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Cotton Research and Development Corporation

NCEA

Real-time irrigation decision-making and control for site-specific irrigation of cotton using a centre pivot, 2012/13

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A Research Centre of the University of Southern Queensland

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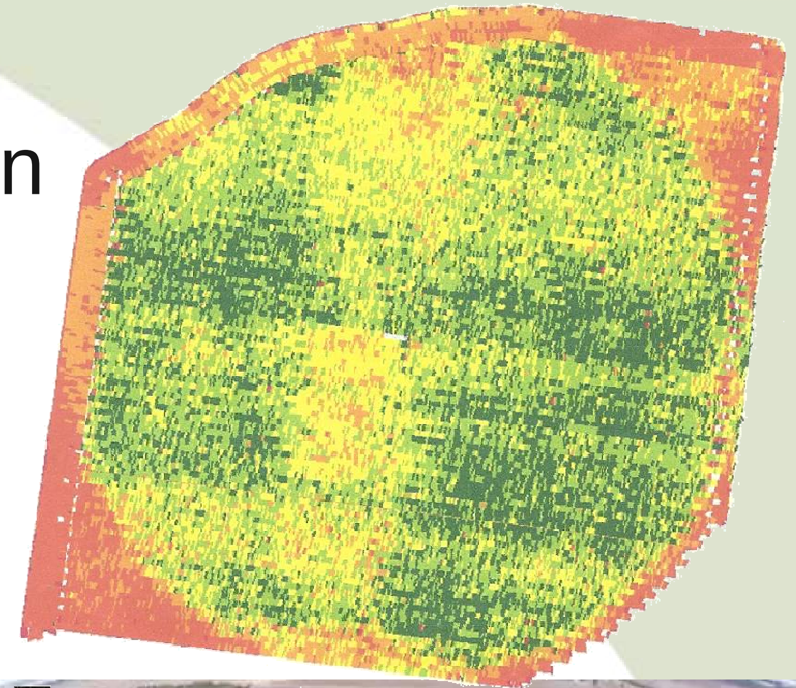
fulfilling lives

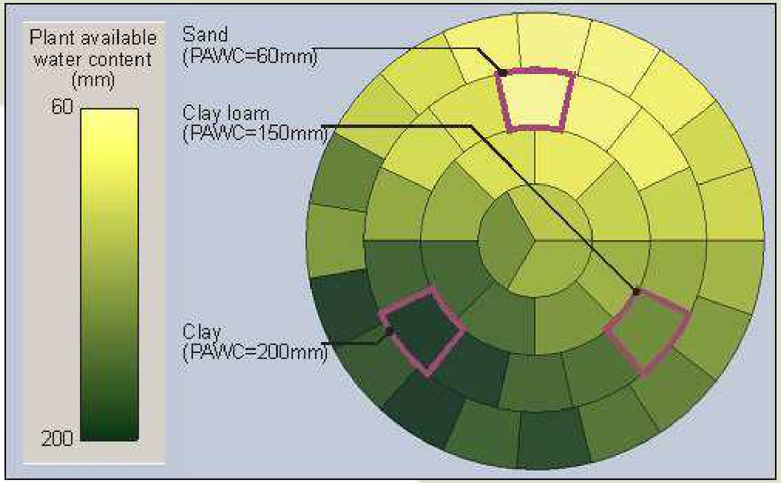
Cotton irrigation in Australia

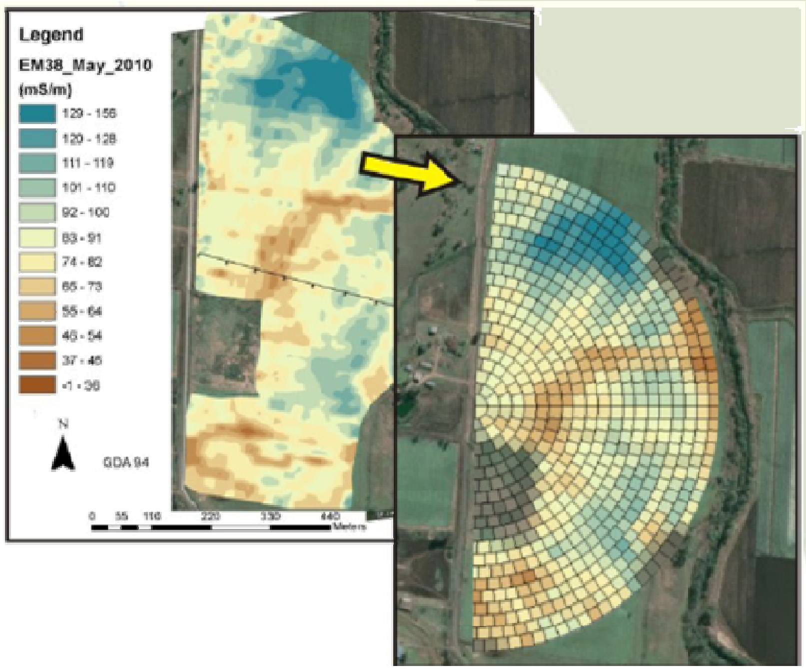
- Cotton industry uses 10% of Australian water consumption
- Site-specific irrigation automation presents opportunities for improved water use efficiencies



VARIwise control framework

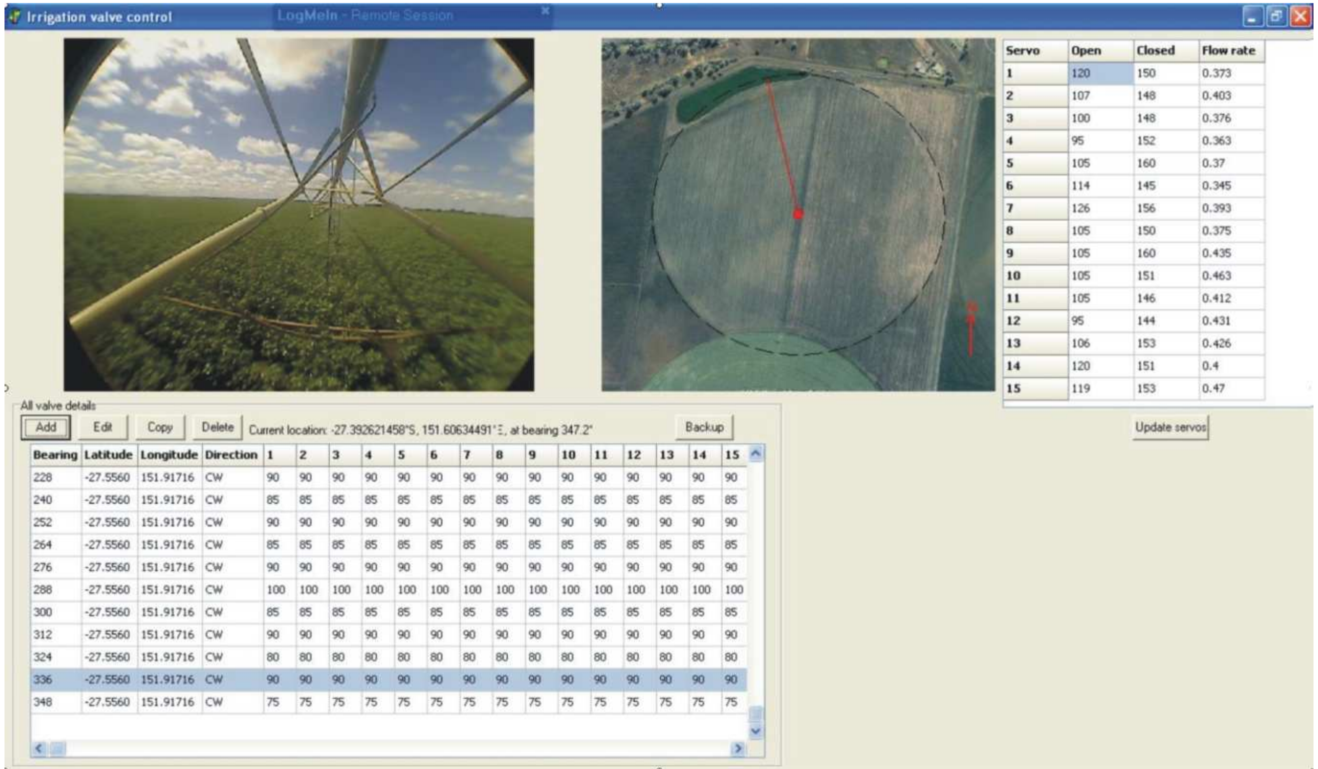
- ‘VARIwise’ simulates and develops irrigation control strategies at spatial resolution to $1m^2$ and any temporal resolution
- *Iterative Learning Control* (ILC) adjusts irrigation volume using error between measured and desired soil moisture
- *Model predictive control* (MPC) uses calibrated model to predict irrigation requirement
- Uses sensed data to determine irrigation application/timing





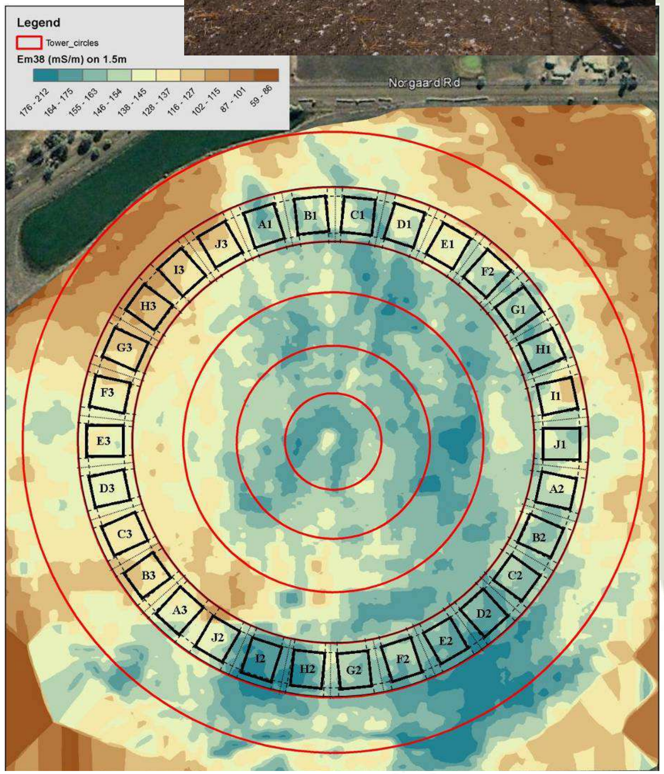
Centre pivot irrigation experimental plan

- Three replicates of MPC, ILC and FAO-56 with different targets and data inputs (weather, soil, plant)
- One span with flow meters and valves



Servo	Open	Closed	Flow rate
1	120	150	0.373
2	107	148	0.403
3	100	148	0.376
4	95	152	0.363
5	105	160	0.37
6	114	145	0.345
7	126	156	0.393
8	105	150	0.375
9	105	160	0.435
10	105	151	0.463
11	105	146	0.412
12	95	144	0.431
13	106	153	0.426
14	120	151	0.4
15	119	153	0.47

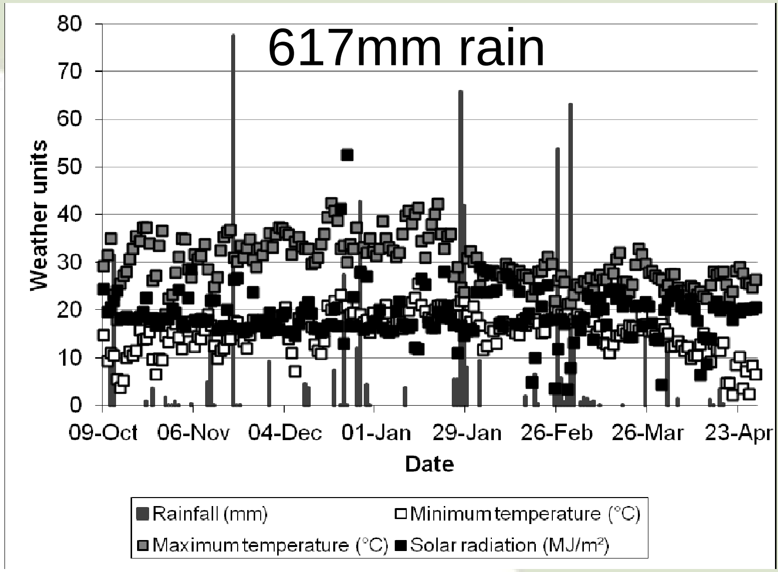
Bearing	Latitude	Longitude	Direction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
228	-27.5560	151.91716	CW	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
240	-27.5560	151.91716	CW	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
252	-27.5560	151.91716	CW	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
264	-27.5560	151.91716	CW	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
276	-27.5560	151.91716	CW	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
288	-27.5560	151.91716	CW	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
300	-27.5560	151.91716	CW	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
312	-27.5560	151.91716	CW	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
324	-27.5560	151.91716	CW	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
336	-27.5560	151.91716	CW	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
348	-27.5560	151.91716	CW	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75



Infield variability sensing

Soil-water estimation

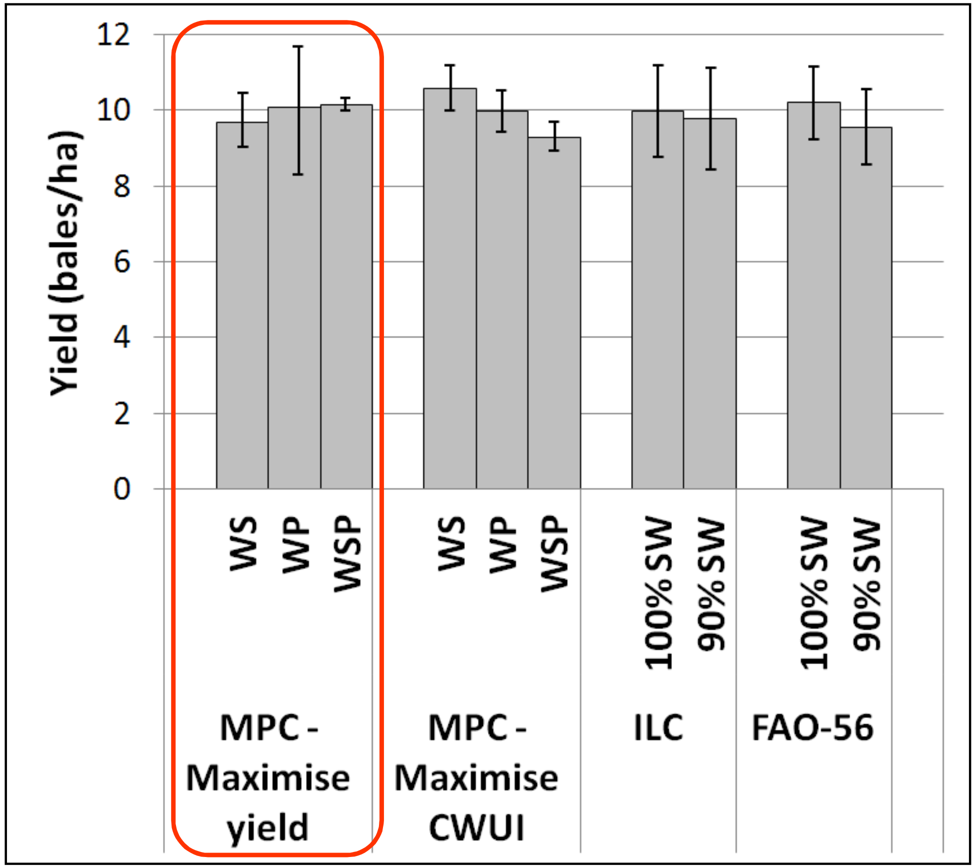
Infield weather station

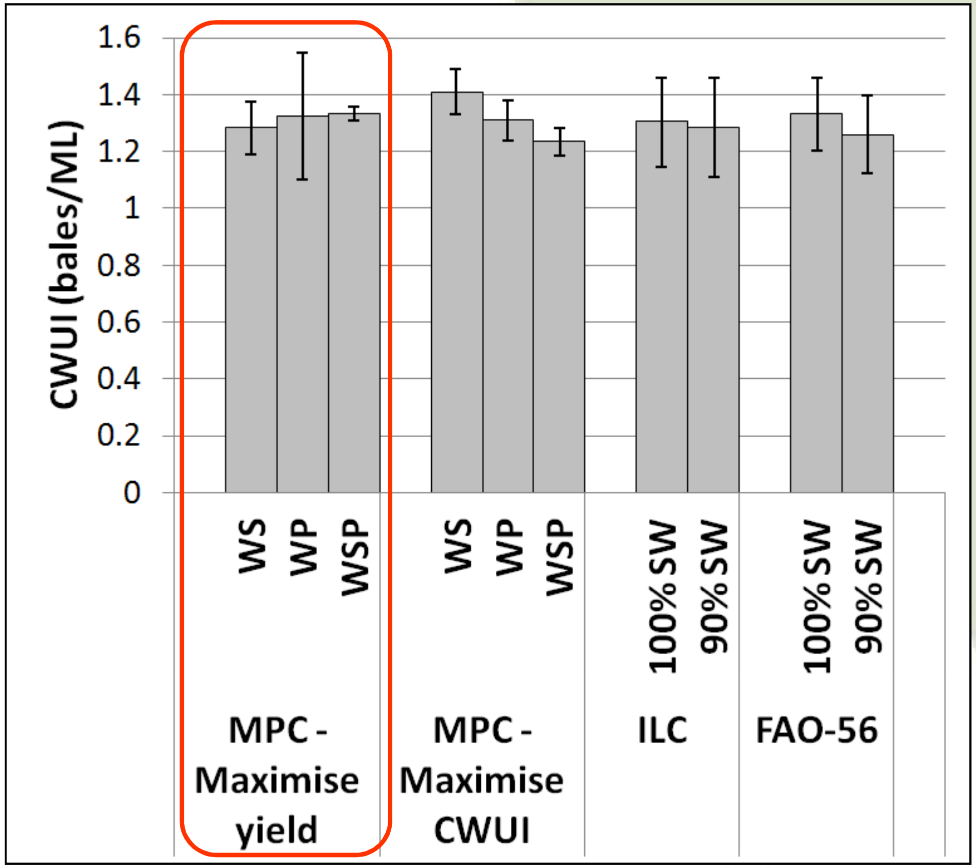


Overhead-mounted plant sensing platform

MPC maximising yield

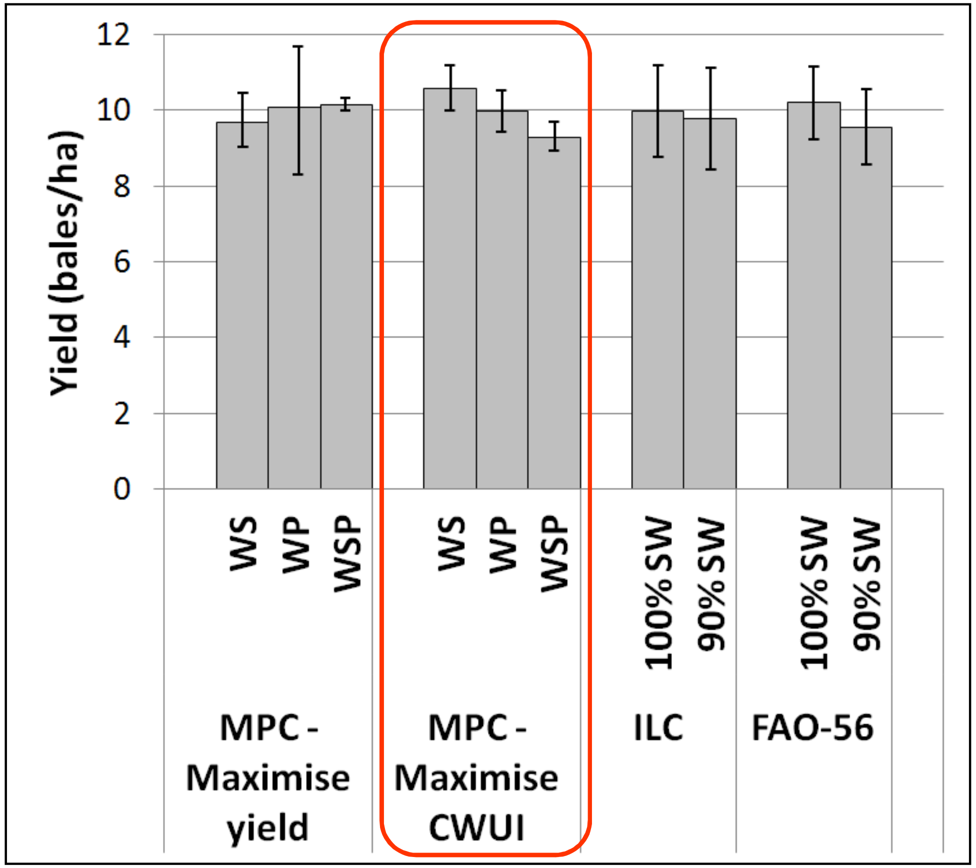
- Plant data input led to higher yield, no change in CWUI
  - Plant data input increased yield for MPC maximising yield

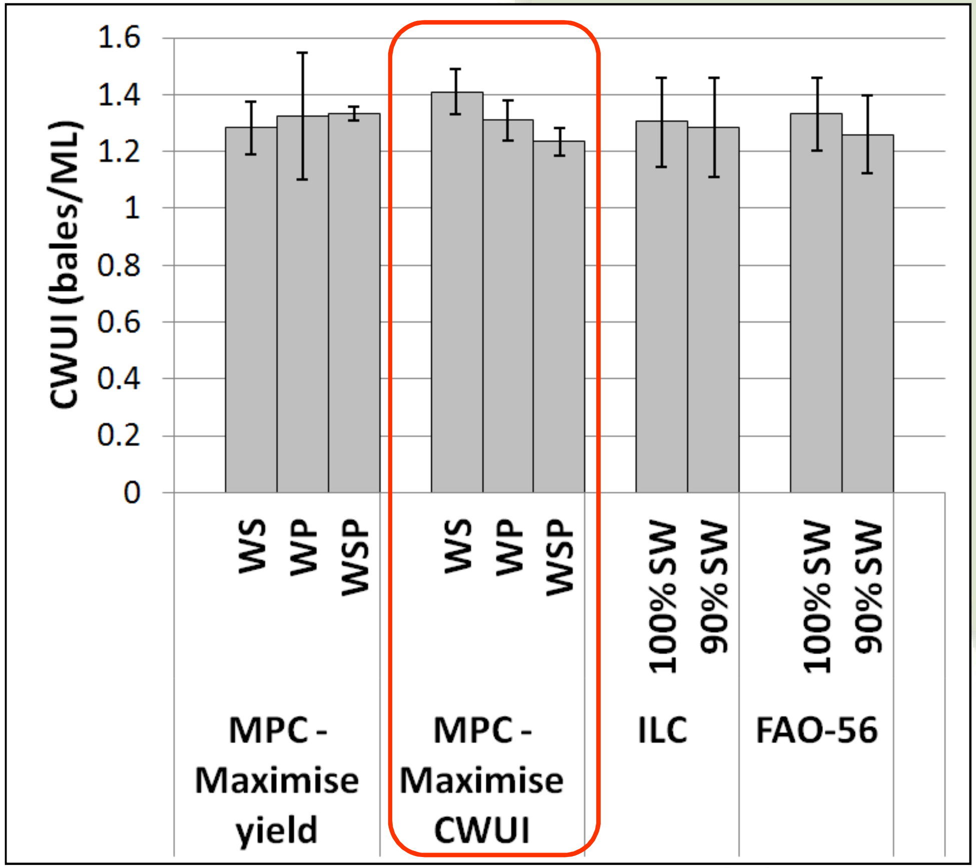




MPC maximising CWUI

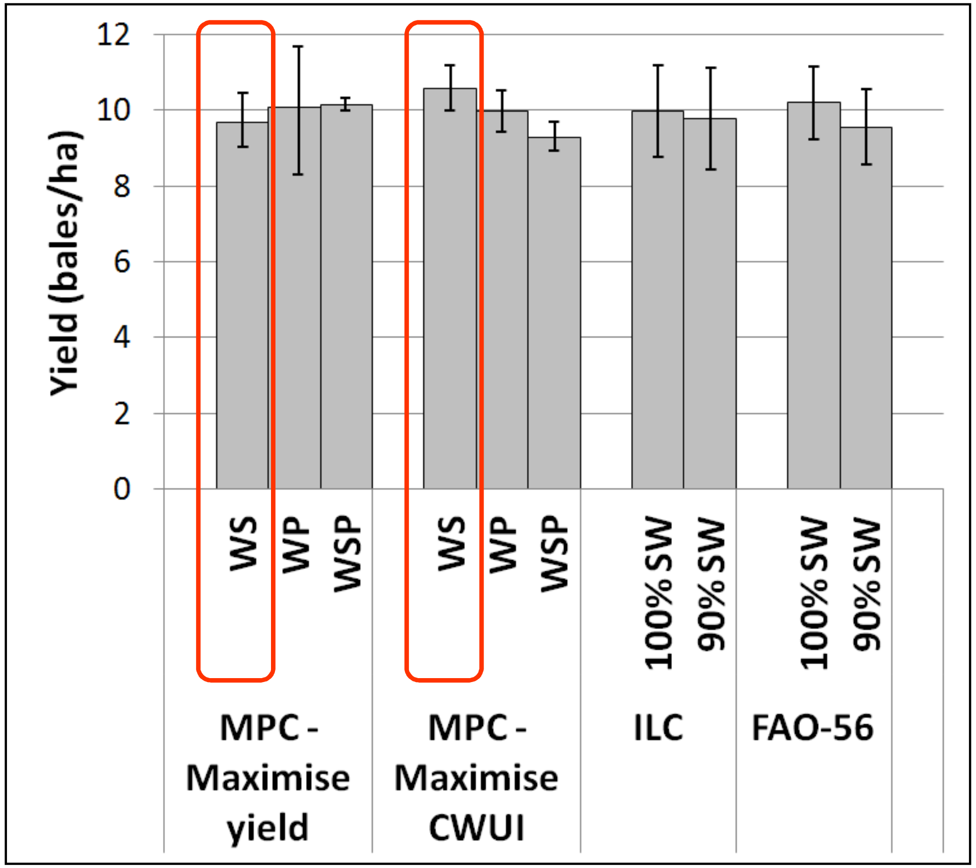
- Plant data input reduced irrigation application, yield and CWUI
  - Plant input not as influential maximising CWUI as yield

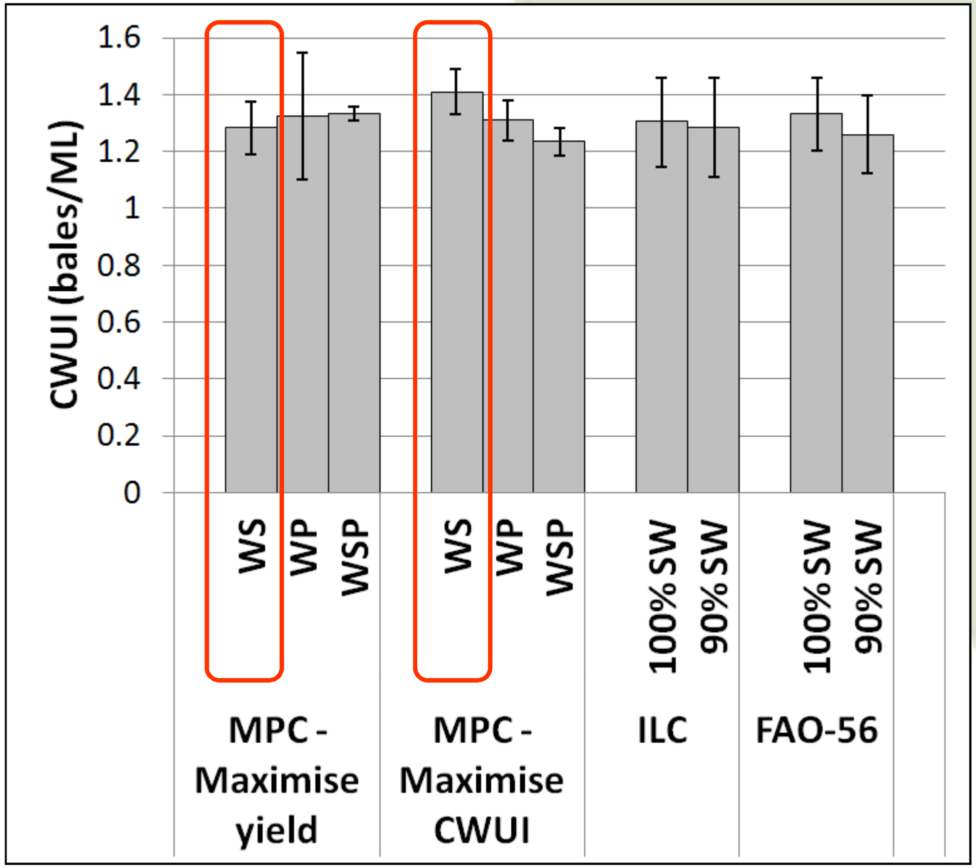




MPC with weather, soil data

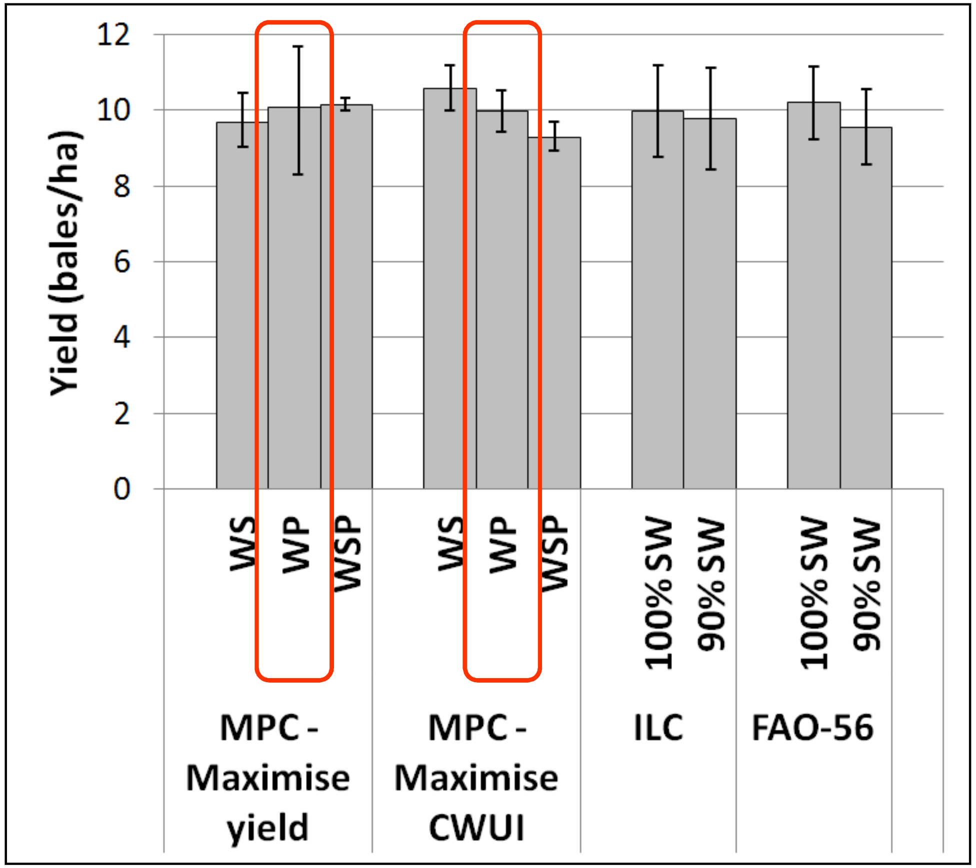
- Lower yield and higher CWUI for MPC maximising yield than CWUI
  - ➢ Sub-optimal model calibration with weather and soil data

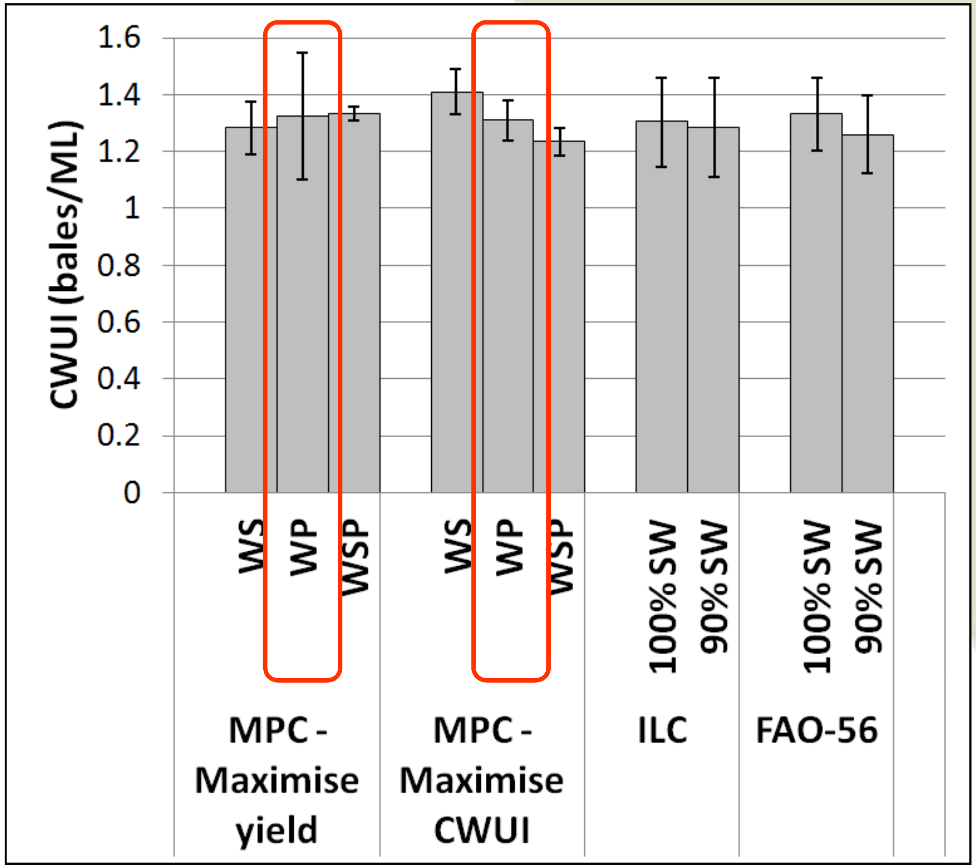




MPC with weather, plant data

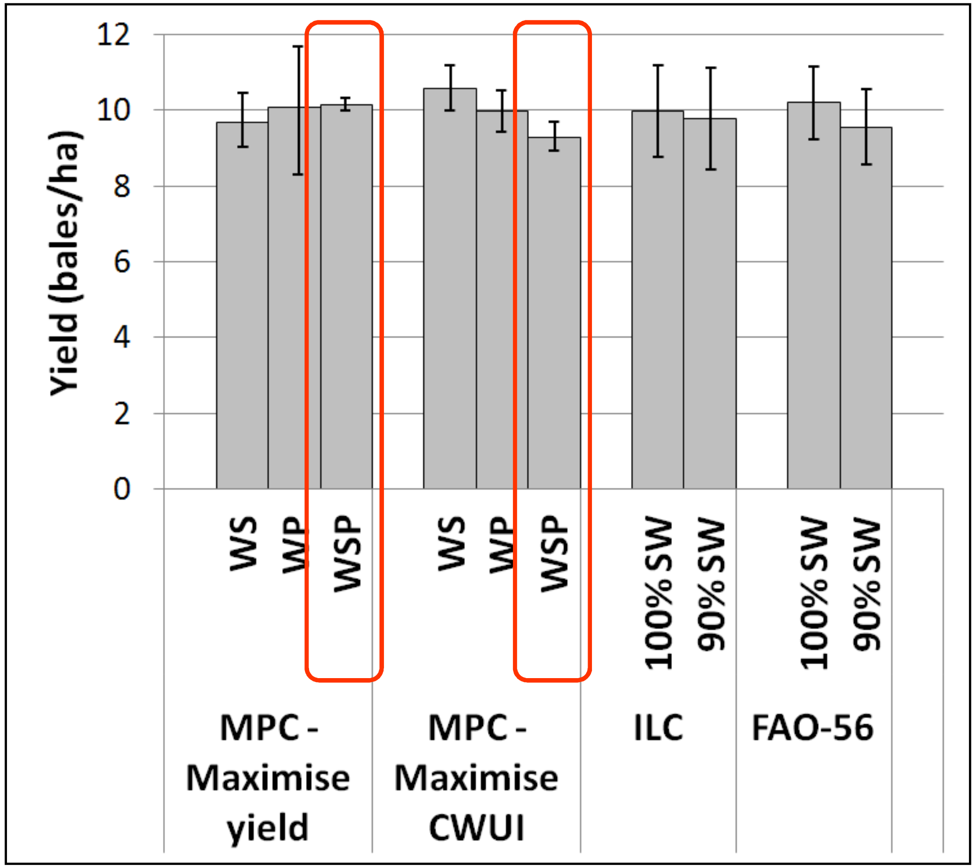
- Yield and CWUI slightly higher for maximising yield than CWUI
  - Plant data input more beneficial for yield than CWUI

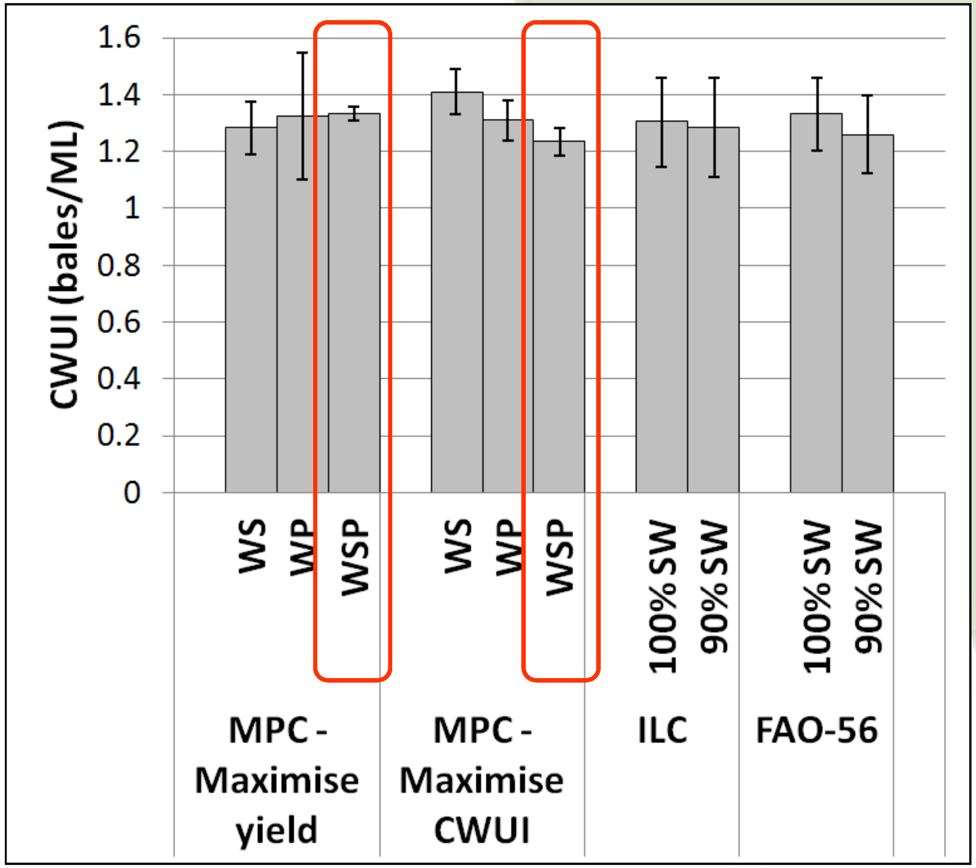




MPC with weather, soil, plant data

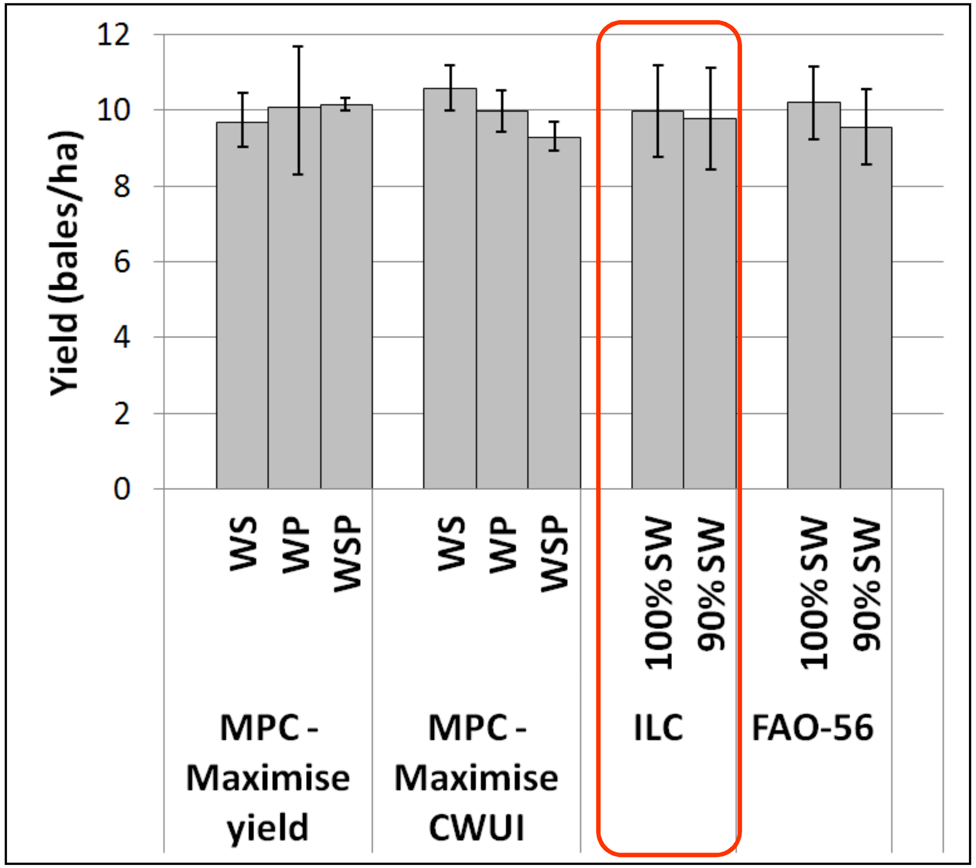
- Higher yield and IWUI for MPC maximising yield than CWUI
  - All data input led to better performance maximising yield

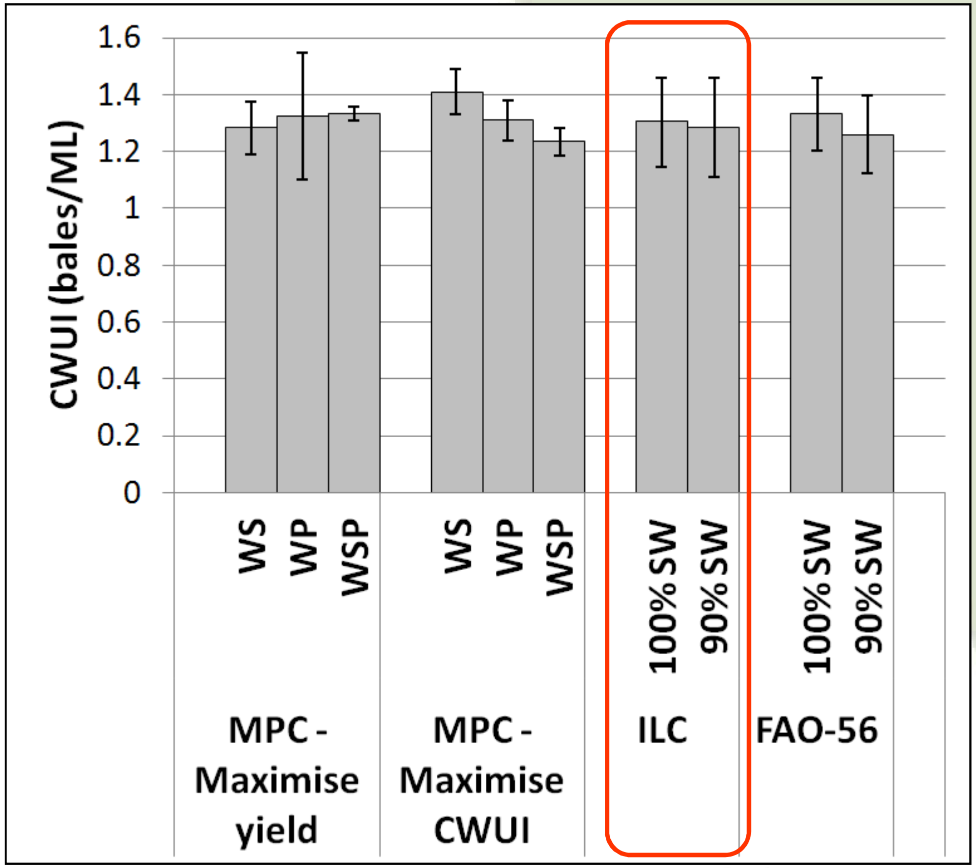




Iterative Learning Control (ILC)

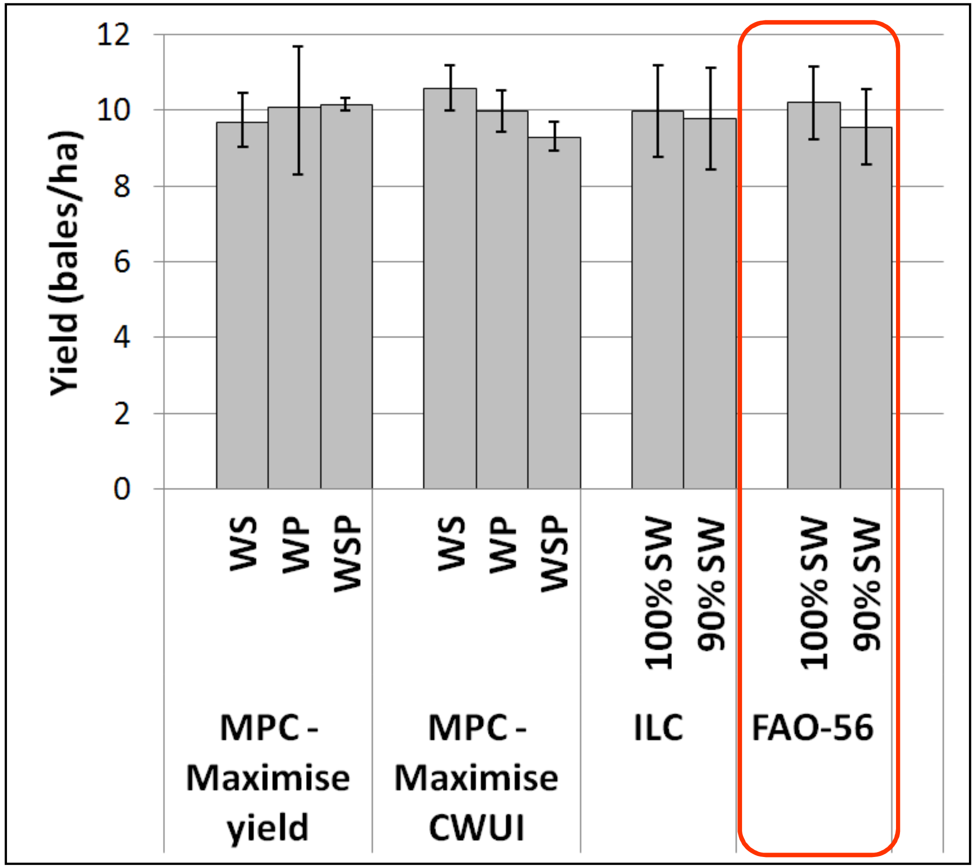
- Higher yield and lower CWUI for full than deficit irrigation
  - Less irrigation reduced yield and increased CWUI

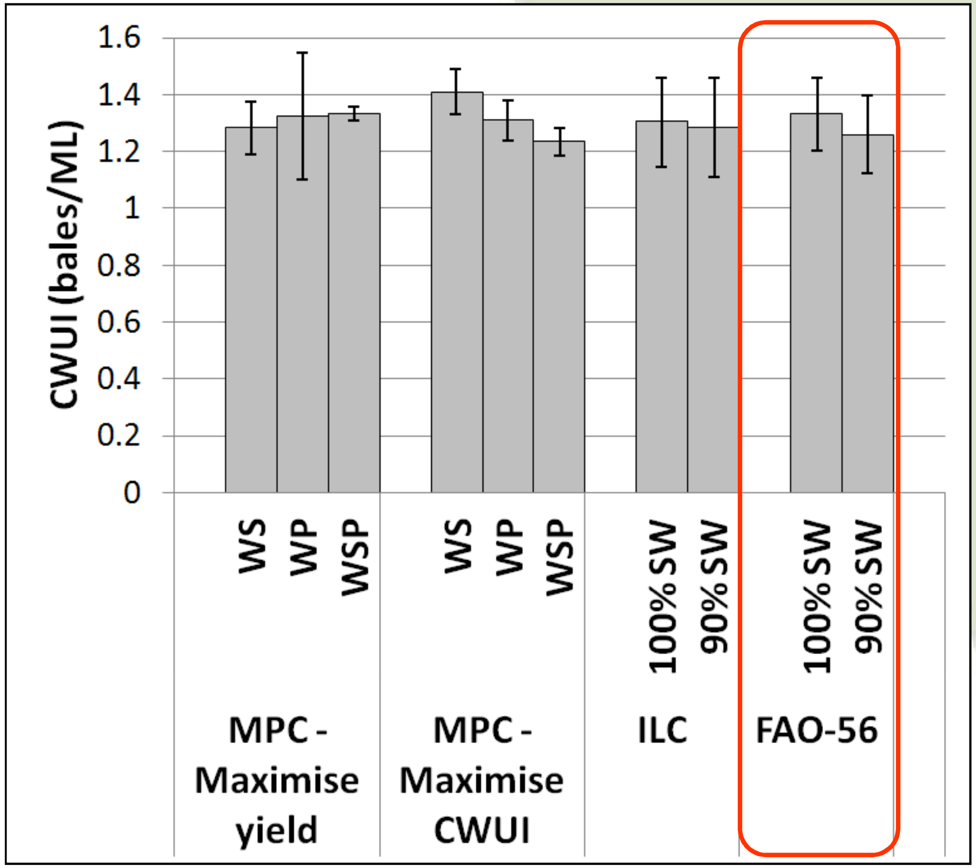




FAO-56 irrigation management

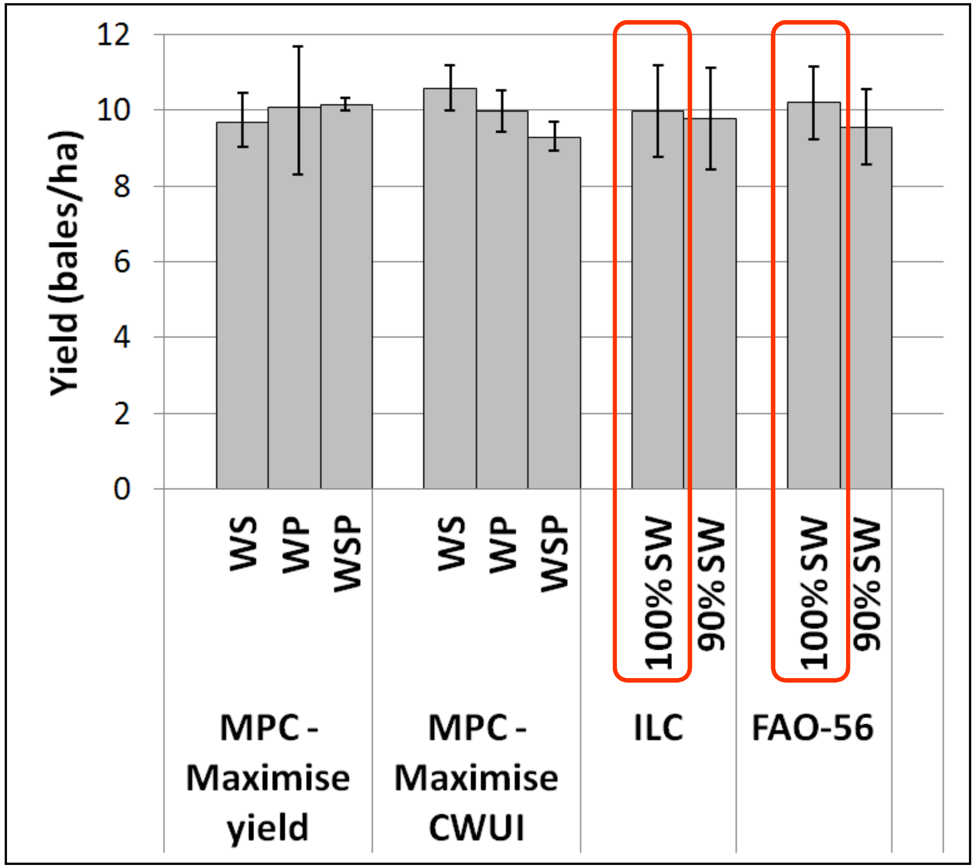
- Yield and CWUI higher with full irrigation
  - Reduced irrigation application led to reduced performance

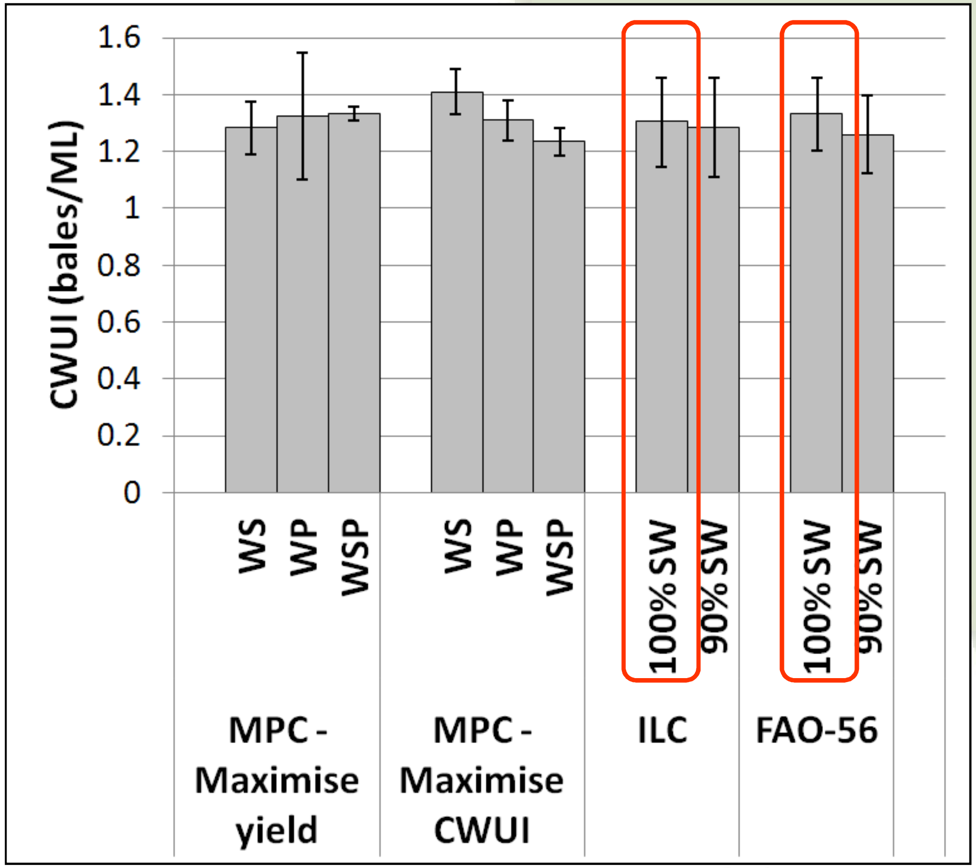




ILC and FAO-56 filling soil water profile

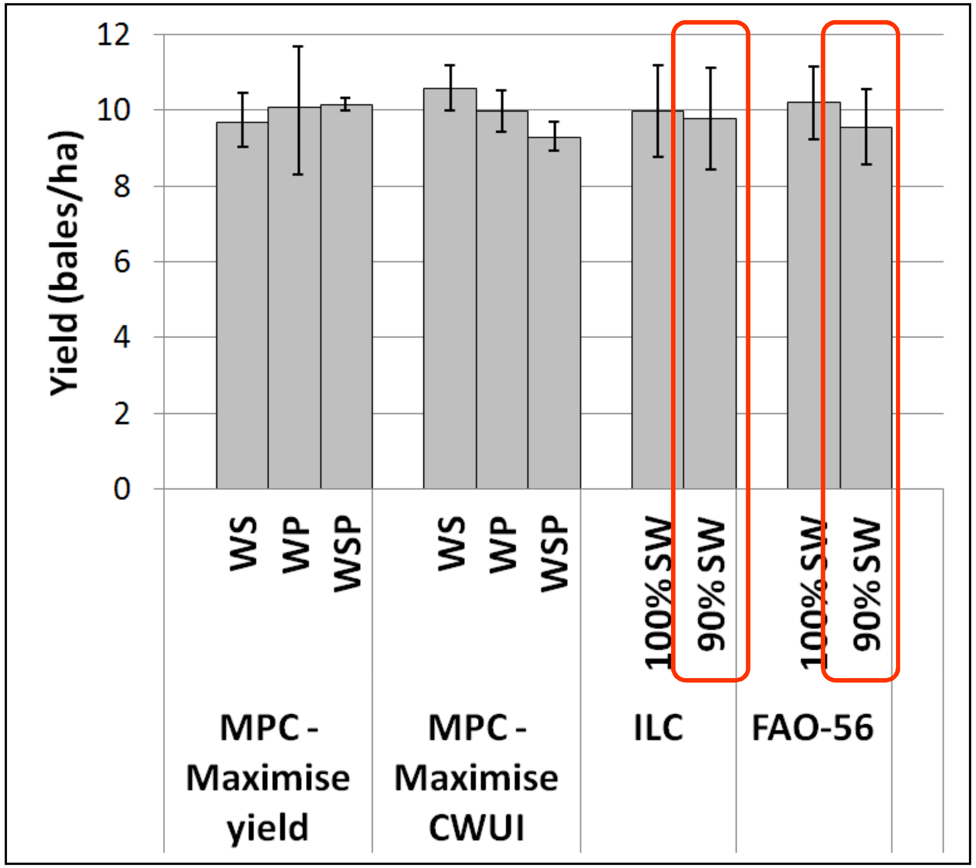
- Higher yield and CWUI for FAO-56 than ILC
  - ➢ FAO-56 would be suitable for full irrigation

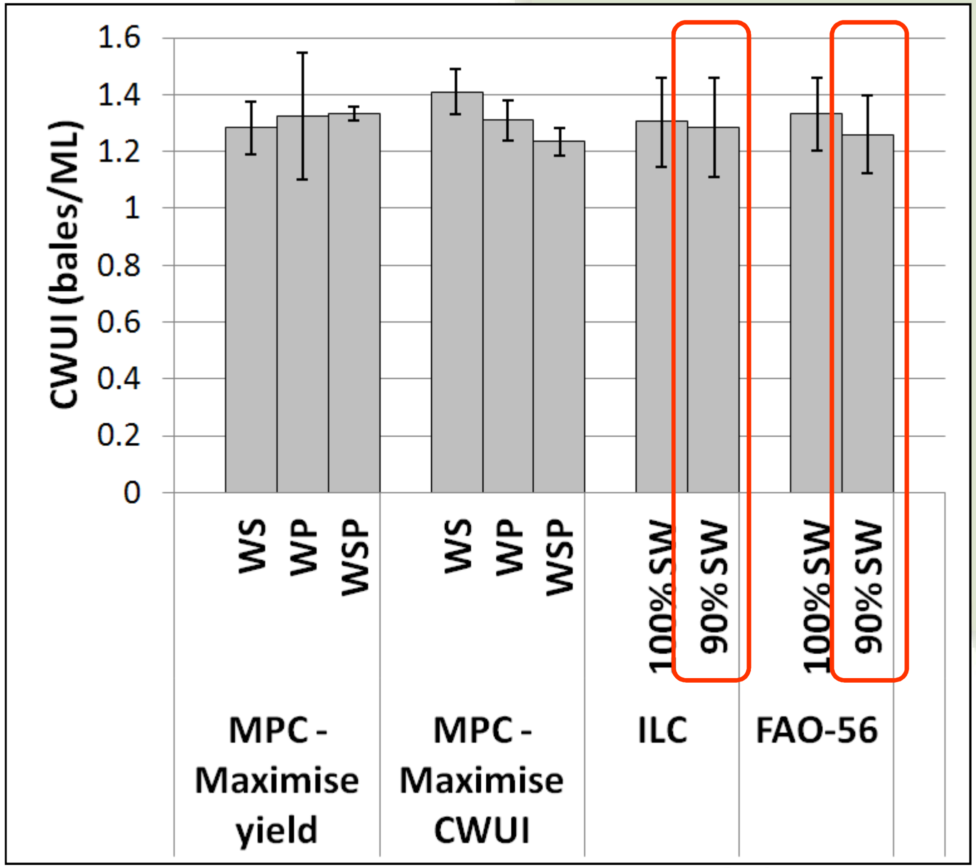




ILC and FAO-56 for deficit irrigation

- Higher yield and CWUI for ILC then FAO-56
  - ILC better for targeting deficit irrigation than FAO-56





Conclusion

1. High rainfall, trial compared control options
2. Plant data input increased yield for MPC maximising yield
3. Plant input more influential for MPC maximising yield than CWUI
4. ILC better at targetting and refining soil moisture than FAO-56
5. FAO-56 sufficient for full irrigation

Acknowledgements

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