SUSTAINABLE USE OF IRRIGATION WATER

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ABSTRACT

The water footprint of irrigation systems can be reduced significantly by combining data from Electromagnetic (EM) soil survey with variable rate technology on irrigators. Variable Rate Irrigation (VRI) is providing annual irrigation water savings of between 25 -50% on farms throughout New Zealand. Flow-on benefits include reduced pumping costs, improved crop yields and soil health along with reduced nutrients leaching to groundwater.

The greatest water savings are on the shoulders of the irrigation season. At this time, with the use of VRI, the farmer is able to mine the soil moisture from high water-holding capacity zones, as identified by an EM soil survey, applying irrigation to the lighter soils as they start to come under stress. In this instance irrigators fitted with VRI are often only operating with 20% of the machine applying water. With VRI the farmer is able to control irrigation application by each individual nozzle along the length of the irrigator. This allows the farmer to manage each soil zone separately as well as avoiding areas like water ways, laneways and water troughs.

The placement of soil moisture probes in zones determined by EM soil surveying means that it is possible to accurately monitor and maintain optimal soil moisture levels. Irrigation water is applied to match the water holding capacity of each specific zone and match the use of the crops that are being grown in the individual zones. When soil moisture levels are maintained at a level between the crop stress point and the soil full point it allows the farmer to capture every rainfall event throughout the growing season. If the farmer can do this without soils reaching the full point they will eliminate any possible drainage.

Improved water quality is an immediate benefit of VRI. Through accurate irrigation water placement the farmer is able to maintain nutrients within the root zone of the plants giving optimal nutrient uptake while avoiding any leaching into the groundwater. When the use of multiple EM survey information layers including data on slope, aspect and drainage is combined with the use of VRI application systems runoff of nutrients, such as Phosphate, into waterways is also able to be avoided

The benefits of VRI are not limited to the environment. There are also significant potential savings in the amount of energy required to irrigate a field or farm. In times of low or restricted availability of irrigation water the use of VRI means that the crops or pastures requirements are more likely to be met resulting in the most profitable outcome for the farmer.

Water is the biggest issue that will effect food production throughout the world both from a productive and environmental perspective. Agriculture uses 70 % of the world's fresh water. With a growing population and need for increased food production the demand for water will only increase. Agriculture needs to get smarter about the way it uses water. This is now happening with the use of EM soil surveys and VRI.

Keywords: Variable rate irrigation, Electromagnetic Soil Survey, Water quality, nutrient management, environment, sustainability, New Zealand,

INTRODUCTION

Water is the biggest issue that will effect food production throughout the world both from a productive and environmental perspective. Agriculture uses 70 % of the world's fresh water. With a growing population and need for increased food production the demand for water will only increase. Agriculture needs to get smarter about the way it uses water. This is now happening with the use of EM soil surveys and VRI.

Drivers for Change of Irrigation Systems

Profitability is a key driver for farmers in any decision making process. In arable farming this is easily quantified with harvest maps from combine harvesters and the use of the appropriate software.

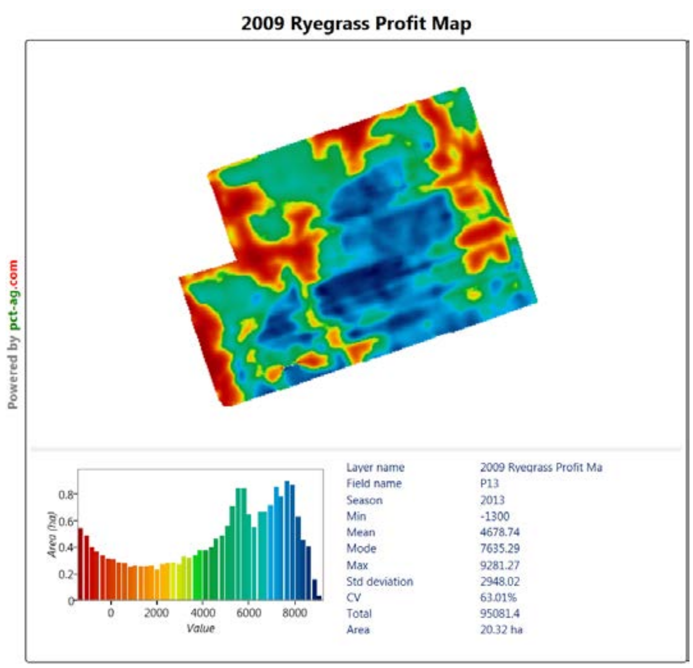

Fig. 1. 2009 Ryegrass Seed Profit Map

Fig. 1. illustrates the areas in blue were highly profitable, up to a maximum of NZD $9281.27 due mainly to better soil types and appropriate amount of water applied in a very dry season. The areas in red show a minimum profit of NZD $ -1100.00. These were dry-land corners and also some areas of light soils which did not receive the appropriate amount of water. The irrigation system at this time was a fixed application system applying a uniform amount of water across the length of the irrigator. The driver was to make all areas profitable so an additional irrigation system was installed to be able to water the corners with a hard hose gun irrigator.

Improving the Irrigation System to allow for soil variability

The water footprint of irrigation systems can be reduced significantly by combining data from Electromagnetic (EM) soil surveying with variable rate technology on irrigators. This is known as variable rate irrigation (VRI). The Water Use efficiency (WUE) for each crop will be increased. This does, however, depend on the crop, the amount of soil variability and crop water use.

The placement of soil moisture probes in zones determined by EM soil survey as shown in Fig. 2. means that it is possible to accurately monitor and maintain optimal soil moisture levels. Irrigation water is applied to match the water holding capacity of each specific zone and match the crops water use in each individual zone. When soil moisture levels are maintained at the optimum level between the crop stress point and the soil full point it allows the farmer to capture every rainfall event throughout the growing season. If the farmer can do this without soils reaching the full point they will eliminate any possible drainage.

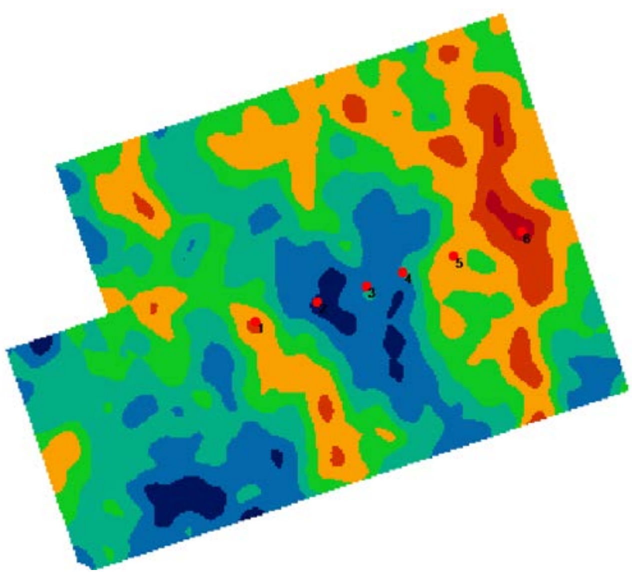

Fig. 2. Soil moisture probe sites as determine by the EM soil survey zones

Fig. 2. describes a crop of Wheat (cv Phoenix) planted 15 April 2011. The crop was grown under a uniform irrigation application system on a 579 metre Reinke

centre pivot irrigator. Six soil moisture probes were installed in six different water holding capacity zones based on EM soil survey results.

The results of the neutron probe results from sites 2, 4 and 5 were used to schedule the irrigation application rates, based on the averaging of the combined readings, as was current best practice.

	Full Point (mm)	Stress Point (mm)	2012 Wheat Yield (t/ha)	EM 0.75m (ms/m)	EM 1.5m (ms/m)	Zone Area
Site 1	187	139.5	17.56	4.84	10.95	0.6
Site 2	233	178	12.31	9.28	16.30	3.0
Site 3	228	178	13.26	8.18	15.02	5.4
Site 4	232	178	15.58	7.85	14.71	7.2
Site 5	181	134	16.48	5.18	12.52	3.6
Site 6	106	70	10.00	3.80	10.32	0.6

Fig. 3 Water full-point/ Water stress-point/ Yield/ EM Readings and Zone Area per soil moisture probe site

It was anticipated that sites 2 and 3 would have the highest yield as these are the best soils in the field. However sites 1, 4 and 5 were the zones that resulted in the highest yields.

Over watering in sites 2 and 3 had a detrimental effect on yield, reducing the yield in these zones by 2.66 tonne per hectare. Based on a NZD $400 per tonne wheat price, the lost profit to the farmer in these zones was NZD $1064 per hectare. The area covered by sites 2 and 3 was 8.4 hectares of the field total of 22 hectares. The yield reduction in these zones equates to a lost profit of NZD $8937 for the season. This loss does not include the potential benefit of increased watering of zone six which has the lightest soil and yield potential

In 2012 VRI was installed onto the Reinke centre pivot irrigator at a cost of NZD $32,000

Learning Irrigation Management under Variable Rate Irrigation

In 2012 with VRI installed, neutron probes were again reinstated in the same GPS located sites as in 2011. Again the netron probe reading were taken weekly and along with accurate weather forecasting from EcoConnect, a weather forecasting service from the National Institute of Water and Atmosphere (NIWA), were used to manage irrigation scheduling.

Fig. 4. shows available water in the top 300 mm of soil for each of the individual neutron probe sites, along with their own individual water holding capacities. This demonstrates that each zone has been kept between the full and stress points. At the start of the irrigation season, 18 October 2012, zones identified as site 1, 2 and 3 have had no irrigation applied. This allowed a reduction in the soil moisture levels of these zones. At the same time, through the use of VRI irrigation the soil moisture levels in site 6 was increased. There are spikes in the data obtained in the earlier part of the irrigation season. This is due to early season rainfall. As we progressed to the drier part of the season, it was

possible to control soil moisture levels very evenly across all sites through the use of VRI.

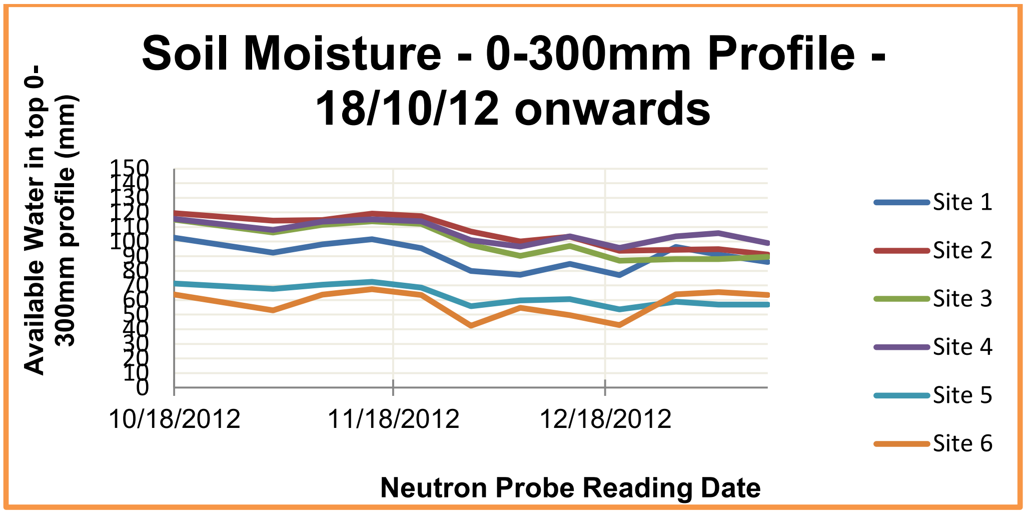

Fig. 4. Neutron Probe reading results from the 2012/2013 season

Continued Irrigation Management under Variable Rate Irrigation

In the cropping year of 2013/2014 at Greenvale, soil moisture probes (neutron probes) were installed in 35 different zones across the farm to monitor individual soil moisture levels. The data was combined with EcoConnect weather forecasting system and individual crop water use to accurately schedule irrigation. Soil moisture levels were proposed to be held at a level half way between the stress point and the full point. This was to increase the likelihood of capturing every rainfall event without reaching the full point and so avoid leaching. This was achieved across all sites, excluding two events at one site. The site was in an area outside the pivot, in corner irrigated by an irrigator gun system.

Probes continued to be read only on a weekly basis. Weekly readings provide some spikes in the data obtained due to less precise management. With the installation of soil moisture probes that can be read daily and telemetered probes delivering information to the office every 15 minutes, a further increase in efficiency of irrigation water application is achievable. It is now possible to check soil moisture probes and weather forecasting at any time, build the appropriate irrigation application map and send it wirelessly to the irrigators in the field from the farm office.

Benefits of Variable Rate Irrigation

VRI is providing annual irrigation water savings of between 25% - 50% on a variety of farming types throughout New Zealand, including dairy, arable, horticulture and viticulture. Flow-on benefits from the reduced irrigation water application include reduced pumping costs, improved crop yields and soil health along with reduced nutrients leaching to groundwater. The greatest water savings are on the shoulders of the irrigation season. At this time, with the use of VRI, the farmer is able to mine soil moisture from high water-holding capacity zones, as identified by an EM soil survey, applying irrigation to the lighter soils as they start to come under stress. In this instance irrigators fitted with VRI are often only operating with 20% of the machine applying water. With VRI the farmer is able to control irrigation application rates by each individual nozzle along the length of the irrigator. This allows the farmer to manage each soil zone separately as well as avoiding areas such as water-ways, lane-ways and stock watering-troughs.

Improved water quality is an immediate benefit of VRI. Through accurate irrigation water placement the farmer is able to maintain nutrients within the root zone of the plants giving optimal nutrient uptake while avoiding any leaching into the groundwater. Where the use of multiple EM soil survey information layers include data on slope, aspect and drainage is combined with the use of VRI application systems runoff of sediment and nutrients, such as Phosphate, into waterways is also able to be avoided

Improved river and aquifer flows are another benefit of VRI. In times of low or restricted availability of irrigation water, the use of VRI means that the crops or pastures requirements will be more likely to be met. An example of this is when water take restrictions are in place from sources such as river due of minimum flow regulations, with irrigation water extraction reduced by 30%, and there are savings of 30% possible through VRI system, the farmer is still able to meet the crop demands while still the water source is able to maintain its regulated minimum water source flows.

The benefits of VRI are not limited to the environment. There are also significant potential savings to the farmer in the amount of energy required to irrigate a field or farm and through any costs associated with a decrease in quantity of irrigation water taken and/ or used.