Developing efficient production practices to optimize water use efficiency of industrial hemp

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Texas High Plains - Crop Production Challenges

- Major producer of irrigated and dryland crops
- Semi-arid region
  - average annual precipitation: 350-550 mm (14-22 inches)
  - average annual evapotranspiration: 1500-1750 mm (59-69 inches)
- Irrigation needs
  - the Ogallala Aquifer
  - withdrawals are greater than recharge

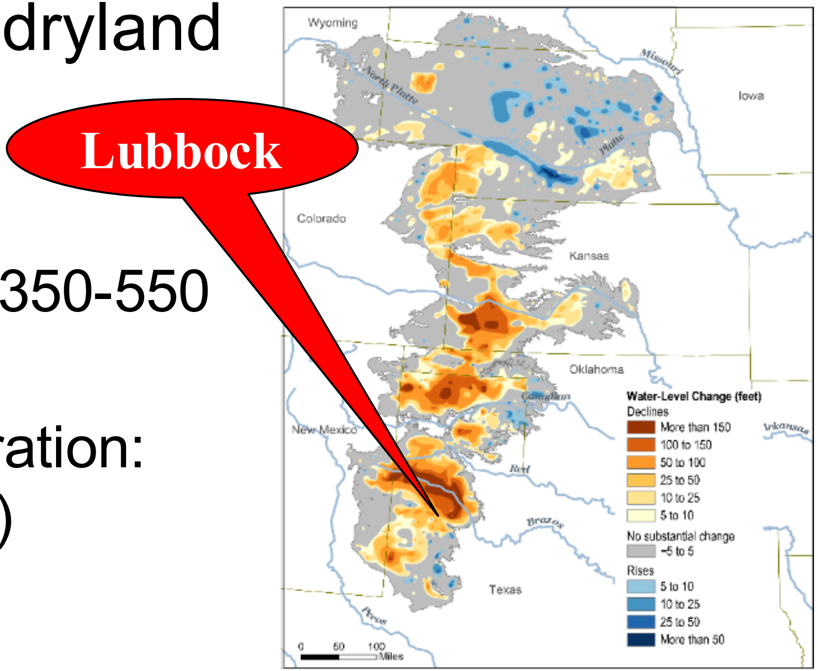
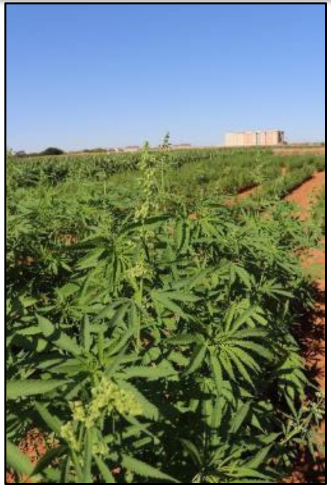


Figure. *The figure shows changes in groundwater levels in the Ogallala Aquifer from predevelopment to 2015.* Source: https://doi.org/10.3133/sir20175040

In a row cropping system, > 50% of irrigation water applied before canopy closure is lost by evaporation (Agam, Evett et al., 2012)

Texas High Plains - Crop Production Opportunities

- Industrial hemp (*Cannabis sativa* L.) - an alternative crop
- Multi-purpose crop - seeds, fibers and cannabidiol (CBD) oil
- Drought hardy
- Applications in biopolymer industry, particularly for the manufacture of composite materials
    - Hempcrete
    - Biodegradable plastics



Texas High Plains - Crop Production Opportunities

- Paper, rope, textiles, clothing, paint, insulation, biofuel, food, and animal feed

https://en.wikipedia.org/wiki/Hemp

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Objectives

The specific objectives are to :

1. Effect of different planting dates and seeding densities on growth, physiology and biomass yield of industrial hemp.

2. Root distribution, soil water depletion, and water productivity of industrial hemp under different planting dates and seeding densities.

3. Study the effect of early and late POST emergence herbicides on weed suppression, crop injury, and biomass yield of industrial hemp.

Objective - 1

1. Effect of different planting dates and seeding densities on growth, physiology and biomass yield of industrial hemp.







Methods (Objective – 1)

- **Location**: Quaker research farm, Texas Tech University during 2022 and 2023.
- **Experimental design**: Blocked split-plot design - hemp cultivar, **Eletta campana** with four replications.
- Main plot factor - **Planting dates**
  - P1- April 19th
  - P2- May 10th
  - P3- June 6th

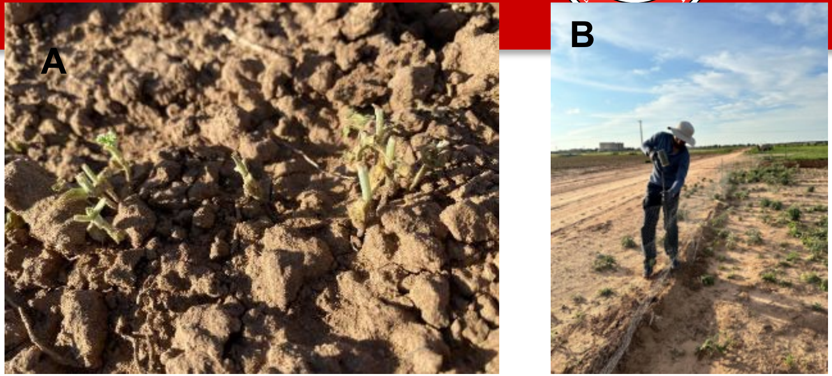


Fig (A): P1 destroyed by rabbits, (B) Fencing the field

Fig (C): Seedling emergence, (D) Planting hemp at Quaker research farm, TTU

Methods (Objective – 1)

- Subplot factor - **Seeding densities**
  SD1- 15kg/ha (845K seeds)
  SD2- 25kg/ha (1408K seeds)
  SD3- 35kg/ha (1972K seeds)

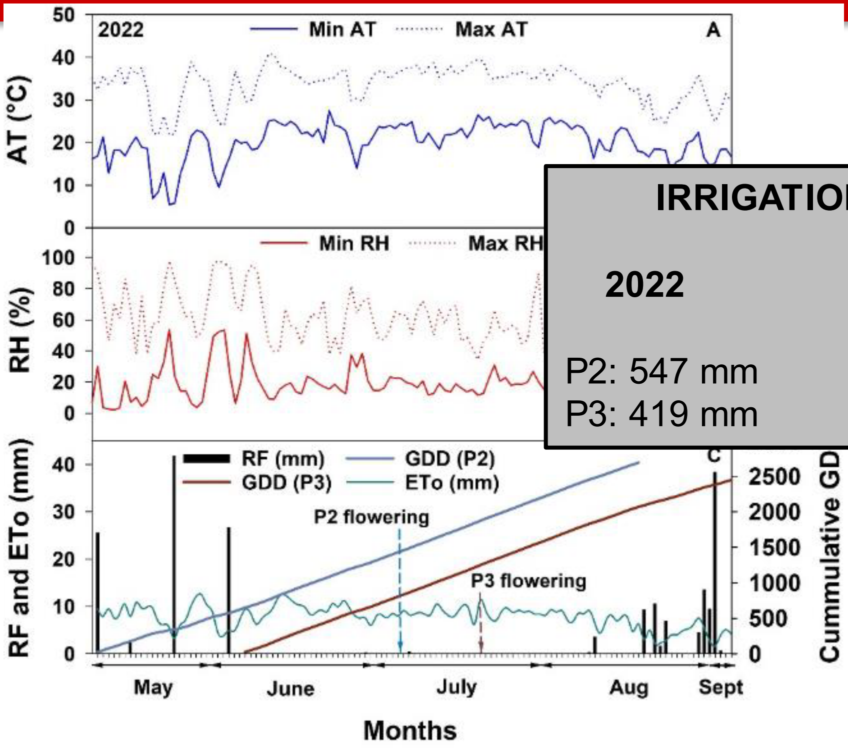
- Irrigation: **Subsurface drip irrigation** system, and application based on the crop evapotranspiration (ETc) requirement.

- Data analysis: Analysis of variance in R version 3.5.2 using the Agricolae package.

Fig: SD1 (A) and SD3 (B) at Quaker research farm, TTU

Fig: Hemp field (C), weather data collection (D) at Quaker farm, TTU

Weather



IRRIGATION APPLIED

2022	2023
	P1: 393 mm
P2: 547 mm	P2: 342 mm
P3: 419 mm	P3: 314 mm

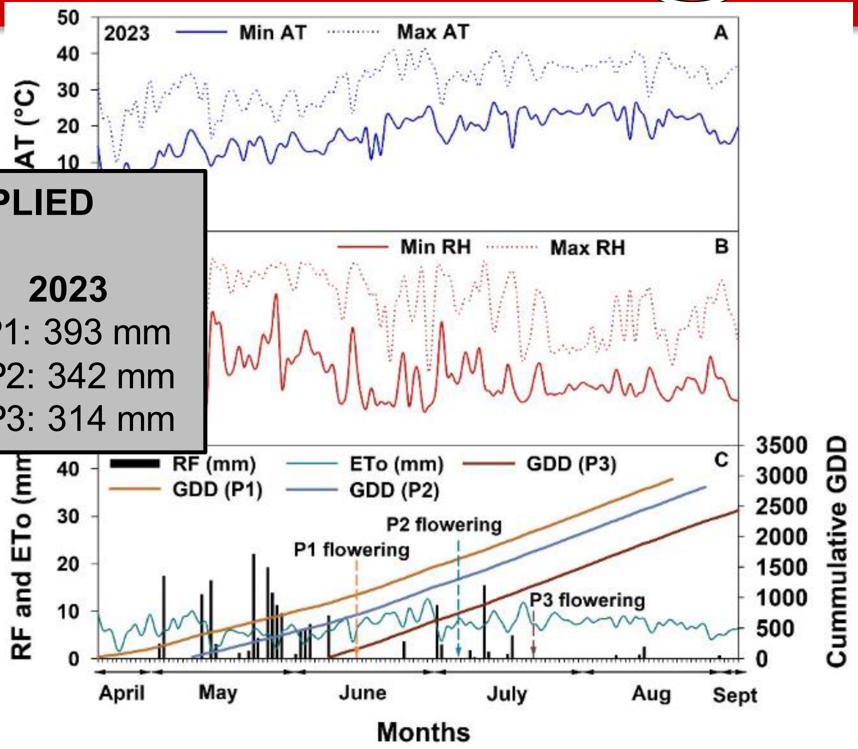
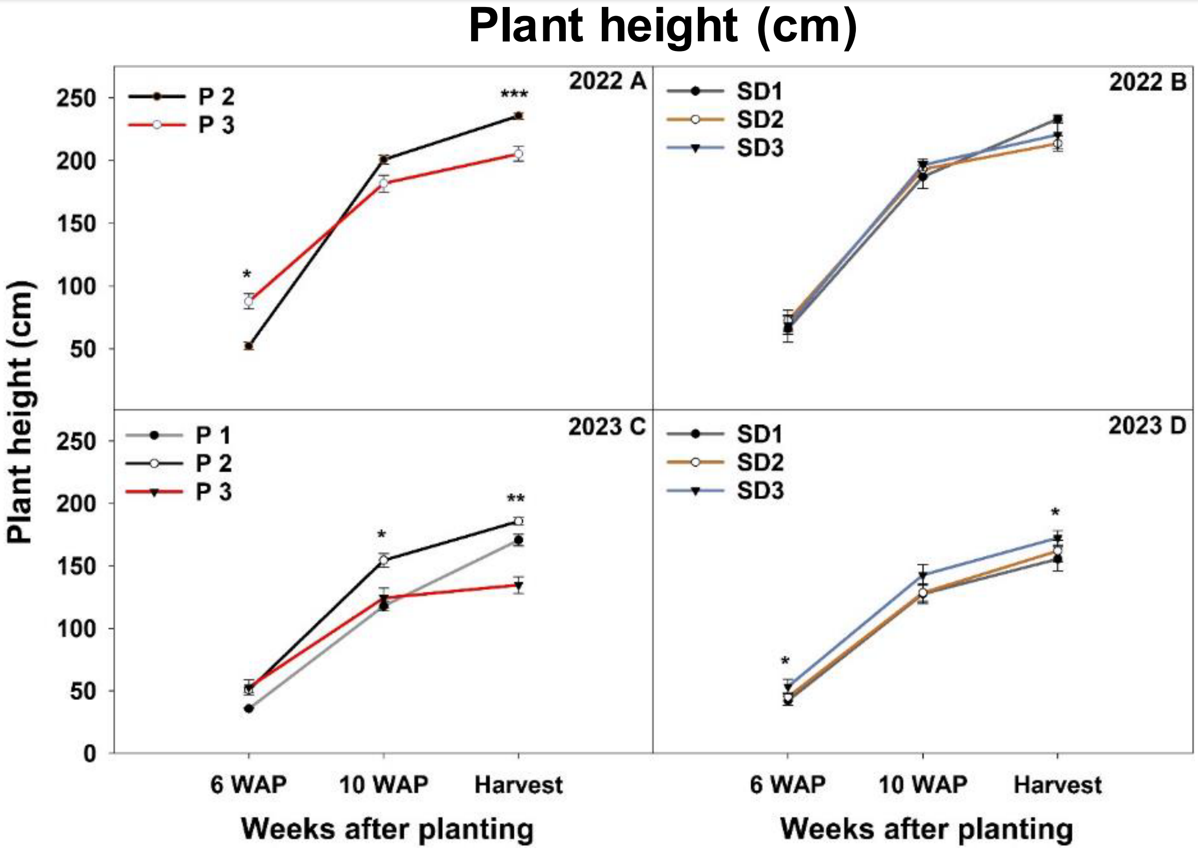
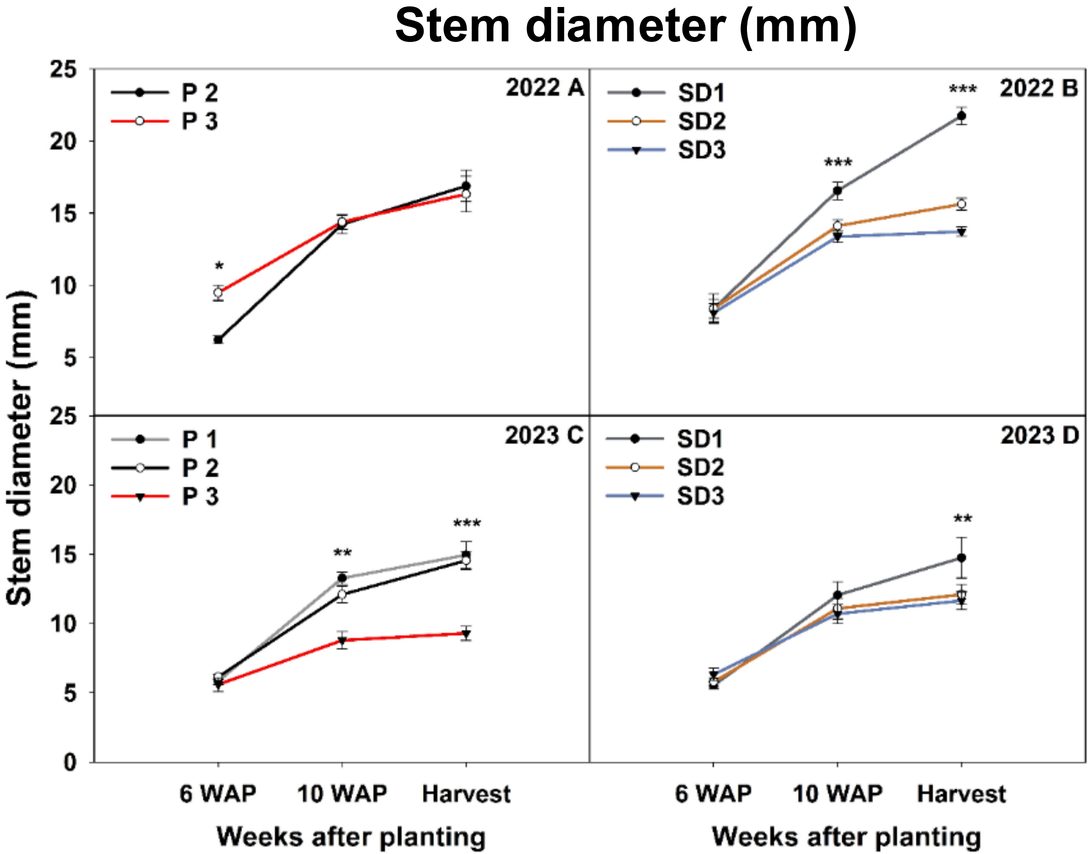


Fig : Daily maximum (max) and minimum (min) air temperature (AT) (A), relative humidity (RH) (B), rainfall, daily evapotranspiration (ETo) and cumulative growing degree days (GDD) (C) during the 2022 and 2023 growing seasons in Lubbock, TX. P: Planting date, SD: Seeding density.

Results: Objective – 1

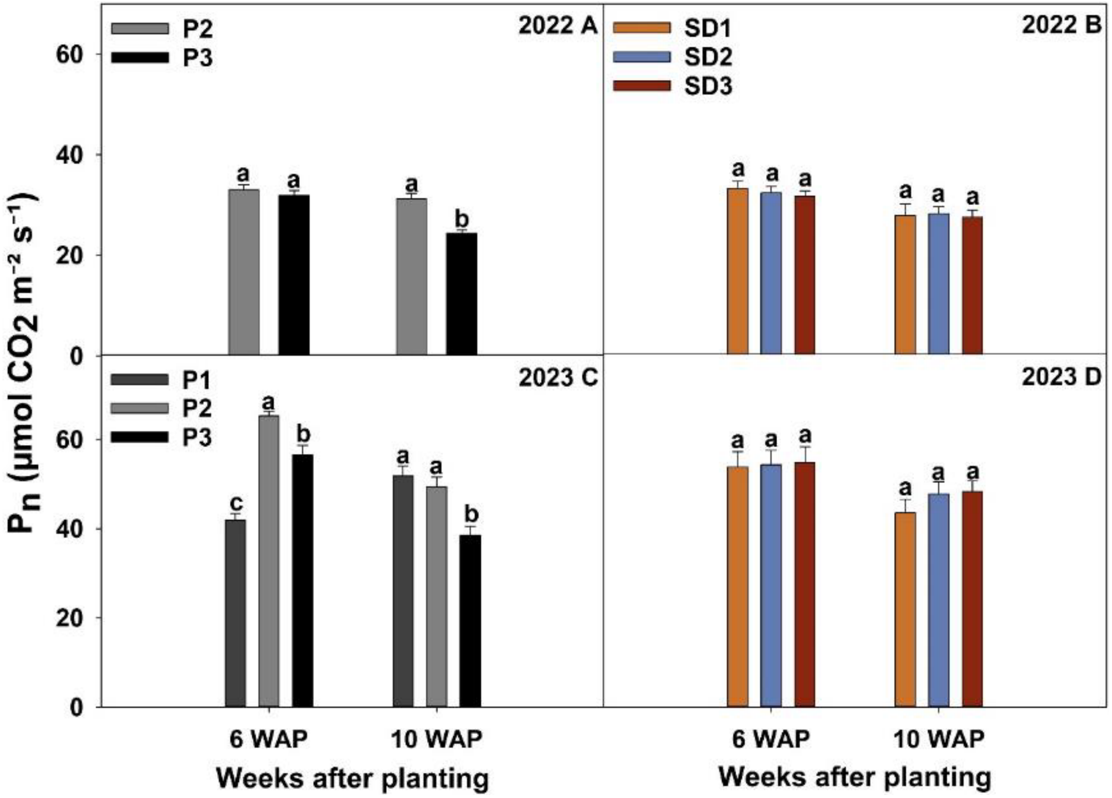


Results: Objective – 1



Results: Objective – 1

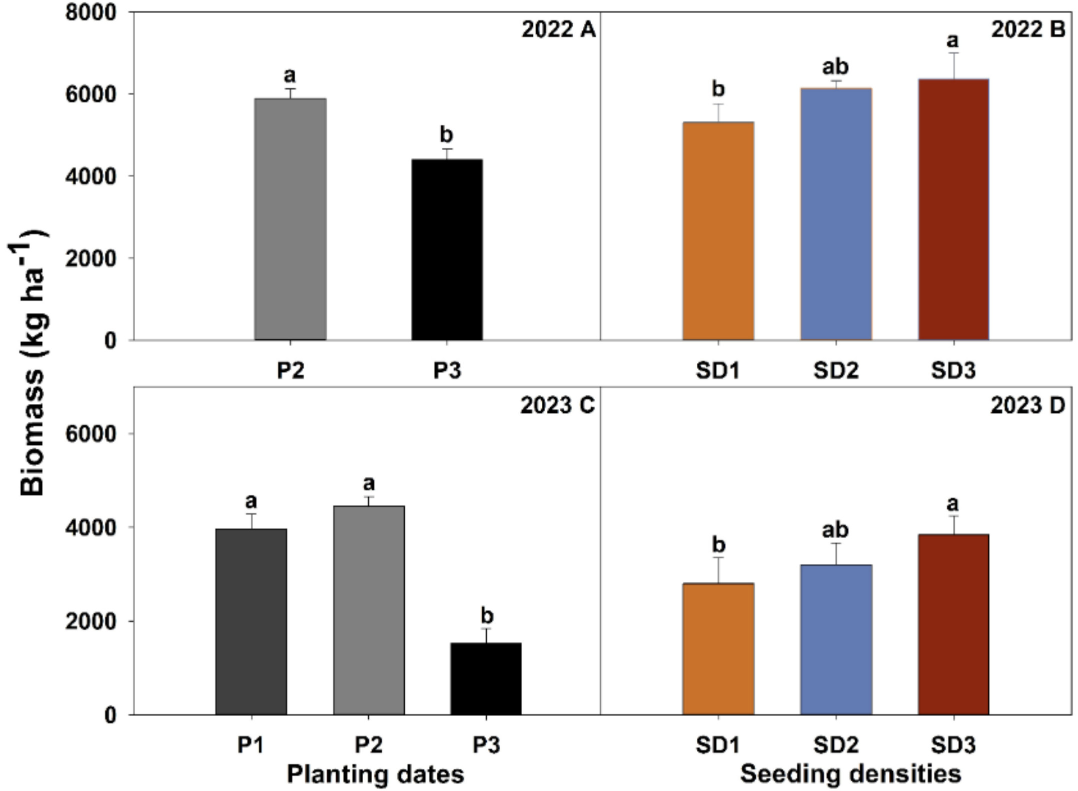
Assimilation (Pn)






Results: Objective – 1

Biomass Yield



Conclusions: Objective – 1

- Earlier planting (P1, P2) facilitated longer vegetative growth enhancing plant height, stem diameter, dry biomass, and fiber accumulation than later planting (P3).

- Higher densities resulted denser canopies, better light absorption, and eventually higher final production.

- Overall, early planting is more productive at higher seeding density in West Texas conditions.

Objective - 2

2. Root distribution, soil water depletion, and water productivity of industrial hemp under different planting dates and seeding densities.

Methods (Objective – 2)

- PR-2 probe access tubes were installed in the center of the plots.
- Volumetric water content (VWC) was measured on weekly basis at 10, 20, 30, 40, 60 and 100 cm soil depth in hemp field.
- Soil water depletion was calculated by subtracting VWC at end from the start of the given period.
- Seasonal change in water storage (ΔS) was calculated by subtracting VWC at harvest from the initial.

Methods (Objective – 2)

- Water balance equation = (ET = Irrigation + Rainfall + ΔS + Drainage + Runoff) in millimeter (mm).
- Water use efficiency was caluculated from the ratio of yield (kg/ha) to seasonal Evapotranspiration (mm).
- A 60 cm soil column for roots was collected by split-core sampler with 10 cm incremental depth.
- Root parameters - WinRhizo Pro software.

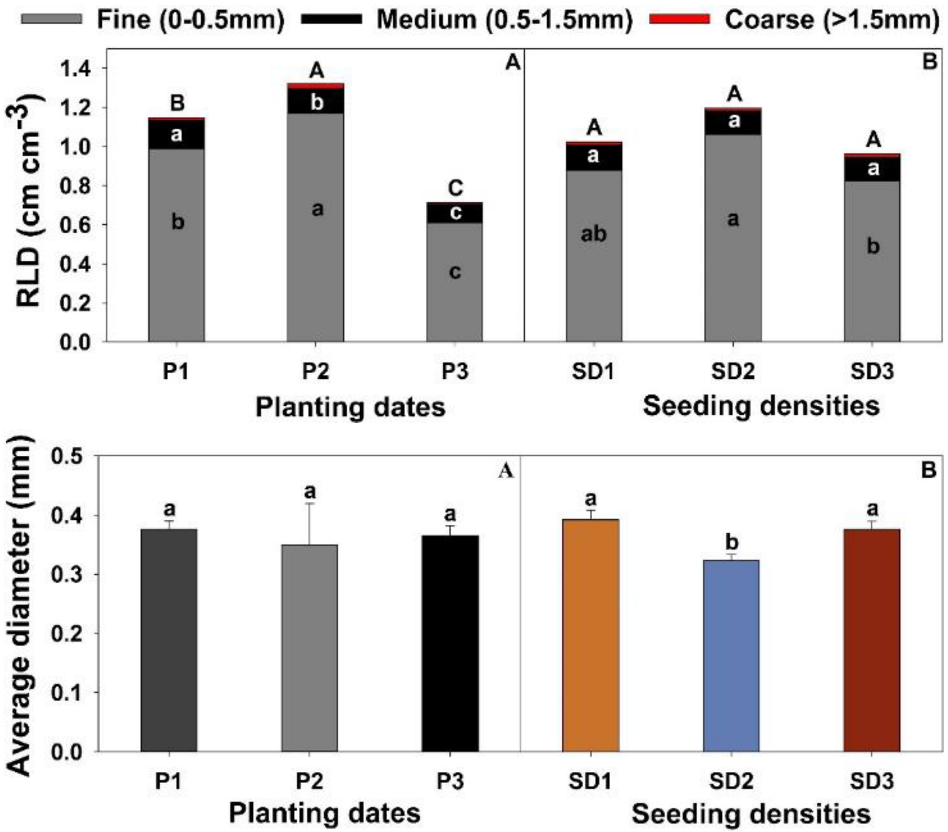

Fig: Moisture reading using PR2 probe


Fig: Extracting out access tubes from field

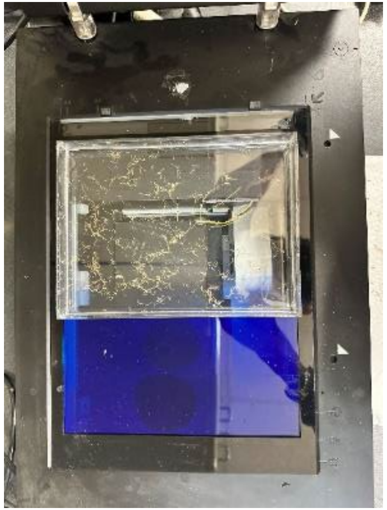

Fig: Root sampling from hemp field


Fig: Root scanning with WinRhizo

Results: Objective – 2

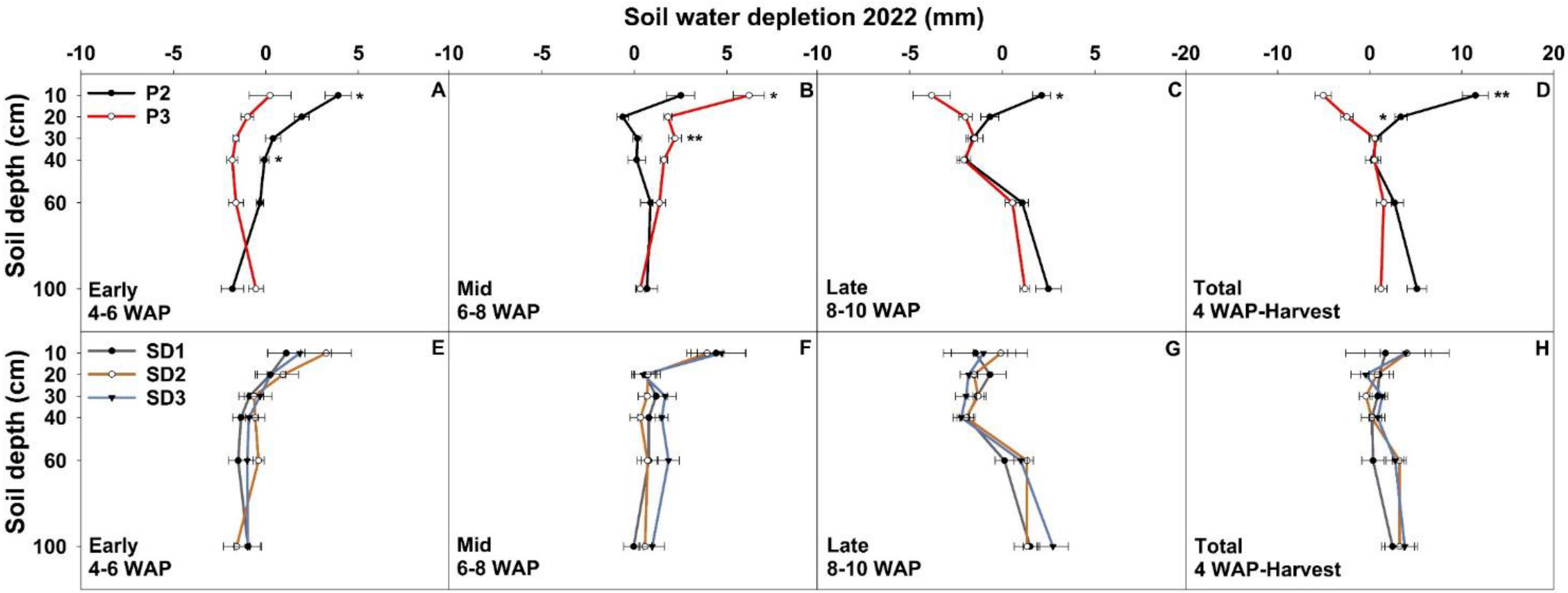


Root length density classification and average root diameter - 2023



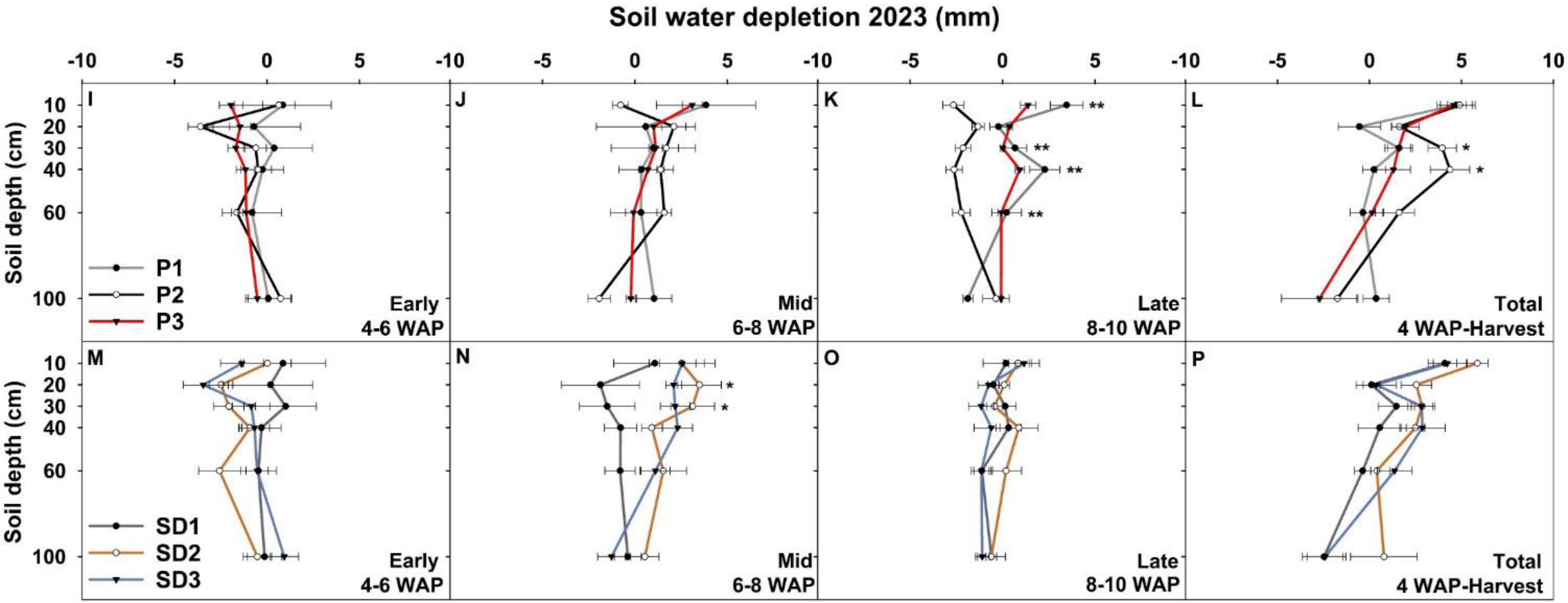
Results: Objective – 2

Soil water depletion with depth (2022)



Results: Objective – 2

Soil water depletion with depth (2023)



Results: Objective – 2

Biomass yield and water productivity in 2022 and 2023

Treatments	ET_w (mm)	Biomass (Mg ha^{-1})	Biomass WP (kg ha^{-1} mm^{-1})
2022			
Planting (P)			
P2	672.8a	5.43 a	8.11 a
P3	517.6 b	4.39 b	8.51 a
Density (SD)			
SD1	593.7 a	4.41 b	7.44 b
SD2	612.9 a	5.10 ab	8.77 a
SD3	594.8 a	5.31 a	8.72 a
P×SD	NS	NS	S
2023			
Planting (P)			
P1	613.9 a	3.97 a	6.44 a
P2	551.4 b	4.45 a	8.08 a
P3	378.2 c	1.53 b	3.82 b
Density (SD)			
SD1	508.7 b	2.80 b	5.21 b
SD2	520.3 a	3.19 ab	5.77 ab
SD3	514.6 ab	3.84 a	7.35 a
P×SD	S	NS	NS

Conclusions: Objective – 1

- P2 (May) demonstrated better root development, which facilitated higher soil water depletion than P3 in 2022, and P1 and P3 in 2023.

- P2 displayed higher water productivity compared to other planting times.

- Overall, early planting time at higher seeding density can be practiced as a water-efficient strategy in West Texas conditions.

Publications from this project

1. Effect of planting date and seeding density on growth and yield of industrial hemp in semi-arid southern high plains

2. Root distribution, soil water depletion, and water productivity of industrial hemp under different planting dates and seeding densities

3. Effect of early and late POST emergence herbicides on weed suppression, crop injury, and biomass yield of industrial hemp

Acknowledgments

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Davis College

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Thank you