HOWWET? - A TOOL FOR PREDICTING FALLOW WATER STORAGE.

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Summary: HOWWET? (1) is a computer based system for estimating soil water storage for fallow periods using rainfall records and a minimum number of regional soil and climate input parameters. Its performance in predicting fallow water storage for a range of sites across Queensland is reported. This analysis indicates that it offers substantial improvement over using a static fallow efficiency model.

INTRODUCTION

HOWWET? is an easy to use computer based system for estimating soil water storage for periods between crops using rainfall records and brief descriptions of soil type and surface conditions. Processes simulated include infiltration, runoff, evaporation and soil water accumulation. The key input parameter for the soil is plant available water capacity (PAWC) to a nominated rooting depth, and for management, average ground cover conditions for the fallowed paddock. Simulation of both soil evaporation and runoff is sensitive to ground cover conditions, allowing comparisons for effect of different tillage treatments on soil water storage.

This paper describes the approach used in HOWWET? for simulating soil water processes and assesses its performance for predicting water storage for fallows across a range of sites and tillage practices in Queensland. Of particular interest is the performance of HOWWET? relative to a simple fallow efficiency rule method requiring no other information than rainfall and starting soil water.

DESCRIPTION OF MODELS FOR PREDICTING WATER STORAGE

1. HOWWET?

HOWWET? has been designed to require minimum input data for parameterizing and simulating the soil water processes of runoff, infiltration and evaporation. The parameters required include PAWC for 3 soil layers to a nominated rooting depth, Curve Number (CN2) for estimating runoff, first and second stage evaporation coefficients and an air dry water content. For this study, the second stage evaporation coefficient (CONA) has been calculated daily as a function of average weekly pan evaporation (CONA = 0.62 * pan + 1.7) to better take account of differences in evaporative conditions between sites and seasons (ie summer and winter).

Algorithm for reducing potential soil evaporation rate and Curve Number in relation to ground cover levels have been adopted from PERFECT (5). The level of ground cover changes as a linear function of time based on initial and final ground cover estimates provided by the user.

Evaporation is only allowed from the surface soil layer and is constrained by the nominated air-dry moisture content. For this study, a 0-100 mm surface layer was used for all experiments. Soil water content to 600 mm is used to determine antecedent moisture condition effects on runoff. In general, this is the bottom of the second soil layer. As drainable porosity is not represented as part of PAWC, drainage beyond the root zone is not simulated and excess infiltration is added to runoff. Drainage and unsaturated flow are not simulated explicitly.

2. Fallow Efficiency Rule.

A single fallow efficiency value (FE) that takes into account the average losses through runoff and evaporation can be used to estimate the amount of water stored in soil using fallow rainfall. This value is usually based on measurement of soil water storage for a number of fallows in a region. A weakness in this approach is that fallow efficiency usually varies with the length of the fallow period and patterns of rainfall. Typically, values are higher at the start of a fallow (around 40%) when the soil is dry and the main loss component is evaporation, and decrease as the fallow period is extended. The decrease in FE with time is often due to an increase in runoff as a result of earlier water storage. Average FE values of between 20 and 30% are typical for southern Queensland.

METHODS

Previous experimentation conducted and reported for five sites in Queensland; Acland (2), Capella (8), Greenmount (2), Wallumbilla (3) and Warra (7) provided soil water measurements and soil and ground cover data needed to test the predictive capability of the HOWWET? routines. Soil water measured at the end of a crop was used to initialise the model and daily water storage, evaporation and runoff was simulated in response to daily rainfall recorded at the sites and ground cover levels during the fallows. Average weekly pan evaporation based on long term records for Capella, Greenmount, Roma (Wallumbilla) and Dalby (Acland and Warra) were used in the simulations.

Table 1. Locations, soil properties, tillage treatments (CT-conventional, RT-reduced, ZT- zero tillage) and number of fallows for which fallow soil moisture storage was measured and used to test HOWWET?

Location	Bay No.	PAWC (mm)	Root Depth (mm)	CN2	U (mm)	Tillage Trs.	No. Fallows.
Acland	-	250	1500	72	6	Burnt, CT	6
	-					Stubb.Incorp.	6
	-					Stubb. Mulch	6
	-					Winter Fallows (RT)	3
	-					ZT	6
						Sub-total	27
Capella	1	150	1050	77	5	ZT (sorghum)	6
	2	158	720	78	5	ZT (sunflower)	4
	3	119	750	75	7	RT (wheat)	7
	4	150	675	73	5	CT (wheat)	5
	5	180	900	72	5	RT (sunflower)	4

	6	155	540	73	5	CT (sorghum)	4
	7	104	600	74	6.6	CT (sunflower)	6
	8	200	960	72	5	RT (sorghum)	3
	9	228	1220	76	5	ZT (wheat)	5
						Sub-total	44
Greenmount	0	229	1500	73	8	ZT/CT	6
	1	268	1500	73	8	ZT	11
						Sub-total	17
Wallumbilla	1	178	1500	95	6	ZT	8
Warra	-	231	1500	80	6	CT	5
						Grand Total	101

PAWC - Plant available water capacity; CN2 - Curve Number (bare soil at average antecedent moisture condition); U - 1 st stage evaporation coefficient [U & CN2 values are generally as derived for earlier studies using PERFECT (5 & 6)].

The experiments included different fallow tillage treatments, and except for Warra, runoff was measured for the fallow periods simulated. A summary of the experiments, and input parameters are given in Table 1.

When estimating PAW at the end of a fallow using the fallow efficiency rule, a value of 20% was used in conjunction with fallow rainfall and the soil water content at the start of a fallow period.

RESULTS

The relationship between observed and predicted PAW at the end of the 101 fallows using HOWWET? and the Fallow Efficiency rule is shown in Figure 1. The average error around the 1:1 line, as measured by Root Mean Standard Deviation (RMSD), was 31 mm for HOWWET? and 42 mm for the fallow efficiency rule. The change in soil water for the fallows simulated varied from -32mm to +144mm. The difference in the RMSD suggests that using a daily time step model to dynamically simulate water losses through evaporation and runoff in relation to the timing of rainfall results in a significant improvement in the prediction of final fallow water storage compared to using average values as incorporated in a fallow efficiency rule.

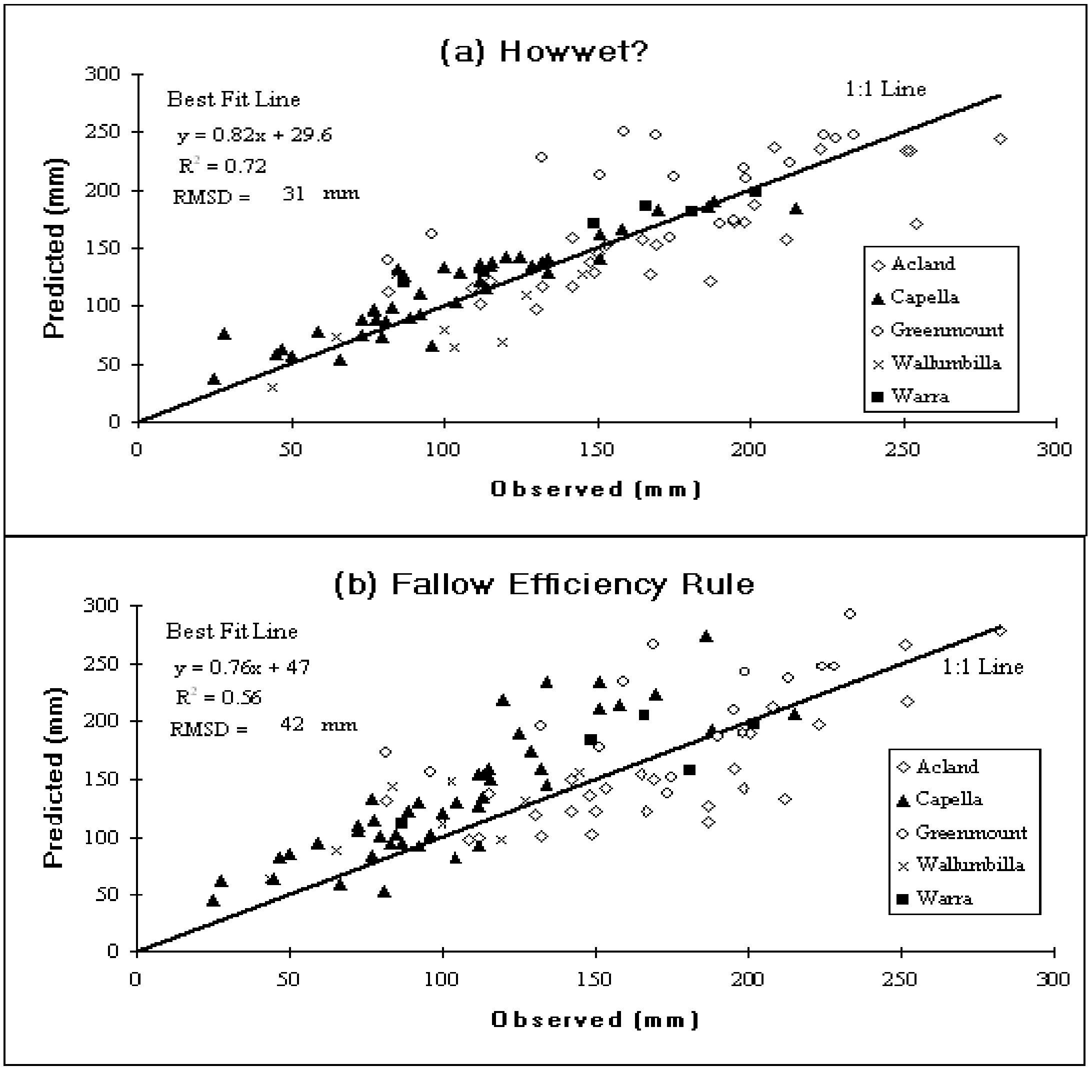

Figure 1. Observed vs predicted plant available water in the root zone at the end of fallows using (a) HOWWET? and (b) a fallow efficiency rule of 20%.

The fallow efficiency rule of 20% generally over-predicted the water storage for the Capella site. Since the average FE calculated using the measured data for Capella was 12%, this is not surprising. However, more importantly, the observed FE varied from zero to 37% with a c.v. (%) of 73%, demonstrating that a single FE value can result in large errors. As seen in Fig. 1a, HOWWET? was able to predict the Capella data quite well, with the points lying along the 1:1 line.

The overall average fallow efficiency based on measured data across sites was 17%, with a range of 0-46% and a c.v. of 58%. Using 17% instead of 20% across sites the RMSD for predicted and observed final soil water content was reduced marginally, from 42 to 40 mm.

Runoff was measured at 4 of the five sites. The RMSD for the observed and predicted runoff using HOWWET? was 25 mm, where the observed total fallow runoff varied from 0 to 171 mm and averaged 27 mm.

DISCUSSION

Rainfall is the primary variable required for simulating the soil water balance for fallow paddocks in dryland farming systems and is routinely collected by farmers. HOWWET? provides farmers and advisers with an easy to use tool for obtaining more quantitative information from the rainfall records they collect. Quantitative knowledge of plant available water at planting is a prerequiste for effective use of crop water use efficiency concepts (4), especially in an environment where fallow water storage can be a large element of the water supply to a crop.

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