Economic Risk Analysis of Crop Growth Stage-Based Deficit Irrigation Strategies: Simulated Trends from Texas Cotton Production

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Background and Objectives

- Due to low and variable precipitation and hot summer, crop production requires intensive irrigation in the Southern High Plains (SHP) of Texas.
- Declining water availability in the Ogallala Aquifer motivates producers to implement more efficient irrigation strategies to mitigate risks.
- This study investigates the economic feasibility of growth-stage based deficit irrigation strategies for cotton production in the Texas SHP.
- This study evaluates the risk-adjusted profitability of growth-stage based irrigation strategies associated with five irrigation scenarios.

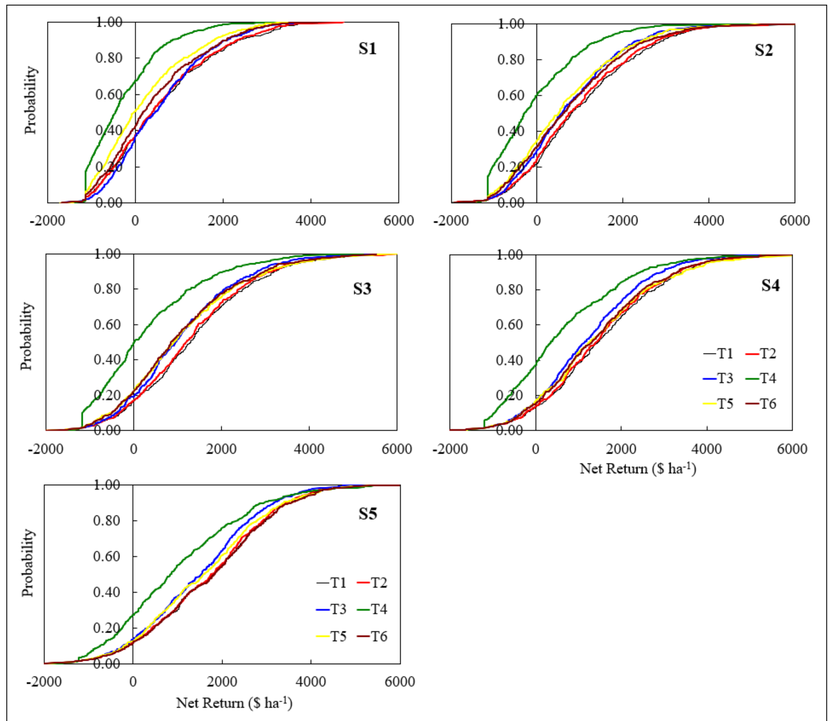
Data and Methods

- Location: Texas A&M AgriLife Research Station at Halfway, TX
- Soil type: Clay loam soil
- Irrigation system: Center pivot
- Climate and precipitation: Semi-arid, 344 mm (May-Oct., 1977-2018)
- Measured data: 2010–2013 growing seasons (*Bordovsky et al., 2015*)
- Simulated data: 1977-2018, under different weather conditions
- Simulation: DSSAT CROPGRO-Cotton model
- Five growth stages (*Himanshu et al.*):
  - i) Germination and seedling emergence
  - ii) Squaring
  - iii) Flower initiation/early bloom
  - iv) Peak bloom, and
  - v) Cutout, late bloom and boll opening
- ***Six treatments*:**
  - ***T1-T5:*** Skipping irrigation in each of the five growth stages (left)
  - ***T6:*** Irrigation water applied in all the five stages
- **Irrigation scenarios: S1:** 240, **S2:** 300, **S3:** 360, **S4:** 420, **S5:** 480 mm
- ***Simulation and analytical procedures*** *(Richardson et al., 2008):*
  - Simetar: Multivariate normal distribution, 500 iterations
  - Validation: Field data vs. simulated data series
  - *Net return = price × yield – total cost*
  - Stochastic Efficiency with Respect to a Function (SERF)
  - Absolute risk aversion coefficient (ARAC)
  - *Certainty equivalent (CE)*
  - *Risk premium (RP)* is the minimum payment that a decision maker will have to receive before switching from risky practices B to A under a certain risk aversion level, r_a.

    i.e., $RP_{B,A,r_a} = CE_{B,r_a} - CE_{A,r_a}$

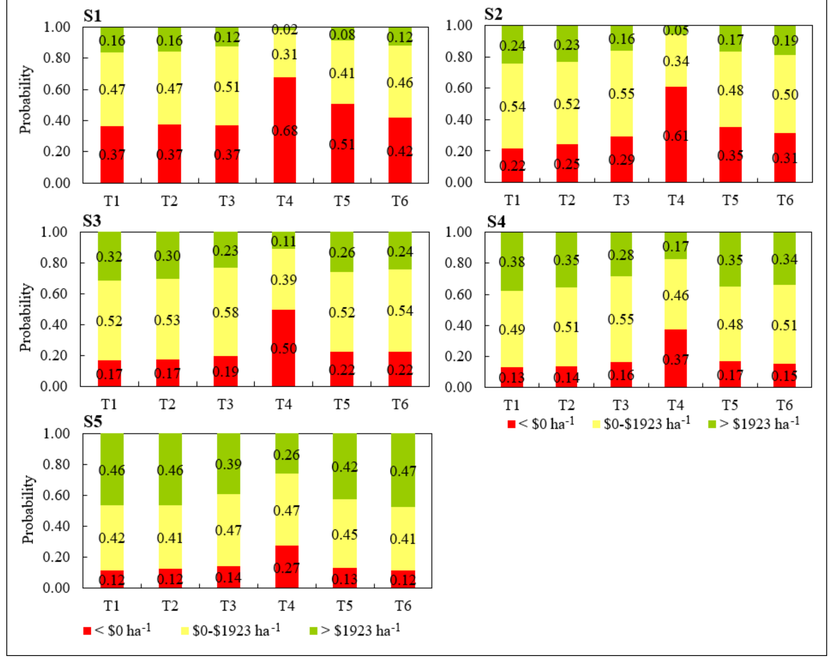
Results – Net Return

- The cumulative distribution functions (CDF) of net returns show T2 and T6 have a distribution further to the right, indicating a higher chance of getting a higher net return from adopting these two strategies.
- Among all the irrigation scenarios, CDF of T4 is further to the left, which indicates lowest farm income.



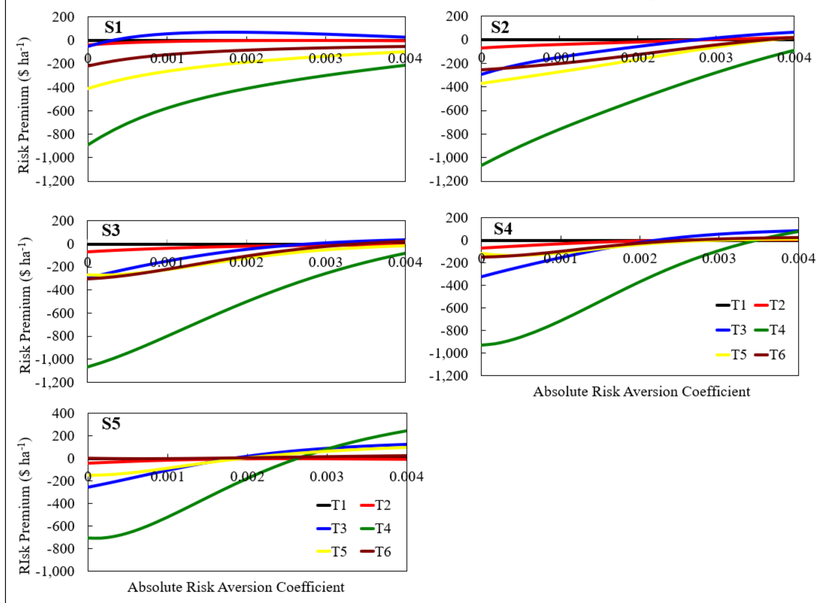
Stoplight Chart

- In the scenarios S1-S4, T1 and T2 show the greatest probability of getting an average net return greater than \$1923 ha^{-1}.
- In the scenario S5, T6 has a greater probability of getting the highest income category, 0.47, and T1 and T2 have a probability of 0.46.



SERF Results

- In the scenario S1, risk-neutral producers are almost indifferent among irrigation strategies T1, T2, and T3, while as the producers get more risk-averse, T3 becomes the most preferred strategy.
- In the scenarios S2-S5, T1 is the most preferred irrigation strategy for risk-neutral, somewhat risk-averse and rather risk-averse producers.



Summary

- The net return distributions show T2 and T6 have a higher chance of getting a higher net return.
- Overall, T1, T2 and T6 show the greatest probability of getting an average net return greater than \$1923 ha^{-1} across the five irrigation scenarios.
- Risk-neutral and slightly risk-averse producers should prefer T1, followed by T2, while very risk-averse producers would be almost indifferent among T1, T2, T3, and T6, except for the scenario S5.

References

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