# AGRONOMIC INTERPRETATION OF PRECISION FARMING DATA MAPS – SOME RESULTS FROM A CANTERBURY ARABLE FARMING STUDY

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## Introduction

The initial excitement about precision agriculture technology is over. Many arable farmers in New Zealand are now disheartened by the cost of monitoring equipment and sceptical about the economic benefits such technology can impart to their farming system, particularly at a time when margins are being squeezed. In an effort to demonstrate the usefulness of such technologies to the farmer there is a need to understand both the temporal and spatial variability that occurs within a paddock (Cook and Bramley 1998). In arable farming the understanding is more difficult than for a perennial crop such as grapes or apples, as it is compounded by the annual nature of most crops and the hence the need for a crop rotation. In New Zealand crop rotations are often more diverse than those overseas; a rotation normally includes cereals, pulses, specialist small seeds (legume, grasses, brassica, vegetable), the occasional use of a pastoral phase, animal grazing of crop residues or managing vegetative growth, process vegetable crops and more recently specialist greenfeed or silage crops. In Canterbury, the major cropping area, soil types vary from light stony soils to heavy silts and clays. Most are predisposed to summer moisture deficit, although many can be irrigated. Hence the yield variability within a paddock and within and between districts can be large.

In an effort to understand this variability a three year study was commenced in Mid and South Canterbury in 1998. This involves intense monitoring of soil, herbage and grain parameters from three paddocks. It will not be possible within the short tenure of these studies to come up with specific recommendations because of the variables discussed above, however some underlying trends are evolving. This paper discusses the agronomic relevance of the data collated to date, suggests what parameters are the more useful, and how this knowledge can be used to improve financial returns.

## Methods

Soil and crop details from the three sites are given in Table 1.

**Table 1. Soil type and crop rotation by site**

| Sites | Soil Type[1] | 1998/99 | 1999/00 | 2000/01 |
|---|---|---|---|---|
| West Bros, Wakanui - irrigated flats | Wakanui and Eyre-Paparua silt loams | Perennial grass seed | Kale seed | Feed wheat |
| D. Howey, Waitohi - dry downlands | Timaru and Waitohi silt loams | Perennial grass seed | Feed wheat | Spring barley |
| Ravensdown, Seadown - irrigated flats | Lismore stony silt loam | Milling wheat | Field peas | Feed wheat |

[1] *New Zealand Soil Bureau Bulletin 14.*

Monitoring points were set up by using a differential global positioning system with most points on a 50m x 50m (West, Howey sites) or 40m x 40m grid (Seadown site). This was used for soil moisture, and soil and herbage nutrient sampling. In 1998 soil depth to clay or stones was measured and soil samples analysed for basic nutrients and organic matter. Each year herbage mass, nutrient status, yield and where applicable seed quality parameters were measured. Annual aerial photographs were also taken. Yield was measured using a yield monitor on the header and this was correlated with those parameters measured to see if any relationships existed.

**Results and Discussion**

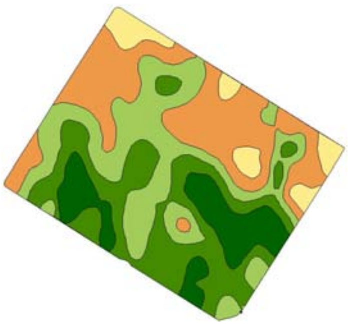
A look at the individual data highlights the large amount of variability that occurs across all three paddocks. In addition where more frequent readings are taken, eg. soil moisture (TDR) readings these also vary within and between seasons. In this paper several sets of data have been chosen to demonstrate this variability and aid in interpretation of the data.

**1. Nutrient data** - A cursory look at the soil nutrient data shows in general a 2-4 fold range in macronutrient status across each paddock, yet in general an area high in one nutrient is often high in another, Craighead and Yule (1999). Often this is related to the past history of the paddock, old stock camps, trees, fencelines etc. In most instances particularly in the first year (1998/99), a comparatively dry year, there was little correlation between harvested yield and soil, plant and grain parameters. This largely held in the wetter spring/summer of 1999/00. While good relationships were sometimes obtained between a specific nutrient and yield for an individual crop, eg. plant Mg (Figure 1.), further examination of the data in this instance indicated that not only was the paddock status well above that accepted for optimal plant growth (mean soil QTMg of 25.2, range 18-37), the relationship did not hold in the previous crop. Further, the relationship in both years was similar for sodium, iron and copper.

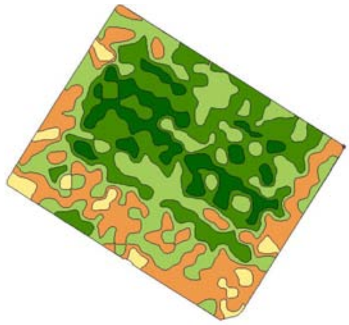
**Figure 1. Relationship between herbage Mg and yield in successive crops, West site.**
*(darker areas represent a higher value)*

kale

Mg $r$ = 0.50



ryegrass

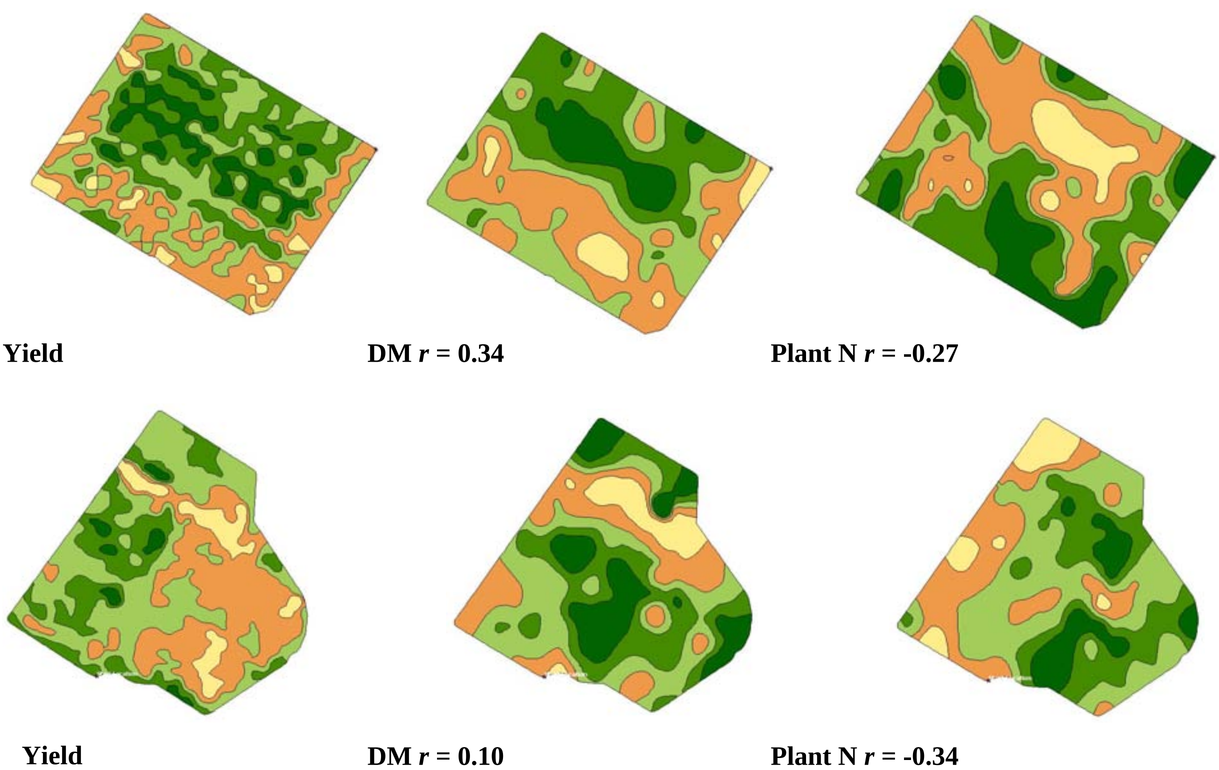


Mg $r$ = -0.19

Rather than conclude one crop responds better to Mg compared to another (something that could not easily be manipulated) a more logical explanation for the high Mg status is due to a higher soil cation status, a reflection of a change in soil type across the paddock. Hence soil type has an important underlying influence on yield.

**2. Ryegrass –** A comparison of ryegrass seed crops at the Howey and West sites in 1998/99 is shown in Figure 2. Although there was some relationship of yield with dry matter several weeks after closing there was a stronger negative relationship with herbage N content, an accepted way to monitor the progress of a ryegrass seed crop. A closer look at the data would suggest that seed yield needs a moderate but not an excessive amount of dry matter to be produced. Previous trial work (Craighead, unpublished data) indicates maximum seed yields are generated by nitrogen treatments which maintain intermediate growth usually with N concentrations of 3.8-4.2%N. The data shown here suggests a herbage concentration of 2.8-3.8% could be acceptable. Previously published trial work would suggest >4.5%N at spikelet initiation, although timing of N is also critical to seed yield (Rowarth et al 1998, 1998a).

**Figure 2. Ryegrass seed yield in relation to dry matter and herbage N content.**
*(darker areas represent a higher value)*




**3. Wheat –** at the Howey site a yield map was available for the previous (1997/98) season enabling a comparison between wheat in the 1997/98 (dry) and 1999/00 (wet) seasons, Figure 3. Despite the moisture difference there are a number of similarities between the two maps.

If we add the 1998/99 ryegrass seed yield map and build a picture of the three year average for the paddock we can find those areas performing above and below the field average. In this instance yields can be compared with an aerial map of the paddock and more stable parameters such as soil depth and drainage, Figure 4.

**Figure 3. Wheat yield maps, Howey site.**
*(darker areas represent a higher value)*

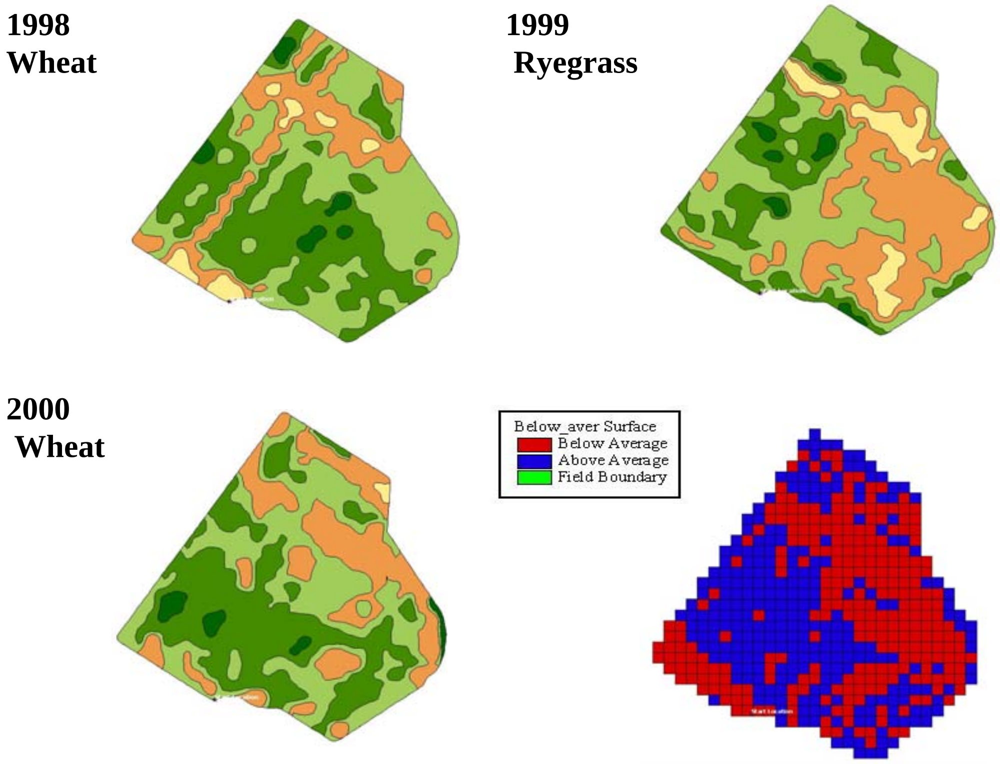
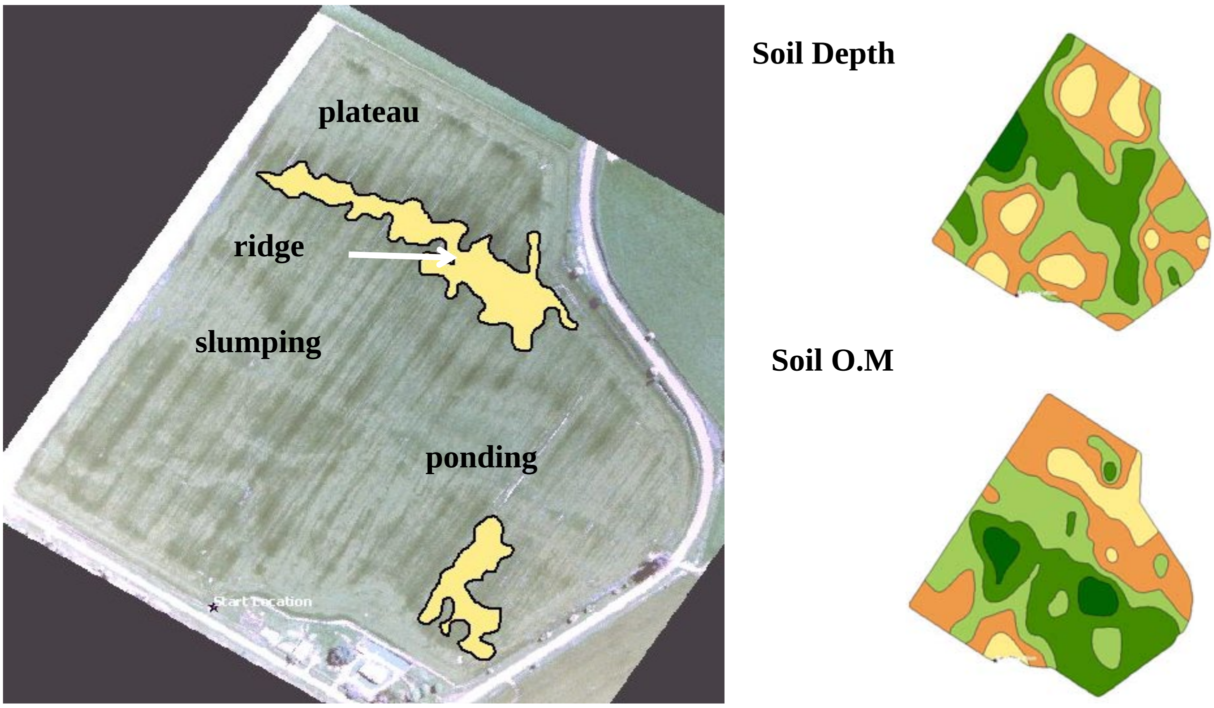



**Figure 4. Howey site soil, moisture and yield maps**
*(darker areas represent a higher value)*



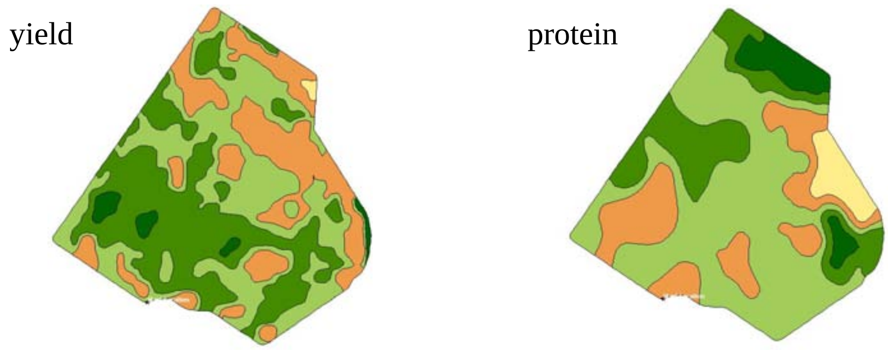
Depth of topsoil and soil texture impact heavily on yield as they influence soil water holding capacity. The aerial map indicates a ponding area, an area that sometimes performs well; its result depending on whether early season wet conditions reduce establishment and encourage weed competition (thereby reducing yield), or whether as the season turns dry, the crop in this region, remains less water stressed, and therefore has a relatively better yield due to improved seed size or pod fill.

In a pea crop at the Seadown site in 1999/00, in zones capable of performing well yield potential was not optimised because prolonged wetting caused secondary weed infestation and competition for assimilates at pod fill. Consequently intermediate areas yielded better.

**4. How can we take economic advantage of this information? –** In the pea example above a second weed spray would cost $36-79/ha applied depending on the weed spectrum present, the breakeven point being 0.1-0.3t/ha or an 3-8% yield increase above the average yield. The benefit or risk associated with this operation can be assessed providing you have a knowledge of the paddocks soil water holding capacity, and an estimate of the crop vigour and weed status. The latter data could be estimated from a crop walk or potentially from an aerial or infra red map.

Taking the example of wheat 1999/00 at the Howey site and comparing the grain protein map we can see that there are areas of high and low protein within the areas of high and low yield, Figure 5.

**Figure 5. Grain yield vs grain protein, Howey site 1999/00 data**
*(darker areas represent a higher value)*




In uniform conditions, for a given amount of N, higher yielding areas would normally have lower grain protein (Craighead 1999). For growing a milling wheat crop, the paddock could be divided into four zones. More N could be applied to the slumped area (zone A) which has more topsoil, to maximise yield and protein. A further option is to reduce the N to the ridge (zone B), where yield is reduced by soil depth. The remainder of the paddock (the third zone) would receive the average N, however the ponding area (the fourth zone) could receive less N when the paddock was waterlogged to reduce leaching losses and more later in the season when some compensatory growth could occur. Hence timing of N is important in this zone. These adjustments could be made manually negating the need for variable rate machinery to alter spreading rates and patterns. Some economics are given in Table 2 which show the benefit of adding extra N to zone A. Some of this N could be reallocated from zone B, where the loss to less N was marginal. If this latter approach were taken, agronomically it would be advisable to reduce the sowing rate and alter the timing of the remainder N. This approach is likely to improve the profit in zone B.

**Table 2. Economics of applying N differentially for a milling wheat crop, Howey site**

| Options | Parameters – assuming normal application of 120kgN/ha | Margin/ha | |
|---|---|---|---|
| Zone A | 6.8t @ 11.8% protein ($271.59/t)* | 1846.81 | |
| Extra 40kgN | 7.0t @ 12.8%protein ($285.03/t) | 1995.21 | |
| | Extra return | + 148.40 | |
| | Less 40kgN (urea $442/t) + spread ($8/ha) | - 44.43 | $ 103.97 |
| Zone B | 4.7t @ 11.8% protein ($271.59/t) | 1276.47 | |
| Less 20kgN | 4.6t @ 11.6% protein ($268.90/t) | 1236.94 | |
| | Loss of return | - 39.53 | |
| | Saving 20kgN (urea $442/t), spread saving | + 27.57 | - $ 11.96+ |

* Protein – Champion Mills 2000/01 contract (for Domino, Monad, Otane)
+ Management changes to complement lower N inputs could easily reverse these losses (see text)

## Conclusions

Interpretation of yield maps is not easy, it requires a lot of accumulated data and local knowledge. Knowledge of soil type and landscape variation offer good starting points and these can be augmented by aerial photography, soil maps and soil depth or texture with some ground truthing (sampling) to verify this variation. Regular soil and herbage sampling of different zones (this does not necessarily need to be on an annual basis) will give an idea as to how best to manipulate soil nutrient, particularly N status, and adjust other management practices to best use this information for economic or environmental advantage.

## References

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