Advances in Using Variable Rate Irrigation and Sensors in Alfalfa

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Precision Irrigation Management (PRIMA) Laboratory

Overarching goal

Develop knowledge that will help farmers and ranchers in Nevada (and other states with arid and semi-arid regions) to make a more efficient use of irrigation water.

Improving the irrigation management of alfalfa

- Alfalfa is the most important crop in Nevada in terms of economic production and area cultivated (USDA-NASS, 2017).
- Alfalfa has a relatively high water demand because it has a long growing season with multiple harvests, a deep root system, and a dense vegetation canopy.
- However, alfalfa is also a flexible crop with a high water productivity that is also drought-tolerant (Putnam et al., 2018), which makes it an excellent candidate for the implementation of advanced irrigation management strategies.

Evaluation of advanced irrigation management strategies applied to alfalfa

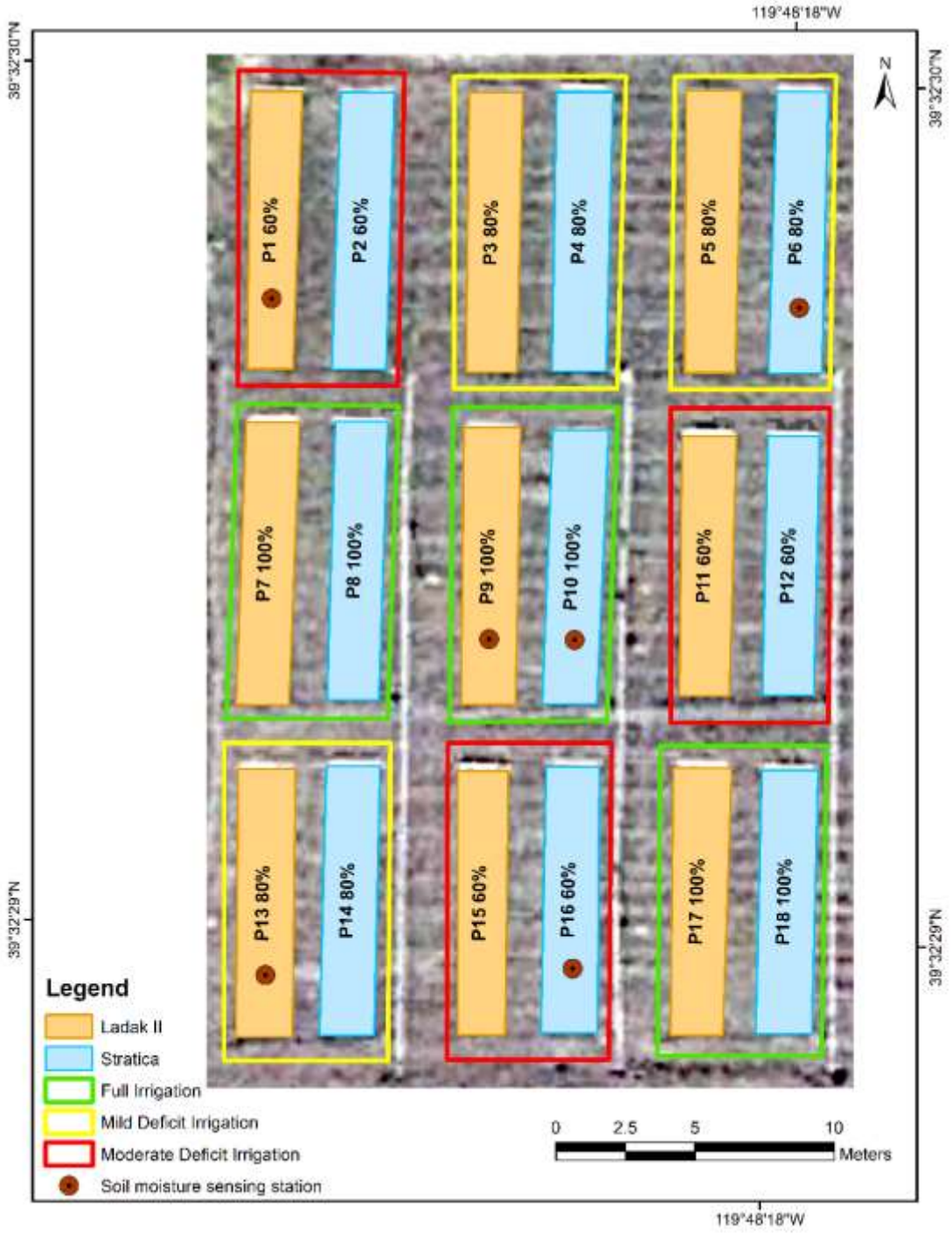
- Deficit Irrigation (DI)
  - Irrigate a crop without meeting its full consumptive water use (i.e., evapotranspiration)
- Sensor-based irrigation scheduling methods
  - Use sensing systems to identify the right irrigation amount and the right irrigation time
- Variable Rate Irrigation (VRI)
  - Apply variable irrigation amounts to different parts of a field based on their individual water needs

Evaluating the effects of constant deficit irrigation on two alfalfa varieties

- Application of full irrigation and two constant deficit irrigation treatments to two alfalfa varieties
  - First variety: Ladak II (Great Basin Seed), marketed as drought tolerant
  - Second variety: Stratica (Croplan), marketed as highly productive
  - Full Irrigation (FI): full replenishment of soil water depletion to Field Capacity (FC) within the root zone
  - Mild constant Deficit Irrigation (DI): 80% of FI
  - Moderate constant DI: 60% of FI

Experimental setup

- Experiment was established in the Fall of 2020 at UNR's Valley Road Field Lab in Reno
- Soil is a Fleishmann gravelly clay loam with 2 to 4 percent slopes (NRCS, 2022)
- 18 plots with dimensions of 30 ft x 5.33 ft (9.14 m x 1.63 m)
- 9 irrigation blocks arranged in a strip-plot design
- Irrigation treatments were applied during three growing seasons (2021, 2022, and 2023)
- Alfalfa dry yield, water use, and forage nutritive value obtained for four harvests



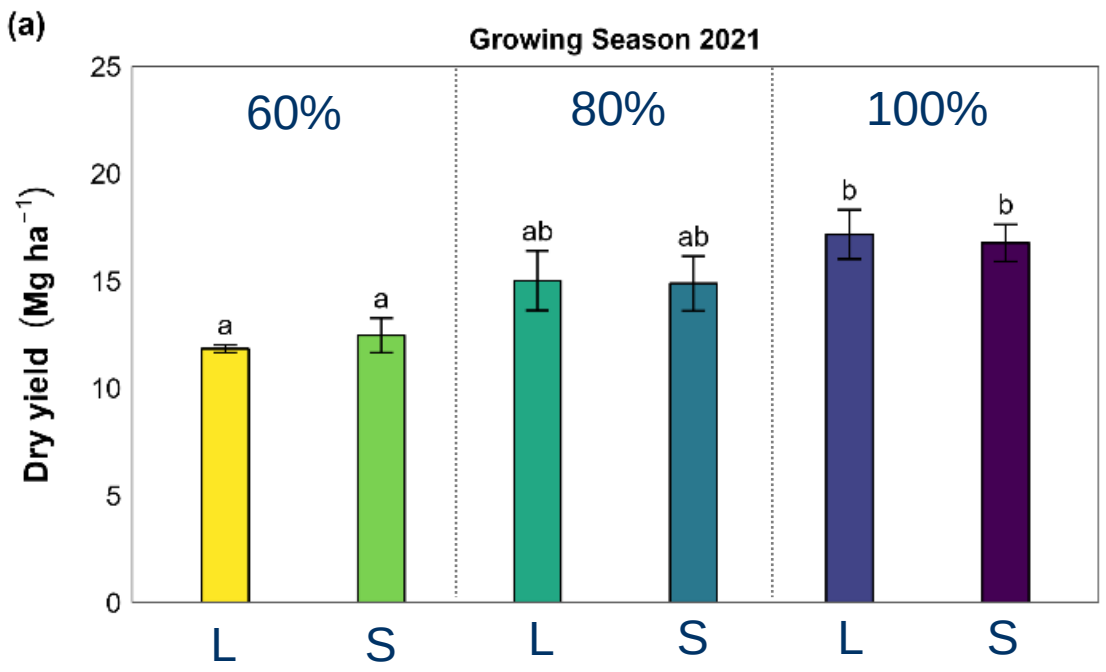
Soil water sensing

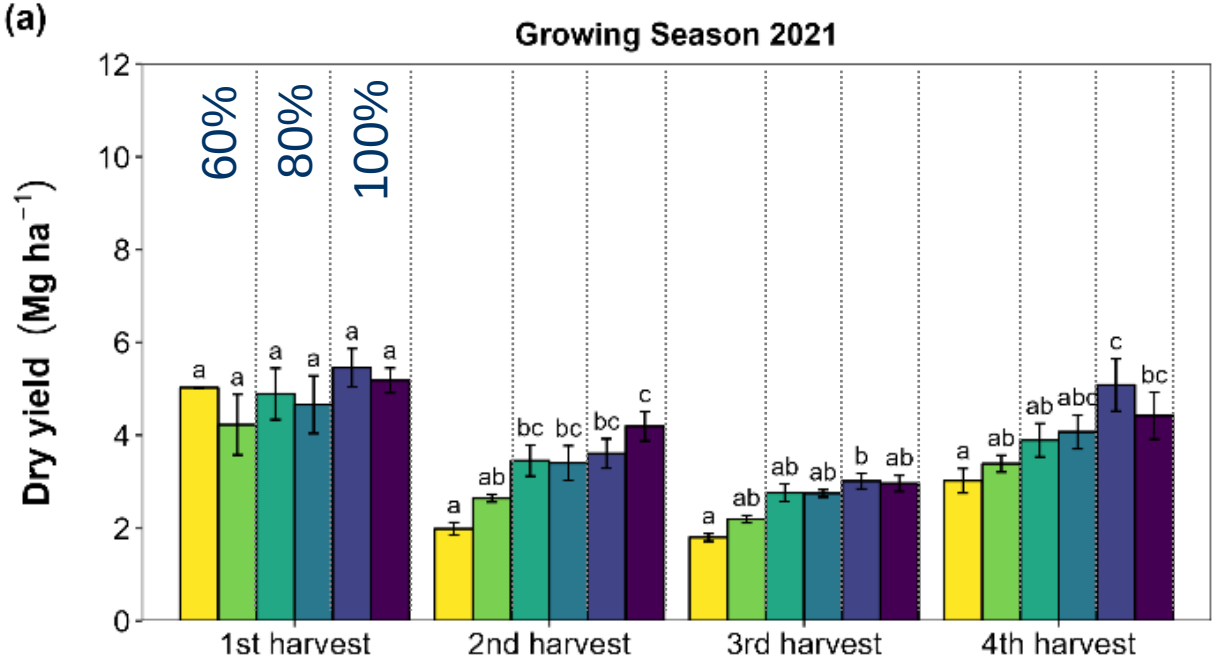
- Irrigation amounts were calculated using soil water sensing stations consisting of three Time Domain Reflectometer (TDR) sensors buried at depths of 7.9, 23.6, and 35.4 in (20, 60 and 90 cm)
- Six soil water sensing stations were installed in total (one per alfalfa variety and irrigation treatment) to track changes in volumetric water content for each variety and treatment
- Soil water sensing stations are connected to the Internet-Of-Things

Irrigation control

- Irrigation amounts were applied with a surface drip irrigation system with running times controlled by timers
- Each irrigation block was irrigated independently so varieties subjected to the same irrigation treatment received the same irrigation amounts
- The Stratica variety consistently required more water than Ladak II
- Full Irrigation amount = average between irrigation amounts required by each variety

Seasonal dry yield (ton/ha) and dry yield per harvest (ton/ha) – 2021 season

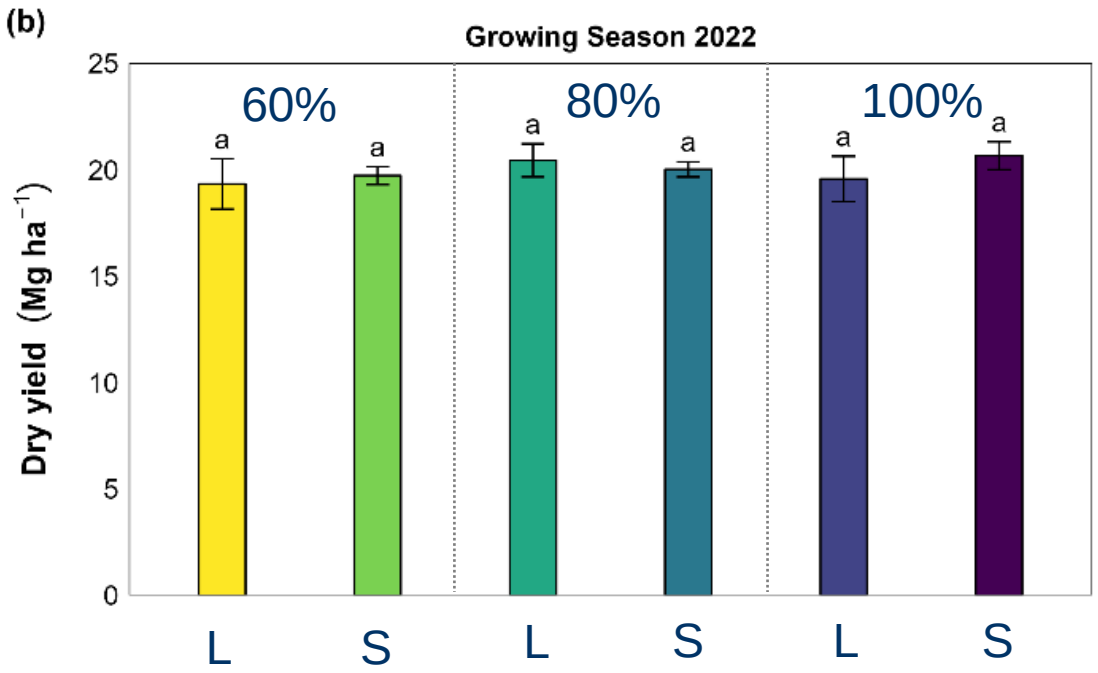


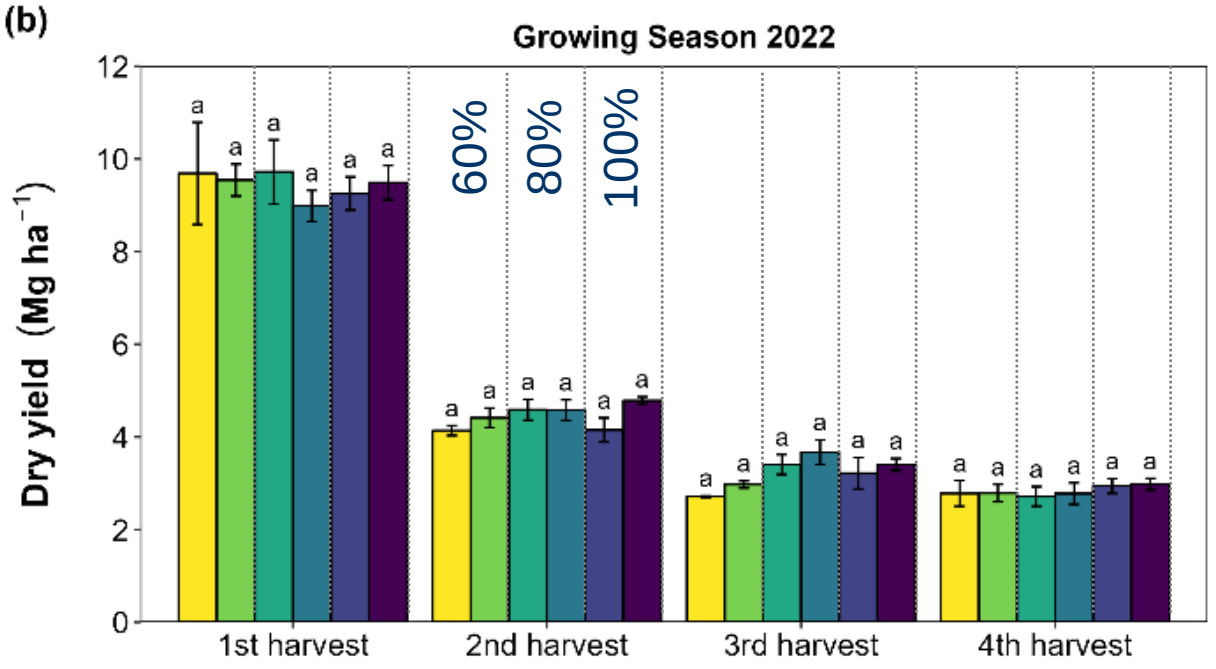


Seasonal dry yield showed a tendency to decrease with water stress, but the difference was only statistically significant between the moderate DI (60%) and FI treatments

Treatment:Variety
Moderate DI:Ladak
Moderate DI:Stratica
Mild DI:Ladak
Mild DI:Stratica
Full irrigation:Ladak
Full irrigation:Stratica

Seasonal dry yield (ton/ha) and dry yield per harvest (ton/ha) – 2022 season

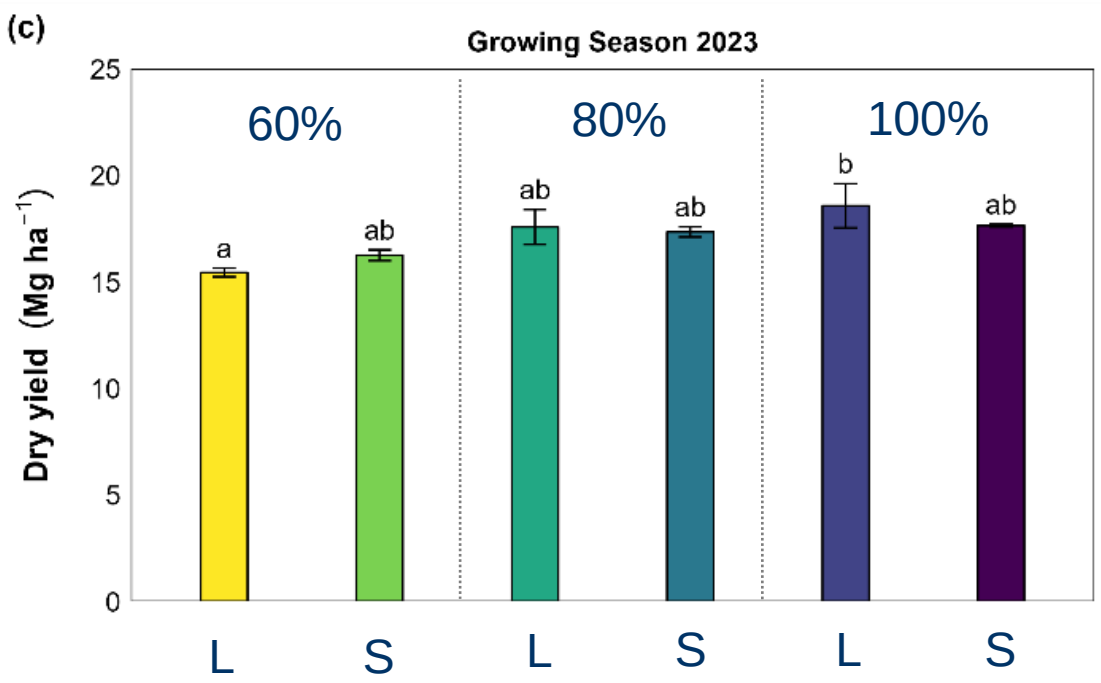


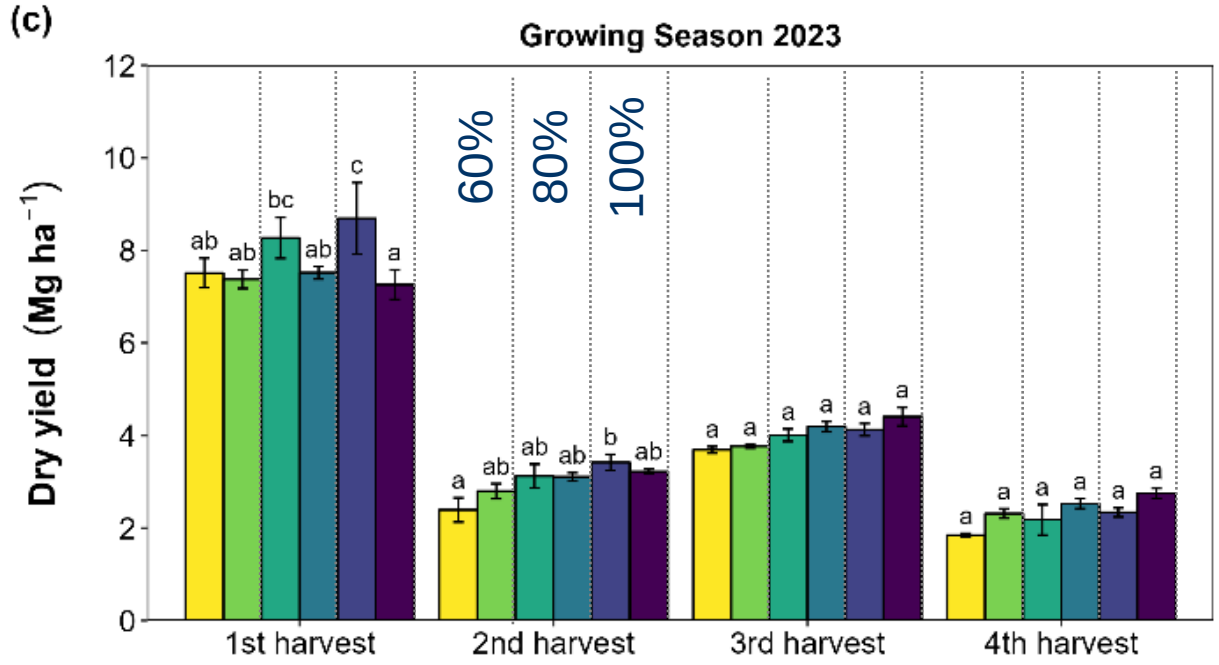


The dry yield obtained during the first harvest accounted for approximately half of the seasonal dry yield obtained during the 2022 growing season

Treatment:Variety
Moderate DI:Ladak
Moderate DI:Stratica
Mild DI:Ladak
Mild DI:Stratica
Full irrigation:Ladak
Full irrigation:Stratica

Seasonal dry yield (ton/ha) and dry yield per harvest (ton/ha) – 2023 season

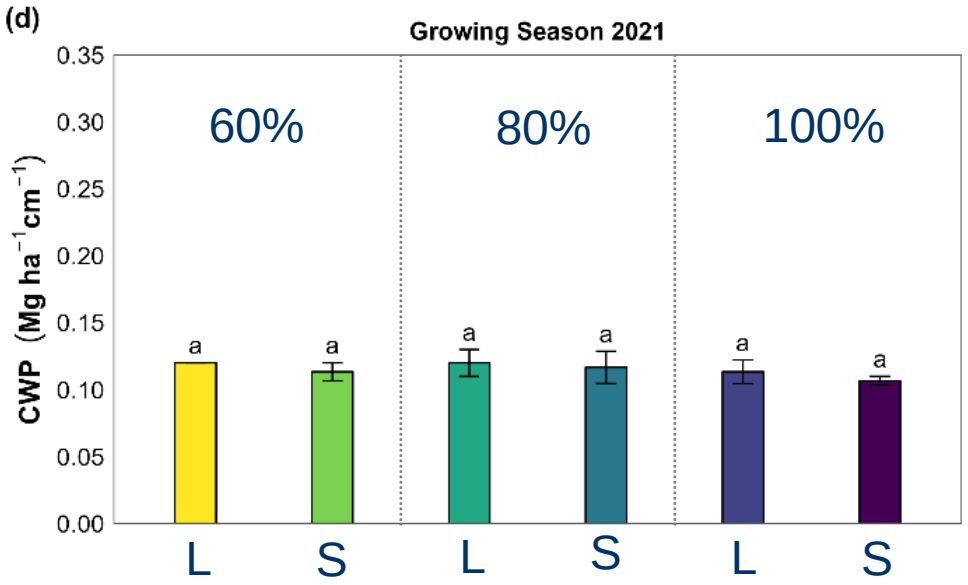


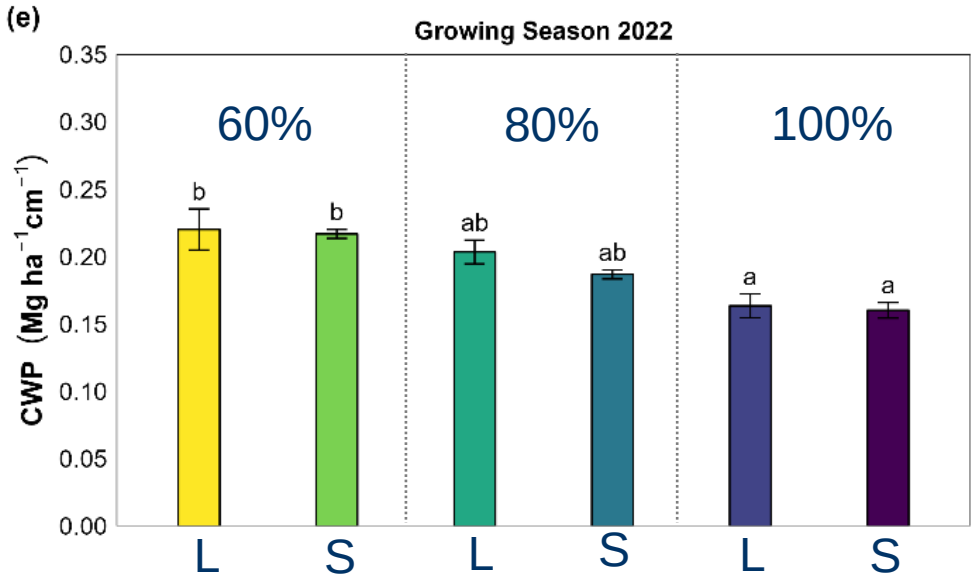


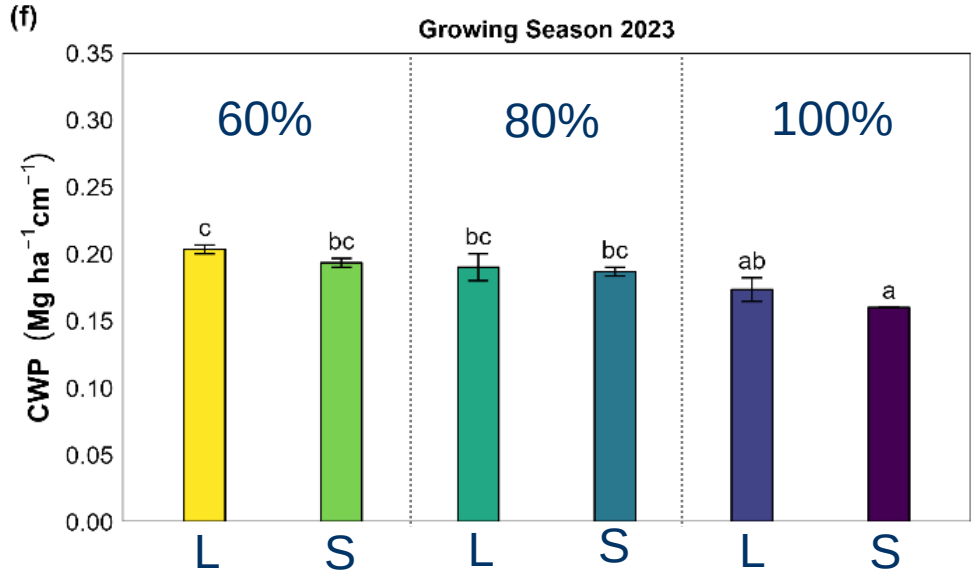
The dry yield obtained during the first harvest accounted for approximately half of the seasonal dry yield obtained during the 2023 growing season

Treatment:Variety
Moderate DI:Ladak
Moderate DI:Stratica
Mild DI:Ladak
Mild DI:Stratica
Full irrigation:Ladak
Full irrigation:Stratica

Crop Water Productivity (CWP) (ton/ha)/cm



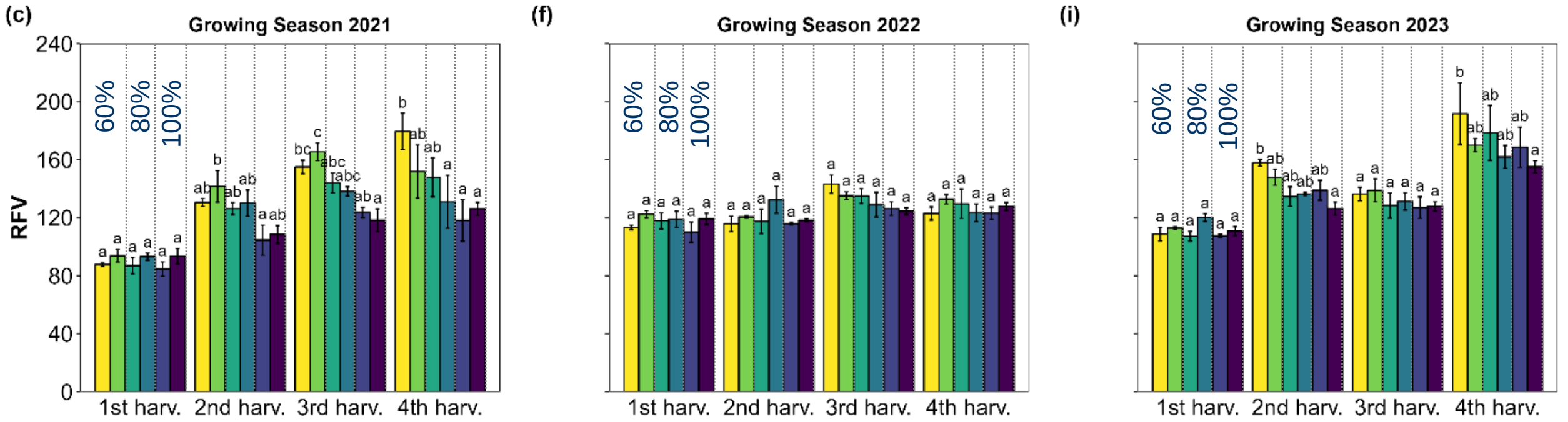




CWP showed a tendency to increase with DI treatments during the second and third growing seasons, but this difference was only statistically significant between the moderate DI (60%) and FI treatments

Treatment:Variety
Moderate DI:Ladak
Moderate DI:Stratica
Mild DI:Ladak
Mild DI:Stratica
Full irrigation:Ladak
Full irrigation:Stratica

Alfalfa Relative Feed Value (RFV)



Alfalfa RFV showed a tendency to increase with water stress, but this tendency was only statistically significant between moderate DI (60%) and FI treatments for 5 out of 12 harvests

Conclusions

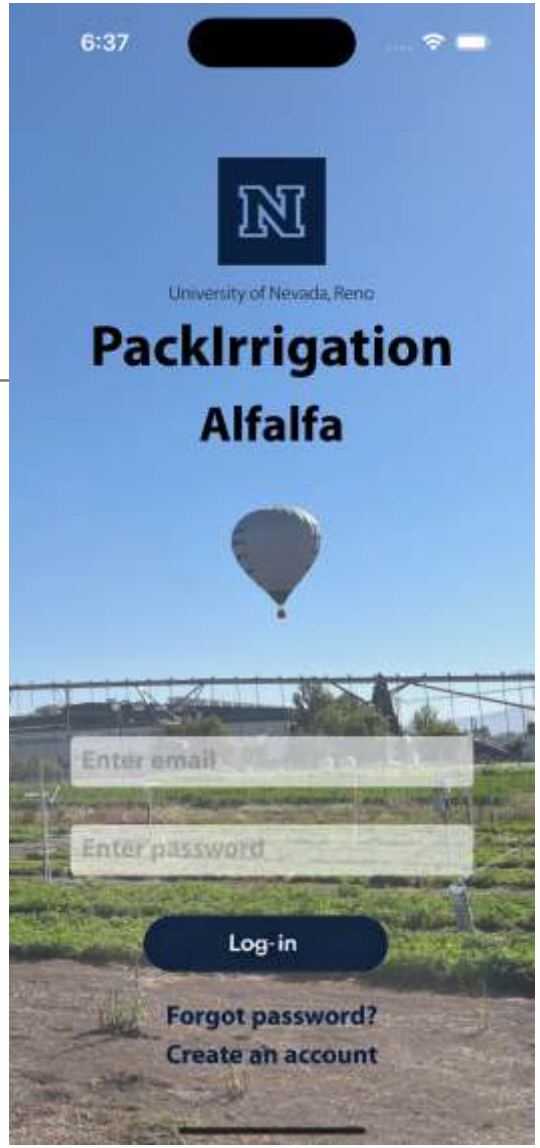
- A drought tolerant variety (Ladak II) offered no statistically significant advantages with respect to a highly productive variety (Stratica) in terms of dry yield, CWP and RFV, when both varieties received the same full and deficit irrigation (DI) amounts
- However, the Ladak II variety consistently demanded less water than the Stratica variety and further research is recommended to compare the Ladak II variety against a highly productive variety under full and deficit irrigation treatments managed independently
- No statistically significant differences were found in seasonal dry yield, CWP, and RFV between the mild DI (80%) and FI treatments, making the mild DI treatment a great alternative for water conservation in Northern Nevada

Variable Rate Irrigation (VRI) of alfalfa

- Evaluation of constant DI and regulated DI using a linear move VRI system
  - Two alfalfa varieties: Ladak II (Great Basin Seeds) and Nexgrow 6516R
  1. Full Irrigation (FI)
  2. Mild constant DI (80% of FI)
  3. Moderate constant DI (60% of FI)
  4. Mild regulated DI (100% of FI during first half of harvest period and 60% during second half)
  5. Moderate regulated DI (80% of FI during first half of harvest period and 40% during second half)

Other PRIMA Lab projects aiming to improve irrigation management of alfalfa

- Evaluation of different VRI scheduling methods supported by weather, plant, and soil water sensors
- PackIrrigation – alfalfa irrigation scheduling app
- Alfalfa Yield Forecasting tool – Artificial Intelligence vs Crop Growth Models
- Evaluation of Ground Penetrating Radar to estimate alfalfa root traits



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