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Hydrologic guides furrow irrigation decisions

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HydroLOGIC is an irrigation management system to assist effective and timely application of irrigations for furrow irrigated cotton crops. HydroLOGIC has been developed by CSIRO Plant Industry, as part of the Australian Cotton CRC, incorporating up to date cotton research into a management decision aid to optimise water use and yield.

Using the HydroLOGIC software can help to evaluate the consequences of different irrigation strategies on yield and water use, using a range of simple plant and soil moisture measurements.

Specifically there are four ways in which HydroLOGIC can help irrigated cotton growers make decisions (Figure 1):

1. Optimise cropping area

Predictions of yield can be made using historical climate information, with a range of water allocations. The optimum irrigated cropping area can then be determined for a given water allocation.

2. Schedule the next irrigation

HydroLOGIC can be used to predict the date when a field will next need irrigating.

3. Conduct scenario analyses

HydroLOGIC can be used to assess the consequences of different irrigation management strategies. Two types of irrigation issues can be explored:

• Timing of irrigations — the effect of changing first and last irrigation dates, and the impact of stretching irrigation deficits. For example “what if I delay irrigating this field in an attempt to save water?” or “what if I irrigate at a lower deficit and more frequently?”

• Amount of water — the effect on yield and water use efficiency with different water availability (allocation and irrigation system efficiency). For example, ‘what will crop yields be if I receive and apply an extra two megalitres

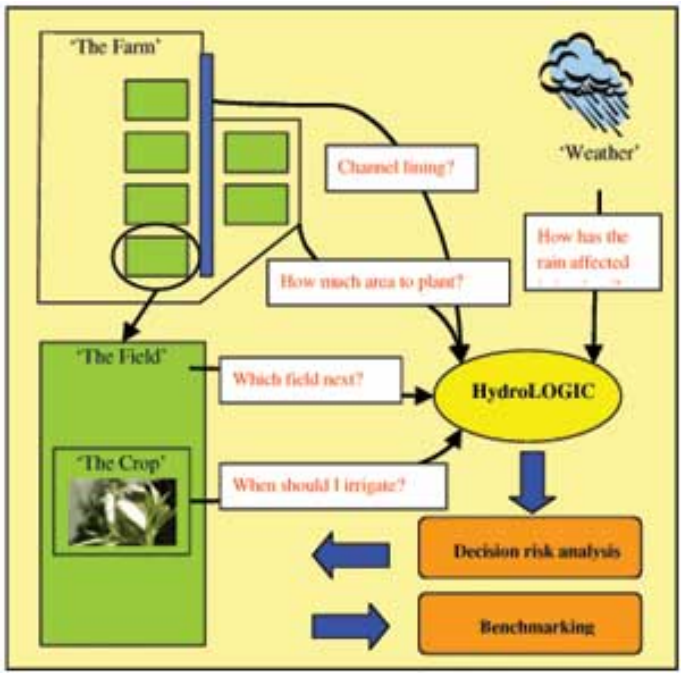

FIGURE 1: HydroLOGIC can operate on many levels of farm decisions

HydroLOGIC can help schedule irrigations.

per hectare of allocation flow?'

4. Benchmarking performance of previous crops

Benchmarking is one way to assess crop productivity and track changes over several seasons, and compare with other fields on the farm. It can be used to:

• Calculate crop water use efficiency figures in conjunction with actual field results, to allow comparisons between crops and seasons.

• Help assess the impacts on crop growth if irrigation management from the previous year had been different.

An important component of HydroLOGIC is the use of actual crop growth (fruit load and leaf area), soil moisture measurements, current weather information (rainfall and temperature) and irrigation information for a crop to the present date in the season. The prediction of crop growth and water usage for the remainder of the season is based on the modelled soil water balance, historical climate information and different management scenarios (Figure 2).

Importantly, HydroLOGIC is designed to complement, not to replace, continuous soil moisture monitoring systems, as information can be used from any existing soil monitoring equipment that has been properly calibrated.

Background

HydroLOGIC uses the OZCOT model developed initially by Dr Brian Hearn and CSIRO. OZCOT simulates the effects of environment (soil, water and temperature) and crop management (such as sowing time, nitrogen and irrigation) on yield development.

Over the past decade OZCOT has shown considerable versatility in simulating commercial irrigated crops with different management regimes. Within HydroLOGIC, each cotton field is treated individually, since irrigation scheduling is conducted on a field basis.

Central to the HydroLOGIC software is the weather information provided through the Bureau of Meteorology SILO project. Most cotton growers will be familiar with another SILO product, the SILO day degree calculator hosted on the Australian Cotton CRC web site. The other major advance in access to climate data has been the development and availability of the Patched Point Dataset for research.

This is a continuos dataset containing daily

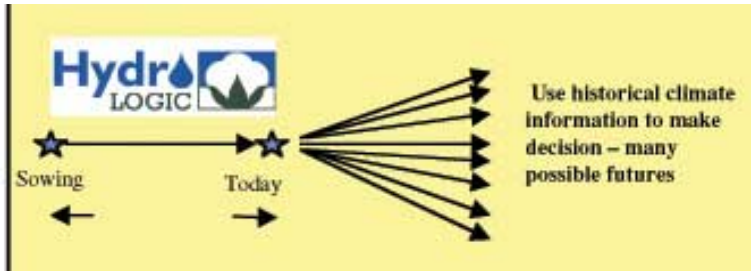

FIGURE 2: The prediction logic of HydroLOGIC

HydroLOGIC can be used to maximise yield and achieve optimal WUE.

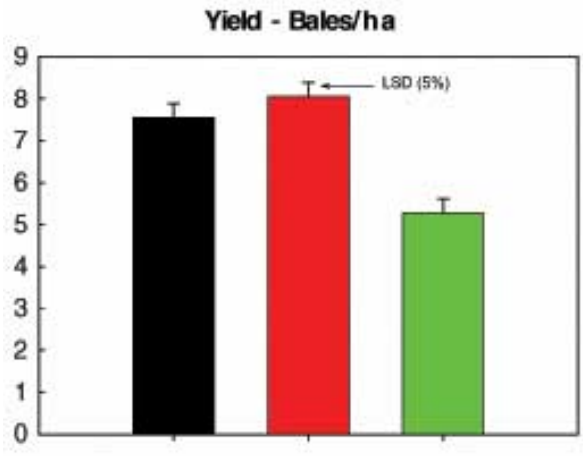

FIGURE 3: Final machine picked yields from the large scale HydroLOGIC evaluation trial at Narrabri.

rainfall, minimum and maximum temperatures, radiation, evaporation and vapour pressure for any weather recording station in Australia. It combines original Bureau measurements for a site, with any missing data filled using estimation from measurements at surrounding stations. Historical climate for any official recording station may be accessed directly from SILO, and then used within HydroLOGIC.

HydroLOGIC performance in the field

In detailed field evaluations of HydroLOGIC conducted during the 2002–03 season, the use of HydroLOGIC for scheduling irrigations was shown to optimise yield, maturity, and water use under both full and limited water situations. A large scale field trial at Narrabri consisted of three treatments:

• Standard management with eight megalitres per hectare;

• HydroLOGIC management with eight megalitres per hectare (Full); and,

• HydroLOGIC management with four megalitres per hectare (Limited).

The trial was sown on October 9, 2002 with Sicot 289RRi, and had approximately 180 kg per hectare of available soil nitrate to 1.8 metres depth at sowing

The standard irrigation treatment was irrigated on 14 day cycles or when plant stress was apparent. A series of simulations was conducted using HydroLOGIC to determine the optimum soil moisture deficit to irrigated at, and to maximise final yield predictions.

Yield and Fibre Quality

Timely water application ensured optimal plant growth and fruit development within the HydroLOGIC treatments. The highest square and boll numbers were achieved under the HydroLOGIC management. This resulted in a harvest of 8.1 bales per hectare under full allocation and 5.3 bales per hectare under limited water allocation. These results compare favourably with the standard scheduling treatment which yielded 7.6 bales per hectare (Figure 3).

Micronaire was not significantly different between the standard and HydroLOGIC managed treatments. These results demonstrate that HydroLOGIC was able to minimise water stress and negative effects on fibre development. Other fibre quality properties were not affected by the

TABLE 1: Water use efficiency indices

Water details	Standard scheduling	HydroLOGIC Full	HydroLOGIC Limited
Total water applied (Ml)	7.2	8.5	4.6
Irrigations	5	6	3
Total seasonal water use (Ml/ha)	9.3	10.8	6.7
Irrigation application efficiency	81	78	88
Gross production water use index (bales/Ml/ha)	0.8	0.8	0.8
Irrigation water use index (bales/Ml)	1.1	1.0	1.2
Crop water use index (kg/mm)	2.6	2.7	2.4

different irrigation scheduling and water allocation.

Water Use Efficiency

During the 2002–03 season only 197mm of rain fell on the crop, which provided ideal conditions to evaluate the value of HydroLOGIC. To determine the total irrigation water applied to the treatments, water flow was measured at the siphon and furrow (tail water) in each treatment during all irrigations.

The total seasonal water use was then calculated using the volume of irrigation applied, the change in soil moisture from sowing to defoliation, rainfall and estimates of deep drainage. These figures allow several water use efficiency indices to be calculated (Table 1):

a. Gross production water use index (GWUI): Is the yield (bales) produced from all water applied to the crop, which includes soil moisture, rainfall and irrigation water.

b. Irrigation water use index (IWUI): Allows irrigators to determine how efficient their irrigation water has been in producing bales of cotton. It is calculated by dividing the yield (bales per hectare) by the water applied as irrigation (Ml).

c. Crop water use index (CWUI): Calculates how efficiently the water used by the cotton crop in evaporation and transpiration (mm), was converted into lint harvested (kg).

The differences between the total water applied as irrigation and total seasonal water use indicates there should have been considerable differences in crop growth. But comparisons of GWUI showed no differences between treatments.

Comparisons between treatments indicated that IWUI (Table 1) was maximised in the HydroLOGIC reduced allocation treatment, where 1.2 bales were produced for each megalitre of water applied. This compared with 1.1 bales/Ml and 1.0 bales/Ml from the standard scheduling and HydroLOGIC full allocation treatment.

Crop water use index showed little variation between the different management treatments, with comparable results achieved under a limited water scenario using HydroLOGIC. The HydroLOGIC full allocation treatment achieved the highest crop water use index of 2.7 kg of lint/ mm of evapotranspiration.

These results demonstrate that HydroLOGIC can

be used to maximise yield and achieve optimal WUE, through scheduling irrigation applications to satisfy plant water demand and maintain good crop growth.

Future features of HydroLOGIC

New features will be incorporated into the HydroLOGIC software in future versions, following feedback from cotton growers and consultants. Some of the features planned include:

• The ability to select particular seasons for comparisons (such as drought years) and analogous seasons based on the current seasonal climate forecasts.

• The ability to customise soil moisture parameters used for predictions of crop growth and import data from existing soil moisture measuring devices.

• A farm water accounting system.

Software

Copies of the HydroLOGIC software are available from the cotton industry development officers, situated in each cotton growing valley, or by contacting the Australian Cotton CRC's Technology Resource Centre at Narrabri. Further details can be found at http://www.cotton.crc.org.au/CottonLOGIC/.