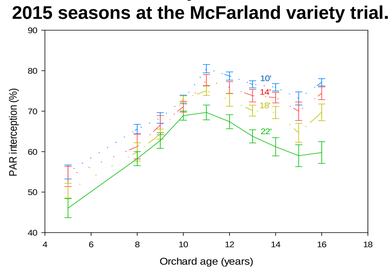

Fig. 3. PAR interception for the 5th through 16th year for Nonpareil trees in a trial in Stanislaus County spacing trial

Figure 2c shows data for the Nickels Soil Lab rootstock trial. This orchard is 18 years old and at a 22' x 24' spacing yet is still producing good yields for it's canopy size.

The yield per unit light intercepted (yield divided by light interception) can be used to compare productivity of different varieties. Figure 2 shows the yield per unit light intercepted for the varieties and selections from a variety trial in McFarland over 7 years. This figure, along with the statistics not shown, suggests that there are differences in productivity per unit light intercepted among varieties. This is likely due to tree height differences. If the previous year yield is known, this information can be used to more accurately predict current year yield based on the current year light interception. The plan is to incorporate nitrogen and water needs into the app based on ongoing work. Fig. 3 shows the light interception pattern for an almond spacing trial in Stanislaus County (yields commonly peak at about 12 years).

Objective 3- The iPAR iPhone application is able to estimate canopy light interception from photographs of the orchard floor shadows. Fig. 4 shows a flow chart diagram describing the iPAR iPhone app.

- Take photos of ground shadows within one hour of solar noon
- Avoid branches hanging down into view of orchard floor
- Take at least 5-10 photos that span variability of orchard
- Process images in polygon delimited by 4, 6 or 9 tree trunks
- Image is processed by flattening view and converting to black and white pixels
- User can choose to discard or reprocess problematic images
- Output can be sent to the screen as well as to an emailed PDF file
- App provides estimate of yield potential based on canopy size
- This can eventually be used as an aid to estimating nitrogen and water needs

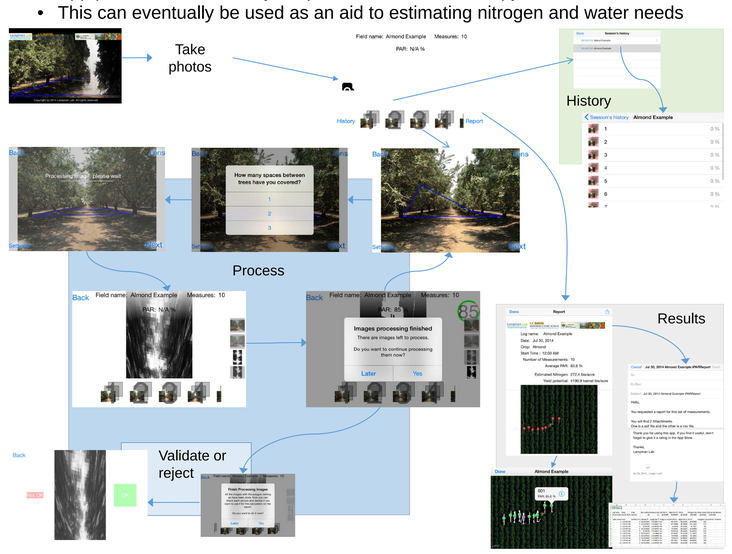

Fig. 4. Flow chart showing iPhone application image capture and processing.

Current and future uses of this technology:

- Investigate light interception/yield relationship (ongoing)
- Adjust treatments for relative canopy area in any type of study such as pruning trials (ongoing)
- Evaluate performance of new cultivars- separate out effect of faster tree growth versus higher productivity per unit canopy light interception (ongoing)
- Investigate role of orchard floor temperature on food safety risk
- Evaluate impacts of different pruning and training treatments on light interception and productivity
- Aid in assessing value of orchards

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Mechanical Hedging to Manage Mature Almond Orchards

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Introduction and Materials and Methods:

An almond orchard site was selected for the hedging trial in Kern County.

- Planted in 2000
- 50% Monterey, 25% Nonpareil and 25% Wood Colony
- 21' by 24' spacing
- Hedged once previously about 3 years earlier
- Midday canopy light interception and yield were measured before hedging treatments were applied
- Hedging treatments were applied in the Fall of 2013
  - Unhedged control
  - 28" vertical hedge cut
  - 38" vertical hedge cut
  - 48" vertical hedge cut
- 12 replications covering approximately 75 acres
- Midday stem water potential measured
  - 2 trees per replication on all 3 varieties and hedging treatments
  - 8 dates in the summer of 2014 and 7 in 2015
- Midday canopy light interception measured in 2014 and 2015
- Yield measured on Nonpareil before treatments were imposed in 2013 and on Nonpareil and Monterey in 2014 and 2015

Results:

In 2013 before treatments were imposed there were no significant difference in yield, light interception or yield per unit light intercepted (Fig. 1). In 2014 after hedging treatments were imposed, midday canopy light interception was significantly decreased in all 3 hedged treatments in Nonpareil but only in the 48 inch treatment in Monterey (Fig. 1). The magnitude of the differences in light interception was quite small with only a 3 to 4% difference between the unhedged and 48 inch hedging (Table 1).

Table 1. Midday canopy photosythetically active radiation (PAR) interception, yield and yield per unit PAR intercepted by treatment, variety and year. 2013 data for Nonpareil was collected the season before treatments were imposed.

Nonpareil

	Hedging Treatment	PAR interception (%)	Yield (kernel lb/ac)	Yield per unit PAR intercepted
2013	Unhedged	78.8 a	3226 a	40.9 a
	28 inches	78.9 a	3178 a	40.3 a
	38 inches	78.1 a	3351 a	42.9 a
	48 inches	77.5 a	3192 a	41.2 a
2014	Unhedged	76.5 a	2414 a	31.6 a
	28 inches	74.4 b	2274 a	30.7 a
	38 inches	73.2 bc	2287 a	31.3 a
	48 inches	72.2 c	2337 a	32.4 a
2015	Unhedged	78.0 a	2735 a	35.0 b
	28 inches	76.6 ab	2662 a	34.7 b
	38 inches	75.5 b	2789 a	36.9 ab
	48 inches	74.5 b	2874 a	38.6 a
2014 + 2015 sum	Unhedged	77.8 a	5149 a	35.8 a
	28 inches	76.8 ab	4936 a	35.3 a
	38 inches	75.7 b	5076 a	37.0 a
	48 inches	75.0 b	5211 a	37.3 a

Monterey

	Hedging Treatment	PAR interception (%)	Yield (kernel lb/ac)	Yield per unit PAR intercepted
2014	Unhedged	72.7 a	2277 b	31.3 b
	28 inches	71.0 ab	2457 ab	34.7 a
	38 inches	71.2 ab	2408 ab	33.8 ab
	48 inches	70.5 b	2526 a	35.8 a
2015	Unhedged	70.9 a	2388 a	33.7 a
	28 inches	69.3 b	2349 a	33.8 a
	38 inches	69.1 b	2372 a	34.2 a
	48 inches	67.9 b	2443 a	35.9 a
2014 + 2015 sum	Unhedged	70.1 a	4665 a	33.3 b
	28 inches	68.6 ab	4806 a	35.1 ab
	38 inches	68.5 ab	4780 a	34.8 ab
	48 inches	67.4 b	4969 a	36.8 a

Monterey and Nonpareil combined average

	Hedging Treatment	PAR interception (%)	Yield (kernel lb/ac)	Yield per unit PAR interceptec
2014 + 2015 sum	Unhedged	74.4 a	4907 a	34.8 b
	28 inches	73.1 ab	4806 a	35.2 ab
	38 inches	72.6 b	4928 a	36.1 ab
	48 inches	71.7 b	5090 a	37.1 a

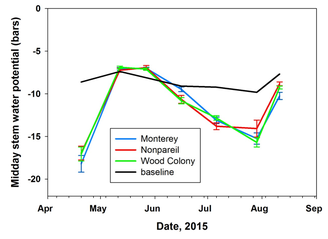

Figure 1. Midday stem water potential over the 2015 season by variety

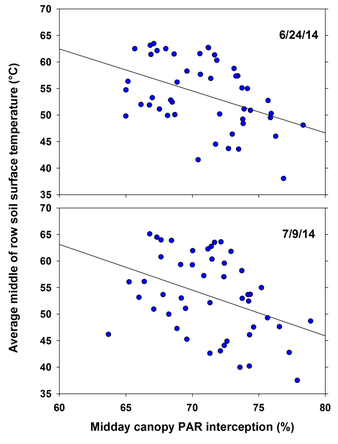

Figure 2. Soil surface temperature in the middle of the drive row as related to midday canopy photosynthetically active radiation interception on two dates in 2014

There were no significant hedging treatment effects on midday stem water potential (data not shown) and very minor differences among varieties with Monterey being less stressed on the June data collection date in 2015 (Fig. 1).

There was a 0.9°C (1.8°F) decrease in center of drive row soil temperature for each 1% increase in PAR (Fig. 2). This would result in a 3.6°C (6.5°F) drop in temperature for the average treatment difference in PAR for the Monterey (Table 1). This could have food safety implications.

Although there was a trend towards a decrease in yield with increasing severity of hedging in Nonpareil in 2014, there was actually a significant increase in yield in Monterey for the 48" hedge compared to the unhedged control. This is likely because the Monterey were smaller in stature and therefore the cuts on the adjacent Nonpareil allowed more light to reach the Monterey. For the two years following hedging, there were no significant differences in cumulative yield for either the Nonpareil or Monterey (Table 1).

Conclusions:

Under the conditions of this trial, there were not any significant negative impacts of any of the hedging treatments on cumulative yield for the two years following treatment imposition. There may be benefits of hedging since in terms of food safety risk since soil surface temperatures in the middle of drive were increased making it easier to dry nuts.

Acknowledgements: This work was supported by the Almond Board of California and The Wonderful Company