# SRA Research Project
# Final Report

Sugar Research Australia

Research Funding Unit

**Cover page**

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| SRA project number: | GGP051 |
| SRA Project title: | Maximising Centre Pivot Efficiencies |
| Name(s) of the Research Organisation(s): | Precise Pivot Management Grower Group |
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| A statement of confidentiality (if applicable): | |

**Body of the Report:**

**Executive Summary:**

The aim of this project was to make centre pivot irrigators even more efficient by being able to alter the amount of water being applied along the irrigator boom. This was achieved using computer controllers to turn off the valves in sections of the pivot as it travels over areas to receive different amounts of irrigation eg fallow blocks, different crop stages, areas not to be irrigated etc.

Farmscan technology was used and this result of applying variable rates of irrigation is a first for the sugar industry. Refer to Figure 1

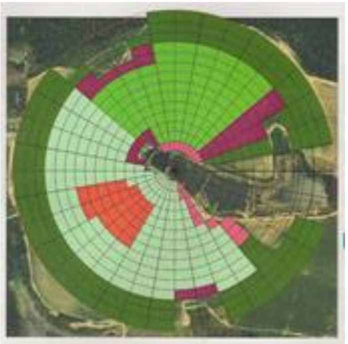


Figure 1 – the Farmscan technology allows the pivot to be broken into sections with different amounts of irrigation applied

Water operated on/off valves were installed which allow the pivot to apply water at different rates along the pivot span. It was also necessary to install a variable pressure/speed pump, install the controller and undertake training on how to write the software to program the controller.

The key results and learnings are:

- The risk analysis conducted with the help of a DAFF economist showed that regardless of sugar price and tonnes of cane harvested in any one year, installing variable rate technology onto this particular centre pivot results in a higher gross margin due to reduced input costs for labour and electricity. A copy of results is provided in Appendix 1
- Results from the distribution uniformity tests showed that the machine operating without the controller turned on had a poor distribution uniformity performance of 81%; and with the controller set to operate at 50% application the distribution uniformity dropped to 76%. This is an unacceptable result and could be due to issues with air being trapped in the pipes that control the valves, causing the open and close times to be altered. However the machine was successful in turning the valves completely off in the sections it was programmed to do so.
- The accuracy of farm maps used to program the variable rate is crucial, with valves not turning on or off if the map does not match the actual paddock. Having control over 0% application on certain areas is an important part of scheduling irrigation under the Pivot for farm use. The ease of use in programming the Pivot to do just this makes it an important tool in irrigation management. John is looking to install this system on another Pivot on the farm to further improve irrigation management.

**Background:**

Centre pivot irrigators are proven to be one of the most efficient irrigation systems. But in the cane industry with long ratoon cycles, and a six month harvest season, a pivot applying the same amount of water over the entire area (and length of pivot) becomes a management issue. With a pivot length of 700 metres, it is common for more than 1 block to be under the pivot at once. It is more than likely that these blocks require different irrigation amounts, while some blocks may not need water at all due to age of crop or blocks about to be harvested, or blocks planted to legume fallows which have different water requirements.

To overcome this problem, many growers use an inefficient high pressure irrigator to water individual blocks which could be irrigated by the pivot, however the pivot would irrigate the entire area which includes blocks not requiring irrigation.

This variable rate technology is new to the sugar industry, so testing of controller and software will be required to evaluate suitability and will incur higher costs. By doing trials and evaluations on the first controller, the group hopes to save time and money for anyone using this technology in the future.

**Objectives:**

The aim of this project was to make centre pivots even more efficient by being able to alter the amount of water being applied along the irrigator boom.

The expected outputs, outcomes and benefits listed in the original application include:

The Project Outputs will be:

- The software to allow for the pivot to be programmed will be developed and made available to other centre pivot irrigators

This was achieved

The project Outcomes will be

- New technology relating to further improving the efficiencies of centre pivot irrigators
- A better understanding of irrigation and water management
- Maximising water use efficiency of centre pivots

This was achieved

The Economic Benefits will be:

- Address limited water supplies without comprising productivity
- Reduce irrigation inefficiencies
- Maximise available water to allow better distribution of irrigation supplies to increase productivity
- Increase the profitability and sustainability of the farming enterprise

This was achieved

The Environmental Benefits will be:

- Improve environmental impacts through reducing water run off from areas not needing irrigation
- Reduce weeds in non-cropped areas in a centre pivot application through not watering these areas
- Implementing the latest technology to maximise water use efficiency
- Reduce supplementary usage of high pressure irrigation systems

This was achieved

The Social Benefits will be:

- Improved irrigation management decisions
- Improved time management through pre-programmed automatic irrigation design
- Cane growers in the Central region will have exposure to the latest technology in a low pressure irrigation system being implemented under local conditions

This was achieved

**Methodology:**

- The pivot was installed
- The necessary extra equipment to allow for variable rate application was installed. This includes the water operated valves, variable speed pump, controller
- A lot of effort had to go into setting up the machine so it would effectively deliver variable rate irrigation. There were also a lot of obstacles to overcome. For instance the pivot was late in being delivered; the tyres of the machine were vandalised and needed to be replaced; wet weather delayed the installation of the controller and valves on the machine because we needed a cherry picker during the installation and it couldn't be used on wet ground; working out which pump would allow the machine to apply at variable pressures and rates was very time consuming; during initial catch can tests the machine was building up pressure and then shutting off, the machine set up was re-evaluated and eventually we found that the wrong valves were supplied with the machine. The springs and plungers needed replacing in all the valves.
- A cost benefit analysis was conducted with the help of a DAFF economist. Her methodology states: In order to determine if the installation of variable rate capacity to the pivot is economically viable an investment analysis was completed to determine the Net Present Value (NPV). The gross margins before and after installation of the variable rate technology to the centre pivot were calculated using the Farm Economic Analysis Tool (FEAT). The change is gross margin from "before" (normal centre pivot) to "After" (with variable rate technology) was used along with the capital cost to conduct an investment analysis providing a Discounted Cash Flow (DCF) and a NPV. The gross margins per hectare of both scenarios were then analysed for risk using PiRisk. A real discount of 7% per annum over an investment period of 10 years was used.
  John Fox provided detailed estimates of cane yields, PRS, land preparation, fertiliser costs, weed and insect control strategies and fallow management. John's machinery costs were also estimated. These variables are very case specific. Therefore any grower seeking to uptake similar changes to practices should seek individual economic advice.
- A catch can analysis was conducted to compare the distribution uniformity of the centre pivot with and without the variable rate controller. This also ensured that the controller was applying the specified irrigation amount.

**Outputs:**

**Cost Benefit analysis results:**

- The risk analysis conducted with the help of a DAFF economist showed that regardless of sugar price and tonnes of cane harvested in any one year, installing variable rate technology onto this particular centre pivot results in a higher gross margin due to reduced input costs for labour and electricity. A copy of results is provided in Appendix 1

**Distribution Uniformity results:**

**System:** Reinke Pivot

Distribution Uniformity = (av. Low quarter depth/overall av. depth) x 100

DU Ratings: ≤77% very poor; 77-82% poor; 83-90% acceptable; ≥90% excellent

Full Rate: 100%

Av. Low quarter depth: **21mm** (468mm ÷ 22 cans)

Overall Av. depth: **26mm** (2333mm ÷ 89 cans)

DU: **81% - poor**

Variable Rate: 50% (target: 12.5mm)

Av. Low quarter depth: **17.5mm** (140mm ÷8 cans)

Overall Av. depth: **23mm** (808mm ÷ 35 cans)

DU: **76% - very poor**

Distribution Uniformity with variable rate engaged has dropped from poor to very poor. The target rate of 12.5mm was not met by a considerable margin.

The Centre Pivot without variable rate engaged only managed 81% Distribution Uniformity, which was disappointing. The target was 25mm applied, and the average of all catch cans was 26mm, which is close to the mark, but with a wide variation across the length of the Pivot.

With 50% variable rate engaged across one paddock, 23mm was applied, measured in catch cans and averaged (area in yellow on map in Appendix 2). The target was 12.5mm. The Distribution Uniformity in this test was very poor at 76%. This result was very surprising since valves were observed to be opening and closing as the Pivot went over the area.

There are some possible issues which may have caused this significant over-application. There was a steep ridge on the test block, and the terrain may have contributed to the result. Air may have been trapped in the pipes which control the valves, causing the open and close times to be altered. This was noticed in the first start-up, but it was assumed that most of the air was out of the system by then.

Blocks with 0% application received no water, and valves turned completely off over the areas in red on the farm map (Appendix 2). The accuracy of farm maps used to program the variable rate is crucial, with valves not turning on or off if the map does not match the actual paddock. Having control over 0% application on certain areas is the most important part of scheduling irrigation under the Pivot for our farm use. The ease of use in programming the Pivot to do just this makes it an important tool in irrigation management. John is now looking to install this system on another Pivot on his farm to further improve irrigation management.

Capacity Building of group members

- We have gained experience in conducting distribution uniformity tests and calculations. We will need to conduct further tests to improve the system
- We gained a better insight into the FEAT program and the process used to conduct the cost benefit analysis
- This system is a first for the sugar industry and has allowed us to better manage our irrigation application particularly in regards to not watering sections under the pivot. Further modifications to the system are required to fully realise all the benefits of variable rate
- We have gained detailed experience in using the Farmscan software, and in establishing the variable rate hardware onto a pivot

**Intellectual Property and Confidentiality:**

No

**Environmental and Social Impacts:**

We have been able to not water sections under the pivot which do not require water, while still being able to irrigate the blocks which do. This has led to better irrigation management and timing.

The most significant social impact has been in the reduced time taken to irrigate. Previously high pressure irrigators were used in conjunction with the centre pivot, but these are no longer required and therefore we have saved a significant amount of time.

**Expected Outcomes:**

Outcomes

- We have successfully installed variable rate technology to the centre pivot which is a first for the sugar industry
- The software can apply 0% irrigation to areas programmed to receive no irrigation
- The cost benefit analysis highlights the financial benefit of this technology, which is realised through reduced input costs for labour and electricity
- Further works needs to be conducted "tweaking" the system to improve the distribution uniformity and allow for more accurate variable rate application of irrigation rates. We will need to re-examine the water controllers and the rest of the operating system to identify the reason behind the poor distribution uniformity figures

**Future Research Needs:**

**Recommendations:**

(Including activities or other steps to further develop, disseminate or exploit the Project Outputs, and/or to achieve benefits)

Appendix 1

## 16. John Fox – Variable rate water application with a centre pivot

Key Economic Drivers of Change:

- Pivot no longer waters fallow blocks
- Pivot can be used for early irrigations instead of using winches
- Reduction in irrigation labour required
- Reduction in irrigation electricity costs
- No increase in yield included
- Capital costs: purchase of variable rate controller, valves/pipes/clips/elbows and installation costs.

John Fox is modifying one of his existing centre pivots to enable variable rate water application as a Sugar Research and Development Corporation (SRDC) project, and also as part of Project Catalyst. This will make it easier to irrigate the 120 hectares of cane land under the pivot. This analysis is a feasibility study and as such requires some assumptions to be made as some information is currently unknown. The pivot is a 700 metre boom that can apply 25 millimetres of water for irrigating 120 hectares in approximately three days.

Currently John is unable to use the pivot for the first two crop irrigations as these early irrigations occur on blocks that have already been harvested, but while there are other surrounding blocks that have not yet been harvested. John irrigates these blocks using an overhead winch so that he does not irrigate blocks that have not yet been harvested as this reduces the CCS (Commercial Cane Sugar) content of the cane and thus income. Using winches also allows John to avoid irrigating fallow blocks that do not require water. However, during this time the pivot is standing idle while the irrigation is done with the more labour intensive winches.

The new variable rate controller on the pivot allows the farm map to be loaded into the computer that controls the pivot, and John can nominate the blocks that will receive water. This means that sections of the pivot will turn off as they come to a block that is not to be irrigated, and turn back on again when that section of the pivot moves over a block that does require water. This will enable John to use the pivot for all irrigations on the land under the pivot, replacing the current requirement for winches. The labour required to operate a pivot is substantially less than the labour currently required for irrigation with overhead high pressure winches. Therefore, John's time can be re-directed to other needs on the property or for off-farm purposes or for additional leisure time. If this labour is directed to additional irrigation on the remainder of the property or timelier spraying/fertilising, there may be some additional economic benefits, but these potential benefits have not been included in this analysis.

The economic analysis of John's variable rate centre pivot project has been carried out only for the area irrigated by the pivot. There is little transition period for the variable rate centre pivot, as it is fully functional over the area it covers as soon as installation is finished. Therefore, the benefits are assumed to occur straight away.

***Methodology***

In order to determine if the installation of variable rate capacity to the pivot is economically viable an investment analysis was completed to determine the Net Present Value (NPV). The NPV is an economic indicator that aids in making a decision as to whether a change in management practice is worthwhile from an economic perspective. The gross margins before and after installation of the variable rate technology to the centre pivot were calculated using the Farm Economic Analysis Tool (FEAT). The change in gross margin from 'before' (normal centre pivot) to 'after' (with variable rate technology) was used along with the capital cost to conduct an investment analysis providing a Discounted Cash Flow (DCF) and a NPV. The gross margins per hectare of both scenarios were then analysed for risk using PiRisk. A real discount rate of seven per cent per annum over an investment period of 10 years was used.

John provided detailed estimates of cane yields, CCS, land preparation, fertiliser costs, weed and insect control strategies, and fallow management. John's machinery costs were also estimated. These variables are very case specific, taking into account the range of elements each grower deals with in regard to soil type, scale, and production system. Therefore, a*ny grower seeking to uptake similar changes to practices should seek individual economic advice.*

***Results***

In table 16.1 it is shown that the total cost of changing the current centre pivot to a variable rate centre pivot is expected to be approximately $30,000. A 40 per cent salvage value for the variable rate controller has been included in Year 10, but no salvage values for the valves, pipes, clips, elbows or installation costs.

**Table 16.1 Capital costs and salvage values**

| Item | Capital Cost ($) | Capital Cost ($/ha) | Salvage Value ($) | Salvage Value ($/ha) |
|---|---|---|---|---|
| Centre pivot variable controller | 15,390 | 128 | 6,156 | 51 |
| Valves/pipes for pivot | 7,150 | 60 | 0 | 0 |
| Labour cost for installation | 2,880 | 24 | 0 | 0 |
| Clips, elbows, etc. | 2,632 | 22 | 0 | 0 |
| Cherry picker hire | 1,200 | 10 | 0 | 0 |
| **TOTAL** | **29,252** | **244** | **6,156** | **51** |

In Table 16.2 it is revealed that before using variable rate technology to the centre pivot, the gross margin was $550 per hectare. After investing extra capital to utilise variable rate technology, the gross margin was increased to $658 per hectare. That is an increase in gross margin of $108 per hectare for irrigating 120 hectares using variable rate technology for the central pivot. The improvement in gross margin per hectare comes from reduced irrigation labour and reduced electricity costs.

**Table 16.2 Investment analysis for variable rate technology installed on a 120 hectare centre pivot**

| Year | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Before gross margin | ($/ha) | $0 | $550 | $550 | $550 | $550 | $550 | $550 | $550 | $550 | $550 | $550 |
| After gross margin | ($/ha) | $0 | $658 | $658 | $658 | $658 | $658 | $658 | $658 | $658 | $658 | $658 |
| Capital expenditure/salvage value | ($/ha) | -$244 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $51 |
| Change in cash flow | ($/ha) | -$244 | $108 | $108 | $108 | $108 | $108 | $108 | $108 | $108 | $108 | $160 |

| Investment Analysis Indicator | |
|---|---|
| NPV | $65,245 |
| NPV per hectare | **$544** |

Table 16.2 also indicates that the annual change in gross margin is discounted at a real rate of seven per cent per annum over a 10 year investment period. This results in a Net Present Value of $65,245 or $544 per hectare over 10 years. As NPV is a measure of wealth this is a good outcome for the investment of $244 per hectare in extra capital to fund this project.

***Risk Analysis***

A considerable amount of uncertainty surrounds the returns from investments that rely on future cash flows. The impact of uncertainty on the acceptability of investment choices to growers can be assessed using a process of risk analysis which allows uncertain parameters in an economic analysis to be tested. This determines the potential risk associated with a change in benefits. In this economic analysis, a risk analysis was completed for sugarcane price and sugarcane yield to determine their impact on Net Present Value.

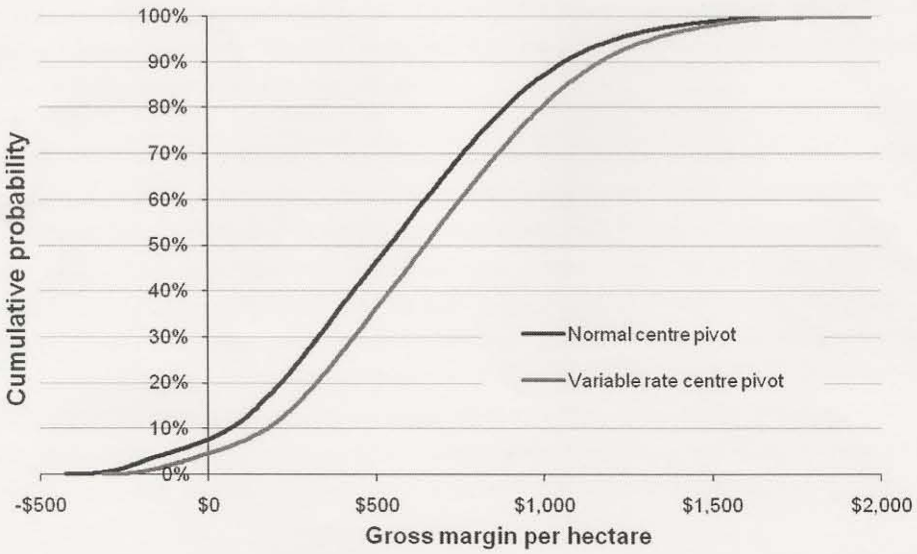


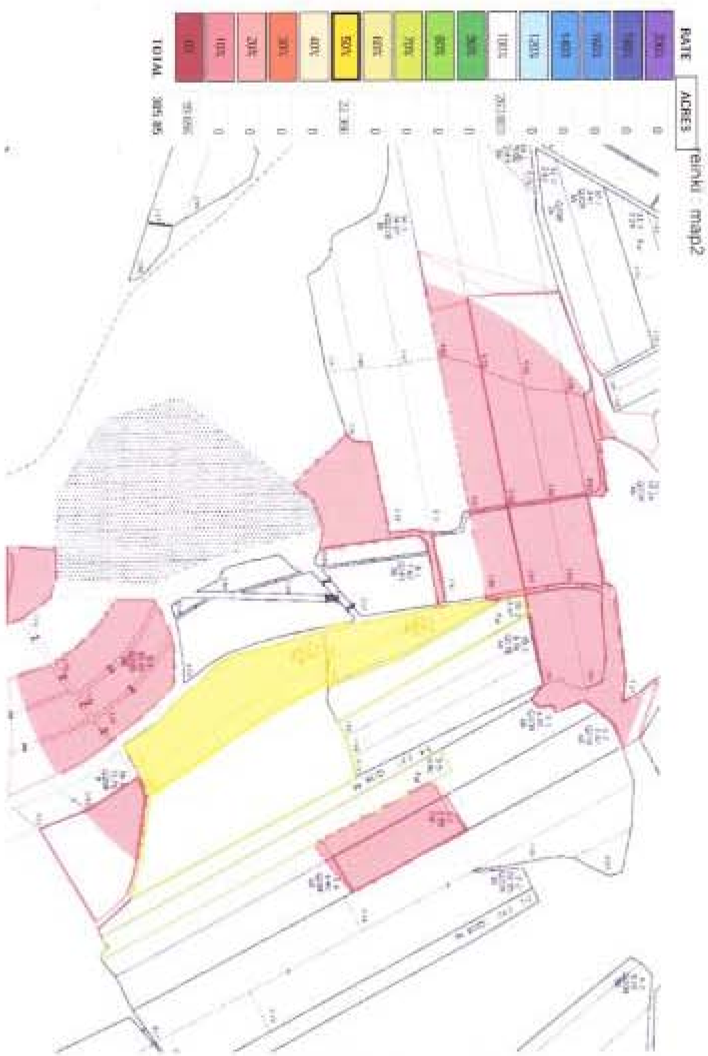

**Figure 16.1 Risk analysis: Installation of variable rate technology onto a 120ha centre pivot**

Figure 16.1 shows the cumulative probability of achieving different annual gross margins per hectare both before and after installation of the variable rate technology onto the centre pivot. The blue line shows the range of gross margins possible for the property when irrigating using winches and a normal centre pivot. Figure 16.1 shows a 8 per cent chance of receiving a negative gross margin in any year (blue line), while after installation of the variable rate technology onto the centre pivot this chance has reduced to 5 per cent (pink line). Similarly, before using a centre pivot, the property had a 50 per cent chance (5 years out of 10 years) of receiving a gross margin of between $540 and $1,857 per hectare, while after installation of a centre pivot, there is a 50 per cent chance of between receiving between $646 and $1,967 per hectare. Figure 16.1 shows that regardless of cane prices and yields, the model farm will receive a higher gross margin in any year with a centre pivot due to the reduced labour and electricity costs and the slight improvement in yield under the pivot.

***Conclusion***

This economic analysis indicates that based on John's machinery, implements and production system, the installation variable rate technology onto his centre pivot improves the gross margin of the property. The level of capital investment required is reasonably low compared to the benefit obtained through the investment, so the investment results in a positive economic return. Therefore, this would be a good investment decision. Any grower wishing to install variable rate technology onto a centre pivot would need to determine if they would make similar labour and electricity savings, or if they would expect a yield improvement. Inclusion of risk analysis shows that regardless of the cane price and tonnes of cane harvested in any one year, installing variable rate technology onto the centre pivot results in a higher gross margin due to reduced input costs for labour and electricity.

Appendix 2 – Farm Map



Photos

The following are photos taken while testing the distribution uniformity. There are photos of the centre pivot operating, the catch cans, measuring the catch cans and recording the results.