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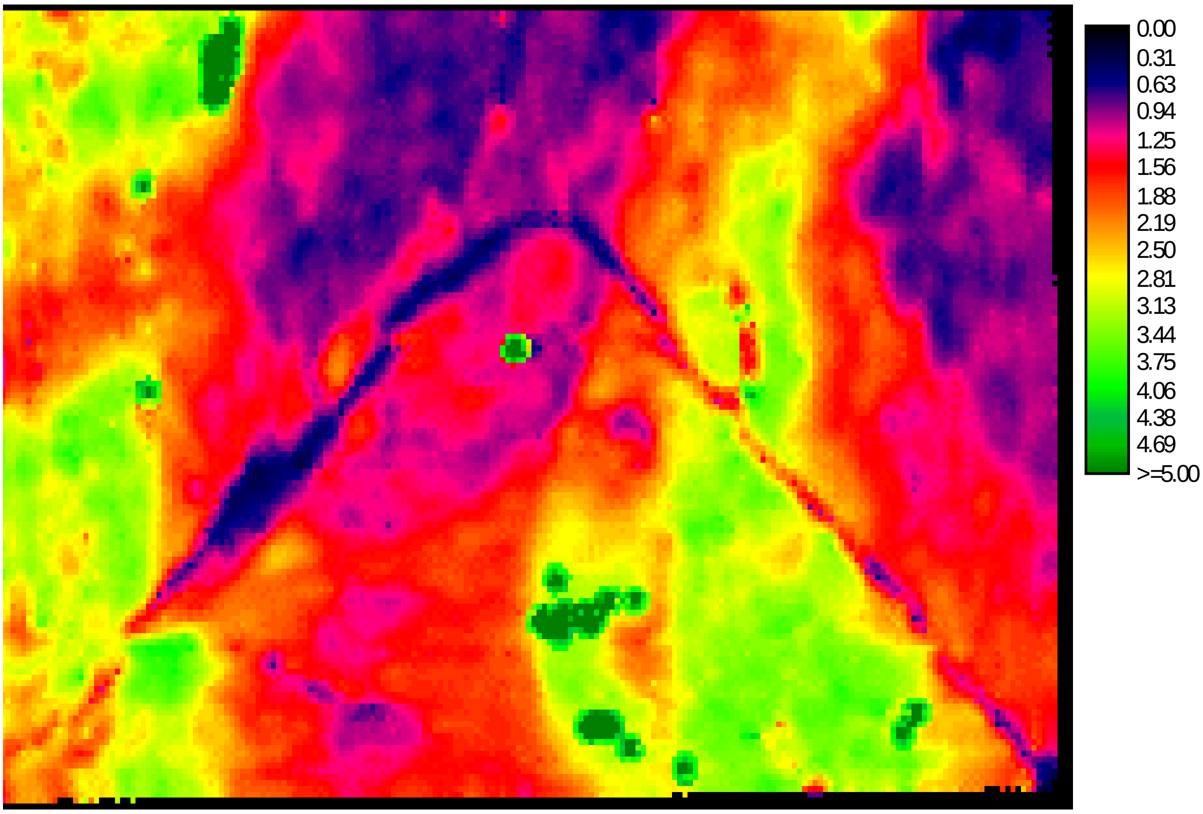
Zone Management in Precision Agriculture by Matching Fertiliser Input to Crop Demand



Yield map of a paddock

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ZONE MANAGEMENT IN PRECISION AGRICULTURE BY MATCHING FERTILISER INPUT TO CROP DEMAND

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Introduction

Growers in Western Australia who have been yield mapping since the mid 1990s have come to realise that grain yield varies across different zones of their paddocks in any given year, as well as between years depending on the seasonal conditions and crop type. This within paddock variation can be as much as tenfold. Higher yielding areas can be due to better growing conditions (which increases the demand for nutrients) and/or better nutrient supply (which reduces the need for some fertiliser inputs). Hence, it is essential to determine the cause of the variation before optimum fertilising strategies can be developed.

When there is substantial yield variation between different zones within a paddock, farmers may be wasting their fertiliser dollars by applying uniform rates of fertiliser to the whole paddock. If farmers can divide their paddocks into different management zones based on the production potential and nutrient supply of the soil, they can increase their profits by tailoring fertiliser inputs to match the requirements of each management zone. Some farmers have variable rate application controllers (VRC) in their seeders, fertiliser spreaders and spray rigs which makes it easy to change fertiliser rates and types on the go according to an application map.

The aims of this brochure are:

- to provide guidelines to farmers on how to delineate management zones within a paddock,
- how to match fertiliser inputs according to crop demand and supply from the soil,
- how to carry out simple on-farm experimentation to fine tune fertiliser application rates and
- to provide an overview of the process of diagnosing the causes of yield variation.

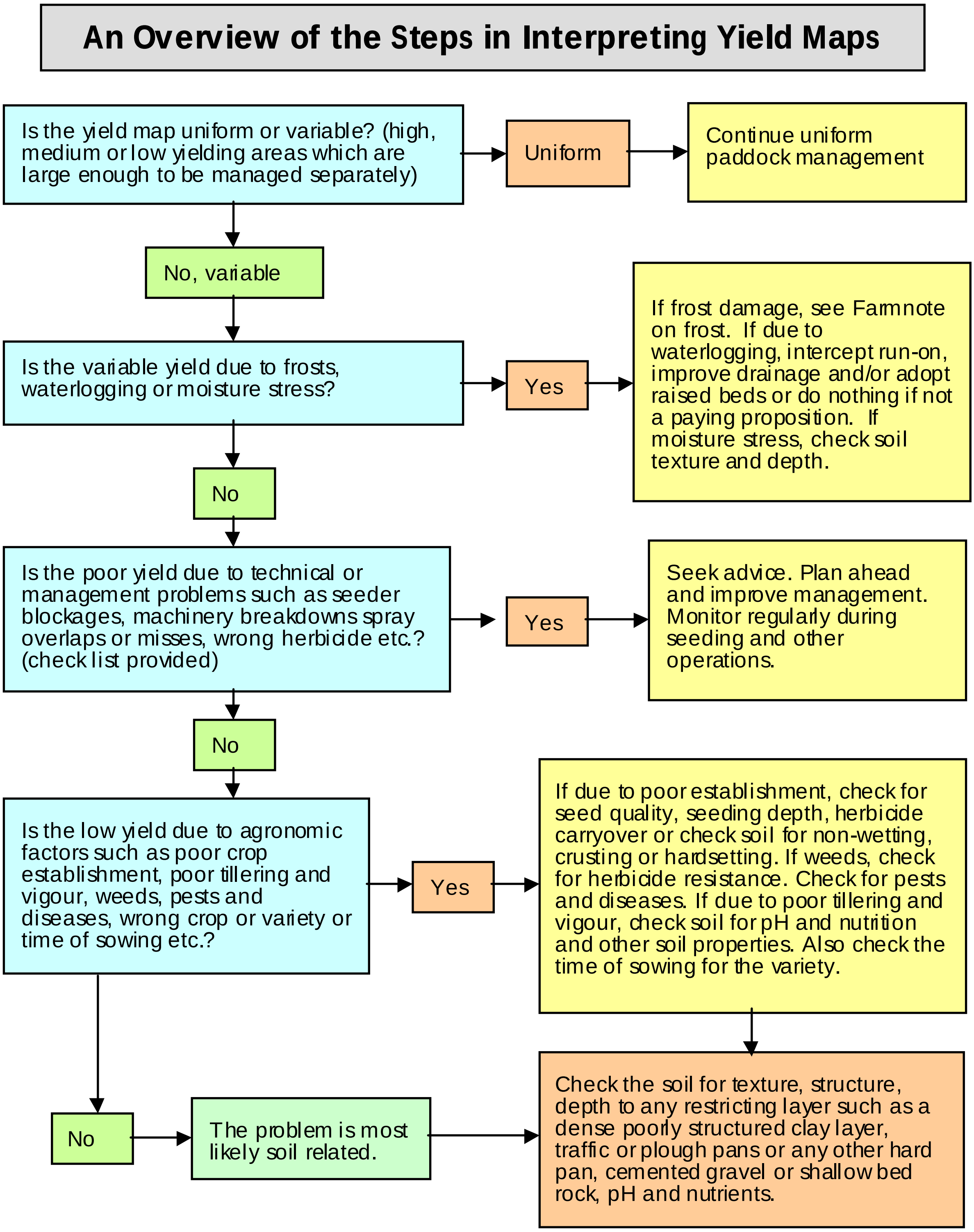
The generic concepts used here have been developed during the GRDC project "Maximising the efficiency of potassium and nitrogen use and profits by matching supply to crop demand" (CSO205).

Diagnosing the causes of yield variation

There are numerous causes why certain parts of a paddock do not achieve the potential yield attainable from the seasonal rainfall. The causes of yield variation include: inherently variable water holding capacity of the soil, soil resistance to root growth, acidity, nutrient deficiency, pests and diseases interacting with management and agronomic factors. In addition, seasonal climatic conditions interact with soil and landscape features, which can result in variable frost damage or waterlogging or moisture stress. If management, agronomy and seasonal conditions are all good, then variable yields are usually due to variable soil properties.

A diagnostic key to identify the most likely causes for poor yields in one part of a paddock compared with another is being developed by the Western Australian Department of Agriculture, which will be available in the near future. An overview or a summary of the diagnostic process is given below.

It is important that growers monitor their crops and keep records throughout the growing season so that they can then identify the likely causes of poor yields. Satellite images are helpful in selecting monitoring sites.



Note: For soil problems, refer to 'Diagnosing and Ameliorating Problem Soils' by Daya Patabendige. Miscellaneous Publication 20/2003, Department of Agriculture, WA.

Figure 1. Overview of the diagnostic process.

Once the main causes of yield variation are identified, it is important to assess the need to rectify them, whether they are management problems, agronomic problems or soil problems. In most cases the soil problems are confined to parts of paddocks. Many soil problems can be corrected if they are within ripping depth. The cost of amelioration treatments can be kept to a reasonable level, as they will be applied only to problem areas and not the whole paddock.

Delineating paddock zones

In Western Australia there is usually more than one soil type in a paddock. Even within a soil type there can be variations in soil chemical and physical properties, which can affect the yield potential of the soil. Landforms, which affect the hydrology and consequently, the soil water status also have an effect on yield potential. All these factors have to be considered along with past yield maps when delineating management zones within a paddock.

Researchers (Mike Wong and others) at CSIRO Land & Water in Perth are developing a tool based on a 'weight of evidence' model to help growers demarcate management zones within a paddock. This process takes into account past yield maps, remotely sensed biomass maps, soil property maps measured by remotely sensed EM38 (soil conductivity) and gamma radiometry (soil texture) and soil chemical analysis. The yield data are weighted according to seasonal rainfall, with data from average rainfall years receiving more weight than below or above average rainfall years. Yields from different crops are converted to a common base by calculating gross margins. These independent spatial sources of information are used to delineate management zones.

Once management zones are identified, decisions can be made on land use and input management for each of the zones.

Soil limitations in poor yielding zones should be corrected if technically and economically feasible. Where the soil limitations cannot be corrected and the grower is consistently losing money by cropping that zone, then he/she should consider culling that area from cropping and find an alternative land use for that zone. If it is not practicable to cull that area, inputs should be reduced to a bare minimum.

In zone management, inputs such as fertiliser and seed rate should match the yield potential of each zone. It may even be possible to vary the herbicide type and rates, where different weed species tend to be associated with different soil types.

Nutrient management within zones

The crop demand for nutrients depends on the crop, its variety, yield potential and grain quality. In rain-fed crops, the yield depends on the amount and the distribution of rainfall and the yield potential of the soil. The main soil properties which determine the yield potential are those which help the soil to retain plant available water and nutrients. These properties include texture (proportion of sand, silt and clay), structure (how the sand silt and clay particles are aggregated together to form structural units which relates to porosity) and structural stability. The crop rooting depth and the depth to any barrier to root growth or water movement are also critical factors.

Farmers can use their estimate of anticipated seasonal rainfall to determine the paddock average yield potential. Using their knowledge of the paddock and/or previous yield maps or satellite imagery for crop biomass, they can scale the yield potential up or down to set yield targets for each zone. Based on yield targets for each zone they can estimate the corresponding demand for each major nutrient (Figure 2).

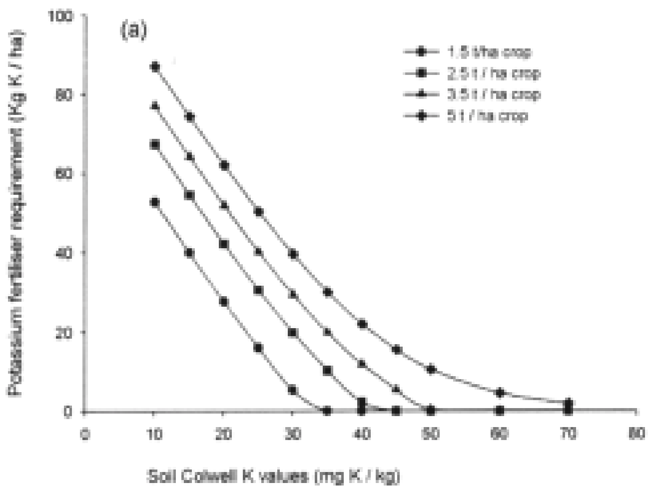


Figure 2. The effect of soil available potassium on K fertiliser requirement for different achievable wheat yields – an example only.

Soil sampling for nutrient analysis

The next step is to determine the amount of each nutrient that can be supplied by the soil. For this purpose it is important to take a sufficient number of soil samples to adequately represent the spatial distribution of the level of each nutrient in the paddock. The best option is to sample the management zones described previously. The number of samples from a zone depends on the size of the area and the amount of variability. When taking samples, log the GPS readings so that the same area can be sampled in subsequent years to monitor the trend in nutrient levels. Take about 10 or more cores to the depth specified by the analytical laboratory (usually 0-10 cm) around the GPS antenna within a radius of 5 m and bulk them. When sampling, take the usual precautions and take cores within and between previous plant rows.

The analytical results need to be interpreted and for some nutrients converted to plant available amounts during the growing season using local calibrations. For this purpose tools such as SYN, NPDECIDE (Diggle, Bowden and Burgess) and ABC of K. (Wong) are available.

On-farm experimentation

Farmers can carry out their own trials using precision agriculture equipment to fine tune their fertiliser rates or seed rates or a combination of both across their management zones. They could also experiment with different fertiliser types, ameliorants, deep ripping treatments, different varieties or any other treatment.

These on farm trials can be categorised into single factor experiments where only one factor such as different varieties or different rates of the same fertiliser is studied or two factor experiments where 2 factors are studied at the same time such as different seed rates and fertiliser rates. Experimenting with 3 or more factors is not recommended, as they are complicated and difficult to analyse.

Single factor experiments

Single factor experiments are the easiest to do and can be layed out in long strips for up and back seeding or as a doughnut for round and round seeding. The following are examples of the type of factors that can be studied in single factor experiments.

- Fertiliser rates – (e.g. 3 N rates or 3 K rates or 3 rates of a compound fertiliser)
- Varieties – different crop varieties
- Seed rates
- Ameliorants – (e.g. lime rates, dolomite, lime sand and burnt lime, gypsum rates)
- Deep ripping treatments

In all these trials it is important to keep all the other treatments and paddock operations the same except for the factor that is being tested. For example, if you are applying a herbicide to a variety trial, apply the same herbicide at the same rate on the same day throughout the trial area.

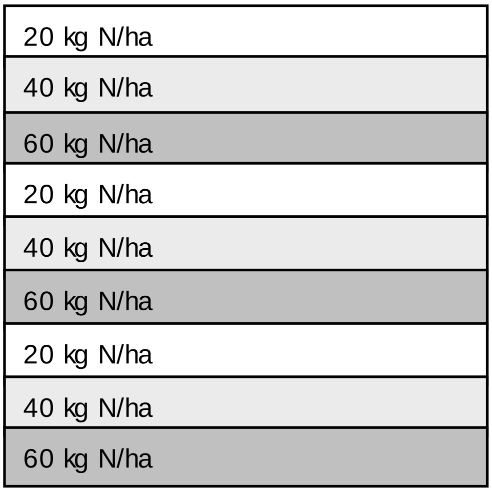


Figure 3a. An example of a Nitrogen rate trial in strips (may be randomised but not necessary if there are many replicates).

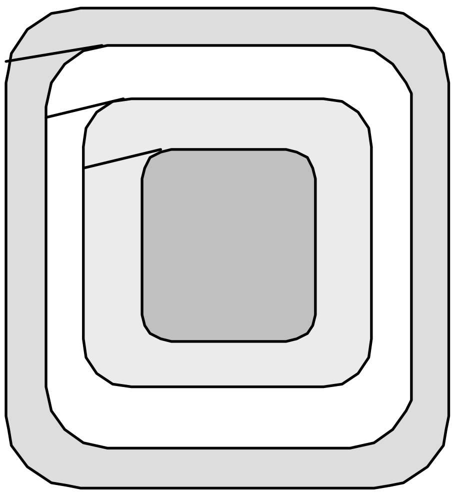


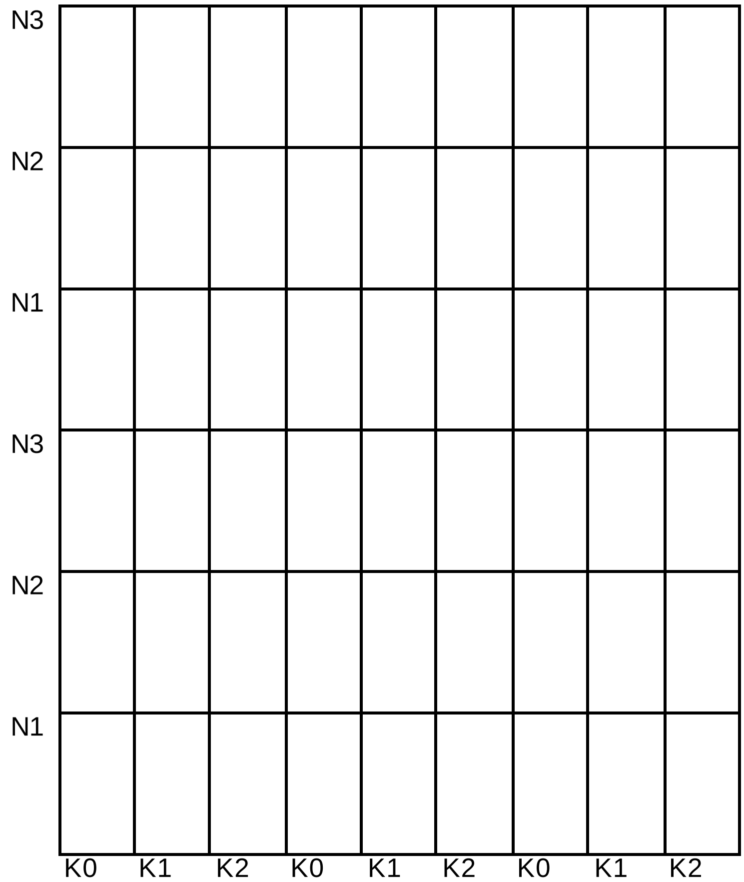
Figure 3b. Doughnut design with 3 treatments.

Two factor experiments

Two factor experiments are suitable for testing 2 variables and their interactions and can be layed out easily by growers. Some of the common treatments that can be tested are:

- Two fertilisers (e.g. 3 rates of K and 3 rates of N)
- Seed rates and fertiliser rates (e.g. 3 seed rates and 3 rates of N fertiliser)
- Varieties and fertiliser rates

The treatments can be layed out cross wise at right angles to each other across the whole paddock or part of the paddock.



Seeding, K application and harvesting to be done up and back the paddock. N application to be done across the K strips at right angles to the direction of seeding. The plots should be at least 50 m long in the direction of seeding and harvesting. The width of plots could be 2-4 seeder widths. It is good if multiple widths of the header match multiple widths of the seeder.

Figure 4. Example of a 2 factor experiment with 3 N rates and 3 K rates (replicated 6 times).

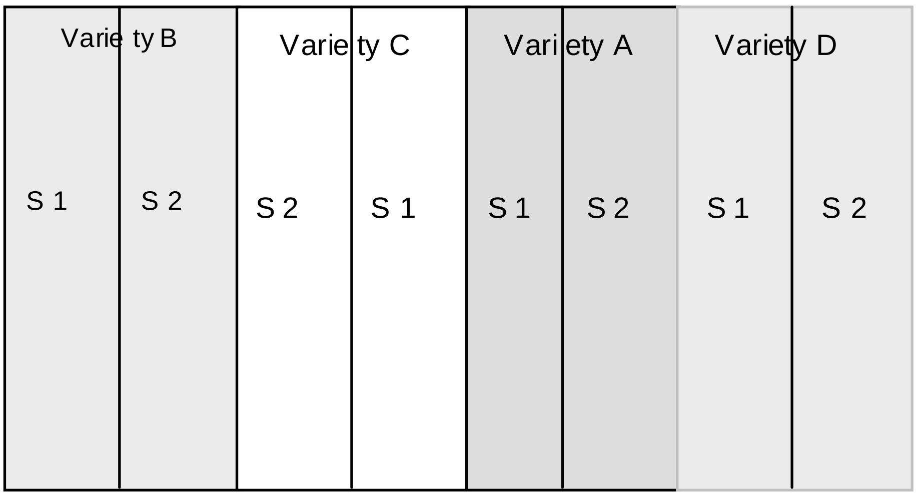


Figure 5. Example of a 2 factor experiment on a split plot design with 4 varieties as main treatments and 2 seed rates S1 and S2 as sub-treatments (need to be replicated).

It is important to repeat the trials to account for different seasonal conditions before conclusions are drawn.

Acknowledgments

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Further information

Growers may contact the following people for further information.

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