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Precision agriculture adaption to rice based farming systems

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PRECISION AGRICULTURE
ADAPTION TO RICE BASED FARMING SYSTEMS

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MAIN POINTS

- There are many sources of information that are valuable in determining field variability, including visual soil colour, soil maps, landforming "cut and fill" maps, EM surveys, visual plant growth, NDVI images and yield mapping.
- The first step in precision agriculture is to locate field boundaries so the soil within a field is as uniform as possible.
- If the field has not previously been landformed we strongly recommend topsoiling. If already landformed, use the cut and fill map to separate the field into zones for soil sampling and subsequent targeted application of nutrients or soil ameliorants.
- Where fields are not landformed, or past landforming has been limited in terms of cut and fill, then EM mapping can provide a basis for directed soil sampling, to assess soil pH and soil phosphorus status, to assist in fertiliser recommendations.
- Use existing data on spatial variability (cut and fill/ EM data) to apply nitrogen fertiliser in a targeted manner to improve rice crop performance, particularly applying higher rates to cut areas prior to permanent water.
- Experimental results show that high rates of combined N and P increased the yield of rice on heavily cut areas equally well as chicken manure which yielded more than if using the same rate of feedlot manure. The heavily cut soils always yielded less than the uncut soils, regardless of nutrients applied.

Farm management is typically based on treating whole fields as uniform units, with all parts of a field given the same level of crop inputs. But grain yield can vary enormously across a field due to differences in soil type, cut and fill levels, nutrients, weeds and irrigation.

Precision Agriculture is about managing field variability by matching layouts, irrigation, crop types, nutrients, farming practices etc with site potential, in order to improve crop performance and quality. The management process is often called "site-specific management".

When we think of precision agriculture often the first things that come to mind are GPS (global positioning system), yield mapping and variable rate technology, but this paper focuses on available sources of information on field variability and options that may help manage the variability present.

Obtain spatial variability maps of factors that determine crop yield and quality.

The first step in precision agriculture is to identify areas within the farm, field and bay that have different attributes to other areas. There are many sources of information available, some are low tech and often free, while others can be high tech and sometimes relatively expensive to obtain.

Low tech sources – visual assessment is the first and cheapest source of information. What you can see is of very high importance. Firstly differences in soil colour that you notice when driving the tractor cultivating your field, or in images from Google Maps™ or Google Earth™ which are available free. The second variation you can see is differences in plant growth across a field, often noticed when spreading fertiliser or harvesting, and the same areas often poor yielding over many years. It is easy to peg these areas and record their positions on a field map. The value of visual sources is dependant on the scale of your farming operation - up to 300 ha they may be satisfactory, but in larger scale operations, with many staff, they may not be as useful or practical.

Landforming "Cut and Fill" maps are a tremendous resource in precision irrigated agriculture and should always be retained for future reference. The effect of landforming, where topsoiling has not been practised, can often still be seen after 20 years or more and in some cases, we question if the effect may never disappear. If for some reason you cannot access the landforming map, the colour of the surface soil is often a good indicator of the cut areas.

Soil maps are a useful tool in identifying where different soil types exist on your farm. Soil maps are available free for many parts of the MIA, CIA and Murray Valley irrigation areas. The soil maps have been digitised and are now available by using Google Earth™ geographic information software (Hornbuckle, et al., 2008).

High tech sources – EM (electromagnetic induction) surveys have become widespread in recent years. The two most common instruments are the Geonics EM31 and EM38. These instruments vary in the depth of soil the reading is generated from. Our research shows the readings from the two instruments are strongly correlated with field patterns from surveys using both instruments being very similar.

EM31 or EM38 surveys have been conducted on many properties as part of Land and Water Management Plans or to identify leaky areas within rice fields. These data are a valuable resource in identifying soil variability and will have been retained by the service provider or irrigation company in case you cannot locate your maps. Commercial EM providers can be contracted to survey your fields if they have not previously been done.

The EM instruments measure the soils apparent electrical conductivity (ECa) which is primarily affected by the presence of salt in the soil, soil moisture and the soil's clay content (texture). It is important that fields surveyed with EM instruments are mapped in areas that have the same irrigation/drainage history or else comparison between readings may be misleading. Generally if a soil has a low ECa value it is light textured which means it cannot hold much moisture and has a high level of leaching which leads to less salt in the profile. A high ECa value soil generally has a high clay content, can hold a lot of moisture, has had limited leaching, and therefore often has a high level of salt is present in the soil profile.

NDVI images of crop growth are another source which can provide evidence and detail of within field variability, but you need to ensure that the variability is not related to weed growth or other management factors that affected crop growth. NDVI images are correlated to the biomass of a growing crop. The NDVI image can be used to divide the field into zones, each of which must be sampled and analysed to determine the rate of application of fertilisers. As the image is taken during growth of the crop and is available soon after, it allows for variable rate mid-season nitrogen applications to improve the poorly growing areas of crop. This can work well as long as nitrogen deficiency is the factor limiting growth. NDVI images often relate strongly to cut and fill maps.

Yield mapping is probably the most talked about and well known source of field variability measurement. Yield mapping capability is becoming common place, as most modern headers have the necessary equipment installed. To be useful in identifying soil differences it is important that the same nutrient and irrigation treatments have been applied across the whole field. It can then be useful for determining zones for soil sampling so that factors creating the yield variability can be identified.

Managing variability using site-specific management recommendations.

Identifying the variability is the easy part. Working out what factors are causing the variability and how to address them, is often much more difficult.

AT THE FARM LEVEL

Due to the drought water is currently our most limiting resource, so precision agriculture should start with selecting your fields, or parts of fields, that historically have the highest yield potential. Use the available irrigation water on these areas first, thereby getting the greatest return from your inputs.

Use soil type and EM maps to help determine soil texture and irrigation frequency/ water use zones within the farm. EM surveys are particularly useful in dividing your farm into areas of similar soil types that are most suited to particular types of cropping and therefore irrigation types and layouts. This is a very important step in precision agriculture that is often overlooked, since we generally think only of infield variation and not of changing field boundaries to include similar areas in the same field. This practice can reduce in-field variability before you start looking at the detail.

It is then important to use the most suitable irrigation layout for the soil and cropping options of each field. Lighter textured soils which are possibly better suited to lucerne and winter cereal production would require border check or maybe sprinkler type irrigation systems. In areas that have rice suitable soils, a bankless channel layout with good supply and drainage gives the best water control. If rice is to be rotated with a range of other crops then a layout with raised beds inside the bankless channel bays may be the most suitable. Rice can be grown in rotation with other crops while allowing the decision on crop type to be made closer to the time of sowing, depending on factors such as commodity prices, without having to change field layouts.

AT THE FIELD LEVEL

Landforming: If the field has not been landformed we strongly recommend topsoiling to a depth of 10cm. This will significantly increase the cost of landforming but field productivity will return to normal immediately, whereas deep cut areas will require extensive application of fertilisers and/or manures and still may not reach the yield potential of the non-cut areas of the field. If the field has been landformed without topsoiling, the cut and fill map will show you the greatest source of variability in the field. We often concentrate our efforts on the cut areas of a field, but in many cases the deep fill areas have had the original topsoil covered with a layer of subsoil from a deep cut, thus also giving it a lower yield potential.

Firstly separate the field into zones based on the landforming cut and fill depths:

- For fields with large cuts and fills use levels of >30 cm cut, 10-30 cm cut, 10 cm cut to 10 cm fill, 10-30 cm fill and >30 cm fill as a good start. These can be modified for fields with different ranges of cut and fill depth.
- Take 10 soil cores from each area, put them together to give a composite sample for each cut and fill range, then have a comprehensive soil analysis undertaken for each of the zones.
- Use the results from the soil samples to determine the rate of nutrients and ameliorants (lime and gypsum) to apply to the zones where they are required. There is often no more cost in inputs, but they are placed at higher rates where needed and not wasted on areas where they are not required.

Manure application: Last season we conducted a number of rice experiments which included the application of composted chicken manure, composted cattle manure and N and P applications to sites of varying depths of cut. Chemical analysis of the manures showed the chicken manure had 1.75 times the nitrogen and 5 times the phosphorus of the feedlot manure. This was obvious in plant growth with the chicken manure treatments far out yielding the equivalent feedlot manure treatments in all experiments. The experiments showed that the combined application of 300 kg N/ha and 51 kg P/ha was equally as good as 20 t/ha of chicken manure which was the best of the manure treatments.

The cost of supply and application of the fertiliser treatments was significantly less per ha than applying 20 t/ha of the manure treatments (Table 1) but the total N, P and S applied (plus all the micronutrients) for the manure treatments was much greater. It would be expected that the manure treatments may supply further nutrients in following seasons as the organic forms break down and become available which would not be expected for the straight fertiliser applications.

Table 1. *Nutrients supplied by manure and fertiliser treatments and cost per ha, including cost of the product, transport and application*

Treatment	N (kg/ha)	P (kg/ha)	S (kg/ha)	Cost ($/ha)
300N + 51P kg/ha	300	51	66	$650
Feedlot manure - 20t/ha	460	144	120	$1020
Chicken manure - 20t/ha	800	720	152	$1220

It was also evident from the experiments that after one application of manure at high rates or combinations of N and P, the deep cut soils did not achieve as high a yield as the non-cut sites. In one field the manure treatments were incorporated before three flush irrigations then applying permanent water. In this situation a large amount of the nitrogen from the manure was lost, suggesting that applying the manure prior to permanent flood for aerial sowing is a more efficient practice where nitrogen is supplied by manure.

Phosphorus: Historically it has generally been agreed that soil phosphorus becomes more available to rice plants after flooding, as ferric phosphate converts to ferrous phosphate which is more soluble in water. But Willett (1989) (CSIRO Griffith) concluded that some of our soils showed very little, or no release of phosphorus during flooding. In Arkansas, USA Wilson *et al.* (1999) reported that soil pH was a reasonably good estimator of soil phosphorus response of rice soils, with high pH soils requiring higher levels of phosphorus application.

Precision agriculture experiments we have conducted in this region show that in heavy cut sites, which have a high pH due to the exposure of calcium carbonate rich soil horizons following removal of the topsoil, additional phosphorus is necessary in combination with nitrogen to increase plant growth and yield.

EM Surveys and soil pH: Research has demonstrated a link between EM values and soil acidity (Figure 1). Low ECa value soils have a lighter texture which reflects a lower buffering capacity of the soil and increased leaching so soils therefore tend to be more acidic (low pH). Soils with higher ECa values have higher clay contents and therefore a higher buffering capacity, and reduced leaching, resulting in higher pH levels (Figure 2). By using the EM map to determine zones in a field, then soil sampling the zones and analysing them separately, you can determine the soil acidity level and soil buffering capacity and consequently the rate of lime required to correct the soil acidity for different parts of the field. If a field has been recently landformed this can disrupt the EM pH relationship as cut areas expose higher pH subsoils and the more acidic topsoil may have been placed in the fill giving a greater depth of lower pH soil in the fill areas.

Figure 1. *Relationship between EM38 values and soil acidity levels for sites from six fields.*

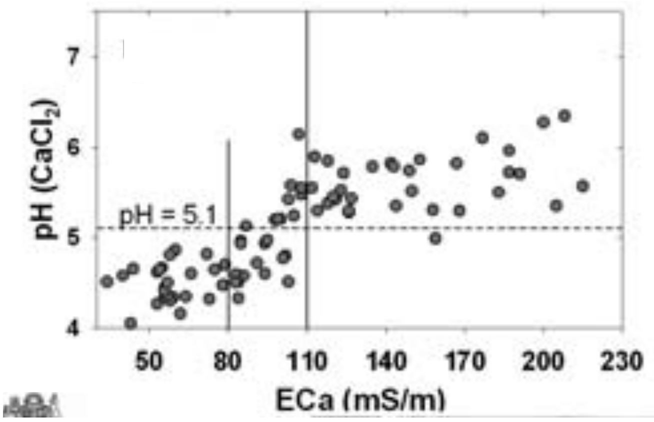
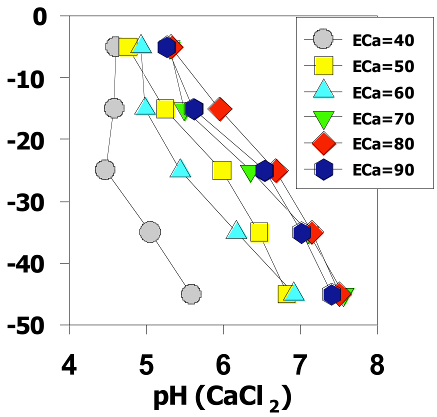


Figure 2. *Soil acidity levels for a range of soil profiles at different EM31 values in the same field.*



Verifying that site-specific management has increased yield and economic return.

One big advantage of yield mapping is that by measuring crop yield after the treatments have been applied it can be used to measure how successful applying variable applications of inputs or management has been. In order to determine the success of precision agriculture you must be able to measure the results and compare that to any extra cost of the treatments imposed. Gross margin analysis can be used with yield map results and records of inputs to determine the profit from different management zones and for the field as a whole.

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