Imaging Alfalfa to Predict Yield and Quality and Impacts of Water Deficits Using Innovative Overhead Irrigation Systems

Daniel Putnam, Umair Gull, Isaya Kisekka, University of California-Davis

RATIONALE & OBJECTIVES

- Overhead irrigation delivery systems offer the possibility of improvements in yield and water productivity (yield per unit water applied).
- With limited water, reduced irrigation applications are required currently and in future.
- Unmanned aerial vehicle systems (UAVs) have provided new tools for imaging agricultural fields for diagnosis, detection of stress, and for modelling yield and quality in the field.

Objectives:

To determine the effects of improved overhead sprinkler systems with Low Elevation Sprinkler Application (LESA) and Mobile Drip Irrigation (MDI) on alfalfa performance under full and reduced irrigation practices.

To develop an image-to-yield relationship using multi-spectral and LiDAR (Light Detection and Ranging) drone imagery for alfalfa under various deficit irrigation conditions.

RESEARCH DESCRIPTION

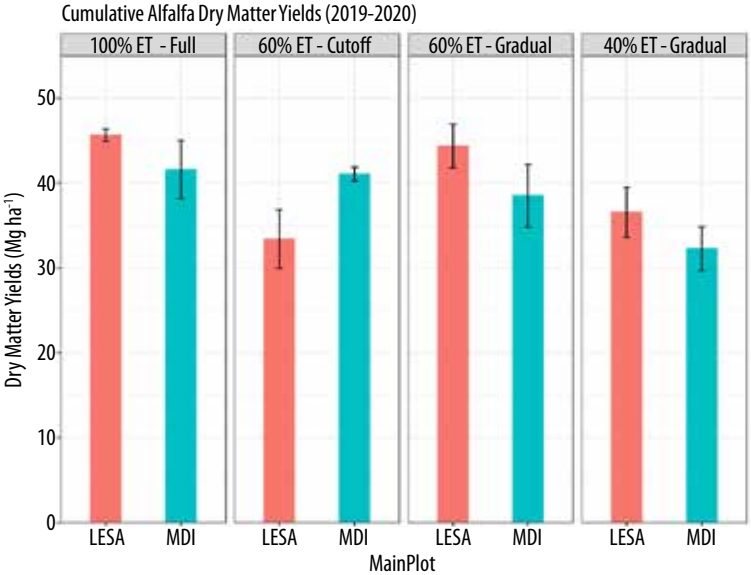
A research trial with cultivar Magna 715 (Fall dormancy 7) was established 9 October, 2018 at Davis, CA, on a Yolo Silt loam soil under an overhead linear sprinkler system in a Split Plot Design, and conducted in 2019-21. Irrigation systems were the main plots. Irrigation treatments were sub-plots. MDI (dragging drip lines on the surface) were compared with LESA (sprays close to the ground, Figure 1) under four irrigation treatments: 100% of seasonal ETc requirement, 60% ETc, summer cutoff, 60% ETc sustained deficit (each cutting), and 40% ETc sustained deficit. Yields were measured, with hundreds of samples taken for yield prediction equations. Quality was determined with NIRS. Multi-spectral images were taken and LiDAR images taken in separate flights. A wide range of models were tested to understand the best prediction tools for predicting yield and forage quality.

Figure 1. Overhead Experimental unit, UC Davis Plant Sciences Farm.

RESULTS

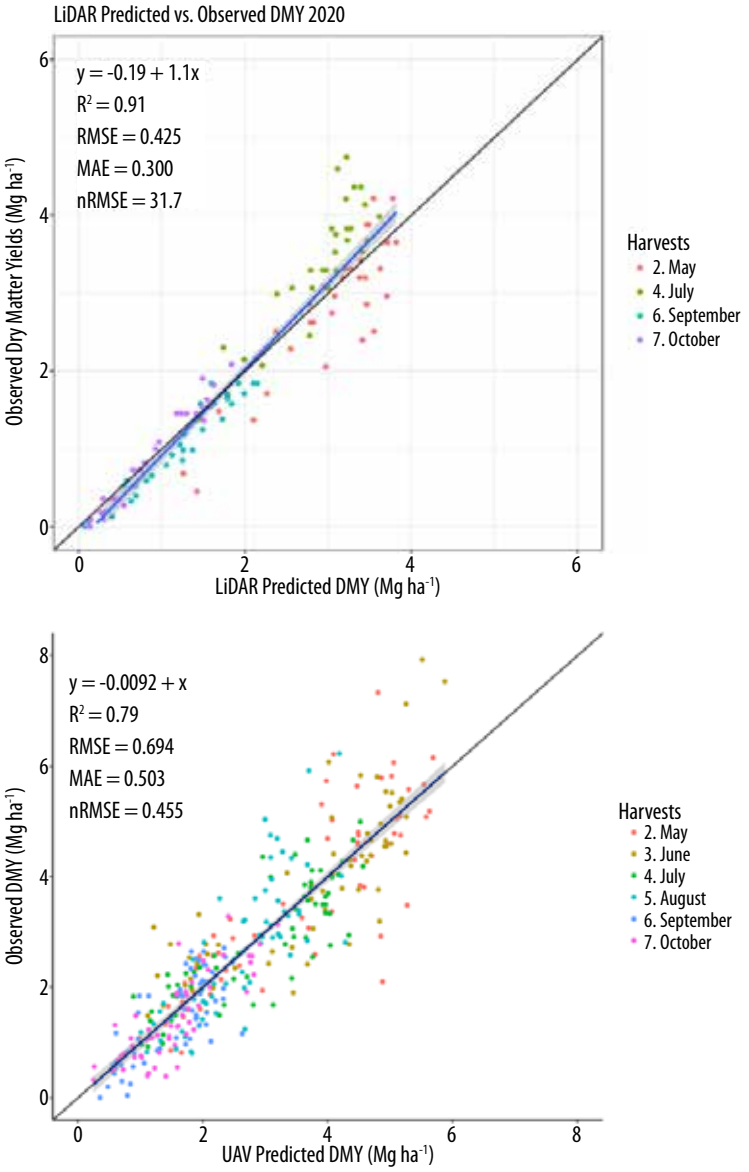
- Generally, MDI and LESA performed similarly, but MDI performed better with the summer cutoff treatment, and the LESA performed better with the gradual deficit treatments. MDI likely delivered more sub-surface moisture. Both are innovative improvements in overhead irrigation.
- Between 77-95% of full yields were achieved with the deficit strategies tested (Figure 2).

Figure 2. Two-year cumulative dry matter yields of alfalfa with LESA and MDI systems, and various water deficits, 2019-2020. To convert to t/acre, multiply X 0.446.



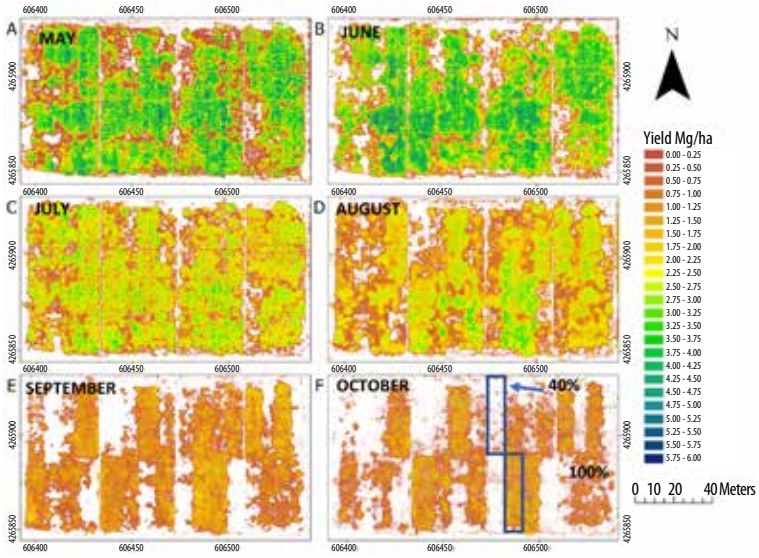
- Both Multi-spectral and LiDAR imaging approaches were effective at prediction of plant height and yield (Figure 3). Imaging was less effective at prediction of forage quality.

Figure 3. Relationship between LiDAR (top) and Multispectral images (bottom) using appropriate equations to predict yield. To convert to t/acre, multiply X 0.446.



- Yield maps over the season describes crop yield response to drought (Figure 4).

Figure 4. Alfalfa Yield map over the season using the UAVs for the second year of deficits (2020) showing progression of the severe drought plots over time. Imaging enables yield estimations to account for the spatial variation within plots, with soils, and across the field. Note range of yields. Example of 100% and 40% ETc plots are shown. To convert to t/acre, multiply X 0.446.



CONCLUSIONS

This experiment examined the utility of MDI and LESA sprinkler approaches to overhead irrigation, each of which have advantages over older systems. Deficit irrigation practices confirmed the ability to partially irrigate alfalfa with some yield losses, but production remains viable. High early cuttings were key to maintenance of yield under deficits. Both Multi-spectral and LiDAR images were successful in prediction of yield and generating yield maps across highly variable areas. This offers the ability to integrate treatment affects across a wider range of soil variability. Applications include more accurate yield estimations and diagnosis of field limitations. Further work to confirm application of prediction equations over larger fields and landscapes would be warranted.

Alfalfa
U.S. Alfalfa Farmer Research Initiative

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