Physiological responses of cotton to subsurface drip irrigation on heavy clay Soil

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Abstract

Cotton in heavy clay soil with subsurface drip irrigation (SDI) @ 50, 75, 90, and 120 % of daily ET and conventional furrow irrigation showed a significant effect on phenology and yield. Plant height, number of branches, nodes and leaf area index increased with increasing amount of water in SDI and were even greater in furrow. However, leaf chlorophyll, dry matter percent of plant and roots decreased with increasing amount of irrigation. Leaf water potential and crop water stress increased whereas leaf photosynthesis decreased with decreasing level of irrigation. Lint yield on SDI at 75% of daily ET was as high as furrow and was accompanied by higher water use efficiency (WUE) (0.6274, 0.4785 and 0.3551 t/ML for SDI at 75 and 120% ET and furrow respectively).

Key Words

Irrigation efficiency, lint yield, water use efficiency.

Introduction

Yield and WUE gains have been achieved with SDI for a number of crops particularly in light-textured, highly permeable soil (1). It has been on the light textured soils or in areas where conventional furrow irrigation are considered unsuitable, that SDI has been successful. However, cotton in Australia is also grown on heavier textured clay soils, and whether the realised benefits of SDI from light textured soils still hold true for heavy clay is not known (2). While installation is important, the management of SDI is crucial to realise potential benefits (3). Crop physiological responses, which can be monitored and measured, are potential clues for management of SDI. Hence, it is imperative to determine suitable physiological indicators of cotton for managing SDI and also quantify WUE with SDI and furrow.

Methods

The experiment was conducted at Emerald, Queensland. SDI tapes were installed at 1 m centres on 8 bays and 2 m centres on 4 bays and were buried at 40 cm depth. The trial consisted of SDI system of 3 replicated irrigation applications at 50, 75, 90, and 120 % of daily ET and a furrow irrigated site each of 0.4 ha. NuTopaz, IngardTM Cotton was planted on a gypsic vertisol on 26 September 2001. The crop was planted in meter rows with 12 plants/metre. Local weather and soil water content was monitored. LAI, CO_2 assimilation, leaf chlorophyll and water potential, and crop relative water stress were measured.

Results

Phenology

Plant height, LAI, number of nodes and branches increased with increasing water on SDI. Furrow effect was similar to SDI 120% ET. Maturity was significantly delayed on wetter compared to SDI at 50 & 75% ET. Density of fibrous roots/m^3 increased with decreasing amount of irrigation. However, total root dry matter was significantly ($P \leq 0.09$) higher in wettest and lowest in driest SDI. Shoot: root was lowest in driest SDI compared to others & furrow scored highest shoot: root (Table 1).

Physiological responses

Leaf water potential at peak squaring was 12-24 bars, with lowest potential in dry and highest on wet treatments. Relative water stress index (RWSI) was 0.1- 0.5; highest for driest and lowest for wet treatments. Net CO_2 assimilation of leaves at peak reproductive stage varied from 14-27 ?mol/m^2/s with lowest values in driest compared to others (Figure 1). The other treatments, except the driest one, maintained higher rate of leaf photosynthesis when they were irrigated. However, leaf chlorophyll concentration, dry matter percent of plant and roots decreased with increasing amount of irrigation water.

Table 1. Effect of level of irrigation on cotton growth and yield.

Treatments	Phenology				Root characters				Yield and related characters			
	Plant Ht. (cm)	Nodes/ Plant (No.)	Shoots/ Plant (No.)	Days to maturity	Root dry mass (t/ha)	Root density (km/m^3)	Shoot : Root (Ratio)	Bolls/plant (No.)	Lint wt./boll (g)	HI	Seed yield (t/ha)	100 seed wt (gm)
SDI 50% ETo	82.2	20	12.1	119	2.253	21.7	15.5	11.93	1.82	0.24	3.598	9.2
SDI 75% ETo	98.5	22	16.3	132	2.674	20.6	20.3	15.07	1.88	0.22	4.970	10.2
SDI 90%ETo	96.5	23	15.9	147	2.490	18.2	18.8	13.20	1.87	0.22	4.286	10.4
SDI 120% ETo	117.0	23	18.9	147	3.28	19.7	17.9	15.73	1.90	0.19	5.169	10.2
Furrow	113.2	22	19.2	139	2.398	17.2	29.3	15.80	1.84	0.19	5.031	10.4
Mean	101.5	22	16.5	137	2.619	19.5	20.4	14.45	1.86	0.21	4.611	10.1
P value	0.000	0.029	0.001	0.000	0.090	0.586	0.345	0.010	0.750	0.004	0.076	0.290
LSD	6.3	2.0	2.2	0.00	0.84	6.695	6.080	2.39	0.200	0.00	1.31	1.50

Lint Yield and Water Use Efficiency (WUE)

Lint yield from hand harvest of sample plants was 2.5-3.5 t/ha (4.5-6.2 bales/acre). Driest treatment produced significantly low yield compared to wet SDI and furrow. Interestingly 75, 90 and 120% ET on SDI did not differ significantly to furrow. Lint yield ranged 1.82-1.90 g/boll and did not differ between treatments. Therefore, yield difference is function of number of bolls/plant that ranged 11.9-15.5. Number of bolls/plant on driest SDI plot was significantly lowest compared to other treatments. WUE is defined as lint yield per unit of irrigation water applied to the crop. WUE of 0.61, 0.63, 0.48, 0.48 and 0.36 t/ML respectively was achieved for 50, 75, 90, and 120% of daily ET and furrow.

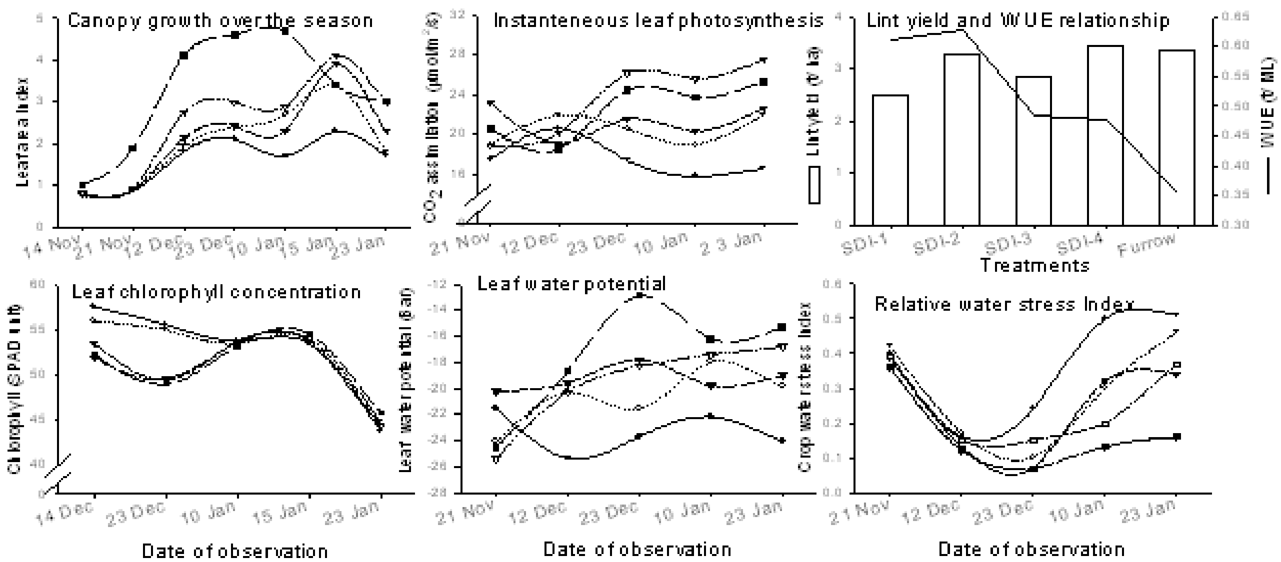

Figure 1. Performance of the cotton crop grown with SDI at 50% of daily ET ( ), SDI at 75% of daily ET ( ), SDI at 90% of daily ET ( ), SDI at 120% of daily ET ( ) and Furrow ( ).

Conclusion

Cotton on 75% of daily ET in SDI produced highest yield and was most water use efficient compared to other treatments. Physiological indices such leaf water potential, photosynthetic assimilation rate, crop relative water stress index would be useful guides for making judgement to schedule irrigation on SDI.

References

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