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

Irrigation scenarios: S1: 240, S2: 300, S3: 360, S4: 420, S5: 480

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) = CE_{BA}/CE_{AR}

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.

Simulation: DSSAT CROPGRO
- Deficit irrigation strategies for maximizing cotton yield, crop water productivity and net returns.
- Under review.

Six treatments: T1-T5: Skipping irrigation in each of the five growth stages (left) T6: Irrigation water applied in all the five stages

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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