IMPLEMENTATION OF PRECISION IRRIGATION TECHNIQUES IN TURF PRODUCTION

FARM 1 CASE STUDY

Turf Queensland
Grow Green

From the Manager: Farm 1:

"The Rural Water Use Efficiency for Irrigation Futures project has generated information which has prompted a review of our farm management practices with regards to profitability, productivity, efficiency and sustainability. Some noticeable outcomes from our involvement in the project were the identification and reduction in harvesting waste, which has truly improved our profitability. It's programs like this that expose the problems within our current farming practices and attracts focus on best management practices going forward".

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 entailed implementing changes and measuring improvements across a number of irrigation parameters.

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:

- 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 South East Queensland in the Albert River catchment. The water supply is taken from a watercourse using two centrifugal pumps (one fixed speed and one variable speed) that supply a seven span centre pivot irrigator.

The irrigated area, which is mostly a clay loam soil, had laid fallow for some time and ten hectares of this area was identified for monitoring changes throughout the project, To prepare the area, laser levelling, aeration, drainage and ploughing were completed. Frequent applications of granular urea and chicken manure were made to improve the soil. A green couch cultivar "Wintergreen" was sown.

The usual management practice is to visually inspect the turf to determine when and how much to water without the aid of soil-water monitors. The same practice applied to the application of fertilisers and nutrients.

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.

Baseline data on energy, water, fertiliser use and yield were not available, but were determined from historical data on an adjoining property.

APPRAISAL of IRRIGATION INFRASTRUCTURE

Irrigation consultants were engaged to assess the uniformity of water application of the centre pivot. The first assessment was undertaken in August 2014 at planting and it showed that the coefficient of uniformity was just 72.5%.

Picture 1: Catch Can Test

Recommendations made to improve the system were:

- Repair/replace the sprinkler pack
- Consideration be given to using rotator or wobbler type sprinklers that are better suited for turf applications
- Change the pressure regulators
- Repair the end gun

PUMPS EVALUATION

The pumps were first tested in August 2014. The fixed speed pump wasn't producing flow rates near its best efficiency point. The overall efficiency of pump and motor was measured at 35%. Its energy consumption was measured at 297 kWh/mega litre pumped.

The overall efficiency of the variable speed pump was measured at 34% and the main issue was cavitation caused by the small diameter suction line. Its energy consumption was measured at 349 kWh/mega litre pumped.

Recommendations made to improve the pumps were:

- the direction of rotation of the pumps be checked,
- check for damage to the pumps and
- the suction line on the variable speed pump be upgraded.

SOIL MAPPING

An ElectroMagnetic (EM38) survey (see Figure 2) was undertaken to determine soil attributes so that the cropping area could be zoned for likely differences in soil conditions. This was used in conjunction with contour mapping (Figure 1) and crop mapping (Figure 3). EM38 soil mapping measures apparent electrical conductivity in the soil profile. It differentiates 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 can later be verified by soil tests. The soil tests inform what fertilisers and micronutrients are required on the farm to support production and correct any deficiencies.

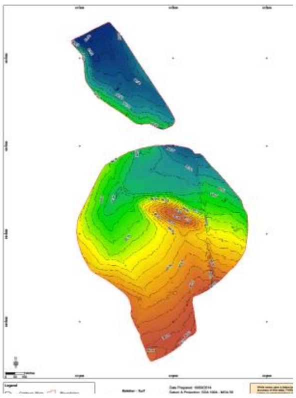

Figure 1: Contour map of the site.

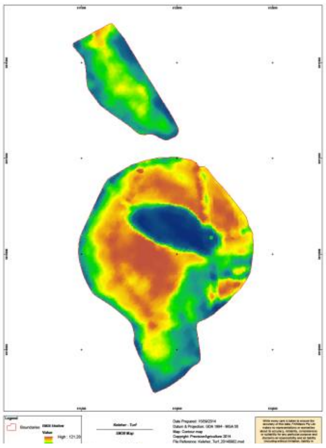

Figure 2: Soil map (shallow), generated from readings from an EM38 (50cm coil). Red/orange readings can indicate soils with more soil moisture or clay.

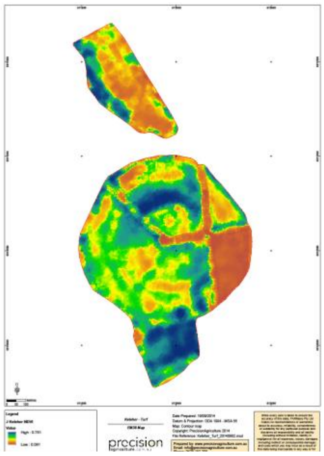

Figure 3: A crop map (NDVI) generated from readings from a Greenseeker. Blue and green readings indicate greater biomass/plant health.

CHANGES IMPLEMENTED

Centre pivot: A number of sprinklers were changed or repaired but not all.

Variable speed pump: New larger suction pipe fitted (after a second assessment in March 2015).

Fixed speed pump: Wet end of the fixed speed pump was refurbished (impeller/seals), delivery pipe repaired and blockages removed.

Fertiliser and nutrient regime: A mechanical agitator with dual impeller was purchased to enable granular and soluble fertiliser to be applied through the centre pivot irrigator. Fertigation commenced on 10 November 2014

Soil health: Property soil mapping was utilised to identify soil types, contours and drainage issues. Soil tests were then undertaken and specific fertilisers identified to support turfgrass production.

Moisture monitoring: The single soil moisture probe (staked) was tested, but found to be unsuitable for turf farms, due to its limited range (10 m radius) and the need for clear open space for machinery movements. A transportable, and hence removable, unit would be more suitable.

Irrigation scheduling: A single probe soil-water monitor was trialled and the web based scheduling tool Scheduling Irrigation Diary was implemented, but neither was used to any extent.

Crop vigour: Crop mapping was conducted (see Figure 3) using Normalised Difference Vegetation Index 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 identify areas requiring watering or fertiliser treatments.

Waste monitoring: 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 yield and profitability.

HARDWARE EFFICIENCY GAINS

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

Centre pivot: The coefficient of uniformity for the system was measured at 79.4%, which was well below its potential, but an improvement on the initial evaluation. There were sprinklers not performing effectively and some were not to specification. The end gun performed better as a result of changes to pumping capacities and pressures.

Variable speed pump: The efficiency of this pump has fallen to 31% and now consumed 462 kWh/mega litre pumped. When it was reassessed, it was found to have cavitation problems. It was then fitted with a larger suction pipe, which improved its efficiency levels; however this effect was not subsequently measured.

Fixed speed pump: This pump now has an overall efficiency of 69% and uses 174 kWh/mega litre pumped.

Table 1: Efficiency of irrigation hardware.

Attribute	1st Assessment	2nd Assessment	Target	Change
Uniformity of Water Application				
Coefficient of Uniformity - Centre Pivot Irrigator	72.5%	79.4%	90%	+6.9%
Energy efficiency				
Combined pumps, energy consumption (KWh/ML)	323	317.5	-15%	-1.7%

Picture 2: Undertaking Soil and Crop Mapping Assessments

PRODUCTIVITY IMPROVEMENTS

Early indications are that fertigation 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 site	Pilot site	Change	Target
Nitrogen (N/ha to harvest)	35	120	246%+	-12%
Phosphorous (P/ha to harvest)	4.6	17.2	275%+	
Potassium (K/ha to harvest)	10.9	38.3	251%+	

Picture 3: Fertiaator

Turfgrass productivity (Table 3) was calculated from data provided by the grower for the site over the harvest period. Water efficiency gains were not quantified as significant rainfall, 7.38 ML/ha, occurred over the growing period reducing irrigation to a minimum.

Table 3: Turfgrass productivity for the pilot site during the test period.

Turfgrass Productivity[1]	Baseline site	Pilot site	Target	Change	Comments
Net square metre harvested per hectare[2] including waste	9850	9900			
Discarded turf (harvested waste) per hectare grown	11%	1.0%	n.a.	11 times less wastage	10% increase in saleable turf harvested.
Saleable turf (net harvest, less wastage) per hectare harvested	8750	9800	+10%	+1050 m^2/ha harvested +12% /ha	Turfgrass productivity improvement (harvestable product) exceeds the target.
Variable cost[3] ($/$m^2$) of production	$0.216/net m^2	$0.161/net m^2	-5%	-25%	Variable costs of production were reduced in the pilot production area

[1] All first assessment figures for turfgrass productivity are based on a similar site on an adjacent farm, as the designated site was not in production when the pilot study commenced. Whilst the figures used are not directly comparable, they are indicative of possible gains under the project.
[2] Some turf is retained in cutter rows for later regrowth.
[3]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

This regenerated site utilised full farm mapping and a planned approach to remedy the worst areas first in accordance with available funding. Laser leveling increased the usability of the land and allowed improved turfgrass growth through much improved drainage. Selecting the appropriate turfgrass varieties to match soil properties has improved productivity and profitability. Aeration was utilised and improved the infiltration of water in the poorly drained areas. Soil testing proved to be a critical component of the farm management program, particularly for the identification of nutritional needs allied with the implementation of the new fertigation system. Advances in understanding, gained from zoning soil and crop conditions using EM38 soil and NDVI crop mapping processes, were welcomed by the farm owner and provided valuable information for incorporation into the Farm Management Plan.

The project clearly demonstrated improvements in production efficiency after modifications to irrigation infrastructure, and nutrition, and an improved awareness of the problem of turf wastage, (which arose from the waste monitoring conducted for the project). The overall farm plan is to develop an effective and efficient turf production business, with the first focus being on having a turf variety mix to suit available soils, nutritional management and irrigation efficiency. This farm continues to have challenges with irrigation capability and considerable work is being done in planning and funding appropriate rectification strategies. Participation in this project has given impetus to the farm plan, and large improvements in water and energy use efficiency and farm productivity are anticipated into the future with planning underway to move into Variable Rate Irrigation[4] and solar powered irrigation.

The farm owner summarised his project experience and the beginning of his journey into precision irrigation techniques. "The use of fertigation equipment has improved yields on our farm, even though the identification of the appropriate fertiliser, as a result of the mapping and soil tests, is an ongoing exercise to maximise yield. The farm has utilised irrigation and pumping assessments to improve the existing irrigator, however, we realised that to significantly improve water use efficiency and to maximise the value of fertigation a new system is required. This will come with the future installation of Variable Rate Irrigation, which is the next step in our farm's development and new to the intensive cropping processes of turf production".

[4] Variable Rate Irrigation (VRI) is a system whereby the field is zoned and irrigation (and fertigation) is managed based on inherent differences in soil texture and crop requirement (e.g. cut versus uncut turf or nutritionally deficient versus healthy crops).

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