Simulating Cotton Yield under Variable Irrigation Management Scenarios

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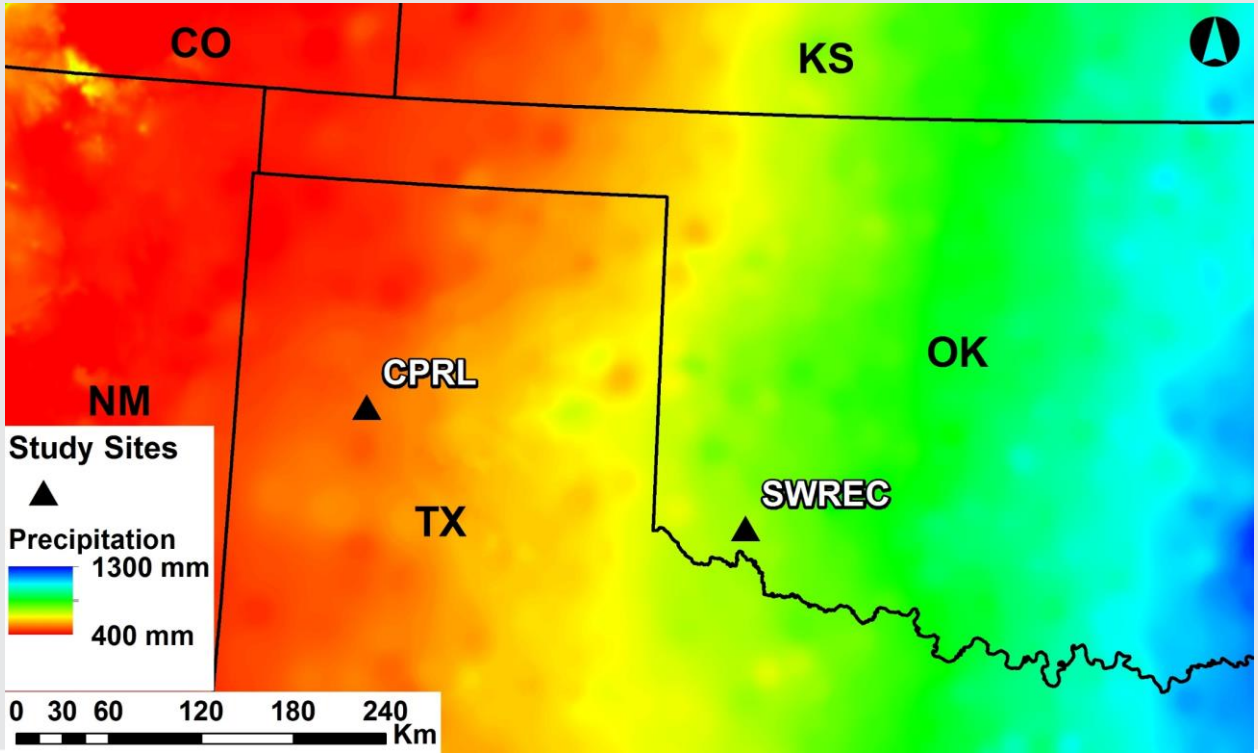
INTRODUCTION

- Cotton is an important economic crop in the Southern Great Plains (SGP)
- Water scarcity and weather conditions limit cotton production in SGP
- Need for assessing irrigation management strategies
- Crop simulation models
  - Cost effective & timely
  - Scenario analysis

MATERIALS AND METHODS

Study Sites

- Conservation and Production Research Laboratory (CPRL)
- OSU's Southwest Research and Extension Center (SWREC)



MATERIALS AND METHODS

CPRL

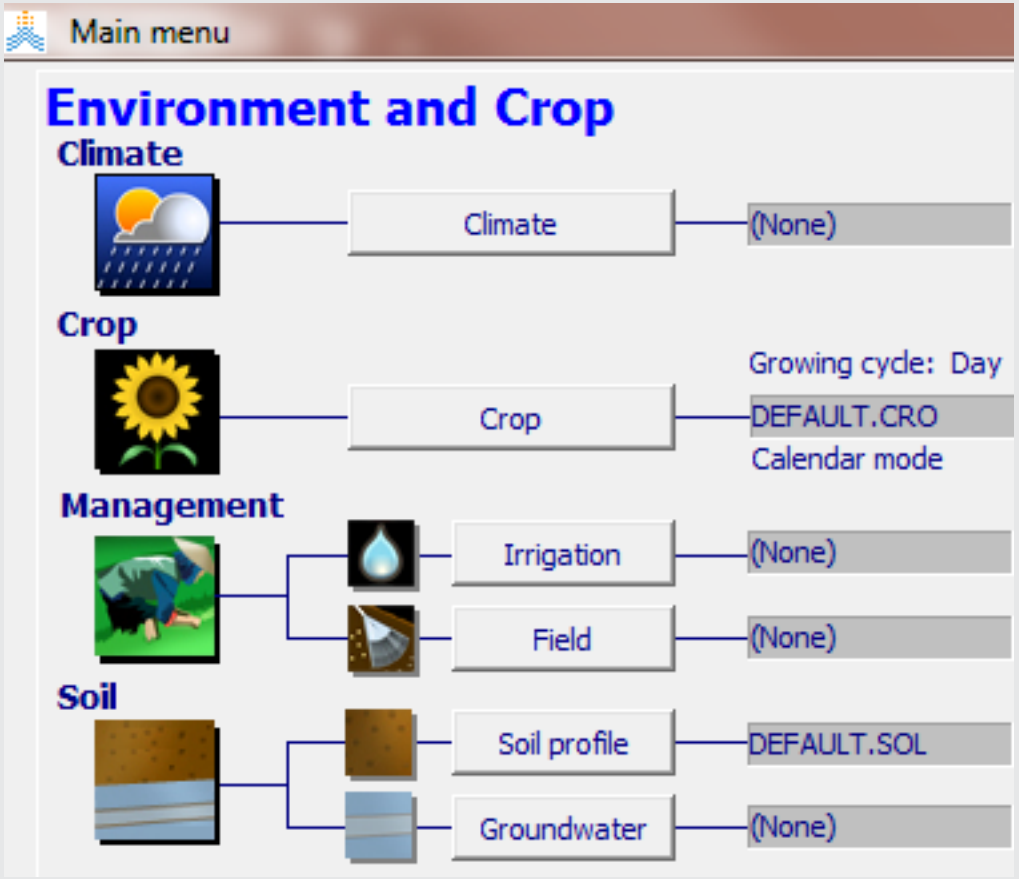
- Linear move irrigation system
- 3 treatments (Full, 50%, Dryland)
- 9 m^2 lysimeter fields
- Leaf area index (LAI), soil water content (SWC), evapotranspiration (ET) & cotton yield
- 5 growing seasons (2000, 2001, 2002, 2003 & 2010)

SWREC

- Furrow irrigation
- 3 treatments determined by irrigation termination date
- Targeted dates: August 16, August 23, and August 30
- Cotton Yield
- 3 growing seasons (2015-2017)

MATERIALS AND METHODS

- **AquaCrop model -** simulates the crop yield response to water



$$B = WP^* \times \sum \left(\frac{T_r}{ET_o}\right)$$

B- biomass; T_r - transpiration;

WP*- normalized water productivity;

ET_o- reference ET

$$Y = B \times HI$$

Y- yield; HI- harvest index

MATERIALS AND METHODS

AquaCrop calibration and validation

- Model was run in growing degree-days
- Simulations were done by first using the default parameters
- Adjustments of crop phenological stages if necessary
- Model performance based on sound prediction of canopy cover, SWC, ET and cotton yield
- Statistical metrics used to determine model performance

MATERIALS AND METHODS

Model Application

- 1981-2013 historical weather data from PRISM
- Center pivot system applying 25 mm net irrigation over 48 ha
- Minimum soil temperature (MinST) approach
- Planting date: first date when MinST ≥ 15 °C

Irrigation capacity ($l\ s^{-1}\ ha^{-1}$)	Irrigation interval	Total irrigation (mm)
0.0	-	0
0.1	27	100
0.3	14	200
0.4	9	325
0.5	7	425
0.6	6	500

RESULTS

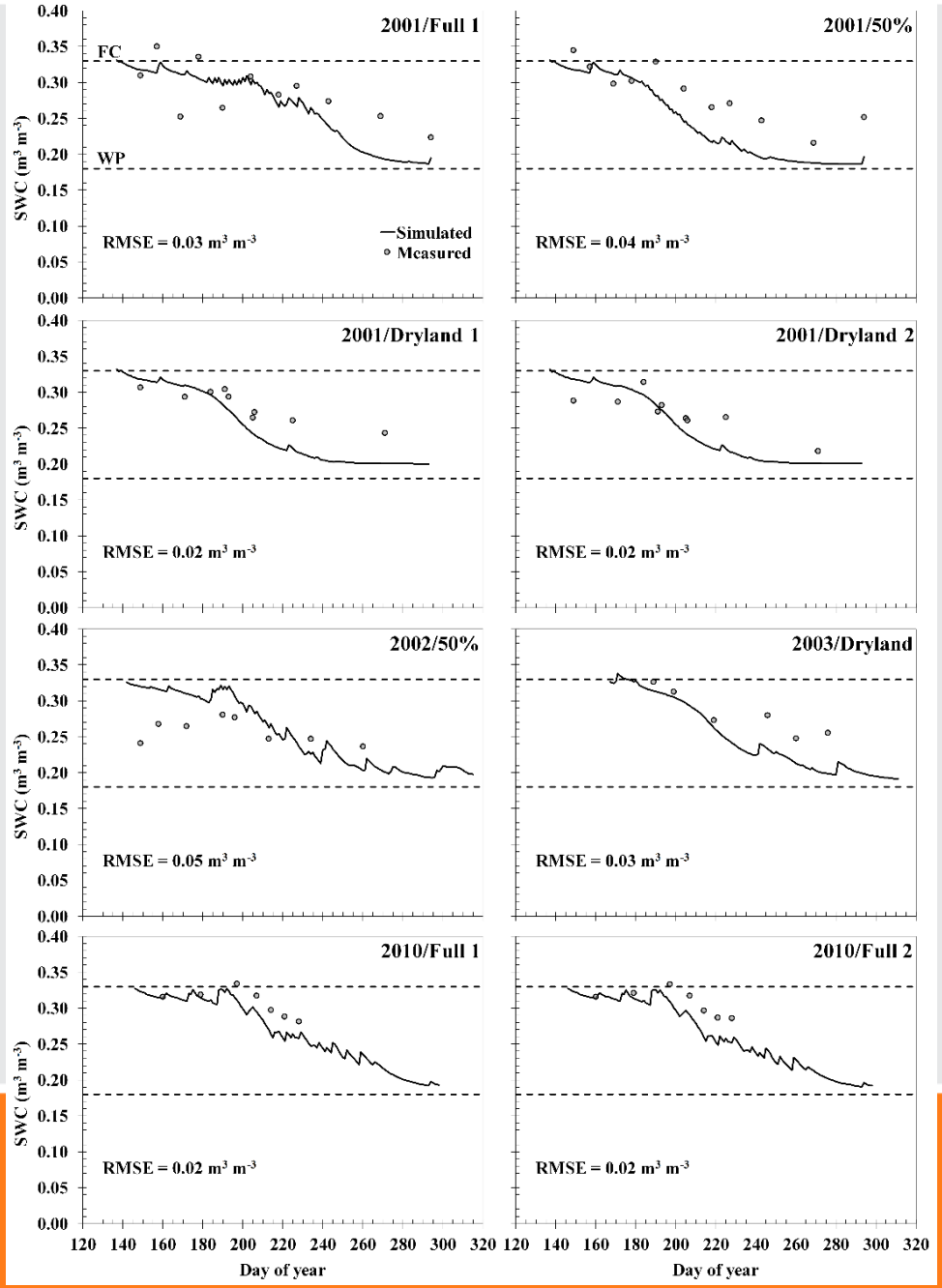
Canopy Cover

- Irrigated treatments attained acceptable accuracy during validation
- Results comparable to Tan et al. (2018), better than Qiao et al. (2016)
- Accuracy was lower in dryland treatments

RESULTS

Soil water content

- RMSEs similar to the findings of Qiao et al. (2016)
- Deviations possibly due to oversimplified root development
- Acceptable NRMSE values (Jamieson et al., 1991):
  - calibration (11 – 20%)
  - validation (6 – 19%)



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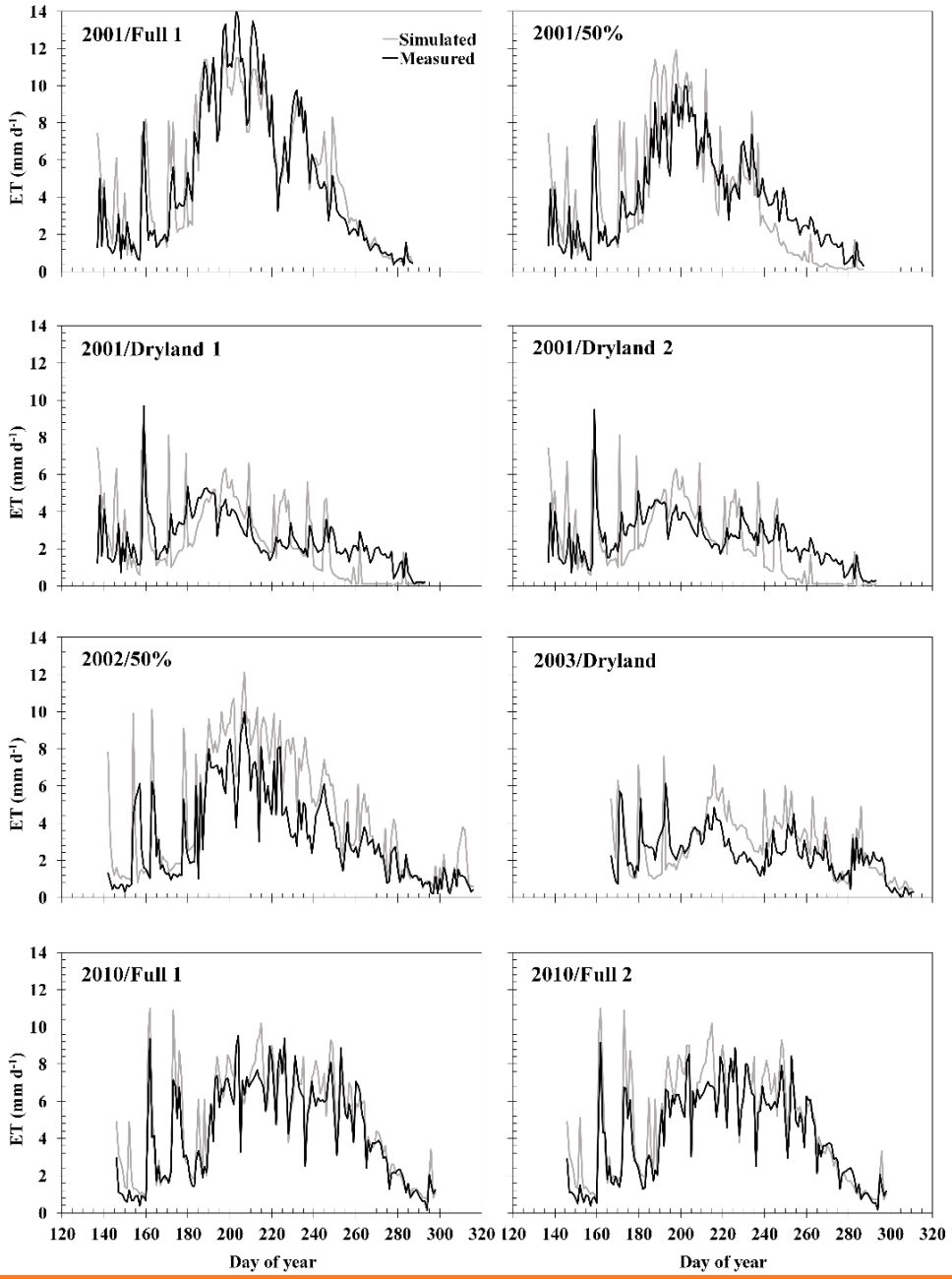
RESULTS

Daily ET

- Good prediction of daily ET trends by the model
- Acceptable accuracy for irrigated treatments (Moriasi et al. 2007)
- Lower accuracy for dryland treatments



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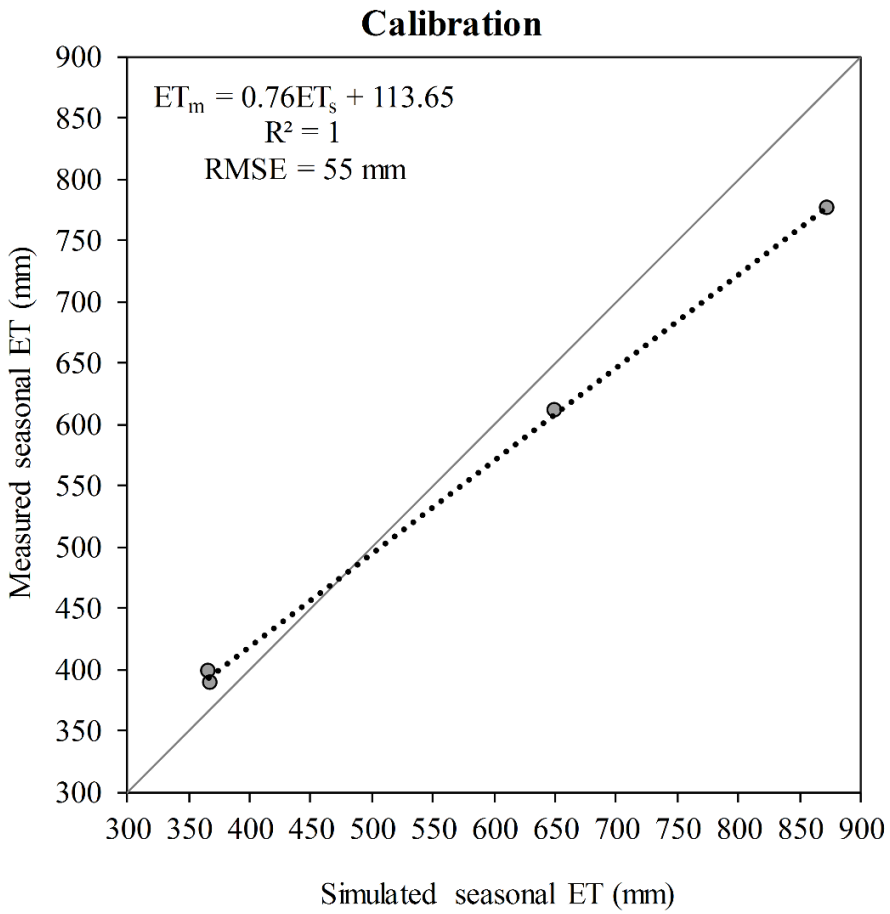
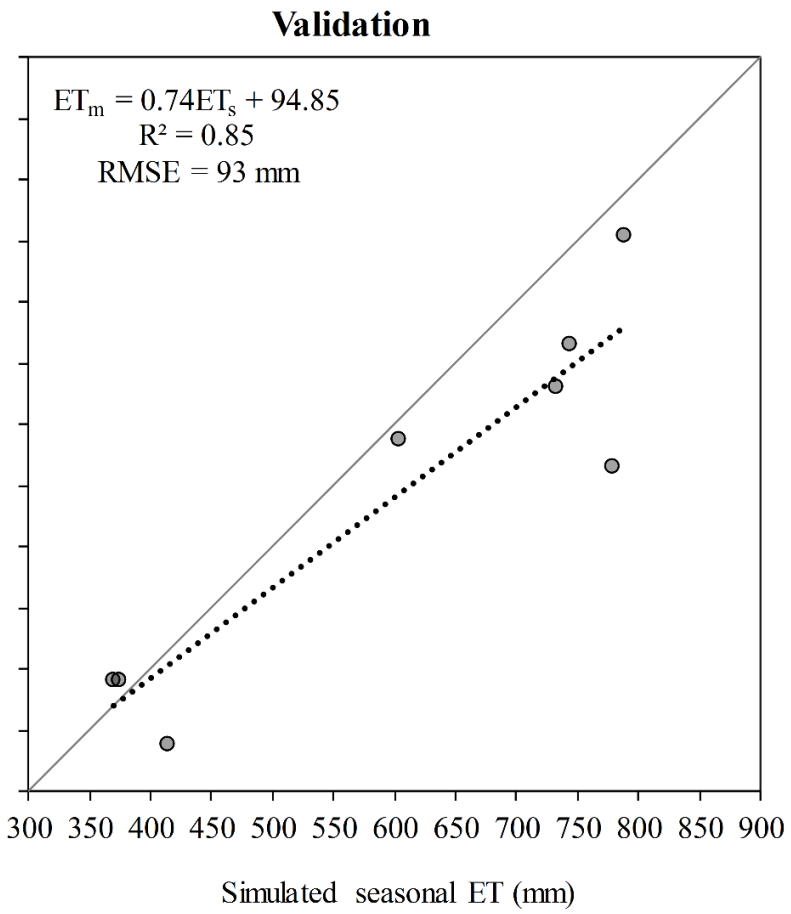
RESULTS

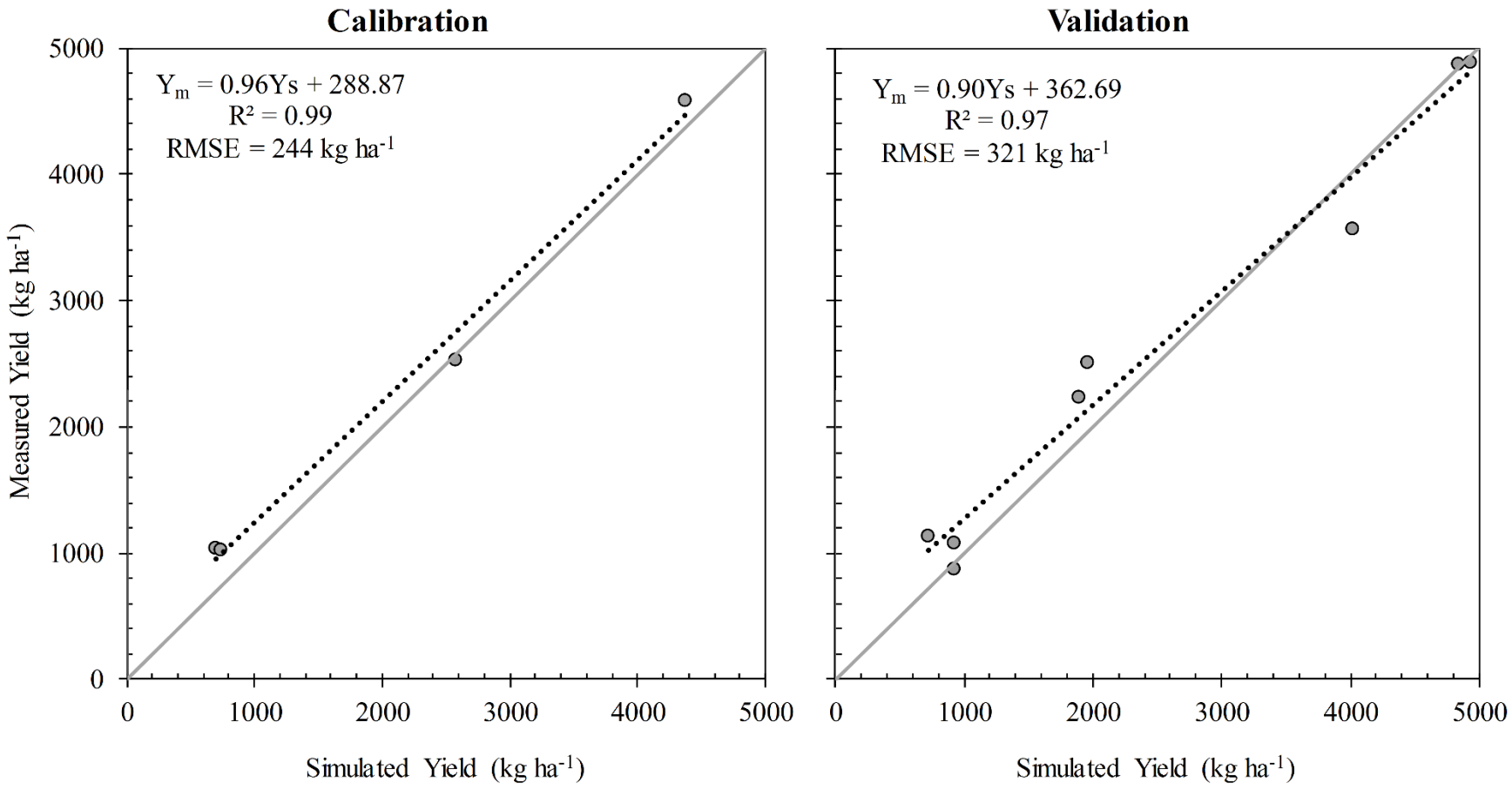
Seasonal ET





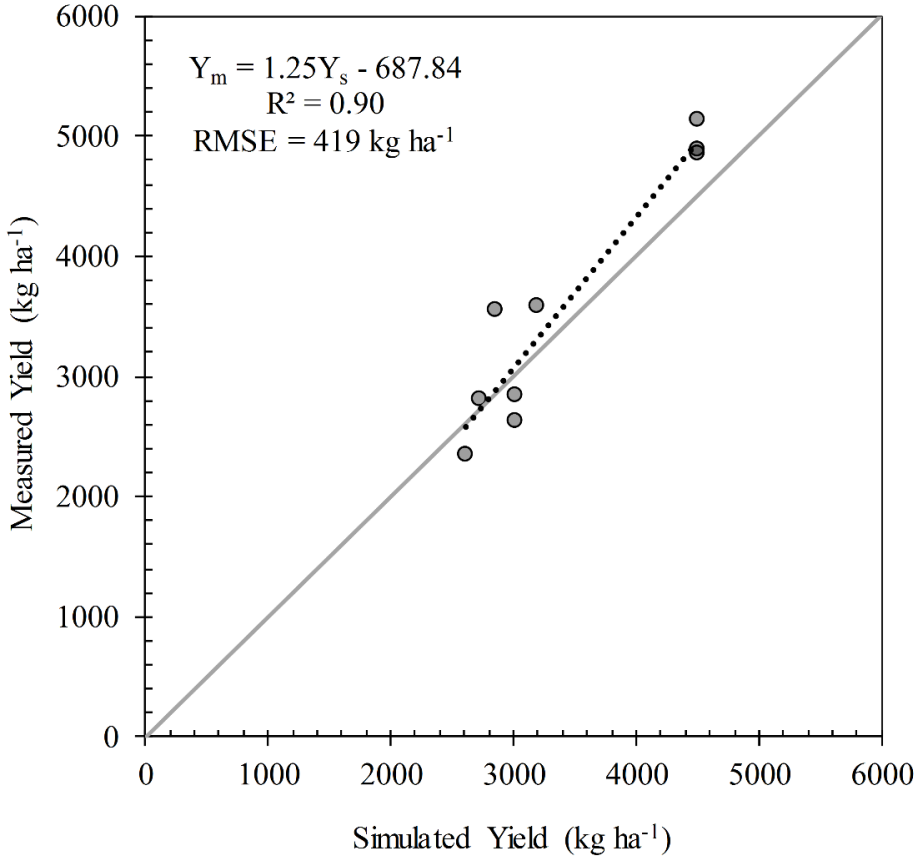
RESULTS

Cotton Yield-CPRL



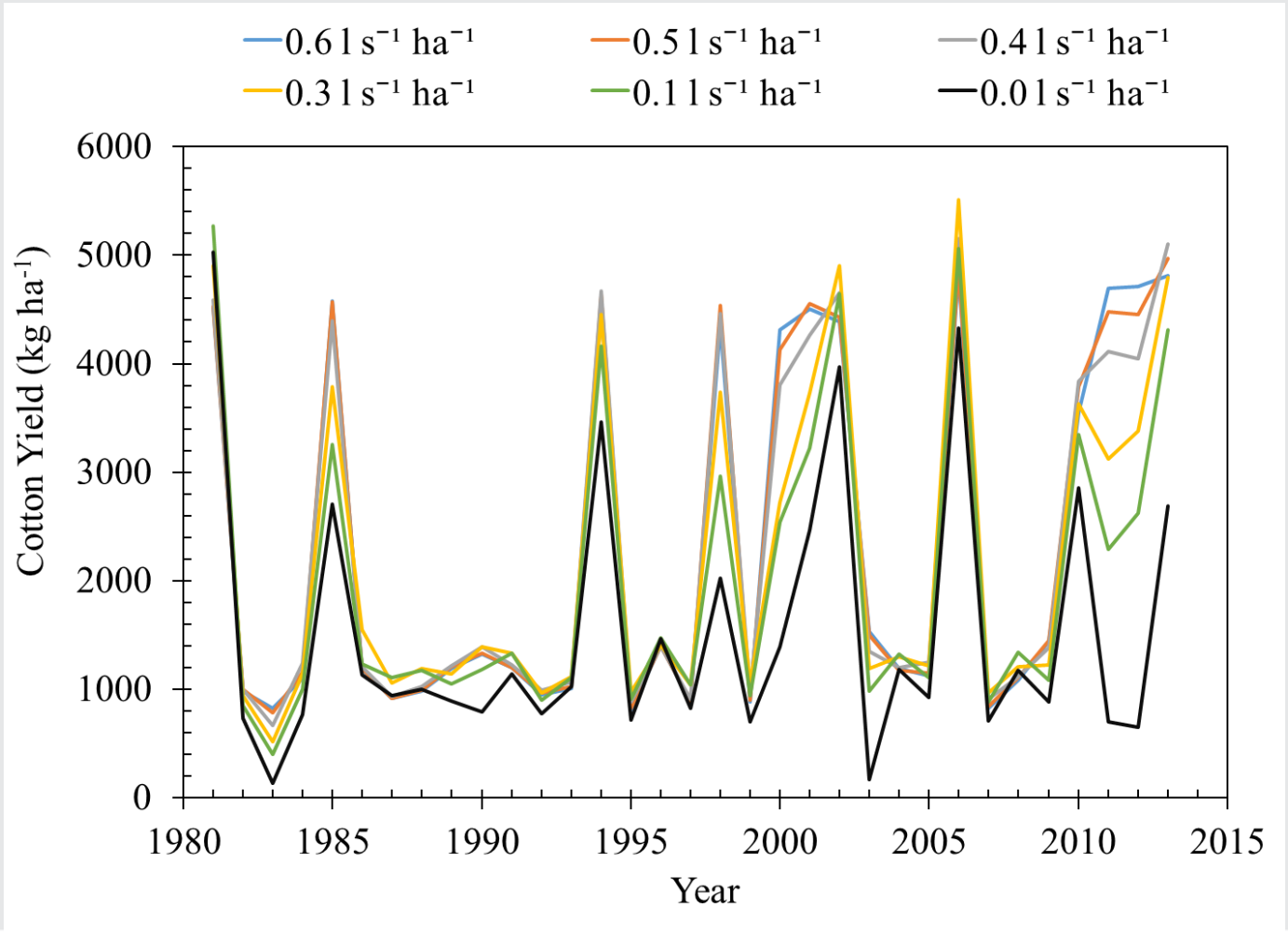
RESULTS

Cotton Yield-SWREC



RESULTS

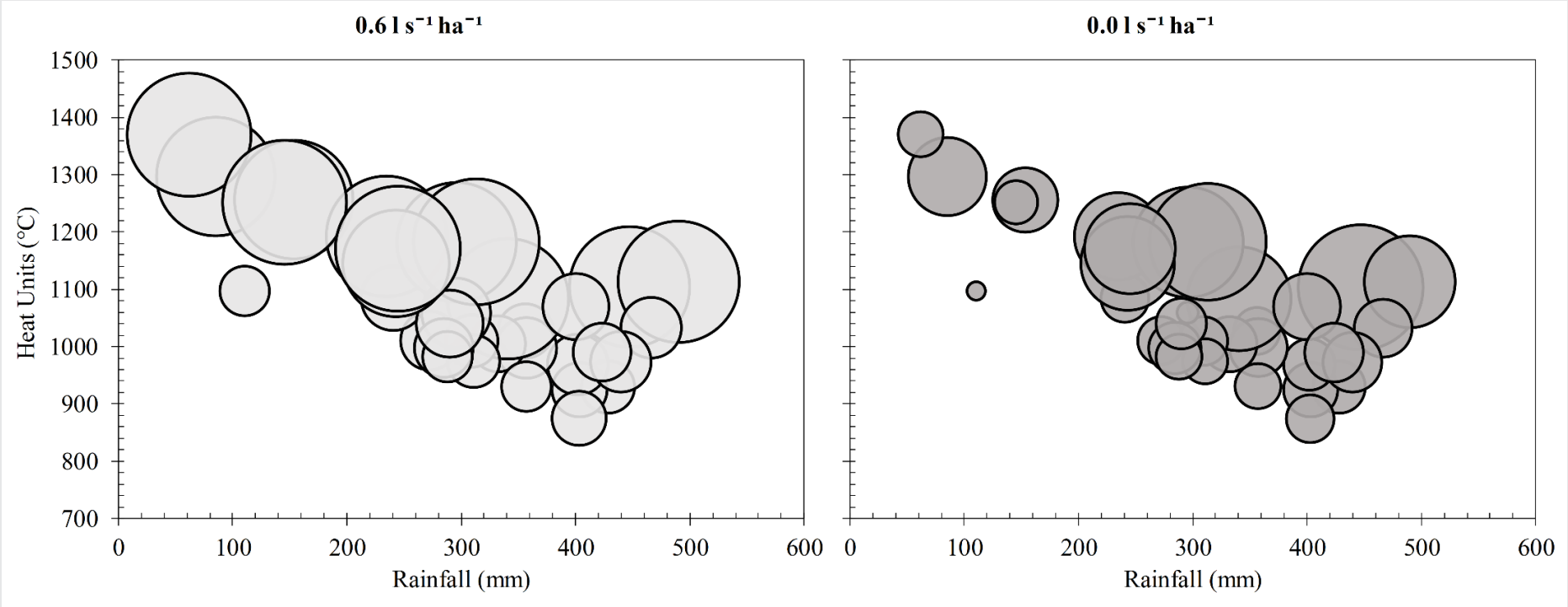
Model Application



IC	Yield
0.0	1525 a
0.1	2004 b
0.3	2201 bc
0.4	2316 c
0.5	2333 c
0.6	2321 c

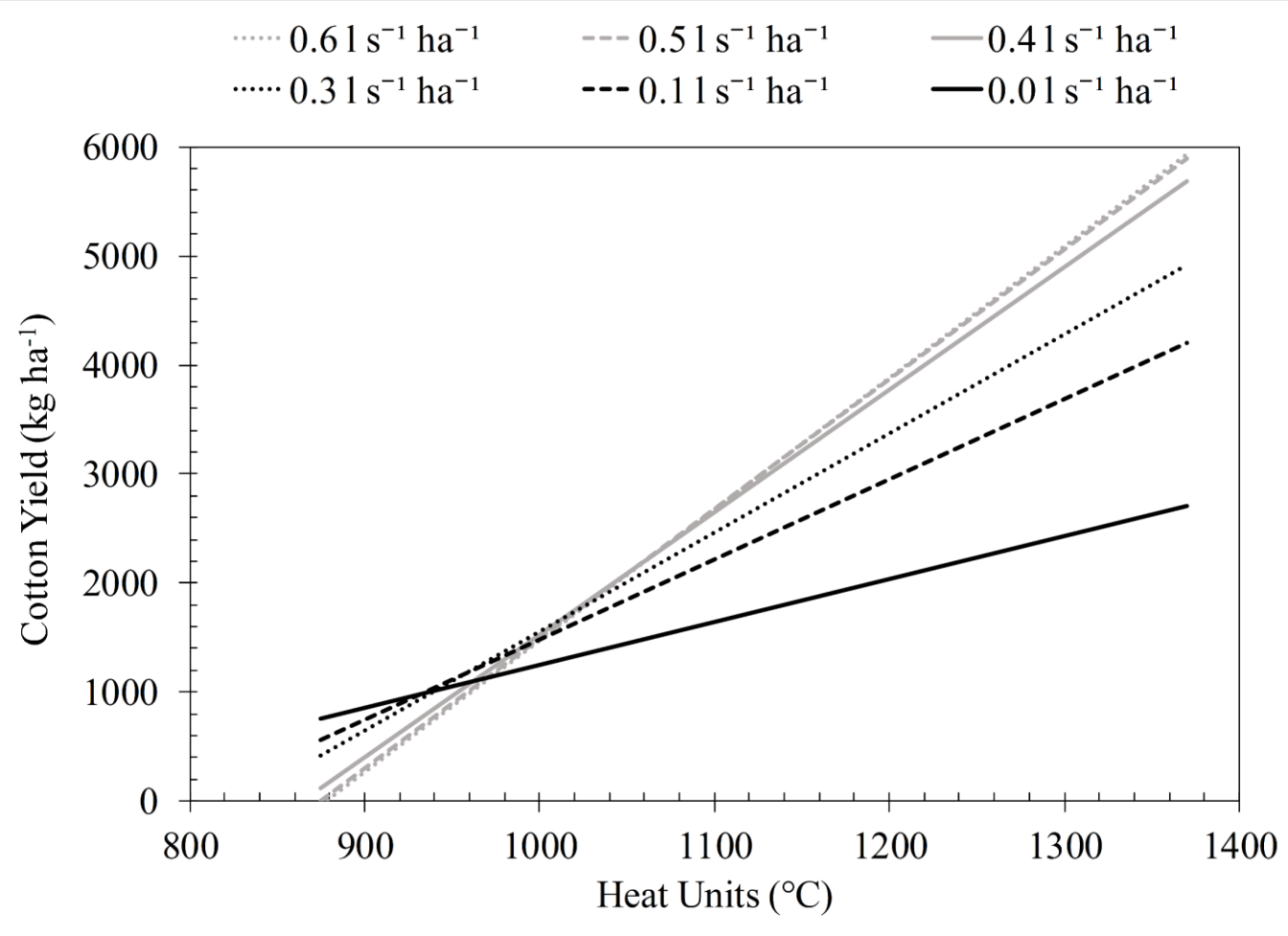
RESULTS

Effects of rainfall and heat units



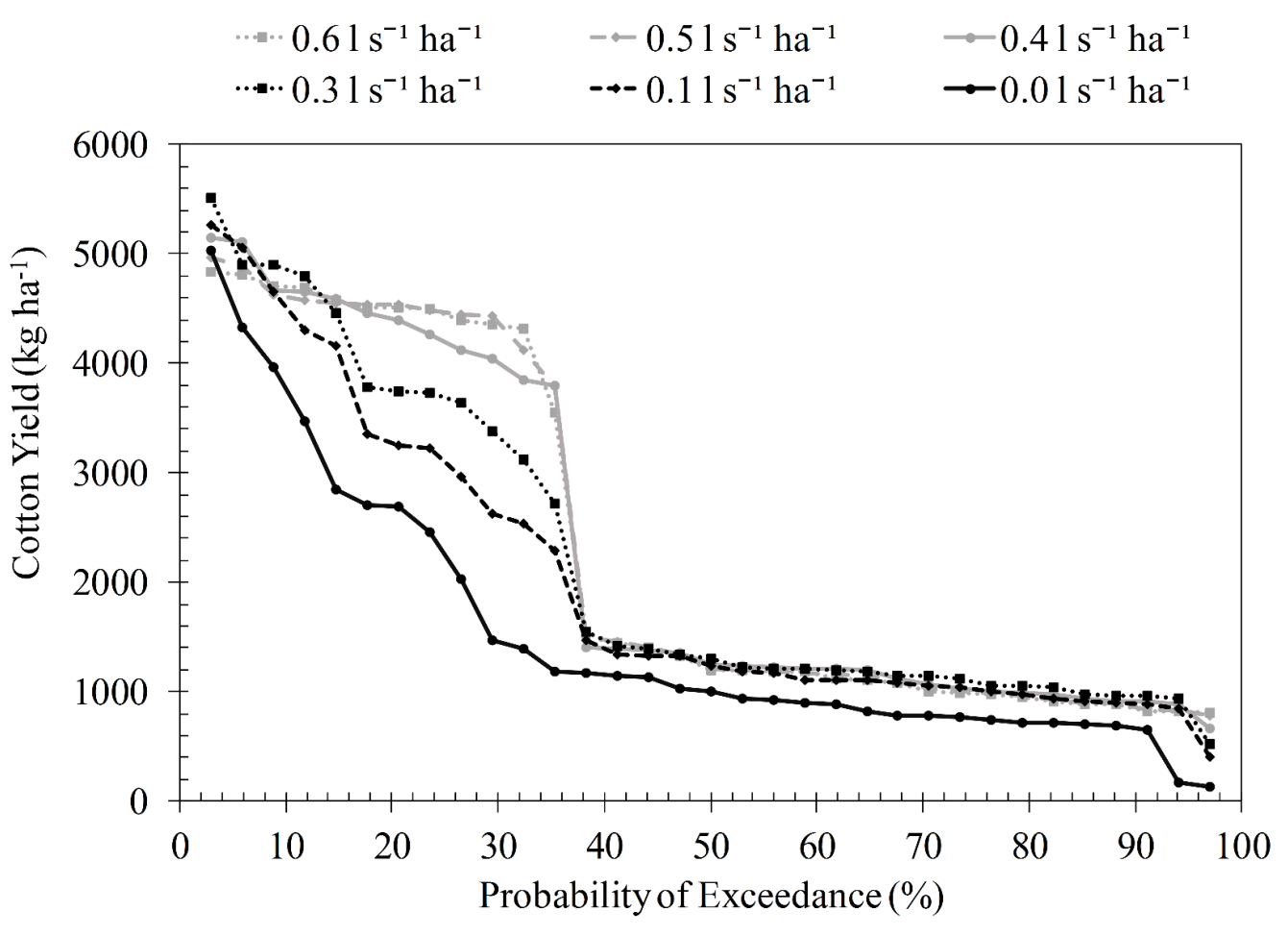
RESULTS

Response of yield to heat units



RESULTS

Probability of Exceedance



CONCLUSIONS

- Results indicated satisfactory performance of AquaCrop for simulating CC, SWC, ET and cotton yield
- AquaCrop model is a potential tool for evaluating irrigation and crop management of cotton in the southern Great Plains
- No significant increase in average cotton yields at irrigation capacities higher than 0.3 l s^{-1} ha^{-1}
- Both water availability and heat unit availability play important roles in cotton yield

ACKNOWLEDGEMENTS

USDA ARS Agricultural Research Service

cotton® Cotton Incorporated

Thank You!

RESULTS

Canopy Cover

Parameter	Treatment	R^2	RMSE (%)	d
Calibration	2000/Full	0.84	24	0.73
	2000/50%	0.84	16	0.84
	2000/Dryland 1	0.50	23	0.68
	2000/Dryland 2	0.44	25	0.59
Validation	2001/Full	0.99	6	0.99
	2001/50%	0.92	7	0.97
	2001/Dryland 1	0.07	20	0.55
	2001/Dryland 2	0.61	11	0.70
	2002/50%	0.98	25	0.75
	2003/Dryland	0.85	9	0.88
	2010/Full 1	1.00	5	1.00
	2010/Full 2	1.00	5	1.00

RESULTS

Soil water content (m^3 m^{-3})

Parameter	Treatment	R^2	RMSE	d
Calibration	2000/Full	0.59	0.03	0.65
	2000/50%	0.72	0.06	0.85
	2000/Dryland 1	0.86	0.06	0.88
	2000/Dryland 2	0.75	0.05	0.87
Validation	2001/Full	0.47	0.03	0.78
	2001/50%	0.81	0.04	0.84
	2001/Dryland 1	0.86	0.02	0.87
	2001/Dryland 2	0.60	0.02	0.81
	2002/50%	0.45	0.05	0.95
	2003/Dryland	0.89	0.03	0.86
	2010/Full 1	0.84	0.02	0.85
	2010/Full 2	0.87	0.02	0.87

RESULTS

Daily ET (mm d^{-1})

Parameter	Treatment	R^2	RMSE	d
Calibration	2000/Full	0.81	1.8	0.94
	2000/50%	0.68	1.9	0.88
	2000/Dryland 1	0.70	1.6	0.95
	2000/Dryland 2	0.64	1.8	0.82
Validation	2001/Full	0.86	1.5	0.96
	2001/50%	0.73	1.8	0.91
	2001/Dryland 1	0.36	1.7	0.74
	2001/Dryland 2	0.37	1.6	0.74
	2002/50%	0.79	1.9	0.88
	2003/Dryland	0.34	1.5	0.72
	2010/Full 1	0.87	1.1	0.95
	2010/Full 2	0.86	1.3	0.99

RESULTS

Cotton Yield-CPRL

Parameter	Treatment	Measured (kg ha^{-1})	Default		Calibrated	
			Simulated (kg ha^{-1})	P_e (%)	Simulated (kg ha^{-1})	P_e (%)
Calibration	2000/Full	4581	2023	-56	4372	-5
	2000/50%	2535	1114	-56	2565	1
	2000/Dryland 1	1036	469	-55	700	-32
	2000/Dryland 2	1022	455	-55	738	-28
Validation	2001/Full	3568	1198	-66	4019	13
	2001/50%	2239	630	-72	1888	-16
	2001/Dryland 1	1081	493	-54	920	-15
	2001/Dryland 2	877	499	-43	930	6
	2002/50%	2507	1828	-27	1957	-22
	2003/Dryland	1132	846	-25	726	-36
	2010/Full 1	4882	1313	-73	4937	1
	2010/Full 2	4868	1285	-74	4842	-1

RESULTS

Cotton Yield-SWREC

Year	Treatment	Measured (kg ha^{-1})	Simulated (kg ha^{-1})	P_e (%)
2015	T1	2343	2605	11
2015	T2	2806	2730	-3
2015	T3	3546	2853	-20
2016	T1	4885	4500	-8
2016	T2	4852	4500	-7
2016	T3	5131	4500	-12
2017	T1	2838	3023	7
2017	T2	2623	3023	15
2017	T3	3587	3187	-11