‘Dynamic Deficits’ for cotton irrigation decision making

Integrating plant stress, soil water and the short-term forecast

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A flexible or ‘dynamic’ soil water deficit that integrates current crop stress, the current soil water and short-term forecast of evapotranspiration (ETo) into irrigation scheduling decisions in high-yielding Australian cotton crops has potential to improve irrigation water use efficiency (IWUE).

Improving furrow irrigated cotton

- Irrigation in Australian cotton crops use schedules based on fixed irrigations points or grower experience.
- This irrigation point is based on an average soil water status to prevent plant stress and does not take into account the actual or future level of plant stress.
- Australia’s cotton production experiences significant in-crop climatic variability
- Availability of more accurate short-term forecasts of ETo could enable the prediction of crop stress to guide decisions on timeliness of irrigation.
- This study investigated the yield and IWUE response to a flexible or ‘dynamic’ soil deficit that integrates current crop stress, the current soil water and short-term forecast of ETo into in high-yielding cotton crops.

This study aimed to:

- **establish that variation in ETo at different plant available water content (PAWC) changes how a crop responds to PAWC; and**
- **test the concept of dynamic deficits on crop production and IWUE.**

Climate, plant stress and soil water

- Measured soil water x plant stress (using leaf water potential (LWP) measure on the same day as neutron moisture meter measurements to 1.2 m)
- Wide variability in LWP at the same PAWC across nine experiments (Fig 1) indicated that climatic conditions were likely to be having a large influence on the level of plant stress.
- Accounting for changes in ETo significantly improved the relationship between LWP and PAWC ($p<0.001$; $r^2 = 0.43$). A simple linear regression with groups showed that LWP measured on “High ETo” days experienced greater stress at the same level of PAWC compared with “Normal ETo” days ($p=0.001$; $r^2=0.44$, Fig 1).

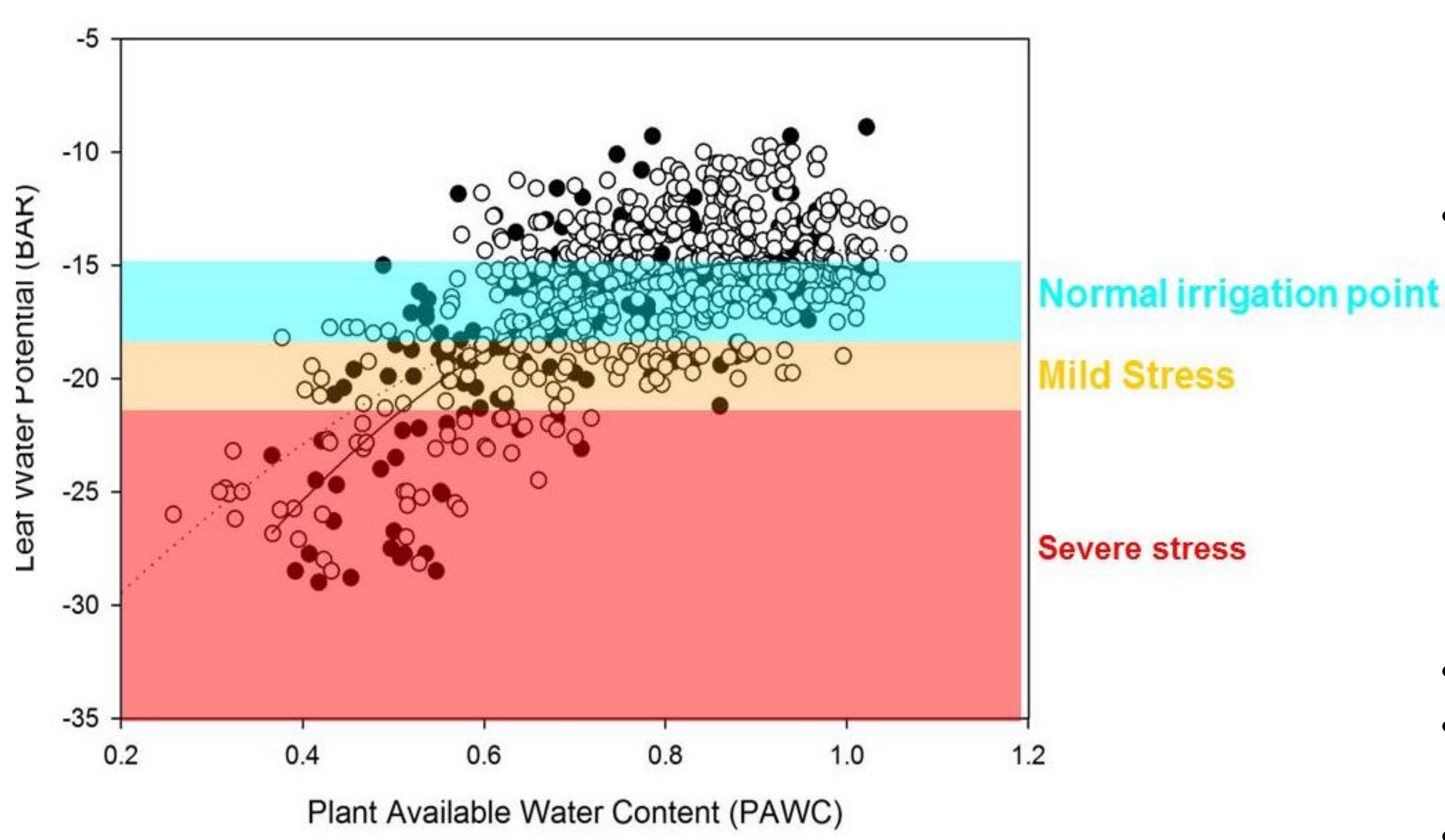

Figure 1. The effect of evapotranspiration (ETo) on the relationship between plant stress (leaf water potential) and PAWC. Data is grouped into high ETo (ETo>7mm/day; solid circles and solid line) and normal ETo (ETo<7 mm/day; open circles and dashed line).

Irrigating dynamically in response to the short-term forecast

In 2009-2010 and 2010/11 two field experiments were completed at Australian Cotton Research Institute, Narrabri NSW. Treatments were applied between flowering and cutout and designed to enable comparison of:

- Control treatment – with irrigations scheduled at the normal 65-75 mm refill point/deficit
- Treatment 2 – was irrigated earlier than the control at a smaller deficit in response to forecasted high ETo.
- Treatment 3 – was irrigated later than the control at a larger deficit in response to forecasted low ETo conditions.
- Treatment 4 – was dynamic, with irrigations scheduled either earlier or later in response to forecasted high or low ETo conditions.

Yield and water use were measured to determine the response to different irrigation treatments.

Table 1. Lint yield and estimated water use for 2009/10 and 2010/11 Dynamic Deficit Experiments. Significant differences indicated by * 95% significance level; ** 99% significance level.

Treatments	Average Lint Yield (bales/ha)	Irrigation Water Applied (ML)	Effective Rainfall (ML)	Total Water (mm)	Bales/ML total water	Bales/ML applied
2009/10						
1 Control	13.0	3.26	3.19	680.8	1.9	4.0
2 Smaller Deficit (High ETo)	14.2	3.24	3.20	678.2	2.1	4.4
3 Larger Deficit (Low ETo)	13.7	3.28	3.20	679.2	2.0	4.2
4 Dynamic	14.5	3.66	3.20	725.8	2.0	4.0
L.S.D	2.5	***0.30**	0.09	41.4	0.4	0.9
2010/11						
1 Control	12.7	3.92	2.84	735.9	1.73	3.3
2 Smaller Deficit (High ETo)	12.1	3.65	2.88	731.2	1.65	3.3
3 Larger Deficit (Low ETo)	11.5	3.11	2.90	682.1	1.68	3.7
L.S.D	1.8	****0.34**	0.06	***43.15**	0.2	****0.2**

- Neither irrigating at a smaller deficit (3 days earlier) or at a larger deficit (6-8 days later) in response to high ETo forecast impacted on lint yield.
- In 2009/10 Irrigations were delayed up to deficits of 105 mm during late flowering compared to 78 mm, with no impact on yield, however in this year, treatment 4 (with two delayed irrigations at larger deficits) used more irrigation water than the other irrigation treatments.
- LWP measurements in 2009/10 showed that despite the control showing mild stress (-20 BAR) and the smaller earlier deficit was less stressed (-16.8 BAR) there was no difference in yield. The same lack of yield response to lower LWP was seen in the delayed, larger deficit treatments in both years where there was higher stress than the control prior to irrigating.
- In 2010/11 in treatment 3 in response to forecasted low ETo, irrigation was delayed 4 days to a planned larger deficit of 90 mm, and in that period there was 33 mm of rain which further delayed the irrigation another 4 days. This resulted in this treatment receiving one less irrigation over the season translating into irrigation water savings of approximately 0.8 ML/ha compared to the control (Table 1).

Implications for Irrigation Management

- **Changes in ETo affected the level of plant stress regardless of the soil water status**
- **Irrigation scheduling potential to take forecasted ETo into account and adjust the soil moisture deficit you irrigate at, not just the frequency of irrigation**
- **Potential to “safely” delay irrigations to a point of ‘mild stress”, maintain yield whilst providing greater opportunities to capture rainfall and improve IWUE.**
- **Important when future climate change predictions suggest increased evaporative demand.**

FOR FURTHER INFORMATION
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