Soil type effect on cotton plant water relations

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Summary

The way the cotton plant responds to water stress on different soil types changes will influence its requirement for water and may change the irrigation strategy used if yield potential is to be achieved. Soil types are different not only in the total amount of available moisture that they hold, but also in how readily the moisture is made available to the plant. This response has been investigated in a three year project measuring plant water stress under different irrigation conditions during early flowering on three soil types. Initial interpretation of results suggests that plants differ in their response to soil moisture stress on light soils compared with heavier soils, when using a standardized measurement of soil moisture status i.e. the fraction of transpirable soil water (FTSW). FTSW is calculated by changing available water content of the soil to a percentage. The advantage of using FTSW to define soil moisture holding capacity is that it allows people working across different known soil types to compare soil types in terms of irrigation schedule and plant moisture availability.

Introduction

There are a range of soils used in the Australian cotton industry, a large proportion of the soils are black earths and grey clays, but there are also red brown earths and alluvial soils. These soils have a number of factors that affect their water holding capacity including: soil structure, organic matter content, profile depth, sodicity, fertility and compaction. As well as having different water-holding capacities, soil types also affect how the plant is able to access the water from the profile. Understanding how the cotton plant responds to moisture stress on the different soil types will assist in developing more robust water management strategies for a wider range of cotton growing regions and may also contribute to the development of better genotypes.

Methodology

Experiments were conducted in the 2003-04, 2004-05 and 2005-06 cotton seasons on two sites at the Australian Cotton Research Institute and at one off-station site. The three sites provided a range of different soil types, heavy clay (heavy), alluvial (medium), and hard setting sand (light) with different available soil water holding capacities. The different soil types were located in close proximity to each other to try to minimise differences in climatic factors, i.e. to ensure soil factors were the major difference between sites. The experiments used Sicot 289BR. The experiments were grown with two levels of irrigation; stressed (skipped two irrigations from just prior to flowering) and fully irrigated. Measurements of leaf water potential, soil moisture, leaf expansion rate, yield and fibre quality were made. Measurement of leaf water potential was made using a pressure chamber; readings were taken both pre dawn and midday to determine minimum and maximum plant stress.

Soil moisture contents for the different soils, obtained using the neutron probe, have been normalized using the fraction of transpirable soil moisture content (FTSW). This takes into account the water holding capacity of the soil and expresses the moisture remaining as a percentage; this enables soils with different water holding capacities to be compared in relation to the amount of available water that they contain.

Results and Discussion

The leaf-water potential results represent the effort that the plant has to exert to extract moisture from the soil profile. Midday leaf-water potential of the cotton plant in relation to the FTSW for all sites across three seasons is presented in Figure 1.

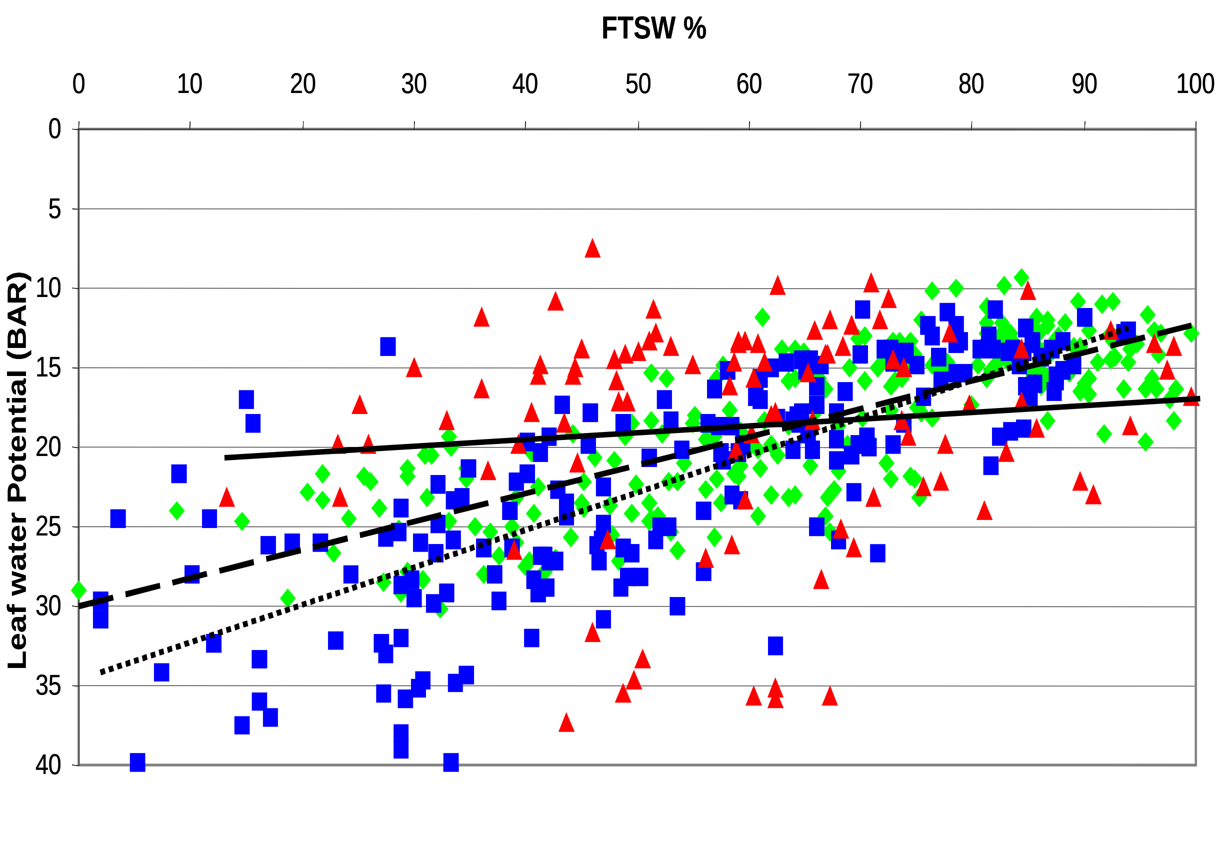

Figure 1. Afternoon cotton leaf water potential (BAR) vs. FTSW for three soil types; heavy (♦, dashed line), Medium (■, dotted line), and Light (▲, solid line) across three seasons.

Plants on the medium (dotted line) and heavy soil (dashed line) types exhibited a similar leaf water potential response to soil moisture depletion. On both soil types leaf water potential increased linearly with decreasing FTSW. On the medium soil type, plants exhibited greater stress at lower FTSW's than in the clay soil. The light soil (solid line) behaved differently to the clay soils and did not show as strong a relationship between leaf potential and FTSW. At some times, plants on the light soil exhibited high levels of leaf water potential under less than 50% FTSW, indicating high plant stress when water is readily available to the plant, at other times the levels of stress were lower in the light soils than the medium and heavy for the same level of available moisture.

Assessing the leaf water potential vs. FTSW results in terms of evaporative demand is the next step in understanding the plant response on each soil type. Climate climatic factors such as relative humidity and temperature can influence the demand for moisture that is placed on the crop. Different levels of evaporative demand will change the water potential of the plant at the same level of soil moisture deficit. In fact under high evaporative demand the cotton plant can experience short periods of moisture stress even when the water supply in the soil is at close to field capacity (Krieg 2000). It is anticipated that the effect of high evaporative demand on the light and medium soils would be greater as they more quickly use all of their readily available moisture and the plant may not have time to acclimatise to the stress conditions.

In terms of irrigation scheduling, it has been reported that the leaf water potential at which the cotton plant becomes stressed is approximately -19 to -20 bar (Hearn and Constable 1984), this is the irrigation point. In these experiments the irrigation point of all three soil types was between 50 and 60% FTSW. This shows that on all soils plants are becoming stresses when around half of the available soil moisture has ben utilized. Further research investigating the effect of climate on plant water status over a wider geographical range is going to be measured to enhance the understanding of climate on cotton water use and yield potential.

References

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