Growth Stage-Based Deficit Irrigation Strategies to Improve Profitability of Cotton Production in the Southern High Plains of Texas

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Background and Objectives

❑ Declining water availability in the Ogallala Aquifer motivates crop producers to implement more efficient irrigation strategies.

❑ Regulated deficit irrigation can increase crop water productivity by applying less water than required to achieve the maximal yield.

❑ This study investigates the economic feasibility of deficit irrigation strategies for cotton production in the Southern High Plains of Texas.

❑ Irrigation strategies associated with five cotton growth stages are evaluated under dry, normal and wet weather conditions.

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

❑ Total cost = variable cost + fixed cost

❑ Net return = $\sum_{(lint, seed)}$ (price × yield) − total cost

❑ Economic efficiency = $\sum_{(lint, seed)}$ (price × yield) / irrigation amount

❑ Breakeven price = var. or total cost / lint yield (control for seed revenue)

Results – Production Costs

❑ Average irrigation costs are $86, $112, $129, $155 and $172 ha^{-1} for the irrigation amounts in scenarios S1 to S5, respectively.

❑ Harvest costs increase from $354 to $669 ha^{-1} as cotton yield increases with more irrigation water applied
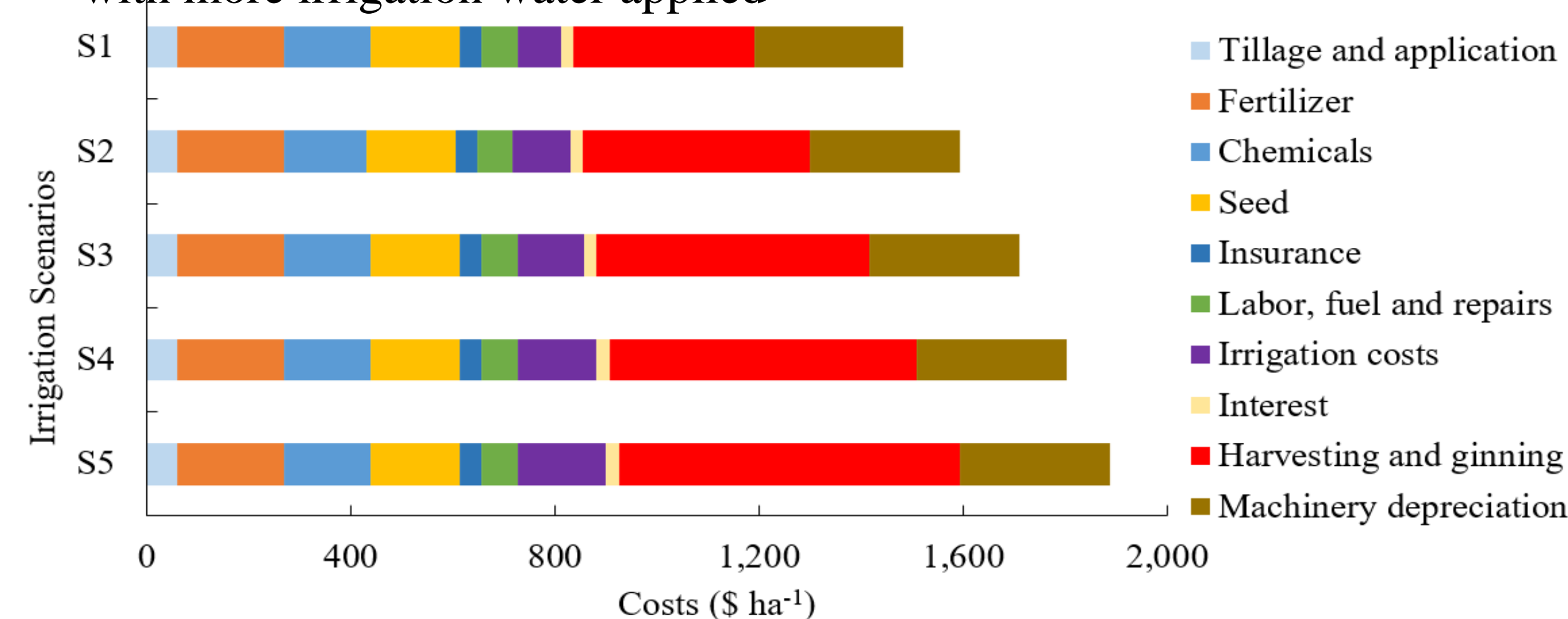

Yield and Net Return

❑ For each irrigation scenario, T4 has the lowest yield, and T1 and T2 shows a similar yield level to that of T6-irrigation in all five growth stages.

❑ For each scenario, T4 shows the lowest net return, and T1 and T2 have an equal or greater net return to T6, especially for moderate or lower irrigation levels, i.e., S3, S2, and S1.
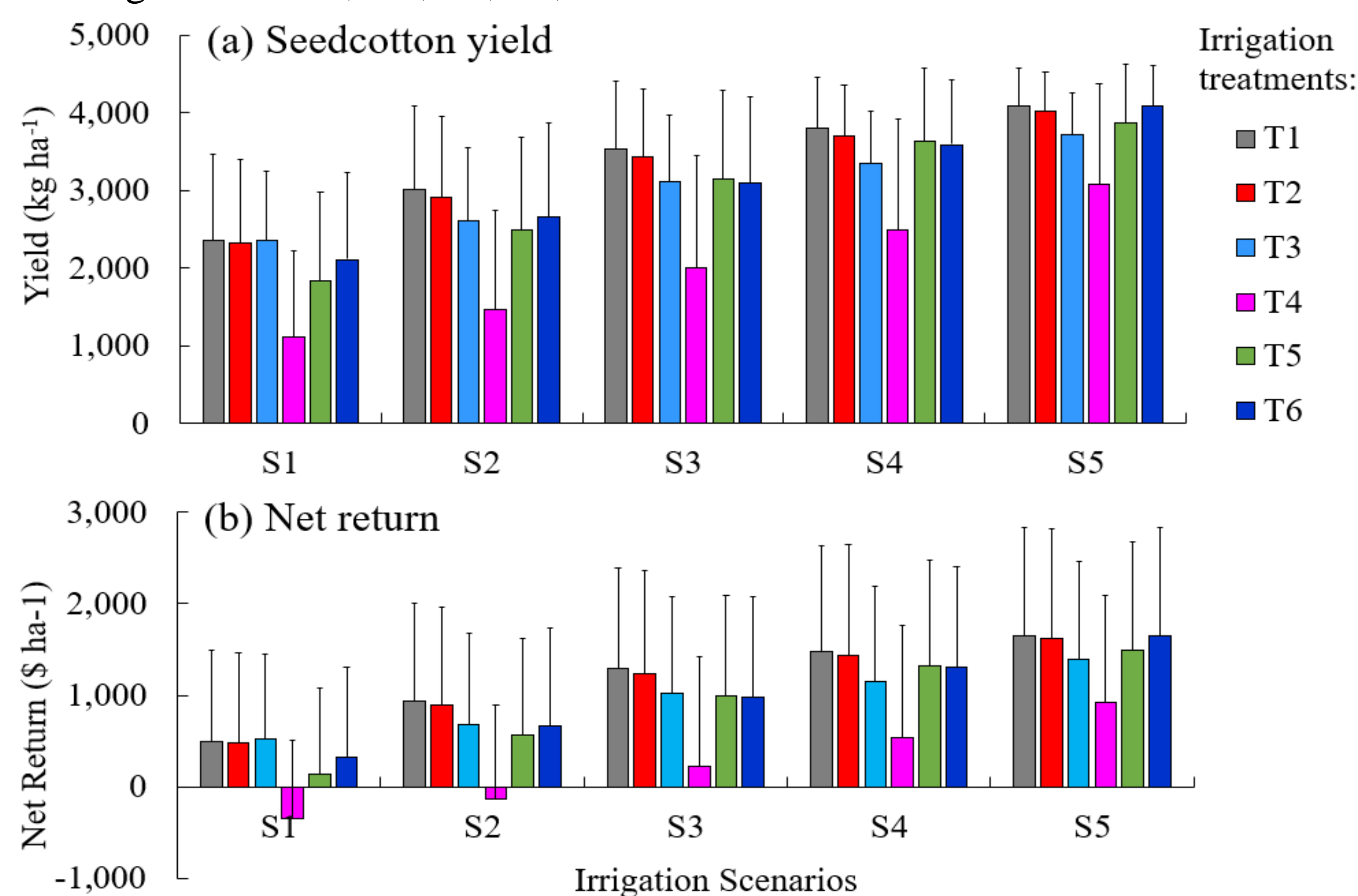

Economic Efficiency of Irrigation Water

❑ In all weather conditions, T1 and T2 have a similar irrigation efficiency.

❑ In dry years, more irrigation increases economic efficiency, and T1, T2, T3 show similar efficiency at S3-S5, i.e., $0.69-$0.73 m^{-3}.

❑ In normal years, T1 and T2 have the highest irrigation efficiency at S2 and S3, i.e., $0.72-$0.75 m^{-3}.

❑ In wet years, highest efficiency is $0.87-$0.89 m^{-3} for T1 and T2 at S1, S2
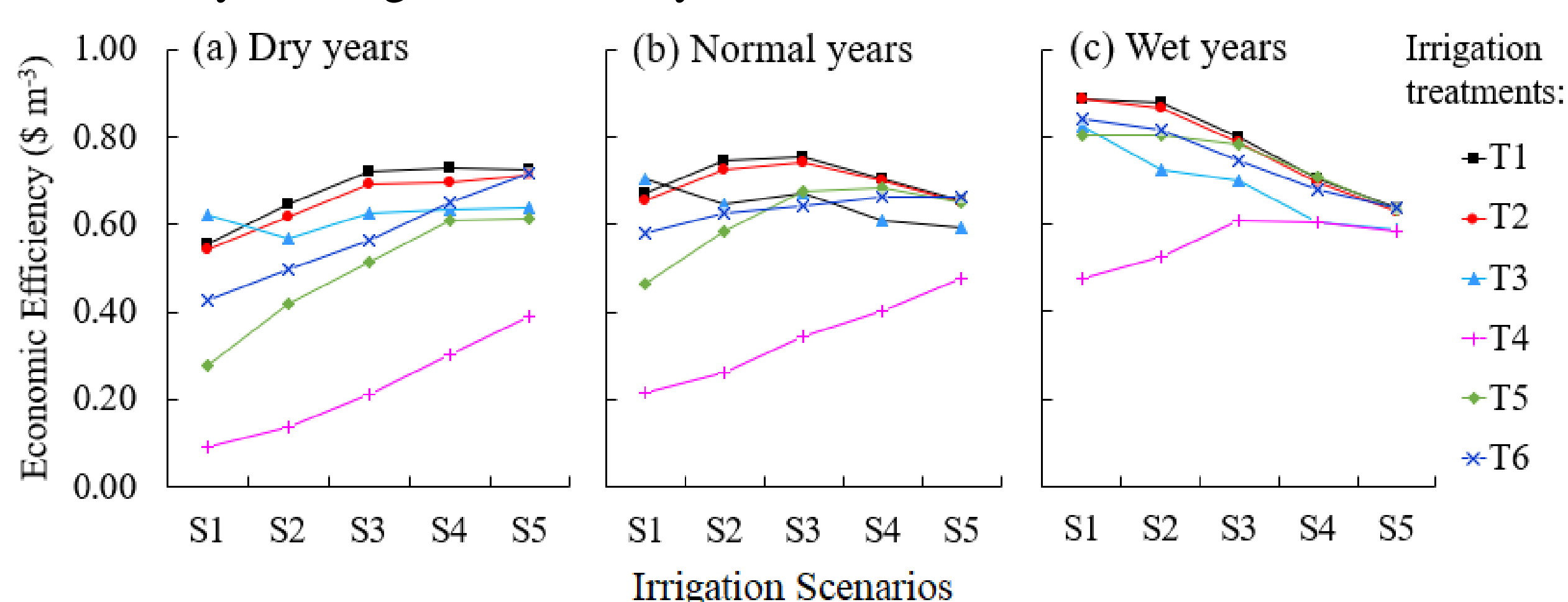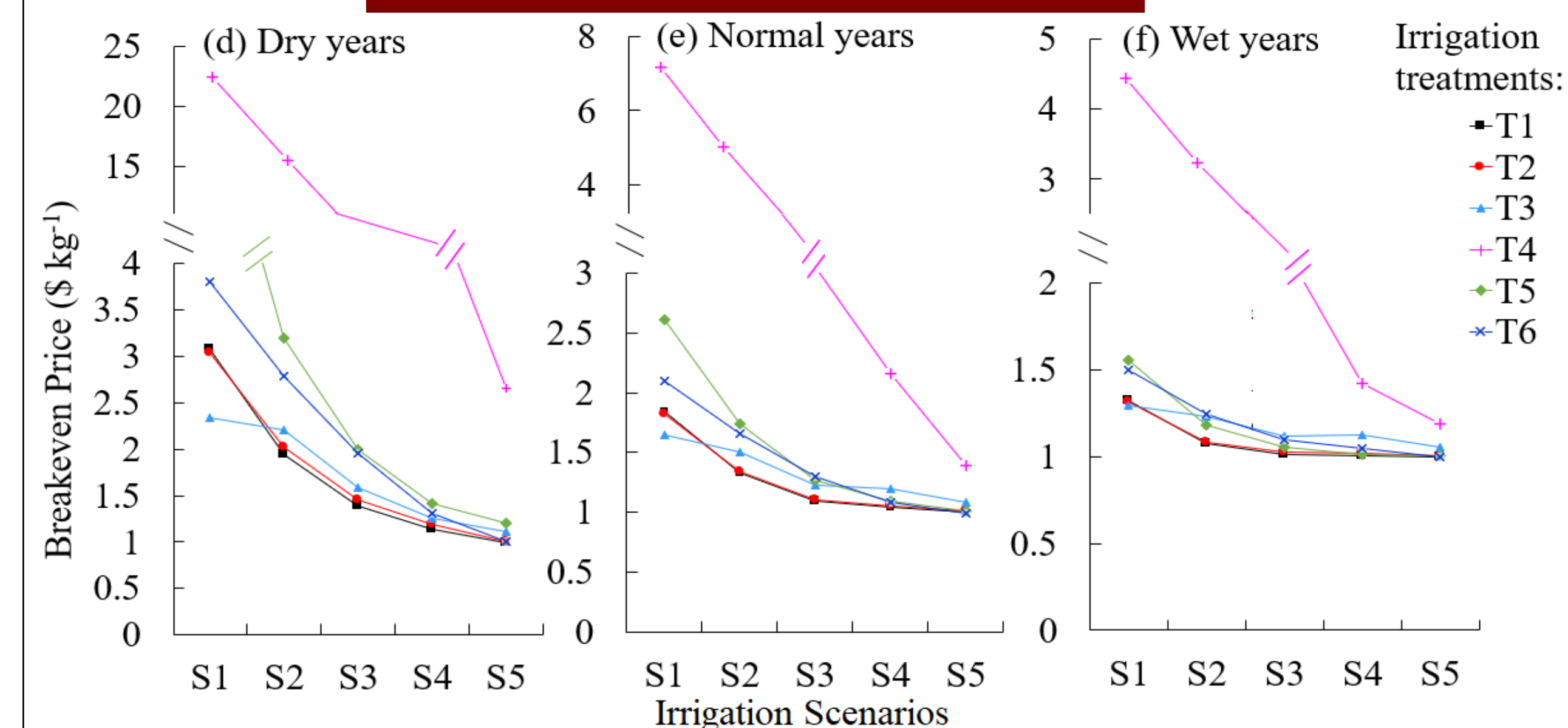

Breakeven Price

❑ Line patterns of the breakeven prices to cover variable cost and total cost are rather similar. T4 has the highest breakeven prices that are even not feasible to achieve except for the highest irrigation level S5.

❑ Significant decrease of breakeven prices in both dry and normal years.

❑ In normal years, breakeven prices to cover total cost for T1 and T2 are $1.33 kg^{-1} at S2, $1.10 kg^{-1} at S3, $1.04 kg^{-1} at S4, and $1.00 kg^{-1} at S5.

To Cover Variable Cost
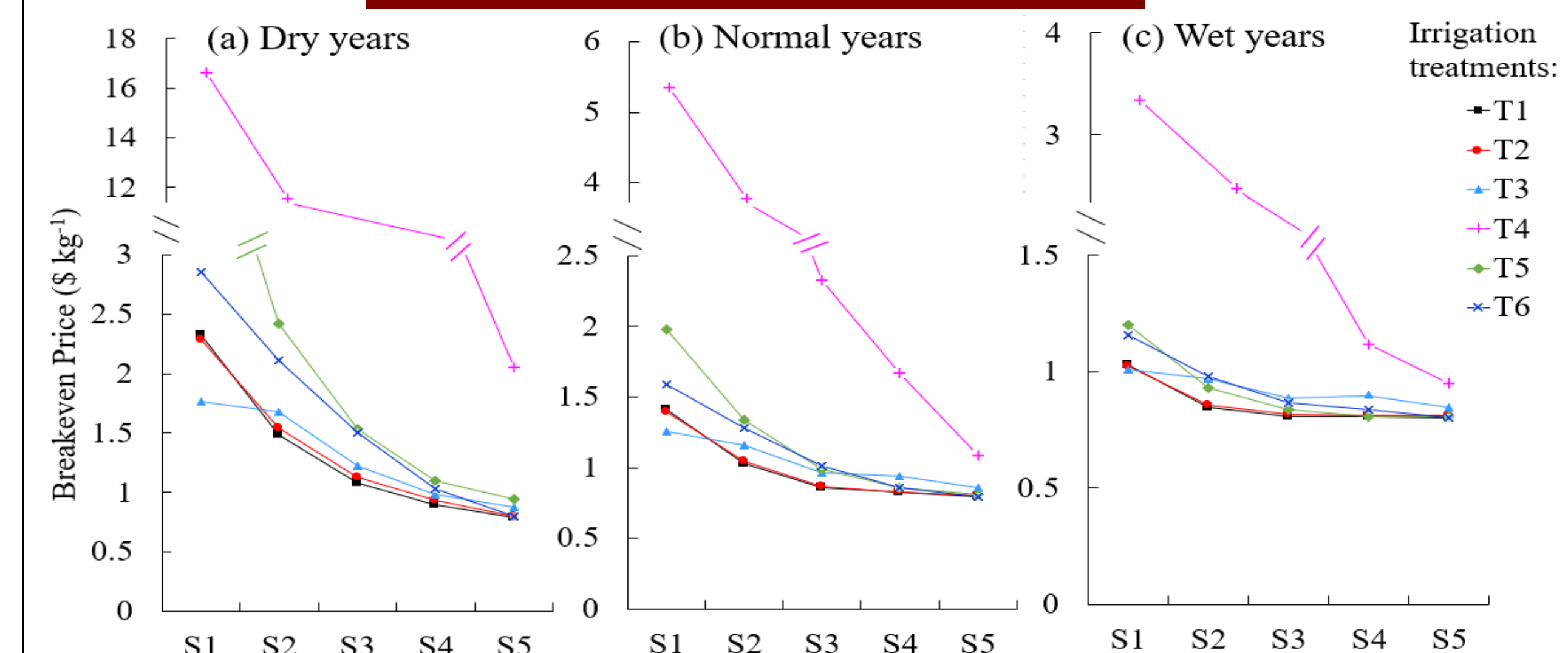
To Cover Total Cost

Summary

➢ Results from net return, efficiency and breakeven price reach a consensus that irrigation shouldn't be skipped at the peak bloom stage (T4) for optimal irrigation decision making.

➢ In normal years, highest efficiency is achieved at S2 and S3 for T1 and T2.

➢ In wet years, more irrigation water decreases the efficiency, and the highest efficiency is achieved at S1 and S2 for T1 and T2.

➢ In normal years, optimal irrigation level is between S3 and S4 to achieve the lowest breakeven prices for all irrigation strategies except for T4.

➢ In wet years, optimal irrigation level is no more than 360 mm (S3) to achieve the low breakeven prices for all strategies except for T4.

References

Bordovsky, J. P., Mustian, J. T., Ritchie, G. L., & Lewis, K. L. (2015). Cotton irrigation timing with variable seasonal irrigation capacities in the Texas south plains. *Applied Engineering in Agriculture*, 31(6), 883-897.

Himanshu, S.K., Fan, Y., Ale, S., Bordovsky, J. P. Simulated efficient crop-growth-stage-based deficit irrigation strategies for maximizing cotton yield, crop water productivity and net returns. *Under review*.

Acknowledgements

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