# Fertilising to soil type (usually) pays.

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## KEY MESSAGES

- High prices for both fertiliser and grain mean that fertiliser needs to be better targeted and used more efficiently because of the increased risks of losses both at the over- and under-fertilising end of the spectrum.
- Using different fertiliser rates (and types) for different zones within a paddock (VRT) pays in a lot of circumstances. Identifying when VRT pays, depends on a multitude of economic, biological and seasonal factors.
- The most important factors are related to an individual grower's attitudes to scales of operation and degrees of risk. One size does NOT fit all

## BACKGROUND

The large increases in grain prices in 2007 and fertiliser prices in 2008, led farmers to think seriously about changing their fertilising strategies. In the past, profit curves were so flat that losses from either under-fertilising or over-fertilising were low; it was difficult to prove that any fertilising strategy would cause a disaster.

Whether fertilising different areas within a paddock differently, pays compared with a uniform application across the paddock depends on a host of physical and biological factors as well as the prices of fertiliser and grain. Each individual paddock and price situation is different, but are there some rough rules which allow growers to better target their fertiliser dollars around a paddock.

This paper uses a spreadsheet model to calculate the returns to targeted soil sampling and subsequent NP fertiliser applications for predetermined yield zones within paddocks on a farm. This model was produced in response to several questions:

1. Is variable rate technology more or less important in the context of higher crop and fertiliser prices?
2. How much within-paddock variation in yield potential is needed to justify VRT and how does this vary with costs and prices and seasonal variation in yield?
3. How much within-paddock soil fertility variation is needed to justify VRT?

## METHOD

The economically optimum rates of N and P were calculated using standard nutrient response curves (similar to those used in the NP Decide model) and nominated levels of water-limited yield potential, taking into account the price of wheat grain (grain protein effects and "haying-off" were ignored) and the cost of fertiliser with a assumed amount of soil N and P. We then calculated the economic gains to be made in supplying the crop in each yield zone (i.e. soil type) with its economically-optimum rates of N and P and compared this with applying the economic rates needed for the paddock-average yield. In all cases we assumed three equal-sized zones (33.3% each). The model was run where crop prices, fertiliser costs, crop yields, and starting soil N and P where all varied. For simplicity when we varied soil fertility levels we assumed the ratio of N to P was constant, where soil N levels were 2.5 times soil P levels. Gains to VRT are calculated without taking off costs of implementation and costs of paying back an investment in equipment.

## THE QUESTIONS

### *Q1: Does VRT pay given changes in costs and prices, & how much yield variation is needed?*

Farmers who have fertilised different paddocks differently, know, if only sub-consciously, that VRT pays. They use different rates in different paddocks because productivity and/or soil fertility and/or soil types vary markedly between paddocks. This variability to which they respond is not necessarily made uniform by fencing the paddocks. Modern seeding equipment makes it easy to change fertiliser rates and sources on the run (if only manually) so there is no reason not to change rates within paddocks if the variability in crop yield justifies it.

Table 1 shows gains to VRT for a paddock with moderate yield variation (1000, 2000, 3000 kg/ha) under a range of costs and price settings. With grain prices and fertiliser costs typical of that two years ago (e.g. grain $200/tonne, N=1.2 $/kg, P=2.5 $/kg) gains to VRT would have been < $10/ha.

Table 1: Benefits of VRT ($/ha above uniform management) for a range of fertiliser costs and grain prices for a medium amount of within paddock yield variation (1000, 2000, 3000 kg/ha). Constant background fertility levels across zones of 30 kgN/ha & 12 kgP/ha was assumed.

| *Grain price* | *200* | *300* | *400* | *500* | *600* | | *200* | *300* | *400* | *500* | *600* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $/kg N | | | | | | $/kg P | | | | | |
| 1.0 | 8.1 | 7.2 | 6.3 | 6.8 | 7.1 | 3.0 | 7.6 | 12.1 | 14.3 | 11.1 | 12.7 |
| 1.5 | 8.1 | 9.7 | 8.5 | 9.5 | 7.3 | 4.0 | 6.1 | 13.8 | 16.1 | 13.7 | 14.5 |
| 2.0 | 8.6 | 10.5 | 11.2 | 9.5 | 10.5 | 5.0 | 3.1 | 14.4 | 18.3 | 16.2 | 15.7 |
| 2.5 | 5.3 | 11.2 | 12.6 | 12.5 | 10.5 | 6.0 | 1.5 | 13.6 | 19.0 | 19.3 | 17.7 |
| 3.0 | 3.3 | 12.0 | 12.6 | 14.6 | 14.0 | 7.0 | 0.7 | 11.8 | 18.7 | 20.2 | 19.5 |

However, with current settings (e.g. grain $300/tonne, N=2.2 $/kg, P=4 $/kg) gains to VRT are > $10/ha. It is obvious from Table 1 that above $300/tonne the big driver of increases in gains to VRT will come from higher fertiliser costs rather than further increases in grain prices. This is the case particularly for N, although this is a function somewhat of the background soil P levels (12 kgP/ha) assumed for this example.

The example in Table 1 is for a moderately variable paddock, and Table 2 shows a wider range of examples for within-paddock variation in water-limited yield potential. Three scenarios of costs and prices are used, representative of cost and price conditions two years ago (A), current conditions (B) and a possible future set of costs and prices (C). In scenario A gains to VRT were less than $10/ha where yield variation was less than ± 500 kg/ha around the medium zone, and it is difficult to exceed $10/ha gain even with future increases in costs and prices used in scenario C. Only when yield variation gets above ± 1000 kg/ha around the medium zone, does the benefit exceed $10/ha. When going from scenarios A to B (equivalent to changes in the last two years) benefits to VRT have increased by $4 to 20/ha depending on degree of yield variation. This suggests that circumstances under which VRT may once have been considered uneconomic, may well now be more suited.

Table 2: Benefits to VRT ($/ha) under various price and cost scenarios and range of yield variation within paddocks. Constant background fertility levels across zones of 30 kgN/ha and 12 kgP/ha were assumed.

| *Water-limited yield potential of paddock zone (kg/ha)* | | | *Scenario** | | |
|---|---|---|---|---|---|
| Low | Medium | High | A | B | C |
| 500 | 1000 | 1500 | <1 | <1 | 2 |
| 1800 | 2000 | 2200 | 0 | 0 | 1 |
| 1500 | 2000 | 2500 | 1 | 3.6 | 8 |
| 1000 | 2000 | 3000 | 9 | 14 | 24 |

| | | | | | |
|---|---|---|---|---|---|
| 500 | 2000 | 3500 | 18 | 27 | 46 |
| 500 | 3000 | 5500 | 29 | 47 | 76 |

*A $200/t, $1.2/kgN, $2.5/kgP, B $300/t, $2.2/kgN, $4/kgP, C $500/t, $4/kgN, $6/kgP

### *Q2: Soil fertility differences needed to justify VRT*

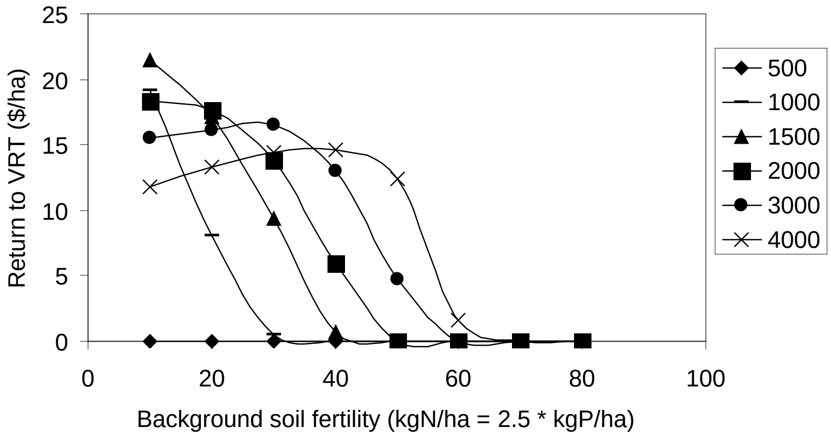

Figure 1: Benefits to VRT ($/ha) as a function of background soil N fertility (constant across zones with N = 2.5 * P) and for various yield potential values (500 to 4000 kg/ha) in the medium zone, the yields of the low and high yielding zones were 50% and 150% of that in the medium zone.

The preceding examples have all assumed relatively responsive levels of soil fertility (N=30kg/ha, P=12kg/ha), but one would expect that as soil fertility varies around this and also yield potential then the benefits to VRT will change. Figure 1 shows that for a wide range of yield levels (1000 to 4000 kg/ha in the medium zone) provided soil N and P levels across the paddock are less than 20 kgN/ha (= 8 kgP/ha) then benefits will be between $10-20/ha. As would be expected as fertility climbs, benefits to VRT fall. Under relatively high yielding situations (>2000 kg/ha in the medium zone) benefits >$10/ha will be expected up to soil NP levels of 30 kgN/ha and 12 kgP/ha. Beyond this though, benefits drop off quite rapidly.

### *Q3: Impact of seasonal variability in yield potential*

Figure 1 can also be thought of in terms of how seasonal variation affects returns to VRT. Each curve represents a yield level with the low and high yielding zones set at 50% and 150% of that in the medium zone. In the example in Fig 1, the highest return to VRT come at low nutrient status (10 N, 4P) – even in low yielding seasons (e.g. $20 when the medium zone yield potentials is 1000 kg/ha). The payoffs to VRT are zero at intermediate nutrient status (50N, 20P) until season/yield potential starts climbing above 2000 kg/ha in the mid zone (1000 kg/ha in the low and 3000 kg/ha in the high zone)

Thus variation in season/management, represented by mid zone yield potential, markedly affects $/ha profitability to adopting VRT depending on the soil fertility status of the paddock. At very high soil fertility, there is no effect of VRT for any seasonal conditions. At low and moderate levels of paddock soil fertility, returns to VRT increase with season which in this example magnifies the potential yield differences between zones.

### *Q4: Impact of differences in soil fertility among zones*

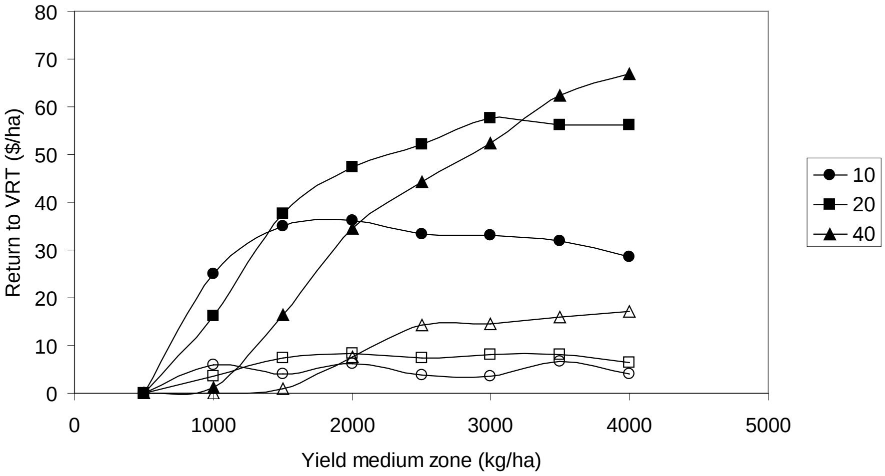

Figure 2: Benefits to VRT ($/ha) as a function of yield of the medium paddock zone where background soil fertility (10-40 kgN/ha) varies **inversely** with zone yield potential (low zone has twice as much N and P as the medium zone and the high zone has 70% of the medium zone). Filled symbols are where there is high variability with the low and high zones are 50% and 150% of medium zone and hollow symbols are where there is low variability with low and high zones are 20% and 120% of medium zone.

In many paddocks with a history of blanket fertiliser applications there has been a build up of soil fertility levels in the low yielding areas / zones compared to the higher yielding areas. In all our previous examples we have assumed constant soil fertility levels across zones. Accounting for zone differences in N and P levels markedly affects projected benefits from VRT (Figure 2). Under the low and high variation scenarios the benefits to VRT would be considered marginal if soil fertility levels were constant across zones (see row 2 of Table 2). However, in this case we assumed that the low zone has twice as much N and P as the medium zone and the high zone has 70% of the medium zone. This is a common occurrence in paddocks we have sampled across the wheatbelt. Estimated benefits are considerable for the high variation situation, when compared to the values in Tables 1 and 2 and Figure 1. Even in the lower variation situation (hollow symbols) with a reasonable yield in the medium zone (>2000 kg/a) the benefits are getting closer to exceeding $10/ha. This suggests to us that in paddocks with a low to moderate variation in yield potential, accounting for a history of nutrient build-up in low yielding areas of the paddock may shift VRT from an unattractive proposition to one that is worth considering.

## CONCLUSIONS

Does VRT technology pay? Of course it does. You just need to be able to work out where and when it pays because it does not pay in all circumstances. There has to be significant yield and/or soil fertility differences on significant areas within a paddock, for it to pay. In WA those differences are every where but the problem is to determine how large and where they exist in cropping paddocks on your farm. Benefits described here need to be weighed up against the size of investment required to enter VRT and an analysis of this has been presented in previous Crop Updates papers.

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