System capacity the key for overhead irrigators

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Furrow irrigating cotton growers are starting to install more centre pivots and lateral moves (CP&LMs) every year.

The main reasons are:

• A reduction of irrigation labour requirements of 80 per cent over that used for traditional furrow irrigation;

• Greater control of soil moisture;

• One bale per hectare average potential yield increase due to reduced crop waterlogging;

• Greater beneficial capture of in-crop rainfall;

• Overall simplicity of use; and,

• A 30 to 50 per cent reduction in applied water possible over traditional furrow irrigation.

System capacity

System capacity is the most important design parameter for CP&LM machines in the Australian cotton industry. Many machines installed in Australia in the past did not have a system capacity large enough to successfully grow a cotton crop.

The 'failures' associated with low system capacity have been the single greatest reason for the continuing low uptake of CP&LMs in Australia. To be successful, these systems must be able to supply water to irrigated cotton fields at a rate to cater for peak crop evapotranspiration.

In Australia's highly variable climate, we can't rely on timely rainfall to help irrigation systems during peak crop water requirement. So future systems must be designed without any allowance for supplemental rainfall.

This discussion assumes no in-crop rainfall and that growers have an adequate volume of water allocated for the irrigated area under their CP&LM.

How to manage your system capacity

The system capacity is the maximum possible flow rate that the CP&LM can apply to the area of an irrigated field (see box story Page 25).

The system capacity of a CP&LM is reduced considerably in the real world by the number of hours the pump is turned off during the irrigation cycle.

Also take into account the non-irrigating time necessary for any pesticide spraying with over-

KEY POINTS

- Ensure the System Capacity of a CP&LM is large enough to guarantee its ability 'to keep up' with peak crop water requirements when managed correctly.
- Using larger diameter pipe spans costs more but lifetime running costs are dramatically reduced. For example, the initial capital cost of a 270 l/s 18 span lateral move with larger diameter pipe spans is eight per cent higher than with small diameter pipe spans. But pumping energy costs are only one-third as high.
- All CP&LMs will operate with sprinklers to germinate cotton crops, including those machines that operate LEPA irrigation throughout the main growing season. Sprinkler packages represent a small part of the overall capital investment (usually less than five per cent), but probably influence the overall performance of the machine more than any other aspect.
- Wheeltrack and wheelrut issues are a problem for new systems, but reduce as levelled land compacts. Simple equipment alterations can help the problem — reduction of nozzle flowrates around towers; relocating LEPA outlets and sprinklers to keep wheeltracks dry; and reducing tower water interception from sprinklers. Consider larger tyre sizes, or the implementation of third or fourth inline wheels and gearboxes on electrically powered towers.
- Span sizes of exactly 48 metres remain a bone of contention between the guidance oriented Australian cotton industry and large overseas manufacturers. Support and assist local manufacturers who are prepared to resize jigs and build 48 metre spans. Guidance systems can now operate in circles for centre pivots, and swath widths can be adjusted under spans that are not 48 metres.
- Ensure that all water drains from span pipes, so that pipe insides remain dusty dry between irrigations. Irrigation water quality tests conducted prior to purchase are essential to ensure compatibility of irrigation waters and pipe coatings. Continue irrigation after fertigation has ceased for considerable time periods to ensure machine is fully flushed.

crop sprinklers and the dry travel time of the CP&LM that you think that you may need.

System capacity is further reduced by losses that occur between the nozzle on the machine and the crop root zone. The ratio of the water that actually makes it into the crop root zone, divided by the total amount of pumped water is called the application efficiency.

For low energy precision application (LEPA) systems, the application efficiency could be 0.98 and for modern over-crop sprinkler systems, between 0.9 and 0.95. So a grower running his CP&LM pump for 204 hours (out of 240) throughout a 10 day period during peak crop water use, using a well-tuned over-crop sprinkler system would be able to irrigate at a rate of 204/240 x 0.95 = 0.81 of the system capacity.

You might have a system capacity of 14 mm/day, but if the pump only runs for three quarters of the time, even with a LEPA system, then on average 10.5 mm/day would be applied into the crop root zone.

Remember that these system capacity values have nothing whatsoever to do with the amount of water applied by the CP&LMs during each irrigation pass. The amount of water that is applied per pass is governed by the pump flow rate and the amount of time that the machine takes to complete one irrigation pass of the complete irrigated area. Just as a constant flow rate boomspray operator would reduce speed to apply a greater amount of water to the field, so too is the average speed of a CP&LM reduced to apply more water per pass.

Choosing your system capacity

A process for choosing a suggested CP&LM system capacity has been developed utilising the evapotranspiration maps of Australia recently developed by the CRC for Catchment Hydrology and the Bureau of Meteorology.

A calibration factor (21.5) has been derived from the system capacities of CP&LMs across the cotton industry and the January map of average point potential evapotranspiration (ETo), to allow growers to choose their location and calculate their own system capacity target.

January was chosen as it represents the period of greatest crop water use for cotton. The calibration factor assumes a pumping utilisation rate of 0.85 and the use of a LEPA system with an application efficiency ratio of 0.98.

Locate the proposed site of your CP&LM on the evapotranspiration map. Then find the closest lines of evapotranspiration for your particular location and divide the value by the cotton industry system capacity calibration factor (21.5). The resulting number will be in millimetres per day, and is a starting point for decisions regarding the appropriate system capacity for CP&LM design.

If growers are concerned about the particular value they calculate, consult appropriately skilled irrigation professionals.

CALCULATING THE SYSTEM CAPACITY

To calculate your system capacity, take the flow rate of water pumped by your CP&LM installation and divide by the area of crop that the CP&LM will cover in any one cotton season.

Example:

A lateral move is capable of pumping 300 litres per second onto 180 hectares in a day — what is the system capacity?

Volume applied (L/day) = 300 L/s x 60 s/min x 60 min/hour x 24 hours
= 25,920,000 L/day

Area irrigated (square metres) = 180 ha x 10000
= 1,800,000 square metres

System capacity (mm/day) = Volume applied (L/day) ÷ Area irrigated
= 25,920,000 L/day ÷ 1,800,000
= 14.4 L/square metre
= 14.4 mm/day (as 1L/square metre = 1mm)

TABLE 1: Lateral move field lengths for various irrigating widths and system capacities*

Irrigating width under lateral move (metres)	Pump Utilisation Ratio (days pumping/10 days)	Wetted Total Field Length for System Capacity of: 12 mm/day	14 mm/day
700	8.5	2570	2200
	9.5	2870	2460
750	8.5	2400	2050
	9.5	2680	2300
800	8.5	2250	1920
	9.5	2510	2150
850	8.5	2110	1810
	9.5	2360	2020
900	8.5	2000	1710
	9.5	2230	1910
950	8.5	1890	1620
	9.5	2110	1810

*Pump flow rates of 300 L/s and an application efficiency ratio for LEPA of 0.98

Overhead systems offer some big advantages for cotton growers.

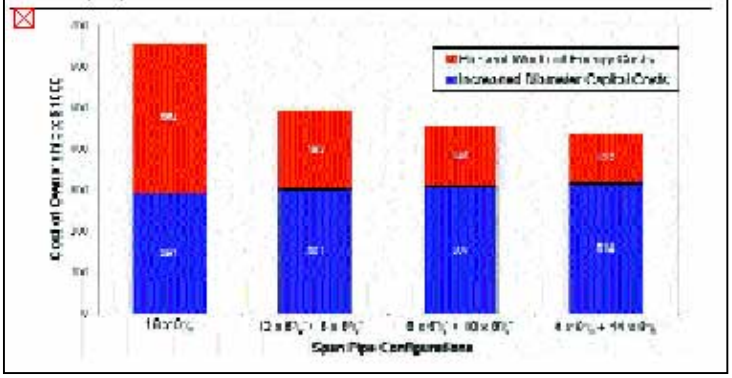
Peak crop evapotranspiration rate

In any growing season, there will always be periods in which crop evapotranspiration is much higher than average. Systems must be designed to handle these extremes and minimise the days when crop evapotranspiration exceeds the system capacity.

When growers choose their irrigation system capacity, they are choosing the level of risk that the machine will not be able to keep up with particularly high evaporative days. Growers who are not prepared to risk the possibility that their CP&LM will 'not keep up', should choose larger CP&LM system capacities.

The real consequences of choosing lower system capacities will be the reduction in the average amount of water held in the crop root zone as each passing day extracts, on average, more than the CP&LM system capacity can supply. This does not necessarily mean crop failure, but rather the gradual decline in the readily available water supply for the crop and the potential for crop yield reduction.

FIGURE 1: Cost of ownership for long term energy costs and up-front capital for four different 18 span lateral move designs with numbers of larger diameter span pipes from 0, 6, 10 and 14



Increasing system capacity

For large lateral moves (whose upper size limit is currently controlled by the maximum flow rate of the largest pumps that manufacturers are prepared to place upon drive carts) the system capacity can be increased by cutting the overall irrigated run length. This is a cost effective and simple matter as no substantial change to the lateral move design is necessary. But costs could be incurred if changes are necessary to the field drainage network.

Increasing centre pivot system capacity could involve changes in the nozzle set at a very minor cost. But alterations in the pump and pipe diameters, both in the span and supply line, can have significant associated costs. And if pumps and pipes are incorrectly designed, the lifetime running costs of the system can be greatly increased.

Remember that choosing larger system capacities for CP&LMs does not mean that larger water volumes are applied to the crop. It simply means that there is adequate capacity to cater for the peak crop water requirements of well-grown cotton when the crop requires it most.

Recent purchases of large lateral moves in the cotton industry have all been with the largest pump flow rate possible for these machines. Based on this fact, a range of different field lengths has been calculated and this is presented in Table 1.

Bigger capacity, lower running cost

One of the largest costs of ownership of CP&LMs is the on-going pumping energy cost associated with supplying irrigation water through the machine. Many growers in the past have not completely understood the implications of purchasing equipment with small diameter pipe

spans. Their overall cost of ownership drastically increased because they purchased a slightly cheaper (smaller) span pipe configuration.

A slight increase in the up-front capital cost can drastically reduce long term ownership costs.

A “present worth” analysis of the long-term pumping energy costs of a large lateral move with four different configurations was conducted, as shown in Figure 1.

The lowest capital cost option of the four different lateral move designs consists of 18 small diameter spans. The most expensive design consists of 14 spans of the larger diameter pipe spans.

Increasing the number of spans with larger pipes, costs an additional 7.9 per cent, but reduces the 15 year pumping energy costs to one third of that using small diameter pipe spans.

This article was adapted and summarised from WATERpak which is due to be released in the next few months.

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