healthy soils case study

LANDFORMATION

Variable Rate application of Fertilisers and Soil Ameliorants following Laser Levelling

A Macquarie Valley case study

The background

Irrigated cotton production in Australia is reliant on laser levelling and landforming to optimise water-use efficiency during the growing season and has dramtically increased crop yields. A side-effect of landforming, or "cut" and "fill" operations, is that the suitability of land for crop production may be altered by the removal, addition, exposing or raising of surface or near-surface soil layers. In many cases, the "cut" operation removes a layer of topsoil and exposes significantly more clayey, alkaline and sodic subsoil material which is often associated with poor crop growth and lower yields. This effect is more pronounced in soils which have contrasting horizons, such as the red-brown earths found in the Macquarie and Lachlan Valleys, than in soils which display similar topsoil and subsoil characteristics.

Why act?

"Beltana" is an irrigation property located near Narromine in the Macquarie Valley, owned and operated by the Rae family. The soils on "Beltana" are a red-brown light clay, typical of many soils in the region. When "Beltana" was first purchased by the Raes the irrigation fields had run lengths of 460 – 480m. The Raes found that it was difficult to get good water infiltration into the beds without running water in the rows for long periods of time, creating a lot of excess tail water. It was decided to change the direction of the irrigation fields to lengthen the runs to 800m. Not only did this improve water infiltration and water use efficiency, but there were also labour savings in fewer irrigation changes and in-crop field operations were made more efficient by the increase in run length.

However, the change of direction in the irrigation fields required a major land forming operation. In some areas, the "cut" was as deep as 35cm. Soil tests in the "cut" areas showed that the subsoil exposed in these areas had an Exchangeable Sodium Percentage (ESP) of 11 and a calcium to magnesium ratio of 1. The soil was also low in organic carbon, nitrogen, phosphorus, sulphur and zinc.

These results indicated that the soil was sodic and would be prone to slaking and dispersion. The soil

"There's no doubt about it – it bloody well worked"

This is the verdict of Matt Rae, shown here with the Cotton Regional Extension Officer for the Macquarie, Sally Ceeny, in an irrigated wheat crop on "Beltana"

would also be likely to form a hard crust on the surface causing issues with water infiltration and seedling emergence. High ESP results in the subsoil also indicate poor internal drainage, making the soil more susceptible to water logging.

Large rates of lime and gypsum were recommended to improve the soil structure along with large rates of fertiliser to remedy the nutrient deficiencies. However, the areas of the field that were "filled" did not require the same treatment. The soil in these areas was not considered sodic and did not have high nutrient deficiencies.

During the landforming operation, the nutrients and organic matter contained in the topsoil of the "cut" areas was removed and placed in the "fill" areas. It was decided that using variable rate technology (VRT) would be the most efficient way of managing the nutrient and soil amelioration requirements of the field.

What is science saying?

"Cut and Fill" maps (Figure 1) were created by Ag n Vet Services and used to determine the soil testing zones. The field was sampled in areas representing heavy cut, minor cut, minor fill and heavy fill. From these results, soil nutrient and ameliorant recommendations were determined and variable rate maps were able to be created. The requirements for a lime gypsum 2:1 blend were up to 8 tonne/ha in the heavy cut areas, compared to 0 in the heavy fill areas (Figure 2). To correct nutrient deficiencies, a 2:1 blend of Granulock® 12Z and Urea was recommended. In the heavy cut areas, rates were required at 600kg/ha, compared to 0 for the majority of the field in the fill area (Figure 3).

The fertiliser blend application rate at 600 kg/ha would provide 136.8 kg N/ha, 70 kg P/ha, 17.6 kg S/ha and 7.96 kg Zn/ha. Table 1 shows that despite very high soil ameliorant and fertiliser rates being required for the cut areas of the field, applying the nutrients at a variable rate meant that the operation was still cost efficient. Applying the lime gypsum blend at 8 tonne/ha in the "cut" area and 0 tonne/ha in the "fill" had an overall cost of $126.68/ha.

If the lime gypsum blend had been applied at a much lower rate of 3 tonne/ha across the whole field, the cost would have been $180/ha. This comparison can also be used for the fertiliser application. The total cost of applying the Granulock® 12Z and Urea blend at variable rates up to 600kg/ha across the field was $79.26. If this same blend had been applied at 200kg/ha across the

Figure 1

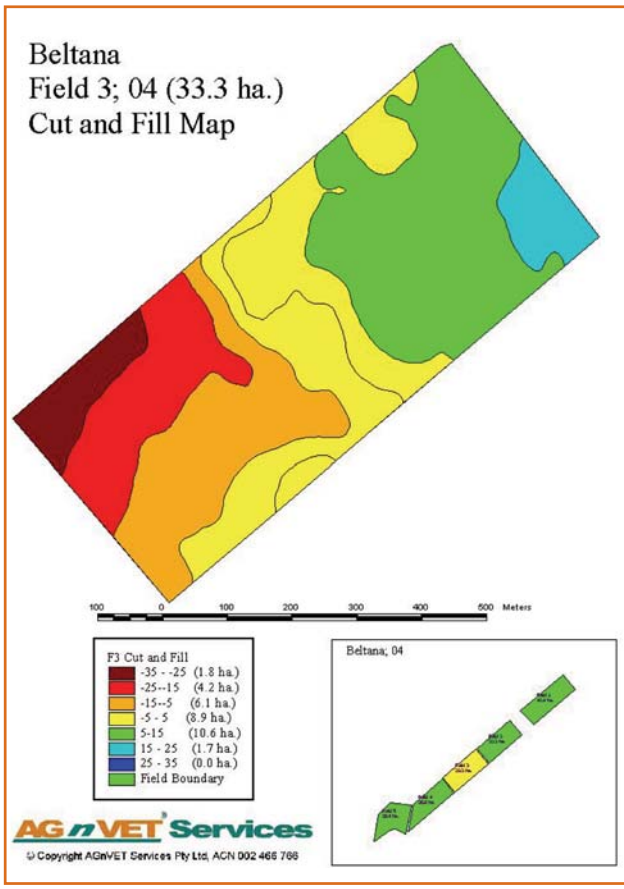


Figure 2

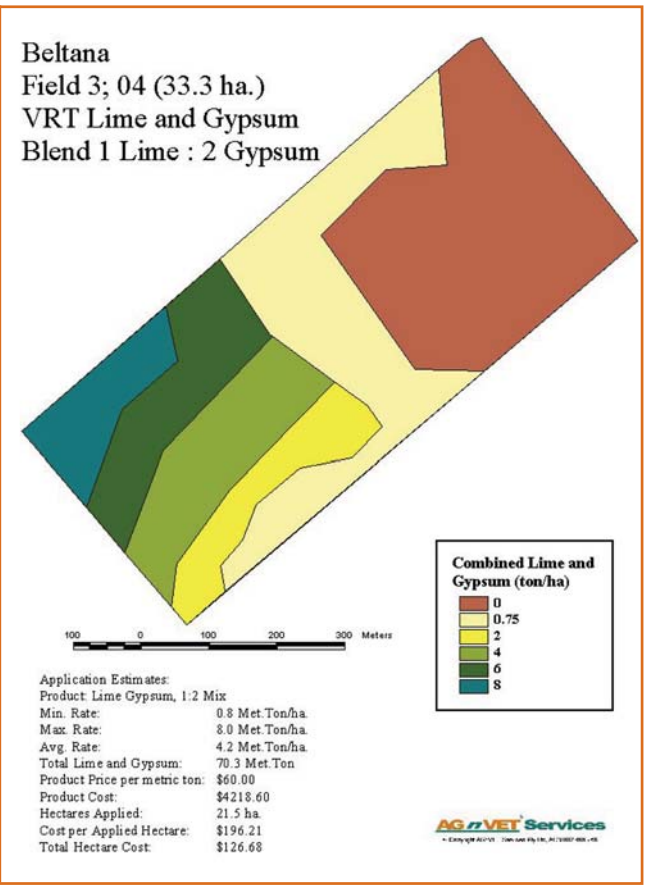


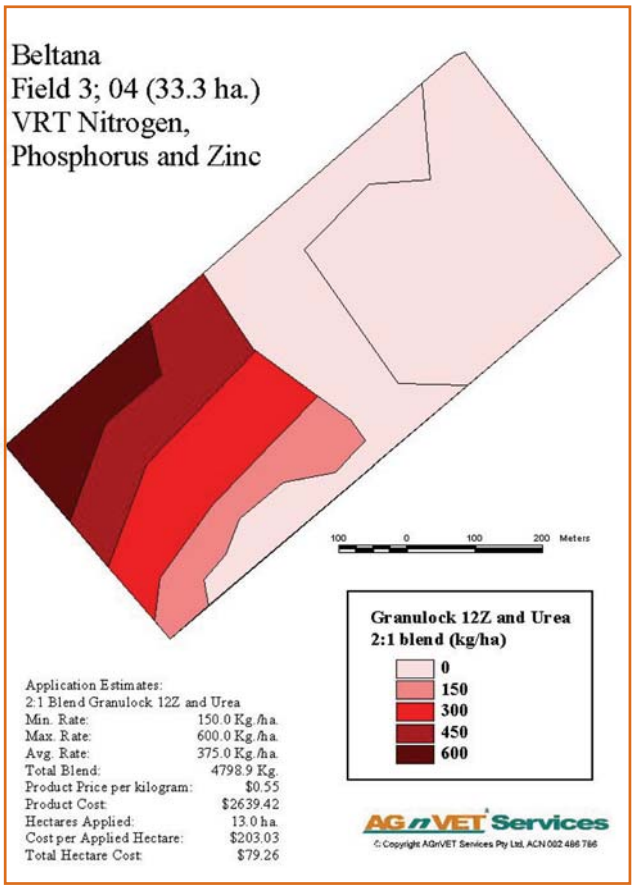
Table 1

Beltana Field 3			
Lime Gypsum 1:2		Granulock 12Z & Urea 2:1	
Minimum rate	0.8t/ha	Minimum rate	150 kg/ha
Maximum rate	8.0t/ha	Maximum rate	600 kg/ha
Average rate	4.2t/ha	Average rate	375 kg/ha
Total requirements	70.3t	Total requirements	4798.9 kg
$/tonne	$60.00	$/kg	$0.55
Total product cost	$4,218.60	Total product cost	$2,639.42
Hectares applied	21.5	Hectares applied	13
Cost/ha applied	$196.21	Cost/ha applied	$203.03
Total cost/ha	$126.68	Total cost/ha	$79.26

whole field the cost would have been $110/ha. Using VRT meant that not only were nutrients and soil ameliorants applied at the rates required and where they were needed but money was also saved on the operation.

The organic carbon of the soil was also very low in the "cut" areas at 0.36%. It was recommended that management strategies to build up organic matter in the soil were incorporated into the cropping system. A crop of wheat was sown into the field following the VRT application. Wheat was chosen as a rotation crop to build up organic matter by retaining stubble and also as the roots of a wheat crop can have a "deep ripping" effect in the subsoil, creating cracks and air holes.

Figure 3



The Solution

The first crop of wheat in 2005 following the VRT application was described by the grower as a "beautiful" crop with no visual difference between the "cut" and "fill" areas. The crop yielded 4.5 tonne/ha and the yield monitor showed a decline of only 0.2 to 0.4 tonne/ha in the "cut" areas. The Raes expected to see a much bigger difference in crop growth and yield between the "cut" and "fill" areas and were impressed that the VRT application of fertiliser and soil ameliorants was so effective in achieving a uniform crop.

The field has since been planted with a second wheat crop in 2007, retaining the wheat stubble from the previous crop. Variable rate fertilisers and soil ameliorants were not applied to this crop and there was some visual difference between the "cut" and "fill" areas (the overall yield was yet to be determined at the time of printing). However, the Raes have noticed that the general tilth of the top soil in the "cut" areas has been greatly improved since the VRT operation was performed. Figure 4 on the following page shows the top soil in the "cut" areas of the 2007 wheat crop. The stubble from the previous wheat crop can be seen, as can cracks in the soil surface. The Raes hae observed that the topsoil is starting to show self mulching characteristics and that water infiltration has been greatly improved.

The Future

The Raes hope to produce irrigated cotton in this field once water becomes available and plan to use zone soil testing and VRT to apply the required nutrients and soil ameliorants prior to this crop. They also believe that two seasons of wheat following the landforming operation has benefited the soil by increasing organic matter through stubble retention and by the wheat roots helping to open up the subsoil and improve water infiltration and the internal drainage of the soil.

This case study has shown that correcting nutrient imbalances and improving the surface structure of the soil can be achieved in a relatively short time after a landforming operation using VRT, however a landforming operation can expose crop root growth to subsoils that are significantly more sodic, saline, alkaline or clayey. All of these factors can restrict crop growth and require long term management practices to improve crop growth potential. These practices may include rotation crops (such as wheat), deep ripping or the application of soil ameliorants at depth. It is important to know your soil profile and what management practices may be required after a major land forming operation to maximise the crop growth potential of your soil.

Figure 4

The top soil in the "cut" areas of the 2007 'Beltana' wheat crop

Landforming of irrigation fields is a common practice in the irrigation industry to optimise water use efficiency. This practice may be used more regularly in the future as the focus on water use efficiency continues to grow. The use of VRT can help to limit the impact that landforming has on subsequent crop growth and yields by delivering nutrients and soil ameliorants where they are most required in the soil in a way that is efficient and cost effective.

Acknowledgements

Ag n Vet Services
Sustainable Soils Management

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PROJECT PARTNERS

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