SOIL WATER EXTRACTION DYNAMICS OF DRYLAND COTTON IN VARIOUS ROW CONFIGURATIONS

P.J. Goyne and J.M. Hare
Department of Primary Industries
-Farming Systems Institute
Hermitage Research Station
Warwick, Q, Australia

Abstract

The soil water extraction dynamics of dryland cotton grown in various row configurations on some major Queensland cotton soils are being quantified. The data will assist in the further development of a cotton simulation model "CERCOT". This model is to be used to determine the outcome of various management scenarios relating row configuration, planting time and plant available water supply. This paper presents some results obtained on one soil type during the 1997/98 season.

Introduction

Monteith (1986) proposed a scheme for determining soil water supply to crops which has been used for sorghum (Robertson et. al. 1993) and sunflower (Meinke et. al. 1993). A full explanation can be found in Meinke et. al. (1993) but briefly:

The analytical framework of the scheme comprises a function describing the downward movement of the extraction front and a function which accounts for the extraction behaviour of a static root system. When the root front arrives at a particular depth and starts to extract water, the soil water begins an exponential decline following the relationship (Figure 1):

$$\begin{aligned} AWC &= MAWC \text{ if } t \leq t_c \\ &= MAWC \times \exp(-kl(t-t_c)) \quad \text{if } t > t_c \quad (1) \end{aligned}$$

MAWC = maximum plant available volumetric water content in each soil layer
AWC = available water content remaining in each layer at time t (days after sowing, das)
t = time (das)
t_c = time of first water extraction in a layer
l = root length density (cm root per cm^3 of soil)
k = constant relating to the diffusivity of water flow (cm^2 per day)

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The derivative of equation (1) with respect to time gives the extraction rate:

$$\begin{aligned} dAWC/dt &= 0 \quad \text{if } t \leq t_c \\ &= (-kl) \times AWC \text{ if } t > t_c \end{aligned}$$

k and l are not determined individually, but are treated as a combined kl 'plant soil constant' ie the rate at which water is extracted within each layer.

tc for each layer can be found from the depth of the extraction front (EF) at any time:

$$EF = EFV \times (t-t_0)$$

EFV = extraction front velocity
t_0 = time (das) at which the extraction front commences its descent at rate EFV.
t_c = EF/EFV + t_0

The current project is deriving values for the parameters kl, t_c, EFV and t_0 for major cotton soils.

Discussion

Row configurations used were no skip, single and double skips based on 1.0m row spacing. Crop development, biomass accumulation, radiation interception, root length density, yield and fibre quality were monitored. The time course of soil water depletion between rows (P1) on the plant line (P2) and at 0.5m intervals from the plant line into the skip area (P3, P4, P5) (Figure 2) was followed weekly with a neutron moisture meter at 10 cm increments down the soil profile to a depth of 1.8m. Parameter values for soil water extraction were fitted via an iterative optimisation procedure (Hammer et. al. 1982).

There were three contrasting soil types in the 1997/98 season one being a heavy black cracking clay (Waco), common in the Darling Downs agricultural region of Queensland. This soil holds about 280mm of plant available water to a depth of 1.8m. Cotton variety Siokra $V15_i$ was planted on 14 October 1997 and thinned to an in-row spacing of 6 plants per metre following emergence. As with other soils in the region that season, little water was held beyond 1.0m at planting and did not increase with rainfall as the season progressed (Figure 3).

An example of the fit of equation (1) for four depth intervals at P2 in a single skip on the Waco soil is shown in Figure 4. Similar relationships for each depth at each sampling position enabled evaluation of t_c. Regressing t_c against depth for each sampling time gave values for t_0 and EFV, (Figures 5, 6, 7).

In the no skip treatment soil water extraction dynamics were similar for positions P1 and P2. EFV averaged 2.0cm/day and t_0, 37.7 das (Figure 5). In the single skip (Figure 6) the extraction front commenced its descent 30.6 das (t_0) in P2, whereas t_0 for P1 and P3 was on the average 11 days later. At P4, t_0 was significantly ($p<0.01$) later (59.9 das) than at the other positions. EFV was similar for P1, P2 and P3 averaging 2.1cm/day but at P4 was significantly faster being greater than twice this rate ($p<0.01$).

Soil water extraction from the double skip was very similar to the single skip (Figure 7). The extraction front commenced its descent much later in P4 and P5 than at the other three positions (P5 = P4>P1 = P2 = P3, $p<0.05$) and its descent rate in P4 and P5 was greater than twice the rate of the other three positions (P5 = P4>P1 = P2 =P3, $p<0.01$).

These EFVs for P1, P2, P3 are in agreement with the "effective rooting depth" rate of progression reported by Lacape et. al. (1998) which ranged from 1.8 to 3.0cm per day.

Water use beyond 0.85m was negligible in all sampling positions for all row configurations. Very low root densities were found at this depth, which was reached during flowering.

Analysis of yield data showed no significant advantage of one configuration over another and averaged 3.3 bales lint per ha for the experiment. This agrees with Marshall et. al. (1994) who showed there was no yield advantage with skip row configurations for yields beyond 3.0 bales lint per ha. However yields per plant were significantly different: double skip>single skip>no skip $p<0.05$). In general longer, stronger and more uniform fibre was obtained from the skip row treatments.

Summary

Soil water extraction dynamics were similar for single skip and double skip row configurations for the Waco soil in 1997/98. EFV for P1, P2, P3 averaged 2.0cm per day. EFV for P4 and P5 was about twice the rate of P1, P2, P3. Soil water extraction reached 0.85m. Data from other soil types across seasons will enhance the capabilities of the prediction model, CERCOT.

Acknowledgements

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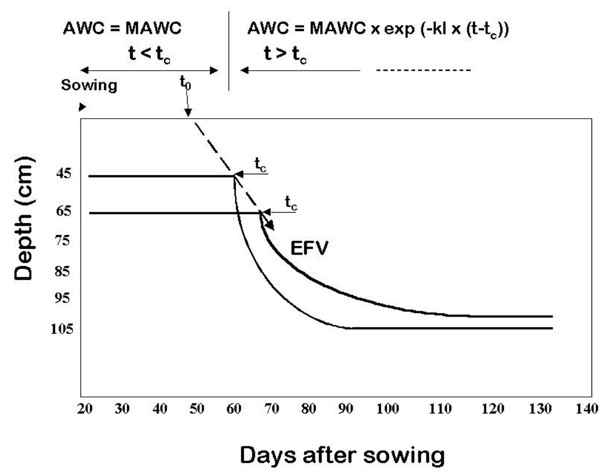

Figure 1. Analytical framework showing the exponential decline of soilwater from the 45cm and 65 cm layers.

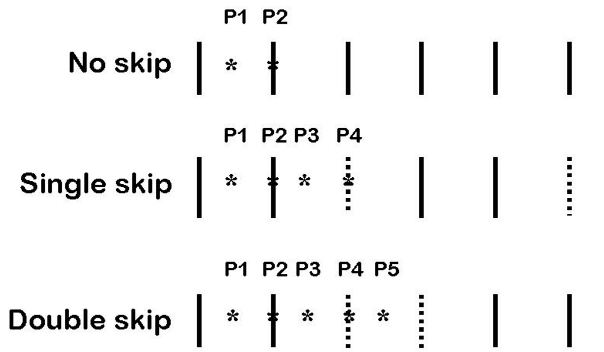

Figure 2. Positions (P2, P2 etc) of the neutron moisture access tubes in relation to the planted rows (solid lines) and the skips (broken lines) for each configuration.

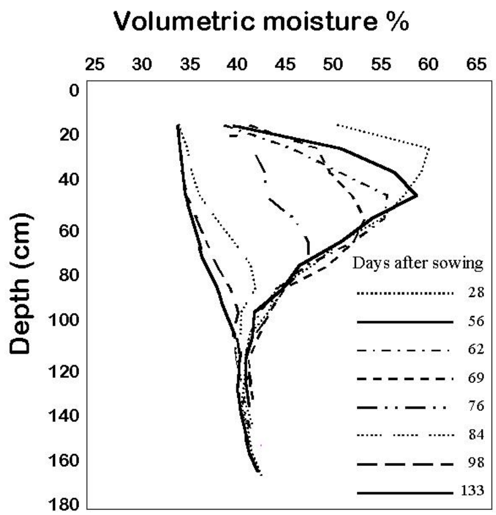

Figure 3. Volumetric moisture content of no skip P2 profile for selected sampling times.

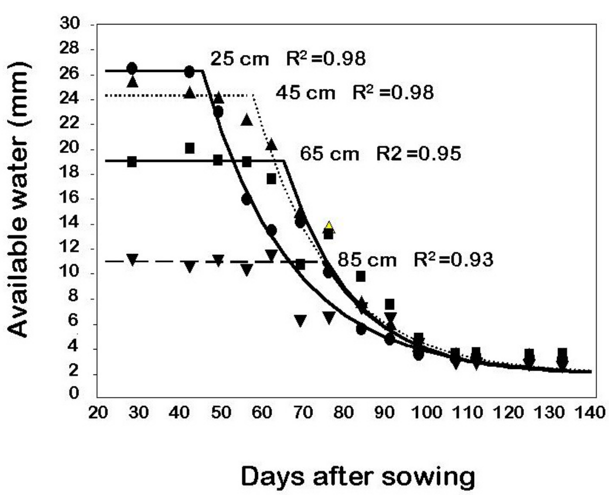

Figure 4. Soil water extraction for four depth intervals at P2 in a single skip configuration.

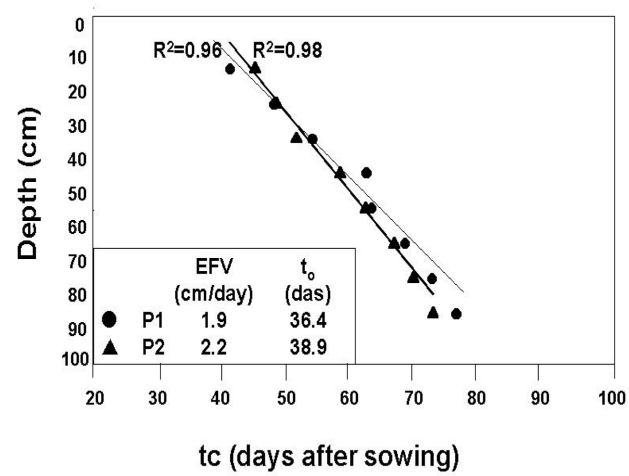

Figure 5. EFV (slope of regression line) and T_o determined by regressing t_c against depth for no skip configuration.

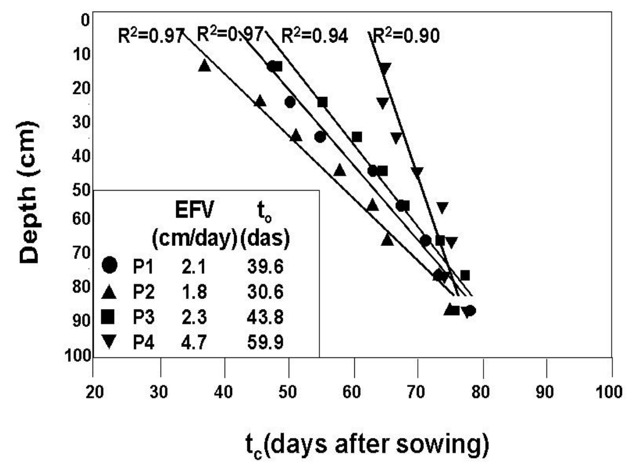

Figure 6. EFV (slope of regression line) and T_o determined by regressing t_c against depth for single skip configuration.

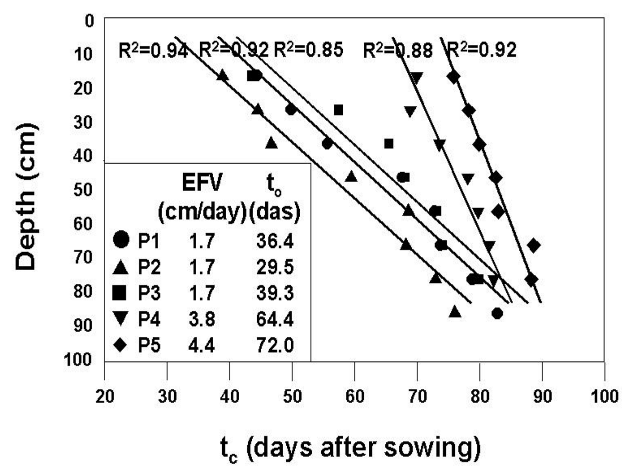

Figure 7. EFV (slope of regression line) and T_o determined by regressing t_c against depth for double skip configuration.