UC DAVIS DEPARTMENT OF PLANT SCIENCES

Utilizing Canopy Light Interception/yield Potential Data to Improve Management of Almond

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Introduction:
The mobile platform lightbar has now been in use for seven 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) The first component of this project involves using the mobile platform lightbar to measure light interception and corresponding yield in almond orchards throughout the almond growing area of California. The goal of this aspect of the work is to help establish the upper limit to the light interception/yield relationship for almond (shown in Figure 1) as well as to use these data to investigate the relationship between productivity and productivity per unit light intercepted.

• Objective 2) The Second objective was to complete calibration of the iPhone app for measuring midday canopy PAR interception and release it on a trial basis to farm advisors and select growers.

Results:
• Objective 1. The mobile platform lightbar was utilized in a total of 21 almond orchards in 2016. 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. Figure 1 shows the data from all years summarized into 6 different categories. The best orchards in trial have produced in the good range over multiple years. An example of a high yielding orchard is the site for the McFarland Variety Trial shown in Fig. 2a. 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. 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 3 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. Fig. 3 shows the light interception pattern for an almond spacing trial in Stanislaus County (yields commonly peak at about 11-12 years).
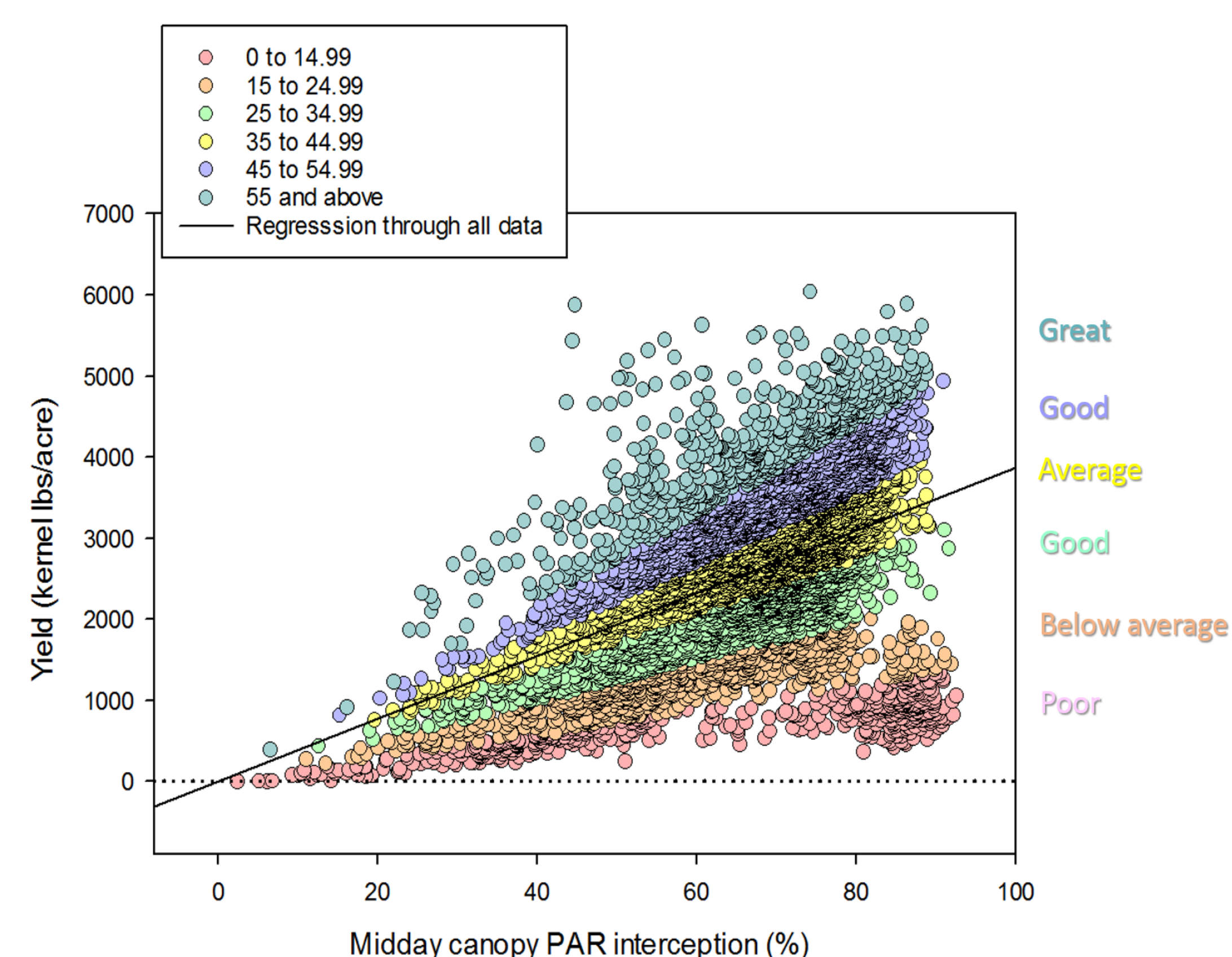

Fig. 1. Midday canopy photosynthetically versus yield for data for all years. Black regression line shows average for all data. The best orchards in our trials have produced in the good range over 3 or more years.
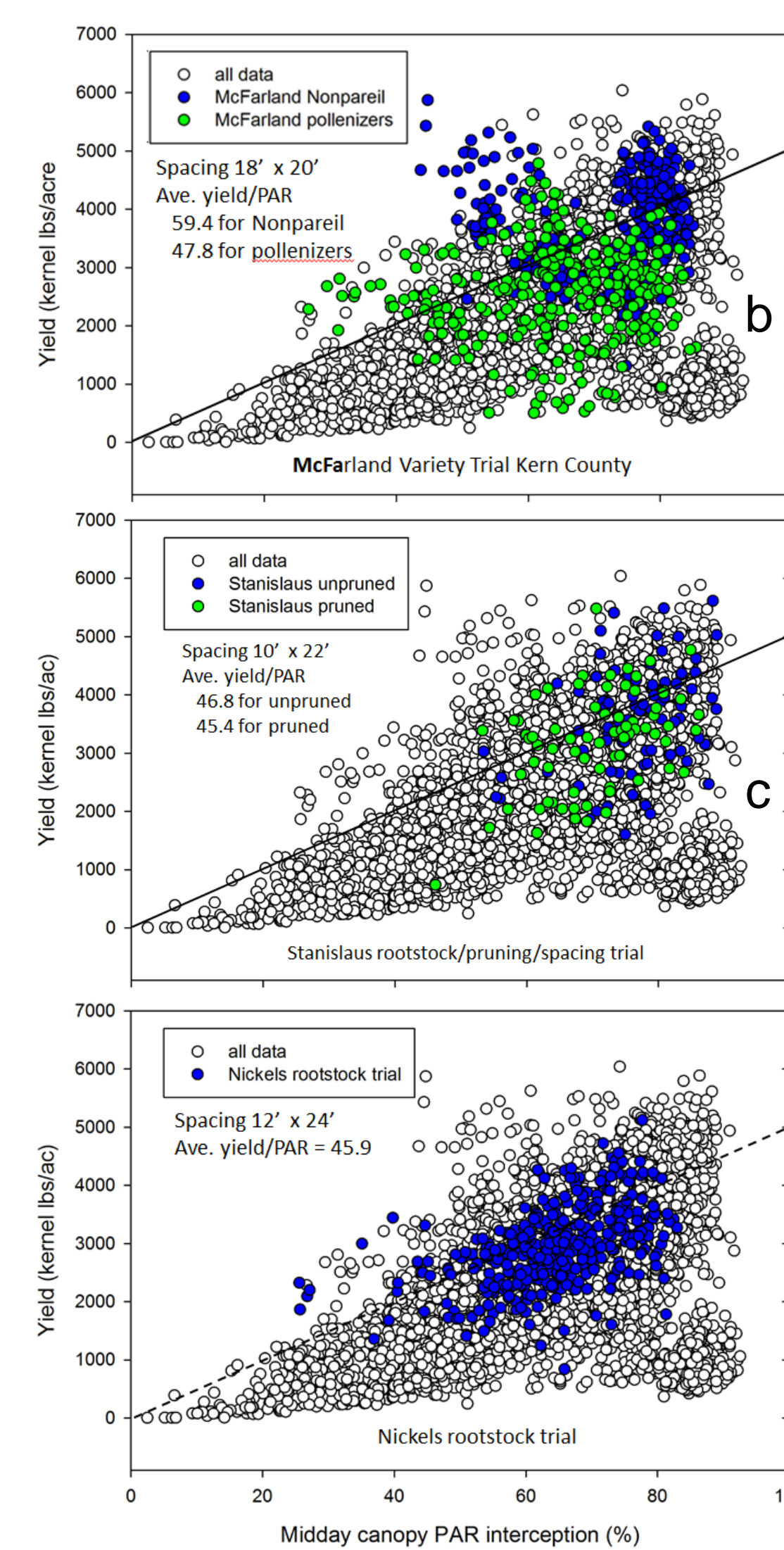

Fig. 2. Midday canopy photosynthetically active radiation (PAR) interception versus yield for (a) McFarland Variety trial Nonpareil versus pollenizers, (b) Stanislaus County unpruned, and (c) Nickels Soil Lab almond rootstock trial. Black regression line indicates point about which the best orchards can alternate.

Fig. 3. Yield per unit PAR intercepted by treatment and variety or selection for 2009-2015 seasons at the McFarland variety trial.

Fig. 4. PAR interception for the 5th through 17th year for Nonpareil trees in a trial in Stanislaus County spacing trial

Objective 2- The iPAR iPhone application is able to estimate canopy light interception from photographs of the orchard floor shadows. Fig. 4, 5 and 6 show screen shots and ouput from the iPAR iPhone app. Fig. 7 shows data from (a) the mule light bar versus hand processed images of orchard floor shadows using ImageJ, (b) mule light bar versus the iPAR app with some bad points included (with a wet drip irrigation pattern impacting results), and (c) the same data with the bad points removed. The relationship between the mule light bar data and the iPAR app are good as long as all the factors listed below are taken into account.

- Take photos of ground shadows within one hour of solar noon
- Avoid branches hanging down into view of orchard floor
- Avoid taking photos when shortly after irrigation when the wetted pattern is distinc
- 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 a report on 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

Data on midday canopy light interception collected with the modified mobile platform suggests that there are a number of potential uses for this technology. The first is for providing a baseline for assessing how an orchard is performing relative to other orchards of similar age and variety. Another is for separating out the effects of rate of canopy growth from productivity per unit canopy light intercepted by different clones or
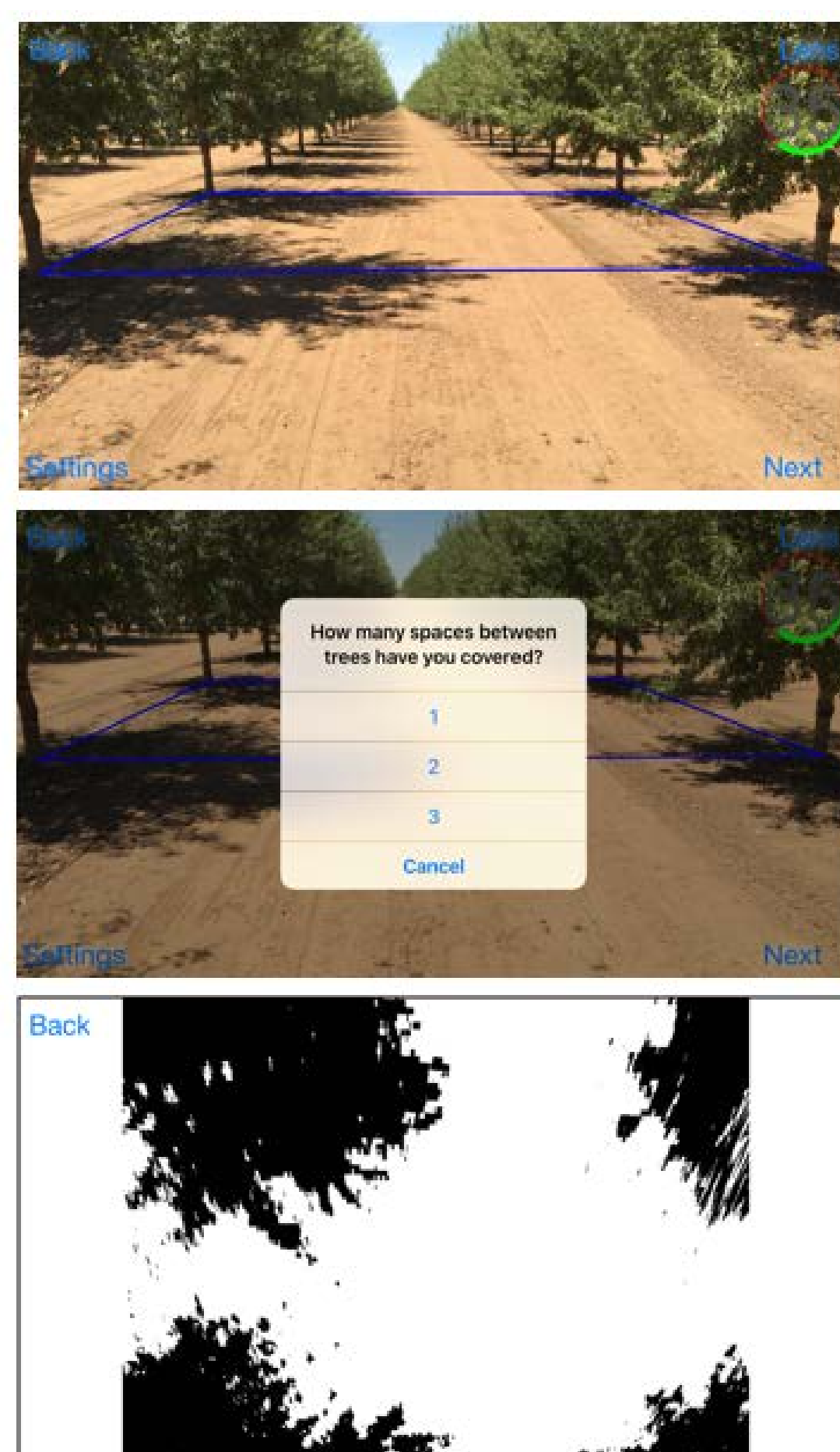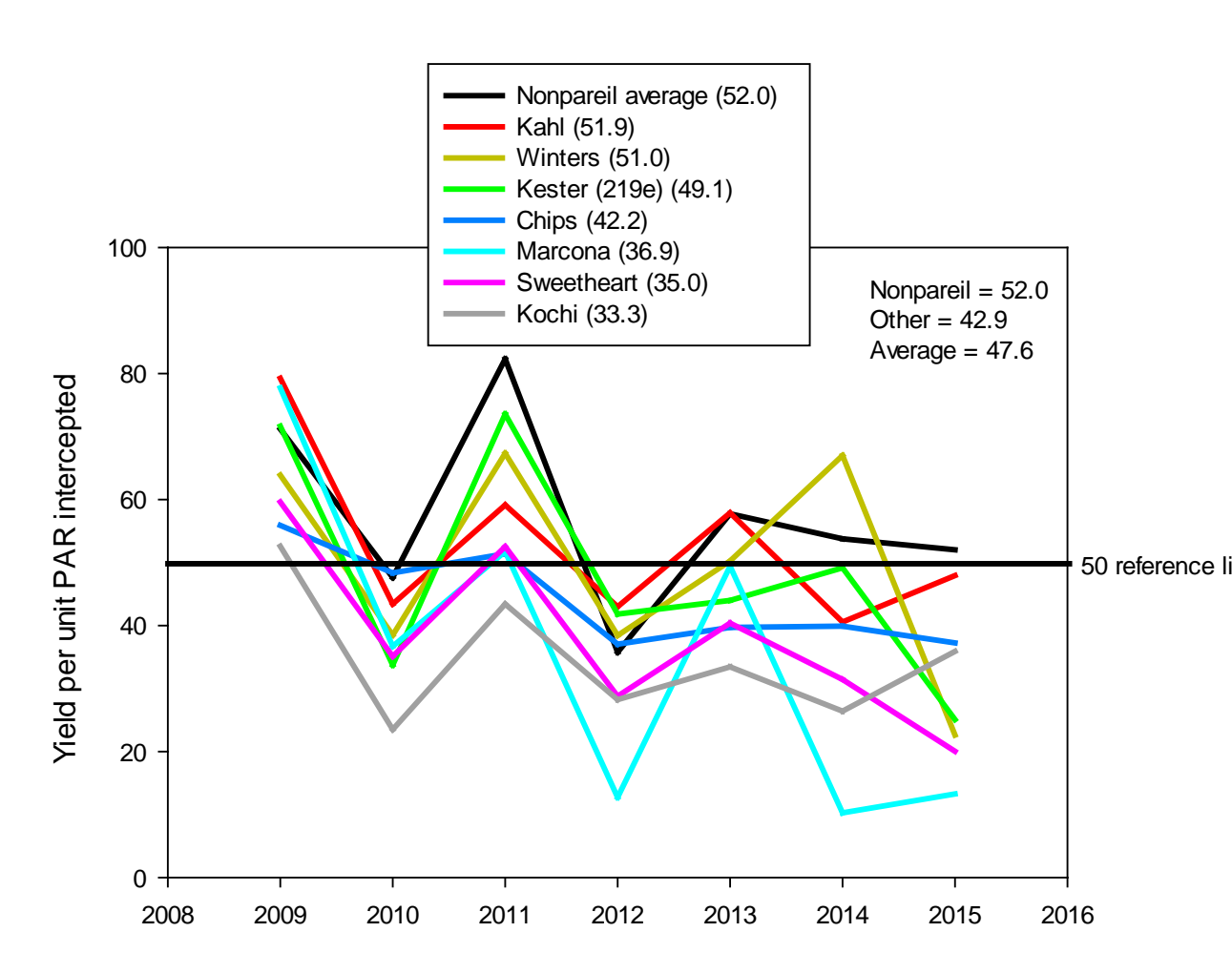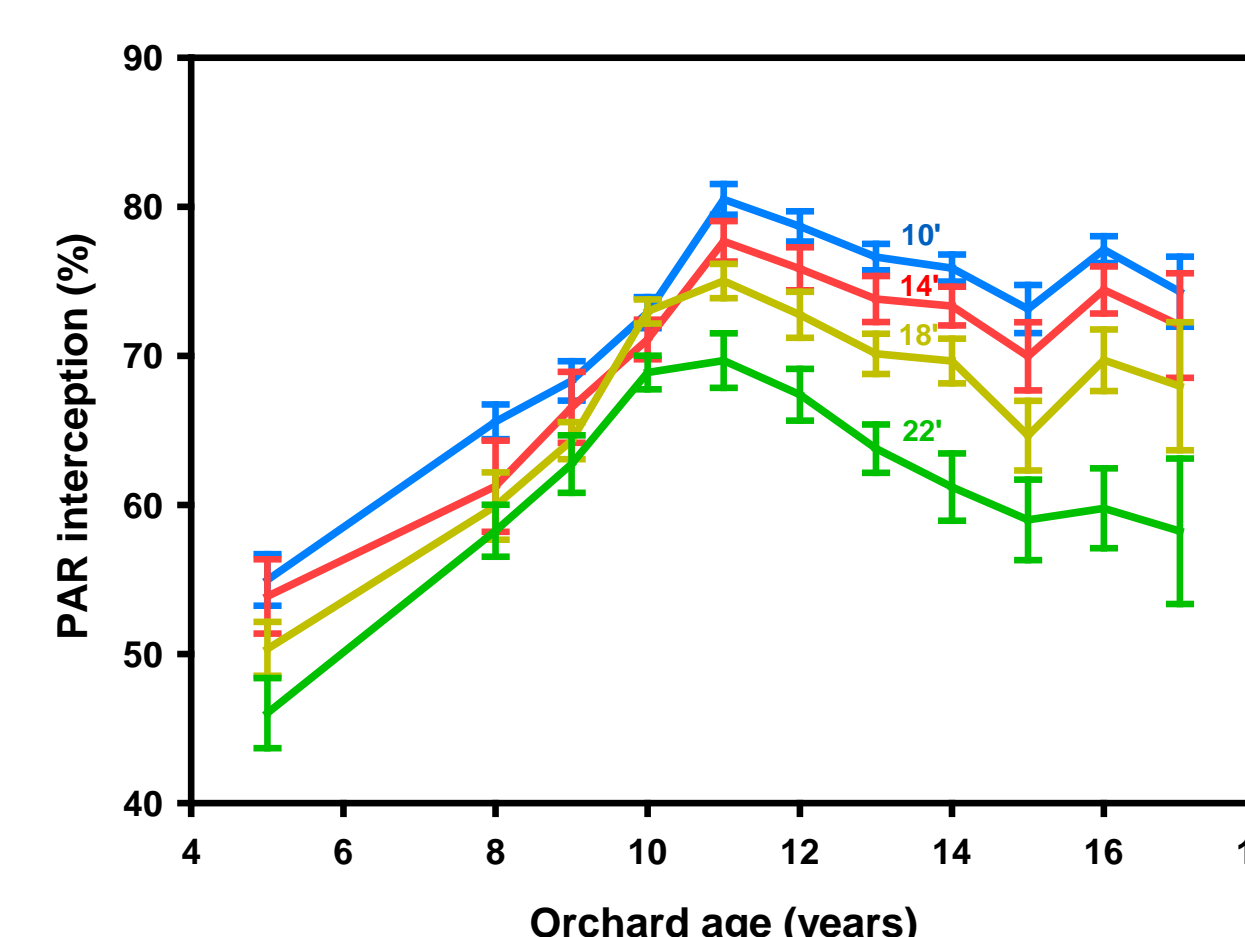

Figure 5. Screenshots from the iPhone app showing (top) image of orchard floor with trapezoid to denote area between 4 tree trunks, (middle) prompt asking if 1,2 or 3 tree spaces were covered, and (bottom) image that has been orthocorrected and converted to a black and white image for pixel counting.

Field name: Joe Martinez Call Menz
Date: Sep 8, 2016   Start Time: 3:29 PM
Crop: Almond
Number of Measurements: 9
Average PAR: 53 %
Water requirements: 37.9 inches
Estimated Nitrogen: 131 - 182 lbs/acre
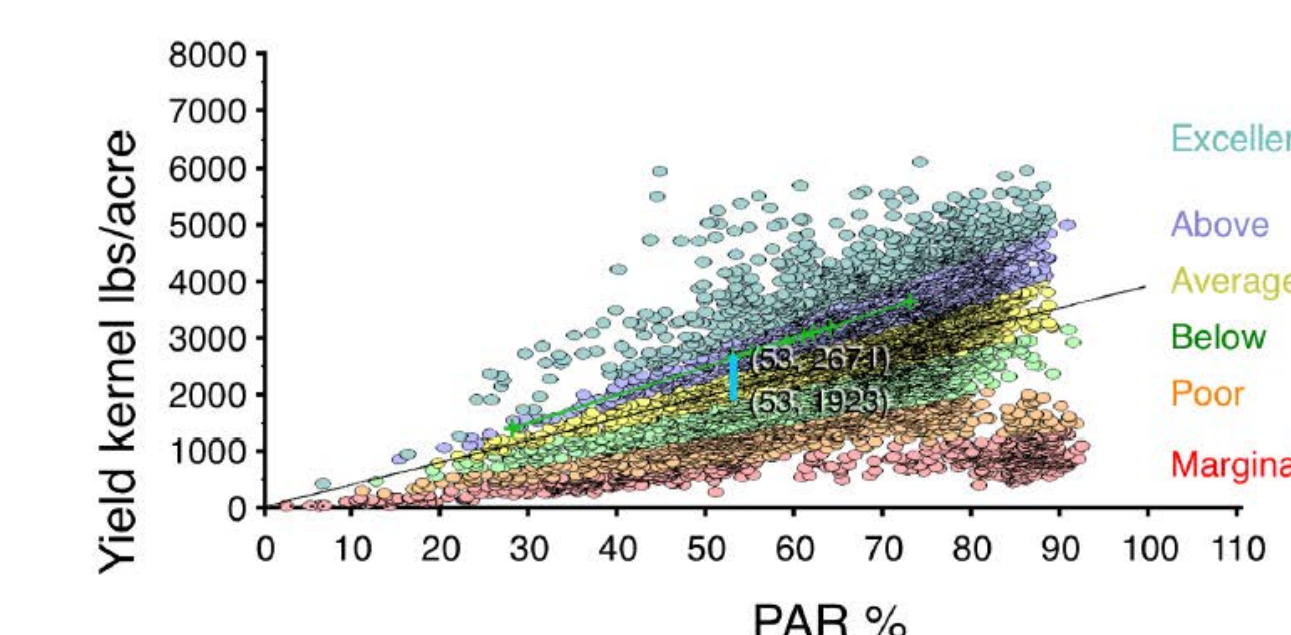Yield potential: 1923 - 2671 kernel lbs/acre

Figure 6. Report generated by the app. The report can also be sent to recipient by email from iPAR app. A more detailed report showing data for each individual photo can also be sent in an Excel file format if desired.
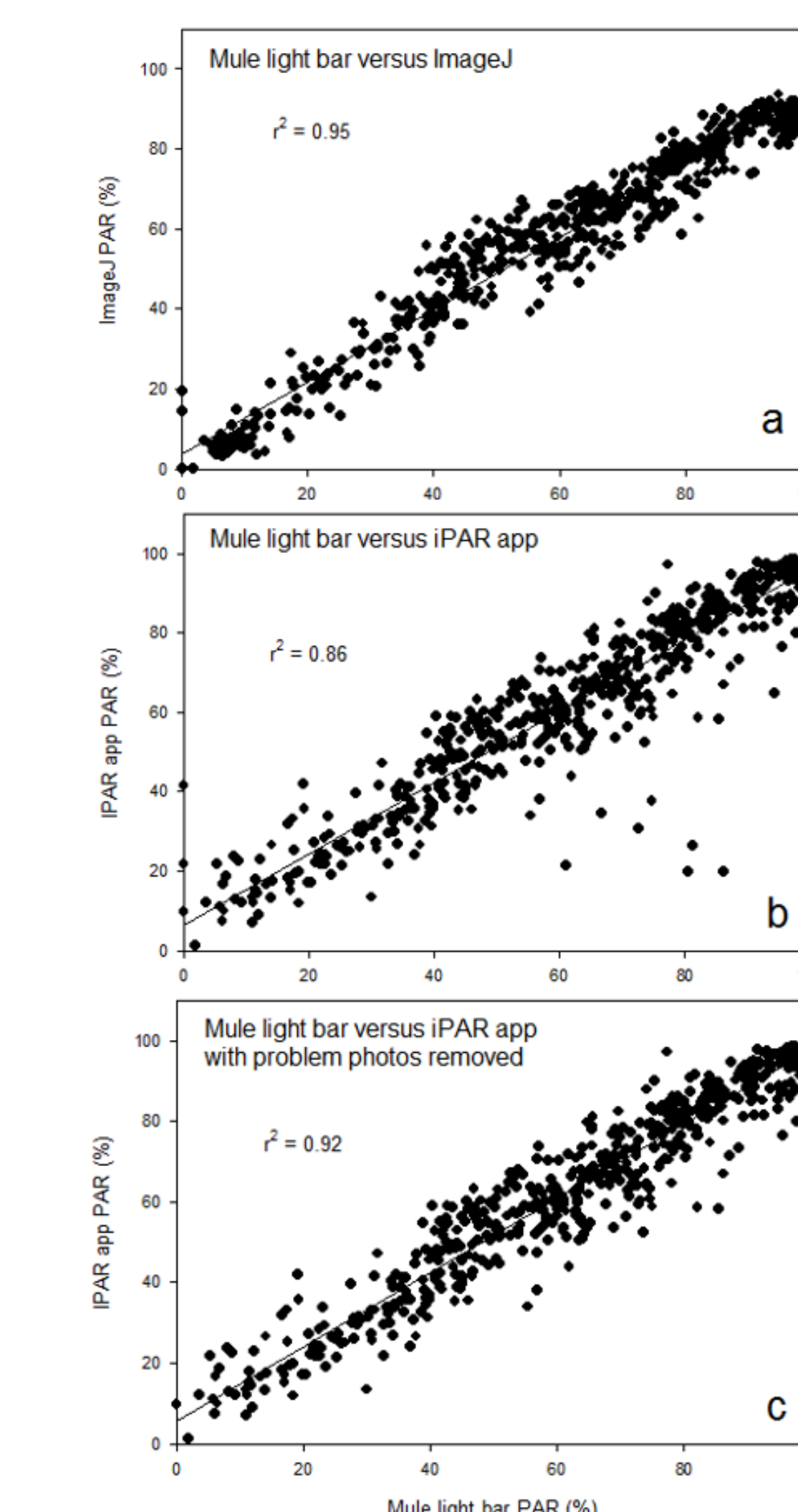

Fig. 7. Photosynthetically active radiation (PAR) interception versus PAR estimated from ground shadows using ImageJ (a), and the iPAR app (b). Points in Fig. 14b on lower right were all from orchards with a wet area around the drip tubing and this caused problems with the photos such that only the wet area was interpreted as shadows. Fig. 14c has these points removed. The recommendation based on this is to not do iPAR photos for several days after irrigation.

ivarieties. The measure of productivity per unit PAR intercepted is proving to be a very useful tool for analyzing orchard performance. A third potential use is for assessing the efficacy of different fumigants by again separating out the effects of canopy size from productivity per unit light intercepted. This information is very useful in evaluating new selections and varieties for their production potential before they reach full canopy size. Additional investigations using this technology include looking at the effect of tree spacing and orchard age on productivity per unit light intercepted. This technology also allows the elimination of canopy size differences from any type of research trial. These data are being used in a wide range of almond research project statewide as well as for providing ground truthing for remotely sensed (aerial and satellite) imagery. Two publications describing the mobile platform light bar are listed at the end of the report.

The iPhone app for estimating light interception was field tested and refined during the 2015 and 2016 seasons. The output was also compared extensively to estimates of PAR interception from the Mule light bar as well as to images processed manually by ImageJ. It performed well and the iPAR app is currently available in the Apple App Store.

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