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Sustaining Alfalfa productivity under limiting water resources

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Background: Water limitations for agriculture may increase in the future due to the need to meet the challenge of feeding 9.7 billion people by 2050 (UN 2015). Additionally, frequent droughts will force hard decisions about water use by crops. The 2011-17 drought, where 46% of CA was under drought was fortunately alleviated in 2017-19 (Figure 1). These uncertainties mean that we need to think about more efficient ways of managing water and how to sustain productivity of major high quality forage crops like alfalfa, which is necessary for the state's #1 agricultural enterprise: dairy. Additionally the California Sustainable Groundwater Management Act (SGMA) will force hard decisions about water allocations on farms and in irrigation districts. Fortunately, alfalfa has many characteristics that may assist in meeting these challenges: particularly the flexibility to 'deficit irrigate' during times of water storage. These experiments were implemented to explore the various strategies for deficit irrigation of alfalfa.

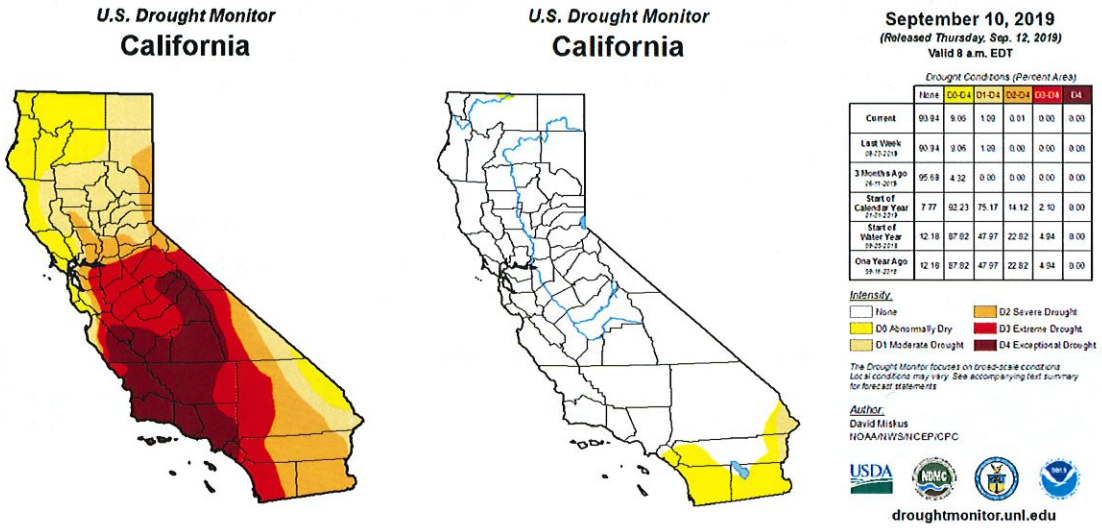

Figure 1 Drought conditions in California (left-October 2016, right-September 2019)

Sub-surface drip irrigation (SDI) can deliver water in small quantities, carefully meeting crop evapotranspiration demands (ET_c). SDI can deliver water near the root zone and eliminate surface wetting. SDI can potentially increase the forage yield and quality when water is scarce or limited, and improve distribution uniformity. The main limitations of SDI in alfalfa are the cost and maintenance of the system, particularly with rodent issues. Keeping in view the advantages of SDI, the study was designed to test the viability of SDI in alfalfa as compared with flood irrigation to understand the impact of deficit irrigation on yield, quality and water productivity.

The objectives of current study were:

- To quantify the water productivity, forage quality, and yield of alfalfa in SDI vs. Surface irrigation.
- To understand the impact of deficit irrigation on yield, quality and stand.

- To determine the use of infrared thermometry and other imagery to assist in management

Methodology: The experiment was conducted at Kearney REC on a sandy loam soil as a randomized completely block design with four replications. Alfalfa was planted on October 18, 2016. The drip tapes were spaced at 30" apart and 12" deep (Figure 2). To monitor the water status of the soil, Watermark sensors were installed at 12", 24" and 48" depth (Figure 3). The treatments were

- T_1 (Flood under current common practice)
- T_2 (SDI 50% Deficit, Midseason cutoff)
- T_3 (SDI 75%, Late Summer cutoff),
- T_4 (SDI 75%, Gradual deficit to 25%),
- T_5 (SDI Full irrigation to 100% of ET)

Figure 2 Connecting sub-surface drip lines with water supply at Kearney. There were 6 lines to irrigate different sections.

Irrigations were scheduled using the reference ET (ET_o) from the CIMIS Station 39 Parlier and estimating the ET_c. The flood irrigation was applied following the common grower practice of one-two irrigations per growth cycle while the SDI treatments were irrigated every other day as soon as the bales were removed till two days before the next harvest. The crop was harvested every 28 days and data on harvest yield, forage quality and water use were recorded. Thermal Infrared camera was used to monitor the crop temperature for the stressed and non-stressed vegetation during the study period.

Figure 3 Monitoring soil moisture using the water marks (left), soil water tension in centibars of fully irrigated treatment under SDI (right) at three depths (12"-green line, 24"-purple line, 48"-blue line)- higher value indicate dry conditions

Results:

During the two years study period, it was found that SDI has the potential to increase forage yield and quality while improving the water productivity. SDI 100% full had a higher dry matter yields along with the higher water productivity during 2017 while in 2018 the yield was not

significantly different. There was a slight increase in forage quality including crude protein and digestibility averaged over the two seasons. A significant variation was observed between the plots once the deficit irrigation was imposed.

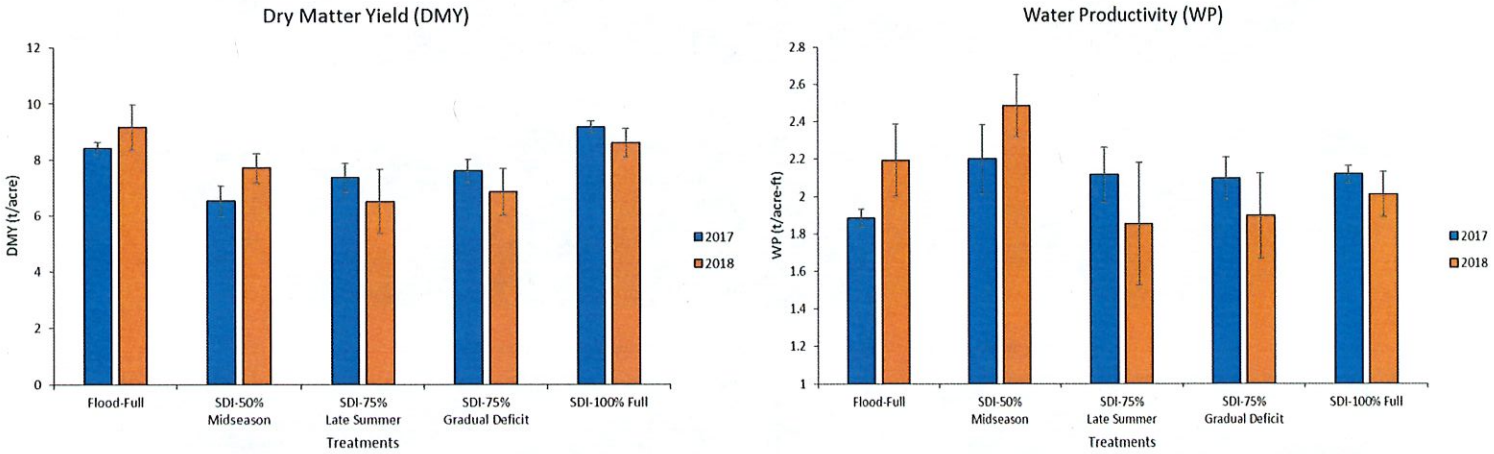

Figure 5 Dry matter yield (DMY) in tons/acre and water productivity in tons/acre-feet for year 2017 and 2018. The WP was calculated using seasonal DMY and water applied.

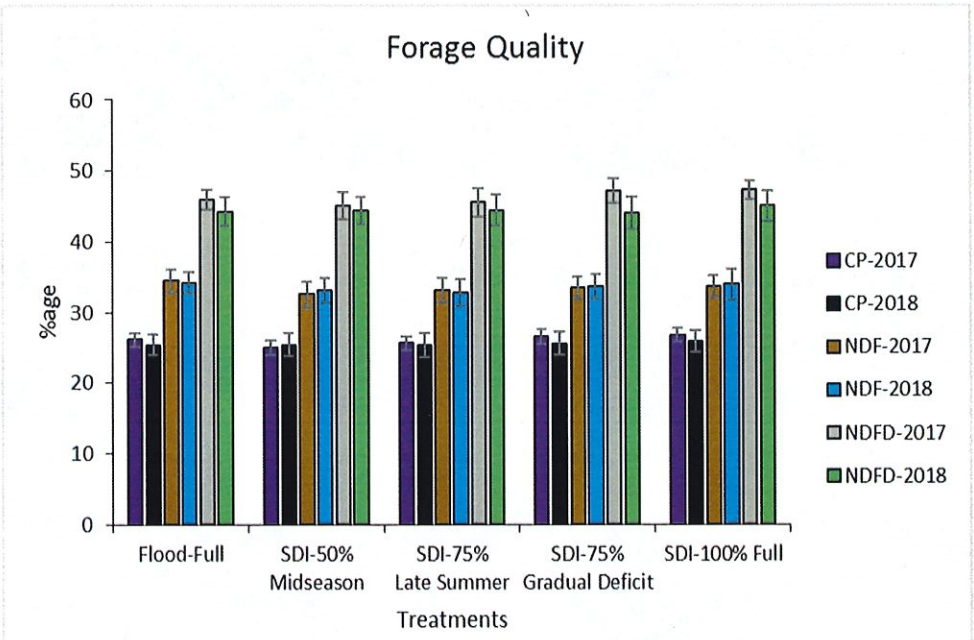

Figure 4 Crude protein (CP), amylase Neutral Detergent Fiber (aNDF) and Neutral Detergent Fiber Digestibility (NDFD) for year 2017 and 2018.

Monitoring crop temperature indicates the level of stress plants are experiencing during the growth cycle. In figure 7, the dark blue represents lower temperature or areas which are cooler due to enough water to transpire, while the red color represents the warmer canopy with less vegetation due to deficit irrigation. It can be seen that SDI fully irrigated, SDI continuous deficit and flood treatments are not different at a certain day.

Conclusions

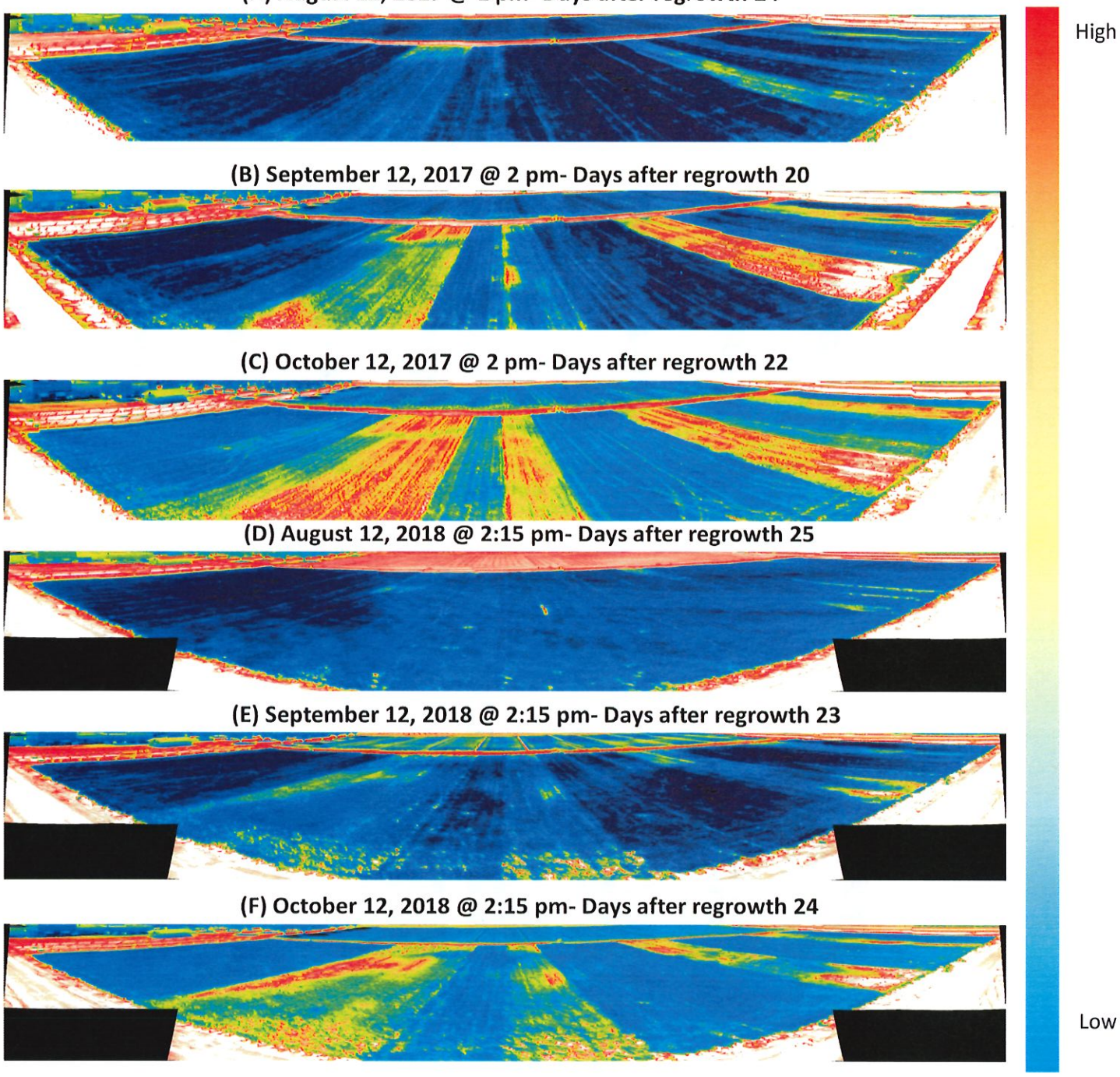

Figure 6 Infrared Thermometry could help in identifying the water-stressed areas with in the field. Figures A-C are from year 2017 while D-F are from year 2018 at different growth stages. It can be seen in these images that 100% Full SDI and Check Flood are comparable