Agriculture Notes

From 'Border-check' to 'Sprinkler'?

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Introduction

This information pamphlet will provide you, the land manager, with some information on the issues associated with the process of conversion from border-check to sprinkler irrigation. It highlights some of the advantages of sprinkler over border-check and also discusses situations where conversion may not be the best option.

Much of the information presented relates to the Shepparton Irrigation Region but some of the technical information can be used in other areas with similar soil and/or climatic conditions. The document focuses on border-check and centre pivot (Figure 1) irrigation systems for perennial pastures.

Figure 1 – A centre pivot irrigator.

The problem

In many situations border-check irrigation is an efficient method for irrigating pastures. However, if poorly managed or used on inappropriate soils, border-check systems can use too much water and contribute to the development of shallow water tables, nutrient losses to river systems and salinisation problems.

In areas where border-check irrigation may be inappropriate, conversion from a border-check to a centre pivot system is one option for reducing water use and alleviating the environmental impacts of irrigation.

How much water does perennial pasture need?

The amount of irrigation water required by a perennial pasture in a season (the irrigation requirement) is equal to the pasture water requirement minus effective rainfall. The average irrigation requirement varies across northern Victoria, increasing towards the north and west (Table 1).

Table 1 – Twenty year average annual irrigation requirement for perennial pasture, assuming 80% effective rainfall.

Location	Irrigation Requirement (ML/Ha)
Swan Hill	9.3
Echuca	8.9
Tatura	8.5
Cobram	8.6

Additionally, effective rainfall and irrigation requirement can also vary considerably from year to year. The variation in perennial pasture irrigation requirement over the last five years at Tatura is shown in Figure 2.

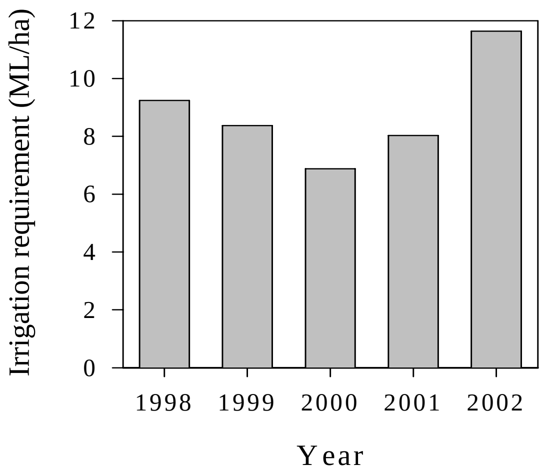

Figure 2 – Variation in perennial pasture irrigation requirement at Tatura.

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The daily amount of irrigation water required by perennial pasture is also important in selecting and designing an irrigation system. At Tatura, the highest average daily irrigation requirement occurs in January (Table 2). The daily irrigation requirement will increase towards the north and west of Tatura.

To determine the centre pivot system capacity (depth of water applied to the whole field each day), this daily requirement is adjusted to allow for system inefficiencies and above average daily crop water demand (Table 2). This system capacity assumes that the system will operate 24 hours a day 7 days a week.

Finally, to allow for breakdowns and flexibility in operations (e.g. to limit irrigation to 5 days a week or to use off-peak power) the system capacity can be increased further. Table 2 shows centre pivot system capacity requirements at Tatura for a system operating 5 days a week and for a system only operating during off-peak electricity rate times (88 hours/week out of a total of 168 hours/week).

When purchasing a centre pivot system you should clarify with a designer how you should/want to operate the system and get a system with appropriate capacity for your requirements. Of course the capital cost of the system increases as system capacity increases.

Table 2 – At Tatura – average daily crop water use in January and centre pivot system capacity for a system operating 24 hrs/day 7 days a week, 24 hrs/day 5 days/week and in off-peak electricity hours only.

Description	Quantity of water (mm/day)
Average daily crop water use during peak water use month	6.0
System capacity (assuming system operates 24 hrs/day, 7 days/week)	7.3
System capacity (assuming system operates 24 hrs/day, 5 days/week)	10.2
System capacity (assuming system operates in off-peak hours only)	13.9

How efficient is centre pivot compared to border-check irrigation?

Irrigation Efficiency (IE) is a measure of the proportion of applied water that goes to the crop root zone. IE is 100% when all applied water is captured by the plant roots and is lower than 100% when runoff and deep percolation losses occur. Irrigation system design and management can greatly affect IE. As soil types become lighter border-check system IE often decreases as deep percolation losses become greater.

The expected range in IE for centre pivot and border-check systems is shown in Figure 3. The general message to be drawn from the diagram is that in appropriate circumstances border-check IE can approach that of efficient pressurised systems. However, management, topography and soil variability impact on the performance of border-check systems to a greater extent than on sprinkler systems. This results in more numerous situations where high IEs cannot be obtained using border-check irrigation. The greater range in IEs for border-check systems in Figure 3 results from this susceptibility to large performance variations.

The improvement in IE associated with conversion from border-check to centre pivot is likely to be greatest where existing border-check systems cannot capture and reuse surface run-off, or where soil types are permeable and deep drainage losses are high.

It is important to note that well managed border-check irrigation can potentially achieve better IE than poorly managed sprinkler irrigation. Thus there are no hard and fast rules on what levels of water savings you can achieve by converting to a centre pivot system.

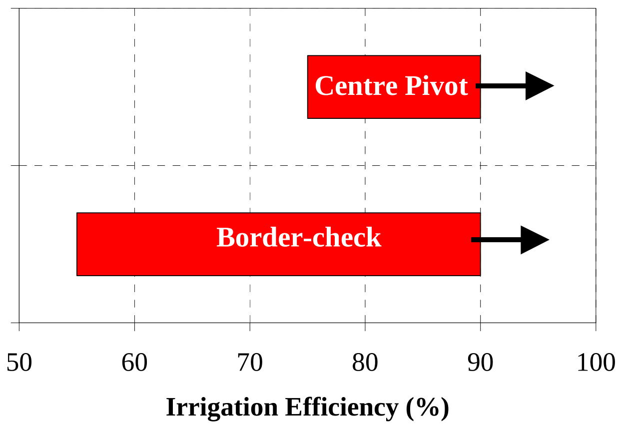

Figure 3 – Expected range of irrigation efficiencies for border-check and centre pivot systems.

How efficiently are you currently irrigating?

You can estimate the level of water saving you may achieve on farm by calculating the IE on your farm. Most simply, IE can be approximated by:

$$IE = \frac{\text{irrigation requirement (ML/ha)}}{\text{applied irrigation water (ML/ha)}}$$

Please note that this equation only holds for farms that supply more water than the irrigation requirement.

Perennial pasture irrigation requirement can be estimated from Table 1. Keep in mind that irrigation requirement varies from year to year. Therefore, it would be best if you can average your irrigation water use over a number of years.

Little scope for water savings exists where high IEs are already being achieved. Conversely, large water savings are possible if your current IE is low.

A local trial comparing sprinkler to border-check irrigation

A 2-year field experiment comparing water use and pasture production under border-check and sprinkler irrigation was conducted at Tatura. The economic implications of adopting sprinkler irrigation were also appraised. The soil type at the experimental site was Lemnos loam.

Lemnos loam is a duplex soil characterised by brown to greyish brown loam to clay loam extending to 0.12 metres. This top horizon is underlain by a 0.30 to 0.35 m layer of reddish brown medium to heavy clay, turning to brown or yellowish brown medium clay from 0.45 to 0.60 metres. The final infiltration rate of Lemnos loam is typically less than 2 mm/hr.

Water use

Border-check irrigation achieved irrigation efficiencies of 75%, while sprinkler irrigation achieved efficiencies of 90%. In both years of the experiment the sprinkler system used 2 ML/Ha less irrigation water than the border-check system. It was assumed that all runoff from the border-check system was reused.

The border-check system used more water because it had greater deep drainage (water table accessions) and evaporation losses. Deep drainage losses are likely to be greatest when the watertable is deep (3 or more metres below the surface) and so does not restrict water flow to depth, or contribute to pasture water use. The experimental site was located near a groundwater pump and did not have a shallow watertable. These conditions meant that the water savings in the experiment were most likely towards the upper limit of what could be achieved on a farm with Lemnos loam soil.

Well managed sprinkler systems should be able to closely match water application with crop water requirement. With border-check irrigation, a larger variability in IE, both within and between farms, can be expected. Thus, the potential water savings derived from replacing border-check with sprinkler irrigation need to be evaluated on a case-by-case basis.

Pasture production and composition

In the first year of the experiment sprinkler and border-check system pasture production were equal. Sprinkler irrigation produced 2 tonnes of dry matter/ha more pasture than border-check irrigation in the second year of the field experiment. The most likely reason for the increase in pasture production under sprinkler irrigation was the more frequent but lighter application of water, which alleviated the waterlogging and water stress problems associated with border-check irrigation. The choice of irrigation system had no consistent impact on pasture composition.

Can you expect the same benefits on your farm? Probably not to the same degree; it is often impractical (or not economical) to apply the high management inputs used under experimental conditions to working farms. However, the experiment showed that in some circumstances there is potential to ‘produce more with less water’ using sprinkler irrigation.

Economics

The information in this section is based on 2003 costs and returns on capital.

Sprinkler irrigation is expensive. Typical costs of purchase and installation of a centre pivot system will be between $2500 and $4000 per hectare. Capital costs include: site survey and design; purchase and installation of pump station, mainline and sprinkler unit; construction of new laneways and fences; earthworks to fill in channels, flatten check banks and make some adjustments to grades to provide adequate drainage; and electricity connection.

Costs increase towards $4,000 as the capacity of the system increases, if electricity has to be run to the site, if a dam for water storage is required and if greater amounts of laneways, fencing or earthworks are required.

Centre pivot capital costs can compare favourably with new border-check layouts if substantial earthworks are required for the border-check system.

Operating costs of centre pivot systems (pumping, maintenance, labour and water) are of the order of $600/ha, compared to about $480/ha for border-check systems.

Conversion from border-check to centre pivot irrigation is expensive. Nevertheless, conversion can be economically viable for a dairy farm if water savings can be achieved and used to expand the area of irrigated pastures on the property. Conversion is less economic when there is no potential to expand the irrigated area on the property.

Where conversion to centre pivot can achieve water savings greater than 3 ML/ha, or if the cost of water increases substantially in the future, sprinkler irrigation may become economic on farms without any available land for expansion. Conversion also becomes more favourable under conditions of reduced water availability.

Deep drainage considerations

The cost associated with the loss of irrigation water through deep drainage will depend on a number of factors. If a groundwater pump can be installed to recycle deep drainage for farm reuse, little water is actually lost from the production system. As the cost of ground water pumping is relatively small, conversion to sprinkler irrigation to minimise deep drainage losses may not achieve any substantial water savings in such areas and might not be economically feasible. However, groundwater pumping and farm reuse is limited to areas with pumpable, low salinity aquifers and large areas of land do not fall into this category.

The cost of deep-drainage losses is likely to be greater where groundwater pumping and farm reuse is not possible (eg. areas with saline groundwater and no pumpable aquifers). Under these conditions conversion to sprinkler irrigation may be a cost-effective option to minimise deep drainage losses to the groundwater system.

Conclusions

This research project clearly showed that there is scope to grow more pasture from less water by using sprinkler rather than border-check irrigation. Economic analysis showed that conversion to sprinkler irrigation can be an economical proposition under some conditions. However, the benefits of converting will depend on individual farm conditions.

A study looking at landowners' perceptions on the benefits and barriers of alternative irrigation systems

A study was conducted by the Department of Primary Industries to assess the views of landowners on the benefits and barriers of irrigation systems other than border-check.

Twenty landowners were interviewed, 13 had changed systems, one had considered changing but did not change, and 6 were considering changing systems. Most of the landowners interviewed were operating dairy farms. The majority of landowners adopting, or considering adoption, of alternative systems ran enterprises that combined grazing and hay and silage making. Centre pivot systems were by far the most common system adopted or being considered for adoption.

Landowners mostly became aware of alternative systems through contact with other farmers and equipment suppliers and manufacturers. In order, preferred sources of information for landowners were other farmers, DPI and equipment manufacturers. Research and extension material was clearly the primary additional information that farmers wanted access to, followed by information on incentives and economic advice.

Landowners indicated dissatisfaction at not being able to access objective advice from DPI. This booklet is one avenue that DPI is using to address this issue. A number of other information sources will be released by DPI in the future.

The reasons for the change to alternative irrigation systems given by the landowners were: soil not suitable for border check irrigation, undulating country, save labour, save water, increase productivity, water sustainability conscious and better farm management.

Capital cost was identified as the major barrier against adoption of alternative systems. Trees, operating cost and shape of the area to be irrigated were highlighted as other barriers to adoption.

Of the landowners who had adopted alternative systems:

- Nearly all (90%) believed that they had increased production by at least 10%. Around 40% of landowners believed that they had increased production by more than a third.
- About half believed that they had saved between 10 and 20% of water compared to border-check irrigation. A third believed that their water savings were greater than 30%.
- Around half believed that their labour savings were in the order of 10 to 20%. A third estimated labour savings of greater than 30% compared to border-check.

The production increases estimated by landowners were generally much higher than was measured in the field experiment at DPI-Tatura that was discussed earlier. The majority of landowners had water savings similar to those measured at the DPI-Tatura experiment. Landowner labour saving estimates were lower than past work at DPI-Tatura has estimated.

There are a number of reasons why landowner perceptions were different from experimental results. The two most obvious reasons are:

- The experiment compared best practice border-check and sprinkler irrigation, whereas farmers were generally comparing production and water use under poorly laid out border-check irrigation (pre-laser) to a new centre pivot system.
- Also, on some farms the area where an alternative system was installed had not been previously irrigated, making 'estimates' of improvements almost impossible.

Other possible reasons include: soil type differences, management practices, crop type, and measurement accuracy. Further farm and experimental work is being conducted by DPI staff to better quantify the expected benefits associated with the adoption of alternative irrigation systems.

Landowners in the survey also identified a number of problems associated with the use of alternative irrigation systems. These included:

- Design application rates were too low and so systems could not apply sufficient water to crops;
- Centre pivot systems got bogged because they were not designed to eliminate irrigation of wheel tracks;
- Corrosion of the system;
- High maintenance;
- Effects of wind on uniformity and spray drift;
- High running costs.

Design issues such as these should be discussed with manufacturers prior to the purchase of systems to ensure that no unpleasant surprises are experienced following system installation.

Finally, it should be noted that all participants in the survey who had adopted alternative irrigation systems were satisfied with their choice.

A Process to Help You Decide Between Systems

Large investments like sprinkler systems require careful consideration of options before implementation. When considering conversion from border-check to centre pivot, a number of issues will have to be addressed.

Five steps in the process of evaluating a change in irrigation system on your farm are:

° Development Goals - clearly establish the goals you want to achieve as a result of the conversion;

- Assess local conditions - collect physical (eg. soils, water availability, land shape, topography) and institutional information (eg. whole farm planning process, regulatory information such as tree removal) to allow assessment of the benefits of conversion;
- Pre-selection - evaluate data to assess the likelihood of achieving your development goals;
- Feasibility design and economics - get detailed designs and costings from qualified irrigation designers. Evaluate the financial implications to your farm; and
- Final selection - based on the 4 points above you can make your final decision.

In these 5 steps there are a number of key issues to address:

1. Development goals

Do you want to save water? **-** if water efficiency is your main aim, check your current IE. Where does your farm sit on the IE diagram? If you are on the high end of the border-check bar, conversion to sprinkler might not save you much water**.**

Current and future land use - do you plan to only grow perennial pasture or do you want your irrigation system to be flexible enough to grow fodder crops as well? Sprinkler allows greater flexibility in water application and is well suited to cropping.

2. Local conditions

Soils and layout - are most of the soils on your farm heavier than Lemnos loam? Is your current border-check layout efficient? Do you have a reuse system? If the answers to these three questions is 'Yes', conversion to sprinkler might not be a high priority for your farm.

Water availability and available land for expansion - are you short of water and/or do you have 'spare' non-commandable land available? In that case conversion to sprinkler might be a viable option.

Watertable and subsurface drainage - is your watertable less than 1 m from the surface for much of the year and you can't find a pumpable aquifer under your property? Conversion to sprinkler could be an option to lower your watertable.

Native vegetation remnants - large sprinkler systems require extensive areas of treeless land. Permits are required to clear remnant vegetation. In some situations it might not be feasible to install a centre pivot system.

3. Pre-selection

At this decision point you use all available information to decide if you will proceed with your development project.

Any decision should include the possibility of upgrading a current border-check system. This will definitely be less expensive than changing systems. If saving water is a goal then watering quickly by increasing the capacity of channel and bay structures or clearing weeds from channels may help. A reuse system or groundwater pump will also help reduce water lost from the farm. If reducing labour is a goal then an automatic irrigation system will be worth investigating.

4. Design and economics

Management – irrigation management with centre pivot systems is very different to border-check system management. A steep learning curve will be encountered in the first season of operation. As a general guide for pasture irrigation in summer in northern Victoria, two irrigations should be scheduled each week, with each applying about 25 to 30 mm of water. Depending on system capacity it will take 2 or 3 days to apply water to the whole area during each irrigation. However management is heavily dependent on factors such as system design and soil and crop type. It is vital that management issues be clarified with designers before a centre pivot system is purchased.

Labour – well designed and maintained sprinkler systems can provide trouble free operation and can be fully automated to minimise labour requirements. Labour inputs of about 2 hrs/ha/yr for centre pivot systems compare favourably with inputs in the order of 4 hrs/ha/yr for border-check. Automated border-check systems can reduce the labour input considerably, but will still require greater labour input than a centre pivot system.

Maintenance – maintenance costs of irrigation systems have been estimated in literature on average as approximately 2% and 4% of capital outlay for border-check and centre pivot systems respectively. An average capital outlay of $3000/ha for centre-pivot would thus result in annual maintenance costs of $120/ha. This cost will be slightly lower when the system is new, and increase over time. Although centre pivot systems are reliable, like any machine they require systematic routine maintenance. Required maintenance procedures should be clarified with designers prior to equipment purchase.

Energy use - for electric centre pivot systems average annual pumping costs are about $150/ha (based on April 2003 costs and considering a mix of peak and off-peak rates).

Installation cost - typical cost of purchase and installation will be between $2500 and $4000 per hectare. This cost can compare favourably with the cost of a new border-check layout development.

Some Basic Information On Centre Pivots

Centre pivot irrigators use low-pressure nozzles to irrigate circular areas. Mini pivot systems are available that water areas from 0.4 to 20 Ha. Large units can be up to 800 metres long with 18 or 20 towers, irrigating approximately 200 Ha.

Centre pivot systems can be powered by either electricity or diesel fuel. Water supply comes from one fixed centre hydrant. The circular shape of the irrigation area results in non-commandable corners of square paddocks. End guns help to capture some of this area, but at least 10% of the area of a square paddock will remain unirrigated.

Centre pivot systems have an average lifespan of 15-20 years.

Other Irrigation Systems

This pamphlet has focussed on border-check and centre pivot irrigation systems as these are considered to have the most potential for dairy farms in northern Victoria.

After centre pivot systems linear move systems are likely to be the most suitable for use on large areas in northern Victoria. They have higher labour input requirements than centre pivot systems. Irrigation application of these systems is similar to centre pivot, but the boom moves laterally along the paddock, allowing full command of rectangular-shaped areas. The system requires water supply along the full length of the field, usually a channel. Often these systems are diesel-powered to allow for mobility of the power source.

Other commercially available irrigation systems include: travelling irrigators, ‘van den Bosch’, K-line systems, fixed ‘pipe and riser’ impact-sprinkler systems and sub-surface drip systems. If centre pivot and linear move systems do not suit your needs you should talk to local suppliers and designers about the applicability of these systems.

Further Information

A number of information sources are available:

DPI Whole Farm Planning officers

- Shepparton Irrigation Area – Chris Nicholson, DPI Tatura, ph (03) 5833 5932.
- Murray Valley Irrigation Area – DPI Cobram, ph (03) 5872 1899.

Irrigation designers

- The Irrigation Association of Australia certifies Irrigation Designers. Information can be found on their website: http://www.irrigation.org.au/CIDLocate.htm
- Local irrigation designers are listed in the yellow pages.

Local sellers of centre-pivot systems

- The Yellow Pages present an extensive list of regional sales agents under the section “Irrigation &/or Reticulation Systems”.

Your bank manager and accountant

- Sprinkler systems are expensive and require capital investment. Financial advice should be obtained before proceeding.

Websites

- Some notes on irrigation system performance on dairy farms in Victoria: http://www.grdc.com.au/growers/res_upd/irrigation/01/RU_I_2001_P15.html
- The Queensland Government provides a useful website with information on a range of different sprinkler systems: http://www.nrm.qld.gov.au/rwue/factsheets.html#irrigation
- A document describing the use of centre pivots and lateral move systems in the cotton industry describes many of the issues that dairy farmers may face when converting from border-check to sprinkler irrigation: http://www.usq.edu.au/users/raine/index_files/IAA2002_Foley&Raine.pdf;
- Many irrigation companies have information available on the web, including:
- Reinke irrigation systems. http://www.reinke.com
- Valley irrigation systems. http://www.valmont.com/irrigation/irrigation.shtml
- Zimmatic irrigation systems. http://www.zimmatic.com/
- Irrifrance irrigation systems. http://www.irrifrance.com/anglais/index.html

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