ADOPTION OF PRECISION IRRIGATION TECHNIQUES IN TURF PRODUCTION

FARM 2 CASE STUDY

Turf Queensland
Grow Green

FARM 2 Manager Comments:

"This project has provided us with elements and information to allow us to review our farming practices with regards to productivity and efficiency. The irrigation and pumping assessments are invaluable along with the soil and crop mapping processes that confirmed to us our direction and some of what we already knew. The installation of fertigation equipment opened up a number of questions that we are still working through to determine the benefits of fertigation against our normal practice—in particular the cost of granular, soluble or liquid fertilisers and the even distribution of fertiliser through fertigation across the whole farm to areas that probably did not need it. Waste reduction and increased yield has resulted from the project and we feel it is well worthwhile. Soil moisture monitoring, whilst recognising its benefits, has its own problems in covering different soils on the whole farm".

INTRODUCTION

Turfgrass producers face increasing competition for scarce water resources and rising costs of buying and applying water to production areas. The Rural Water Use Efficiency - Irrigation Futures (RWUE-IF) project is a timely collaboration between the Queensland Government and Turf Queensland to foster practice change amongst irrigators with the goal of improving on-farm water use and increasing productivity. Turf production is a broad acre scale endeavour, often with tight time frames and an extremely valuable final product. This places unique pressures on producers looking to implement savings in water, energy and fertiliser.

PROJECT OUTLINE

Precision irrigation techniques have many advantages in reducing costs and improving productivity. The equipment is technologically sophisticated and there is a cost in both money and time to make a change to new systems. This project collected baseline data on water use, energy use, fertiliser use, fuel use, labour, turf yield and turf waste. The targets were:

- Energy efficiency calculated as kWh/ML (kilowatt-hours per megalitre of water pumped)
- Water use efficiency calculated as ML/ha/cut (megalitres of water used per hectare of production)
- Nutrient efficiency calculated as kg N/ha/cut, kg P/ha/cut, kg K/ha/cut (elemental nitrogen, phosphorous and potassium applied in kilograms per hectare)
- Productivity calculated as net m² turf harvested/ha/cut
- Economic yield calculated as total production variable costs $/net m²

The first step was to carry out an audit of the various inputs required to produce a crop. These included:

- the irrigation system ,
- pumps,
- soil and water,
- irrigation scheduling and
- management practices.

BACKGROUND TO THE CASE STUDY SITE

The case study farm is located in Southeast Queensland's scenic rim Logan catchment. The farm is supplied with water from a dam, with three pumps feeding irrigation systems on the property. The pilot site was a 10 hectare quadrant of a 40 hectare area, with a medium clay soil, and planted with half "Wintergreen" green couch and half "Sapphire" soft leaf buffalo. The pilot site was intensively managed, for a supply contract, being planted 28 November 2014 and harvested 1 April 2015—a four month (summer) production window. The pilot site is supplied with dam water, through a fixed speed pump, to a six span centre pivot irrigator with an end gun, irrigating 40 hectares. The farm has a total of 60 hectares under turf and has been in operation for eight years—the paddock with the pilot site for six years—with laser levelling undertaken 18 months ago. The pilot site was intensively managed during the test period (28 November 2014 to 1 April 2015). The standard practice of aeration to improve the infiltration of water and fertiliser in poorly drained areas was utilised, along with the normal processes of irrigating, fertilising, mowing, weeding and harvesting.

The usual management practice is to visually read rainfall from gauges and inspect the turf to determine when and how much to water to apply without the aid of soil-water monitors. The same technique was used for the application of fertilisers and nutrients.

The single soil moisture probe that was installed was unsuitable for turf farms, which require a clear open space for machinery movements. A transportable, and hence removable, unit would be more suitable. An automatic rain gauge was installed, which fed rainfall figures directly to the computer.

Whilst waste is a significant issue for the turf grower there was no systematic approach to account for the amount of waste generated per harvest. Waste on the whole site, including the pilot site, was monitored at harvest.

APPRAISAL of IRRIGATION INFRASTRUCTURE

Irrigation consultants were engaged to assess the uniformity of water application of the centre pivot. The initial assessment was undertaken in February 2014, and showed that the coefficient of uniformity (CU) was acceptable at 88.5% (industry benchmark 90%). This could be improved with targeted maintenance.

Picture 1: Catch Can Test

Recommendations made to improve the system were:

- Repair/replace identified sprinklers or install a new sprinkler pack
- Give consideration to using rotator or wobbler type sprinklers that are better suited for turf applications.

PUMP EVALUATION

The pump was first tested in February 2014 and was found to have low efficiency, supplying more water and pressure than was needed by the centre pivot. The overall efficiency of pump and motor was measured at 42.4%. Its energy consumption was measured at 274 kWh/megalitre pumped.

Ironically, reducing the flow rate on the pump to match the irrigator needs would lead to higher energy consumption per ML of water pumped, as the excess energy would be released as heat and less work would be performed. The pump duty did not match the system requirements, however, the farm manager indicated that the specifications were correct when the pump was purchased.

Recommendations made to improve the system were:

- Investigate reducing the flow rate of the pump to match the requirements of the centre pivot.

SOIL MAPPING

An ElectroMagnetic(EM38) survey was undertaken to determine soil attributes, so that the cropping area could be zoned for likely differences in soil conditions (see Figure 2 and Figure 1 contour map). EM38 measures apparent electrical conductivity in the soil profile. It will differentiate soils having higher clay content, higher moisture levels or higher levels of dissolved salt, either alone or in combination. Significant variation in EM38 measurements were observed under the pivot irrigator. These were later verified by a number of soil tests.

The soil tests informed what fertilisers and micronutrients were required on the farm to support production and correct any deficiencies. On this farm, both the soil and water are alkaline (pH 7.7). The alkaline water raises the potential for the clogging of emitters in irrigation systems. The water also presents a medium salinity hazard,

however sodium levels are contained. A consequence of these results is that great care needs to be exercised in determining both the appropriate type and rate of application of fertilisers applied via the irrigator on this site.

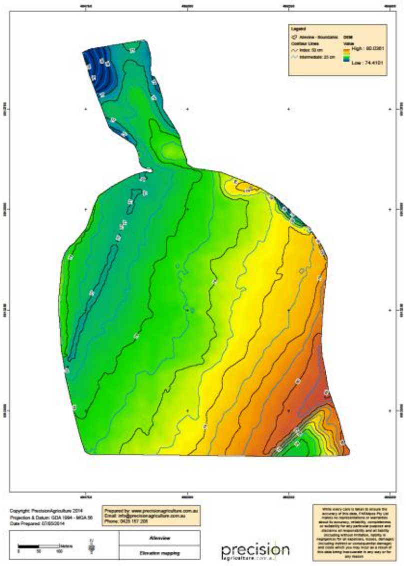


Figure 1: A contour map of the farm.

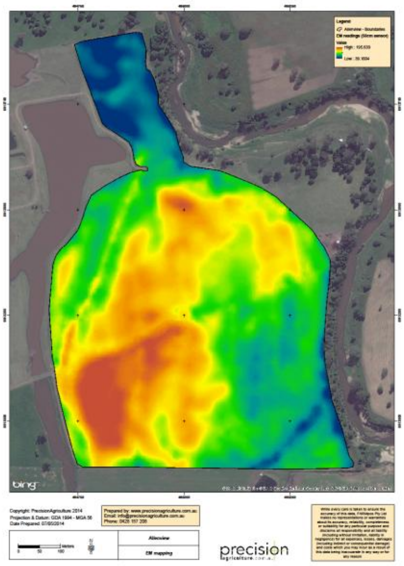


Figure 2: Soil map (shallow), generated from readings from an EM38 (50cm coil). Red/orange readings can indicate soils with more soil moisture or clay.

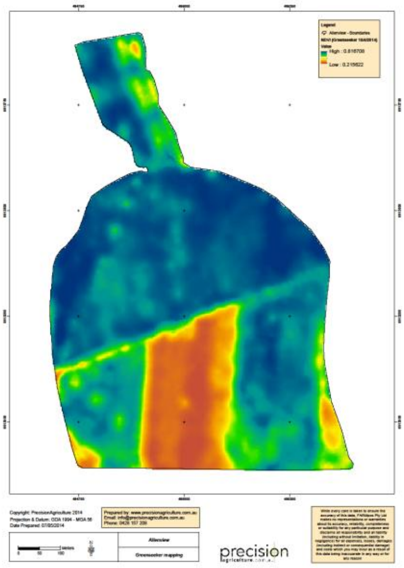


Figure 3: A crop map (NDVI) generated from readings from a Greenseeker. Blue and green readings indicate greater biomass/plant health. Orange indicates recently harvested areas.

CHANGES IMPLEMENTED

Centre pivot: No changes were made before harvest of the pilot site due to production pressure and the coefficient of uniformity being very close (within 1.5%) of the industry benchmark. Jets were cleaned and some of the sprinklers were replaced in June 2015, after a second assessment, which showed further deterioration in performance.

Fixed speed pump: No changes were made due to turfgrass contract requirements and uncertainty surrounding the benefits. No changes to the pump are planned.

Fertiliser and nutrient regime: A mechanical agitator with an impeller was utilised to enable granular and soluble fertiliser to be applied through the centre pivot irrigator. Fertigation commenced on 28 November 2014, but was only used twice amid concerns around rates of fertiliser application, the cost, and uncertainty about the potential for jets to clog and pipework corrosion. These issues are still being investigated by the producer and fertigation has not been implemented.

Irrigation scheduling: A single probe (stake) soil-water monitor and an automatic rain gauge were trialled. The web based scheduling tool Scheduling Irrigation Diary (SID) was installed and training undertaken, but only briefly connected with either monitoring system. A tipping-bucket rain logger was tested. However, whilst the manager could see future value in the rain logger, it did not save time compared to reading the existing rain gauge which is conveniently located, near the office, in the middle of the farm. The single probe soil-water monitor was too site-specific, resulting in unreliable data, and was incompatible with the movement of large machinery (it was run over).

Soil Health: Property soil mapping was utilised to identify soil types, contours and drainage issues. It was identified that the main drain required regrading. This was attended to after the harvest period. Soil tests were then undertaken, the areas zoned and the information used to confirm that existing fertilisers were appropriate to crop needs.

Crop vigour: Crop mapping was conducted using Normalised Difference Vegetation Index (NDVI) values derived from the reflectance of bands of light hitting the crop. The measurements can be used as indicators of plant biomass and health and to identify areas requiring watering or fertiliser treatments. The NDVI values from April 2014 indicated that the turfgrass was relatively uniform. The grower had manually compensated for the strong underlying variance revealed by the soil map with judicious fertilising using a boom sprayer. Rates of fertiliser application were increased in areas of nutrient deficiency by slowing tractor speed to give a uniform crop.

Waste monitoring: At harvest the amount of waste turf was recorded. Across the farm, daily records of turf wasted at harvest are now kept by the harvester operator. The figures collected are used for comparison with other production areas and to track turfgrass yields and profitability. With the focused monitoring of weaker slabs and their location, extra topsoil was added to affected areas to improve sod strength and support productive growth. This and an investment in a new harvester has equally contributed to the improved overall uniformity and productivity of the harvest.

HARDWARE EFFICIENCY TESTS

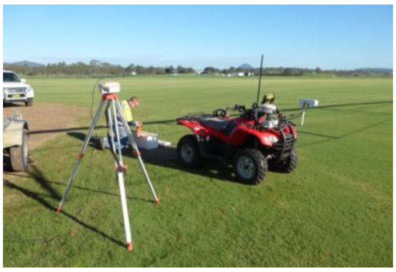
In March 2015, when the turfgrass was at a harvestable stage, further assessments were made of the pump and centre pivot.

Centre pivot: A second assessment in March 2015 showed the CU had slipped to 85.2%. Sprinkler replacement and maintenance was now required to meet the target of 90% coefficient of uniformity. This was implemented at the end of the strict turfgrass supply contract, but was not undertaken in the short time frame of the project.

Pump: A second pump test was undertaken in March 2015. There was little change in the energy efficiency per megalitre from the previous assessment. Even though the testing indicated acceptable levels, modifications could be made to the pump to move it closer to the targeted Best Efficiency Point (BEP), however, no changes are planned.

Table 1: Assessments of irrigation hardware.

Attribute	1st Assessment	2nd Assessment	Target	Change
Efficiency of water distribution				
Coefficient of Uniformity - Centre Pivot Irrigator	88.5%	85.2%	90%	-3.0%
Energy efficiency				
Pump, energy consumption (KWh/ML)	274.73	275.38	-15%	-0.2% No change



Picture 2: Undertaking Soil and Crop Mapping Assessments

PRODUCTIVITY IMPROVEMENTS

Fertigation was used twice. Early indications are that this reduced labour requirements on the site, however this has not been fully quantified.

Table 2: Elemental fertiliser applied to the pilot site during the test period.

Fertiliser efficiency	Baseline[1]	Pilot site
Nitrogen (N kg/ha to harvest)	14.8	133
Phosphorous (P kg/ha to harvest)	4.3	30.4
Potassium (K kg/ha to harvest)	11.4	61.4

Picture 3: Fertigator

Table 2 contains details of elemental N:P:K applied to the pilot site compared to an average (unforced) turfgrass crop. Fertigation was only used twice on the pilot site and boom spraying and broadcasting were also deployed. Hence, the changes in fertiliser use are not attributable to fertigation, but to the need to accelerate the production of high quality turfgrass for a specific contract.

[1 & 2] The baseline figures for both fertiliser use and turfgrass productivity are based on historical averages of non-forced turfgrass crops produced on the site in the 12 months prior to the start of this project.

Turfgrass productivity (Table 3) was calculated from data provided by the grower for the pilot site at harvest. Water efficiency gains were not quantified as significant rainfall (5.36 ML/ha) occurred over the growing period, and a further 5 ML/ha was applied to grow the crop to a premium quality standard. Average rainfall figures for the (traditionally wetter) summer period from December to March is 4.8 ML/ha. For a crop that is not being forced, this would be supplemented by 2 ML/ha irrigation.

Table 3: Turfgrass productivity for the pilot site (measured at harvest) for the test period.

Turfgrass Productivity[2]	Baseline data	Pilot site	Target	Change	Comments
Net square metre harvested per hectare, including waste	9000[3]	9750[4]			
Discarded turf (waste) percent of harvest	8%	2.5%	n.a.	3.2 times less wastage	5.5% increase in saleable turf harvested increasing profitability.
Saleable turf (net harvest, less wastage) per hectare harvested	8200	9500	+10%	+1300 m^2/ha harvested +13%/ha	Turfgrass productivity improvement[5] (harvestable product) exceeds the target.
Number of harvests per annum	2	2.26[6]			
Variable cost[7] ($/$m^2$) of production	$0.34/net m^2	$0.25/net m^2	-5%	-26%	Variable costs of production were reduced considerably at the pilot site. This was largely due to reduced labour costs resulting from efficiencies arising from the purchase of a new harvester, which compensated for the increase in other variable costs.

[3] 10% of turfgrass was left in the paddock due to poor alignment of an older harvester.
[4] At the pilot site the older harvester was initially repaired, then replaced by a new harvester, which reduced the retention of turfgrass in the field.
[5] This result can be attributed to two factors: 1. a more efficient harvester and 2. good sod strength in an intensively managed site. Waste monitoring, which was adopted throughout the farm as a result of the project, raised awareness of the issue and may have improved how the pilot site was managed.
[6] The time from one harvest to the next was accelerated on the pilot site, which had a crop under intensive management. This further improved the annual productivity of the pilot site.
[7]Variable costs are non-capital items, such as labour, water, nutrients and electricity (the amount spent varies with production levels, species and the efficiency with which inputs are used).

DISCUSSION OF RESULTS

ADOPTION ISSUES

This farm was operating at capacity during the test period, with experienced staff, a functional centre pivot and a suite of effective management strategies for irrigating and fertilising. The health of the turfgrass was good. Although the pilot site was only 10 ha, any input changes to irrigation levels and fertiliser applied through fertigation would need to be applied over 40 ha. When precision irrigation technologies are applied to a high value crop, such as turfgrass, on such a scale, it is important that managers have confidence in the new techniques. Technologies such as fertigation and SID need to be backed up by a plan for change management.

The installation of fertigation equipment in the absence of Variable Rate Irrigation is a one-size-fits-all approach to fertiliser application, which does not necessarily fit with the stage of cropping and varietal mix over 40 hectares. Although the underlying soil mapping (and 2013 satellite imagery) indicates that this farm would benefit from Variable Rate Irrigation, the farm is currently being managed to compensate for man-made and natural soil variances already. The skill of the staff is crucial to the results achieved. In moving to fertigation, appropriate levels of applied nutrient need to be determined, preferably using trials over areas much smaller than 40 ha. Fertiliser rates need to match turfgrass requirements (there are normally several species at different stages of grow-in within the centre pivot radius) or the quality or health of the crops may be at risk. Gross changes to fertiliser application are best not undertaken during periods of high production pressure. Additionally, alkaline water plus inappropriate nutrients could conceivably increase the risk of irrigation jets clogging on this farm. For these reasons, along with concerns regarding the costs involved in applying fertiliser to areas that don't require it and chemical corrosion in an expensive irrigator (over $100 000 and without a protective plastic coating on the pipe-work), the manager has taken a cautionary approach to implementing fertigation. This illustrates the need for already operational farms to appropriately stage and pace the move into precision irrigation systems via their farm management plans.

The first assessment of the irrigator and pumps indicated that the irrigator was close to the industry benchmark and that altering the pump to its Best Efficiency Point would reduce energy use efficiency. The case for change was relatively weak and the production pressures were high. After the second assessment, the coefficient of uniformity on the irrigator had deteriorated further. When renovating an irrigator with a new sprinkler pack, other components may require replacement and repair, incurring unexpected costs and downtime. When a large irrigator covering 40 ha of turfgrass is serviced, it is temporarily inoperable. The short term gains to be made in implementing irrigation hardware changes were modest, staff were fully extended and it was crucial that the centre pivot was operable. Unless the equipment is malfunctioning, experienced turfgrass managers avoid the risk of extended downtime and leave irrigator servicing for quieter periods of their production cycle. This was the case with this project. Some of the sprinklers were subsequently replaced and blocked nozzles cleared, beyond the project time-line.

During the short duration (four months) of the trial period on the pilot site, the farm was under pressure and working day and night, seven days a week, to deliver a high value contract within a strict timeframe, with similarly strict quality requirements. Failure to meet the delivery date and quality standard was also a threat to farm income, incurring financial penalties. The short time frame, during the summer high rainfall period, and the move to forced cropping meant that water use efficiency gains could not be quantified. The grower did not ignore the information provided by the assessments, however, the project time line became incompatible with production pressures.

OUTCOMES

The farm manager found the irrigation hardware assessments, the soil and vegetation mapping, the data collection and waste assessments undertaken by the project invaluable. The rain logger was seen as potentially useful, but not the soil moisture probe. There are practical and cost barriers to be overcome before SID irrigation scheduling and fertigation are implemented. Follow-up by the producer in implementing recommendations and undertaking soil tests will be critical to ongoing productivity and profitability improvements.

Some outcomes attributable to the project, which continued beyond project's term, were improved record-keeping, changes to irrigation, understanding farm needs better through soil and crop mapping, and soil and water testing married to better communication with the fertiliser supply company

Although no efficiencies were demonstrated in water use, energy consumption or fertiliser use in the project timeframe, changes to the irrigation system, which would be expected to improve water use efficiency, were made later and the farm has an enhanced awareness of water, energy and fertiliser usage. Property mapping assisted the planning phase, confirming the farm was on track with its objectives. The monitoring of waste turf grass was new and proved useful in confirming productivity gains made through intensive management practices. Waste monitoring was adopted across the farm for all harvests and affected areas are now managed to improve sod strength. Waste turf, which is also a waste of inputs into its production (such as water, energy and fertiliser), is no longer accepted as "unavoidable". Case study 2 also highlighted issues that all turf farmers need to be aware of when considering fertigation.

Productivity improvements occurred during the term of the project, compared to the previous year, with an increase in turf harvested per hectare, a reduction in waste and a reduction in variable costs which improved economic performance. However, whilst the implementation of waste monitoring, soil and crop mapping, and soil and water testing was undoubtedly of value, these can't be directly linked to productivity outcomes.

In the longer term, there are gains to be made on this farm in the move to precision irrigation, particularly if VRI is implemented. However, it is noteworthy that farms that are running efficiently with existing systems have less to gain in the short term from changing to a new system. In the longer term they stand to benefit more from precision irrigation, as the culture of maintaining turfgrass quality and production performance will continue through to getting the best outcomes from new precision irrigation technologies. Without risk to its short term operational imperatives, this project has greatly expedited the farm's move towards incorporating precision agriculture techniques into its long term management plans.

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