IMPLEMENTATION OF PRECISION IRRIGATION TECHNIQUES IN TURF PRODUCTION

CASE STUDY 3

Turf Queensland
Grow Green

FARM 3 Manager Comments:

"After operating a small farm and entering into the development of a larger new farm with different soils and equipment, the RWUE-IF project has provided a large amount of information to assist in the development of new farm management practices targeting improved profitability and productivity. The shift to pivot irrigation delivered major savings in water used, even during the wetter summer period, and more substantial water savings are expected in our drier winter. Even though our equipment was relatively new, the project highlighted that adjustments were needed. Fertigation equipment, whilst used sparingly due to wet weather, was valuable. Discussions continue with fertiliser supply partners on optimising fertiliser formulas and rates for the turfgrasses we grow. The identification and reduction in turf waste has truly improved our profitability. We believe the project to be a great success".

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 help irrigators improve on-farm water use and increase productivity. This project looked at the effect of implementing precision irrigation techniques on a new farm, the location of the pilot site. On this farm, the manager made a commitment to using fertigation in a new centre pivot irrigator with a view to improving turfgrass productivity and profitability and conserving resources.

PROJECT OUTLINE

Precision irrigation techniques have many advantages in reducing costs and improving productivity. In order to quantify what these might be, baseline data was collected 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:

- Irrigation system.
- Pumps.
- Soil and water,
- Irrigation scheduling
- Management practices

The study looked at water and energy use efficiency, soil mapping, fertigation, what fertilisers were used, soil moisture monitoring and irrigation scheduling.

BACKGROUND TO THE CASE STUDY SITE

The case study farm is located near Lockyer Creek, a major drainage system in the Lockyer Valley of South East Queensland. The farm is supplied with water from a dam, fed to the irrigator by a newly reconditioned fixed-speed pump. The dam is filled from a bore. The farm was laser levelled, ploughed and tilled prior to planting. The pilot site was a 5 hectare quadrant, under centre pivot irrigation and planted with 'Wintergreen' green couch. A total of twenty hectares is covered by the centre pivot system, with 50% of the area being planted to 'Wintergreen' green couch and the remainder being 'Palmetto' soft leaf buffalo grass. The soil was an alluvial grey loam, which was rich in nutrients and organic matter, having been previously under lucerne.

The pilot site, on a newly purchased property, was set up to demonstrate production efficiencies resulting from a change from a hand shift irrigation system on a nearby existing farm to a new centre pivot system with fertigation under the same manager. The pilot site tracks the results of the first harvest of the new site, covering the period from 29 January 2015 to 17 May 2015. Soil tests were used from the outset to guide the rate and type of fertiliser applied through fertigation. The higher clay content of the soil at the pilot site contributed to waste reduction, as it was better able to bind the root system at harvest.

The comparator (older) property had a depleted sandy loam soil and used an inefficient hand shift irrigation system with a wetting area of 4,800 m^2 to apply water to the crop. The water for this property was pumped from a dam, and solid fertilisers were used for nutrition. On this property, irrigation and fertiliser applications were determined from experience only. The sandy soil also produced waste due to its loose consistency.

The current on-farm management practice was to visually identify rainfall from gauges and continuously monitor the turf to determine when and how much to water without the aid of soil-water monitors. The selection of rates and types of fertilisers to use was undertaken by similar manual processes.

Whilst waste is a significant issue for all turf growers, there was no current systematic approach to account for the amount of waste generated per harvest.

APPRAISAL of IRRIGATION INFRASTRUCTURE

Irrigation consultants were engaged to assess the uniformity of water application of the centre pivot. The initial assessment on the new centre pivot was undertaken in May 2014 and showed that the Coefficient of Uniformity (CU) was 91.6% (industry benchmark 90%).

Picture 1: Catch Can Test

No recommendations were made to improve the new system.

For the purposes of comparison, the hand shift irrigation system was assessed in November 2014. It was found to be very inefficient in distributing water and had a Coefficient of Uniformity (CU) of 60.1%.

PUMPS EVALUATION

The high pressure (85psi) pump on the old farm was tested in June 2014 and found to have an overall efficiency of 54.1% and a relatively high energy consumption of 330.03 kWh/ML.

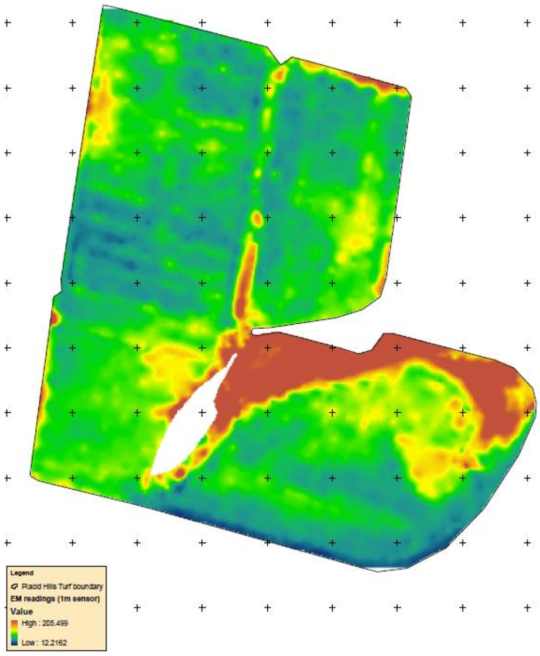
In May 2014, the reconditioned low pressure (30psi) pump on the new farm had an overall pumping efficiency of 60%, consuming 154.3 kWh/ML of power and operating close to its Best Efficiency Point. However, it was connected to old irrigation infrastructure and a review was recommended.

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. 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 on the site, however the area under the centre pivot irrigator had good soil uniformity at both depths tested (50 cm and 100cm). These differences were later verified by soil tests. No contour map was produced for the site as it had recently been laser levelled.

There is no case for Variable Rate Irrigation (VRI) based on soil type for the centre pivot system, however VRI could still be implemented based on zoning for the requirements of different turfgrass species or the stage of crop growth. No crop mapping was conducted. However, fitting the mowing tractor with a Greenseeker, which uses a light

reflectance technique and GPS to map turfgrass health, would allow problem areas to be rapidly identified and treated, thus improving crop uniformity..



The soil tests conducted informed what fertilisers and micronutrients were required on the farm to support production and correct any deficiencies. The fertiliser supply partner used the results of soil testing to advise on rates and timing of liquid fertiliser and associated microbial amendments applied through fertigation.

Figure 1: Soil map (deep), generated from readings from an EM38 (100cm coil). Red/orange readings can indicate soils with more soil moisture or clay. The centre pivot is located on the upper (northern) field.

CHANGES IMPLEMENTED

Centre pivot: No changes were required as it is a new centre pivot recently installed.

Pump: No changes were made to the pump itself, as it was newly reconditioned. A review of the old infrastructure attached to the pumps was recommended. Following the first assessment, new infrastructure valves, pipes and gauges were installed.

Fertiliser and nutrient regime: An Agri-Inject Fertigation unit was utilised that draws fertiliser from a bulk tank and injects solution uniformly into the irrigation system. The unit provides for precise metering and pumping accuracy and is directly joined to the pivot irrigator with fully interlocking connectors. Fertigation commenced on 29 January 2015.

Moisture Monitoring: The single soil moisture probe that was installed was unsuitable for turf farms, which require a clear open space for machinery movements. A single probe soil-moisture monitor also measures too little of the property, producing potentially unreliable results. A more flexible and portable field unit would be more suited to the task. An automated rain gauge was also installed and was regarded as useful.

Irrigation scheduling: A single probe soil-water monitor and automatic rain gauge were trialled and the web based scheduling tool Scheduling Irrigation Diary (SID) were installed, but none were used to any extent. Farm management preferred to utilise the existing manual/visual system. Uptake of suitable moisture monitoring technologies will occur over time.

Soil Health: Property soil mapping was utilised to identify soil types. This confirmed the suitability of the site for the centre pivot. Soil tests were then undertaken in identified areas. This coincided with a switch to organic fertilisers and the soil test results were used to build the fertigation component of the new fertiliser regime. Recommendations for the rate and timing of liquid fertiliser applications through the centre pivot irrigator were established. Fertigation was then applied to the pilot site at commencement, mid-way and three weeks before harvest of the crop.

Waste monitoring: Daily records of turf wasted at harvest are now kept by the harvester operator. The figures collected are used to track turfgrass yields. The process has raised awareness of turfgrass wastage and management practices to combat the problem. Improved water distribution, a new fertiliser regime, microbial amendments and a more suitable soil, reduced wastage at the pivot site.

WATER USE

For the period January to May 2015, 4.53 ML/ha of rainfall fell on both the pilot site and the old farm. This is above average rainfall (3.29 ML/ha) for the equivalent period. To grow the crop on the pilot site under centre pivot irrigation 2.22 ML/ha of water was applied through to harvest. During the same period on the old farm with hand shift irrigation, 3.27 ML/ha was applied to bring the same crop to a harvestable stage. The old farm has a depleted sandy soil, with potentially lower water holding capacity (not measured). The hand shift irrigator had a poor Coefficient of Uniformity, so to evenly wet the freely drained site, additional water was applied to some areas in order to adequately wet the drier zones. Due to the free draining soil, this practice did not create overly wet areas. The ratio of the water use on the pilot site to that of water use on the old farm is 2:3 and the ratios of the Coefficient of Uniformity between the two sites is the inverse, being 3:2. Given that a manager has irrigated to produce 'Wintergreen' of a certain standard, the data is consistent with a water use efficiency gain of around 30% at the new site. This is at least partially attributable to the more uniform distribution of water with the centre pivot irrigator; however soil characteristics are also important.

HARDWARE EFFICIENCY GAINS

In March 2015, follow-up assessments were made of the pump during the growing period of the crop, but not the centre pivot, which was new.

Centre pivot: Only some minor adjustments to sprinklers were required as the centre pivot was newly installed and achieving 91% CU (effective area), above the target of 90%, in May 2014. No second assessment of Coefficient of Uniformity was undertaken.

Pump: A second pump test was undertaken on the reconditioned pump in March 2015. The pump was still operating close to its Best Efficiency Point, but a small increase in energy use was recorded. It is not clear whether this is a result of the changes to associated infrastructure (which should have made a positive, not negative, difference), the pump itself or to a modest variance in how measurements were taken by different consultants.

There is, however, a striking difference between the energy use efficiency between the high-pressure fixed speed pump at the old farm (330.0 kWh/ML) and the low-pressure fixed speed pump (154.3 kWh/ML) at the new farm. The energy cost per megalitre pumped was greatly reduced from $72.60 per/ML on the old farm to $33.95 per ML on the new farm, **a 53.2% reduction.**

Picture 2: Undertaking Soil Mapping Assessments on the newly ploughed

Table 1: Assessments of irrigation hardware.

Attribute	1st Assessment	2nd Assessment	Target	Difference
Efficiency of water distribution				
Coefficient of Uniformity - Centre Pivot Irrigator[1]	Not undertaken	91.6%	90%	+51.2%
Coefficient of Uniformity - Hand shift irrigator[2]	60.57%	Not undertaken	90%	
Energy efficiency				
Reconditioned pump[3], energy consumption (KWh/ML)	154.3	163.4	-15%	+5.9%
Cost per KWh	$33.95	$35.95		**+$2.00**
High pressure pump—old farm[4] (KWh/ML)	330.0	Not undertaken	-15%	
Cost per KWh	$72.60			**-$38.65**[5]

PRODUCTIVITY IMPROVEMENTS

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

Fertiliser efficiency	Baseline site	Pilot site	Change	Target
Nitrogen (N/ha to harvest)	93	46	-50%	-12%
Phosphorous (P/ha to harvest)	26.4	11.6	-56%	
Potassium (K/ha to harvest)	69	29.9	-57%	

Picture 3: Fertigator

Fertigation was commenced on the site using an injection system to apply liquid urea (once), chelated N:P:K plus a range of other chelated macro and micronutrients and sulphur (three times) and a microbial compound (once). However, being a new site, the area was also fertilised with chicken manure, and later, pig manure and granular N:P:K. The baseline site (old farm) was heavily fertilised, as the site was sandy and the soil depleted. Although there is reduction in fertiliser usage between the two sites, this is largely attributable to the manuring and granular fertiliser amendments required to grow turfgrass to a standard on two different soil types. The soil on the pilot site is

[1] Located at the pilot site. Measured 29/5/14. System is fed by a reconditioned low (30 psi) pressure pump. Difference is between the hand shift irrigator and the centre pivot.
[2] Located on the old farm. Measured 26/11/14. System is fed by a high (85 psi) pressure pump. Thirty two sprinklers assessed.
[3] First assessment 29/5/14, second assessment 17/3/15, both for the same pump.
[4] Assessed 2/6/14.
[5] Difference in electricity cost per ML pumped between the reconditioned pump at the pilot site and the pump at the old farm at their first assessments. Electricity cost = $0.22 KWh.

also better able to retain nutrients (and water). The benefits of the introduction of fertigation to the site are unable to be quantified for the pilot site.

Labour savings of 34 hours per hectare were achieved by moving from hand shift irrigation on the old farm to centre pivot irrigation on the pilot site. However, a portion of this saving is attributable to the pilot site being one large paddock and the older farm being a number of smaller areas. The overall savings in labour cost between the pilot site and the old farm is 54 hours per hectare, as the pilot site is easier to irrigate, mow and harvest. This has contributed to the reduction in variable costs given in Table 3.

Table 3 summarises the differences in turfgrass productivity and variable costs between the new farm and the previous site. Turfgrass productivity was calculated from data provided by the grower for both sites and an on-site visit when the pilot site was harvested.

Table 3: Turfgrass productivity.

Turfgrass Productivity[6]	Baseline data (old site)	Pilot Site	Target	Change	Comments
Net square metre harvested per hectare (m^2/ha harvested)	10,000m^2	10,000m^2		No change 0%	
Discarded turf (waste) percent of harvest	8%	1.2%	n.a.	6.7 times less wastage	6.8% increase in saleable turf harvested increasing profitability.
Saleable turf (net harvest, less wastage) per hectare harvested	9200	9880	+10%	+680 m^2/ha harvested +7.4% m^2/ha harvested	Turfgrass productivity improvement. Excellent results on the pilot site..
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.

There was a difference in the productivity of turfgrass between the old and the new site. The similarities common to both sites are: the same manager, with the same turfgrass grown to a standard; the crop ('Wintergreen" green couch) and the comparison is provided for the same time of year. The big differences between the technologies applied to the sites are: centre pivot versus hand shift irrigation and fertigation plus topdressing versus topdressing alone. However, the sites have soil types with very different performance characteristics. The old site is a sandy loam and depleted of nutrients, having been cropped for ten years. It has poor root binding capabilities, leading to excessive wastage of turfgrass that is harvested. The new site is an alluvial loam with a relatively high fertility, having

[6] All baseline figures for turfgrass productivity are based on data from an adjacent established farm, as the new farm was at the start of its first production cycle when the pilot study commenced.

[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).

been cropped previously with lucerne, a crop known to increase soil nitrogen (and potentially soil carbon). The binding capability of the soil at the new site was good.

The difficulty in interpreting the productivity results attributable to the project is that, whilst some of the productivity gains are undoubtedly due to improved irrigation technology and fertigation, the effect of the project can't be quantified. The soil at the new site was considerably better for turfgrass production; both for crop nutrition and harvesting purposes, and this in itself would have improved the net harvest and reduced waste percentages. The grower achieved very high productivity with the new centre pivot system and fertigator. The result highlights the need to optimise all production inputs to gain the most benefit from an investment into precision irrigation. However a similar new system on the old farm would have been unlikely to have achieved the yields seen at the pilot site. The variable costs of production were **reduced by 26%** between the old and the new sites, largely as a result of savings in manual labour. Water and fertiliser use and the energy needed to pump water were **also reduced** on the pilot site. These were lesser factors contributing to the reduction in the variable production cost.

DISCUSSION OF RESULTS

As the new farm housing the pilot site was recently purchased, modified and adapted from a lucerne farm, with the assessments being undertaken on the first harvest, further productivity improvements are expected beyond the project timeline (such as shortened intervals between planting and harvest). The soil mapping provided a good indication that the farm was uniform in the center pivot area and suited to turfgrass production. This case study compared the efficiency of water distribution of the new centre pivot irrigator on a site with alluvial grey loam with the results from an existing hand shift irrigator on the old farm with sandy loam soil. Unsurprisingly, the centre pivot system was found to have **51% better Coefficient of Uniformity** than the older system. The hand shift system at 61% CU was well below industry standards; however the new centre pivot system was fully compliant. The hand shift system was **wasting around 30% of all water applied**, as the grower had to compensate for the poor efficiency of water distribution by applying additional water to bring the crop up to standard in the drier zones.

Soil testing as a result of EM38 mapping, proved to be a critical component of the farm management program, assisting with the identification of soil nutrient status for more targeted fertiliser application to meet the needs of turfgrass production. A number of soil tests were undertaken across the farm and, in conjunction with a fertiliser supply partner, a fertigation regime was established and implemented.

The project demonstrated the benefits and savings made by upgrading technology; with changes to irrigation infrastructure, and nutrition. Irrigation scheduling with the SID requires better a monitoring processes and further training.

CONCLUSION

Participation in this project has provided evidence that investment in irrigation infrastructure can produce major **water savings and excellent turfgrass yields**. It also demonstrated that older hand shift irrigators can be wasteful of water and energy, in addition to their high labour costs.

The farm manager found that the irrigation and pumping assessments were valuable, along with the zoning of soil conditions using EM38 soil mapping. Measuring wastage also fed back into an improved management of both sites. Fertigation provided a more even and efficient means of distributing fertiliser. Soil testing contributed to the identification of fertiliser requirements by the fertiliser supply partner. Soil test results were used to establish the rates and type of fertiliser used in fertigation.

The project was beneficial in confirming the strategic direction of the property and various recommendations from it have been factored into the existing Farm Management Plan. These include: improved rainfall monitoring on farm and in adjacent areas, the establishment of rates and types of fertiliser to be applied via the centre pivot irrigator, and the recording of waste turfgrass at each harvest, then adjusting the management of affected areas to increase yield.

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