# Fertiliser management on continuous cereal paddocks

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## Take home messages

- *Strategic (up-front) Nitrogen (N) was useful in a wet year, but no N rate used was high enough to anticipate the wet and cool spring at Ouyen.*
- *Phosphorus (P) application was unnecessary on the dune, slope and swale soils in this paddock, as expected from high soil test results. If N had been less limiting (yield > 2.5t/ha), it is possible that P may have been an issue.*
- *In wet years on continuous cereal paddocks, factors besides P (disease, N) are also likely to be limiting.*

## Background

Improvements in weed control and the understanding of cereal diseases have allowed Mallee farmers to sow some paddocks to cereals year after year. These paddocks tend to be nitrogen (N) deficient on sandy dune soils, and test high to phosphorus (P) on all soils. Agronomists typically recommend up-front N on dune soils, with further 'tactical' N top-dressed depending on the season. Although soil tests may suggest no P should be applied, farmers typically apply a little on constrained soil types and a 'replacement' rate on the rest.

The management issues are:

1. Farmers are often reluctant to apply zero P even when soil test levels are high due to concerns they will 'miss out' on yield in a wet year, and
2. If the season outlook improves after sowing, applying sufficient N by top-dressing across a large cropping program can be difficult.

An alternative to the 'tactical' approach with N is to take a 'strategic' approach and apply a larger amount up-front. In dry years when the up-front amount exceeds crop requirements, it is important to know how much of the excess remains in the system, on different soil types. In wet years when it is too little, tactical supplements are still possible, but it is also important to verify that mineralisation will assist in available nitrogen release and not too much yield will be lost.

Mallee Sustainable Farming, together with Victorian DPI and CSIRO, established an experiment to test this over a number of years at Ouyen in 2010 as part of a national Water Use Efficiency improvement project. The experiment combines tactical and strategic N approaches, with 0 and higher P rates, over a typical range of soil types on a continuously cropped cereal paddock.

## Aims

1. To verify cereal crop production can be maintained with 0P rates when soil tests advise applying 0P, on a range of soil types in a continuous cereal paddock.

2. To test strategic management of N (up-front application) as a long-term approach, compared with the currently recommended 'tactical' (in-season, top-dressed) method, on a range of soil types in a continuous cereal paddock.

## Method

Experiments were established on the dune, slope and swale areas within a continuous cereal paddock at Ouyen. Each area had the same factorial design of three P fertiliser rates applied at sowing (0, 6 or 12kg P/ha) x two N strategies which were as follows:

*Strategic*. Sufficient N applied at sowing to satisfy the demands of a crop (40kg N/t yield) with yield estimated from the available water at testing (late March) and average growing season rainfall. Mineral N was determined on 100cm deep soil cores that were collected in April 2010. The treatment was different on the swale soil, where a default 20kg N/ha was added to ensure a treatment difference in a year where a 'tactical' application would be unlikely.

*Tactical*. Sufficient N applied at sowing to grow a 1.5t/ha crop. N top-dressed as urea in response to seasonal conditions at GS32 (August 13; intended to be GS30), according to consensus interpretation of Yield Prophet® reports by researchers involved in the project.

Both N strategies were applied at 0, 6 or 12kg P/ha using a complete randomised block design.

The site was topdressed with gypsum before sowing to correct any possible sulphur deficiency. The wet conditions in 2010 contributed to several agronomic issues. The Yitpi wheat crop at the site was severely infected with yellow leaf spot, although it recovered in spring. Weed control was also delayed until late August (not intentional) and will have affected yield potential, although yields achieved (2 – 2.5t/ha) were similar to other continuous cereal paddocks in the area.

Grain yield and protein were analysed by analysis of variance. Apparent electrical conductivity from an EM38 survey of the site in March 2010 was used as a co-variate to fit some of the soil-related variation in yield and protein not accounted for by replicates.

Although N and P treatments were implemented with superphosphate and urea so that N and P were not confounded, gross return net of fertiliser cost was calculated by assuming P supplied as MAP, with N supplied by MAP deducted from urea-N costs. Prices used were 23 December at Birchip AWB. Tactical application costs were assumed to be $10/ha.

| | |
|---|---|
| Location: | Ouyen (Latitude -35.056, Longitude 142.331) |
| Replicates: | 3 |
| Sowing date: | 3-5 May 2010 |
| Seeding density: | 70 plants/m² |
| Crop type/s: | Yitpi wheat |
| Seeding equipment: | 8 row cone seeder with knife points set to 30cm row spacing |

## Results

*Soil tests and treatment decisions*

Fertiliser decisions about the 2010 crop were made with approximate soil data (samples were taken slightly south of where trial plots were located and crop lower limits were estimated). Nitrogen at sowing was particularly low on the dune soil, with little at depth (Table 1). The slope and swale soils had higher N and more at depth.

The initial decision about the 'strategic' N rates was based on target yields of approximately 3t/ha dune, 2.5t/ha slope, and 1.8t/ha swale (given average Ouyen GSR of 175mm). In hindsight the yield expectation for the slope and dune should have been reversed, regardless of the year.

The decision on 'tactical' N rates was difficult, because soils were only partly characterised, which affected Yield Prophet runs at that stage (August 11). Ouyen GSR was just under decile 5 (130mm), and the SOI outlook for August – October was a 45 – 50% chance of above-median rainfall.

After some internal debate, the project team applied 25kg N/ha, which was also the rate being applied on dune soils by local farmers. Subsequently 140mm rain fell during the remainder of August – October.

*Table 1. Pre-sowing N and soil water, and N applied in the 'strategic' and 'tactical' treatments.*

| Soil: | Dune | Slope | Swale |
|---|---|---|---|
| N 0 – 60cm (kg/ha) | 38 | 47 | 58 |
| N 60 – 100cm (kg/ha) | 12 | 29 | 45 |
| PAW* 0 – 60cm (mm) | 28 | 33 | 40 |
| PAW* 60 – 100cm (mm) | 21 | 31 | 37 |
| Nitrogen treatments: | | | |
| Strategic – Sow N (kg/ha) | 70 | 20 | 20** |
| Tactical – Sow N (kg/ha) | 20 | 0 | 0 |
| Tactical – GS32 (kg/ha) | 25 | 25 | 25 |

**PAW = Plant Available Water, calculated from actual soil water using estimated crop lower limit.*

***Default treatment – applied to ensure a difference with the 'tactical' treatment in a dry year.*

The slope and swale soils had higher Colwell P (Table 2), but all soils were well above their 'critical' Colwell P (the level which gives cereal yields at least 90% of maximum).

*Table 2. Surface soil Colwell P, Phosphorus Buffer Index (PBI) and 'critical P' for each soil type.*

| Soil: | Dune | Slope | Swale |
|---|---|---|---|
| Colwell P (mg/kg) | 21 | 44 | 35 |
| PBI | 21 | 48 | 47 |
| Critical P (mg/kg) | 15 | 21 | 21 |

*Yield and quality*

Ouyen had 271mm growing season rainfall, almost 100mm above the average of the last 12 years (175mm). Yield and protein results (Figures 1 and 2) imply that all treatments were severely nitrogen limited. There was a significant response to strategic nitrogen on the dune, with a 0.37t/ha yield and 0.7% protein increase corresponding to the additional 25kg/ha N applied. On the slope and swale, where N inputs were similar in both treatments, the yields were also similar. It was surprising that yields were not higher on the swale, where more N was available in the profile. It is possible that this may have been leached.

There were no signs of a P response in yield. There was a significant interaction in the protein response to P on the swale (Figure 2), where the effect of P was visible earlier in the season. The 12P treatment had lower protein with strategic (0) N, whereas the 0P treatment had lower protein with tactical N.

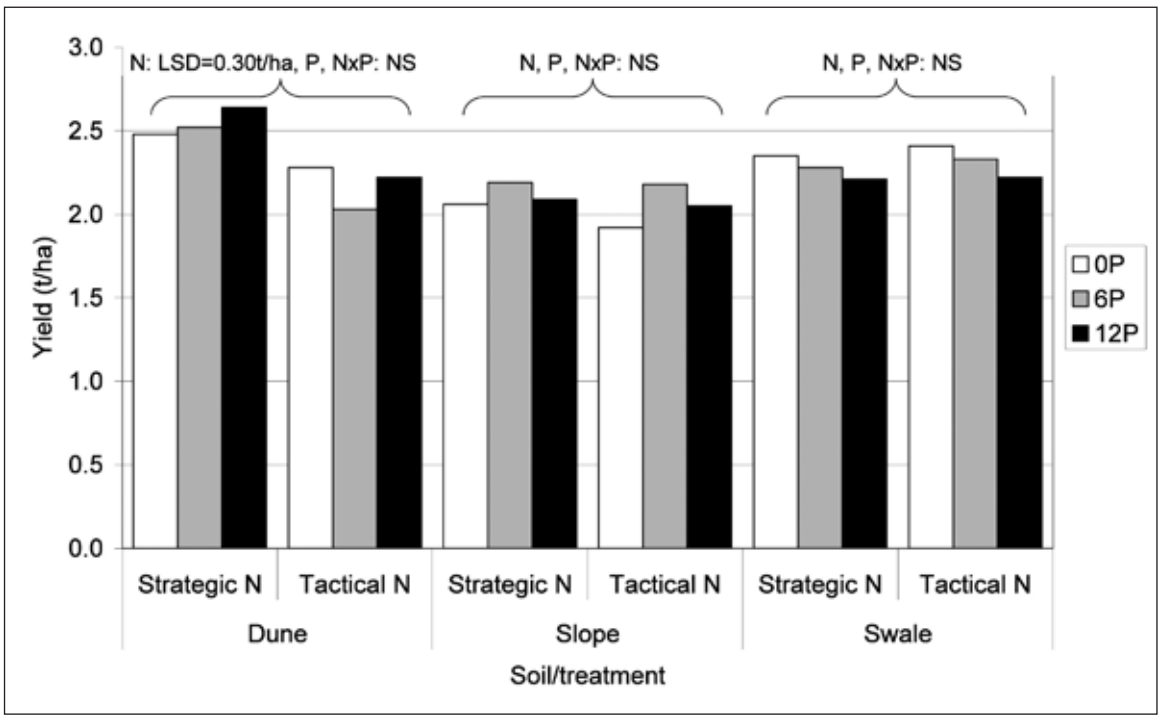


*Figure 1. Yield for nitrogen and phosphorus treatments on dune, slope and swale soils. Least Significant Difference (LSD) is given for significant (p<=0.05) treatments; NS = not significant.*

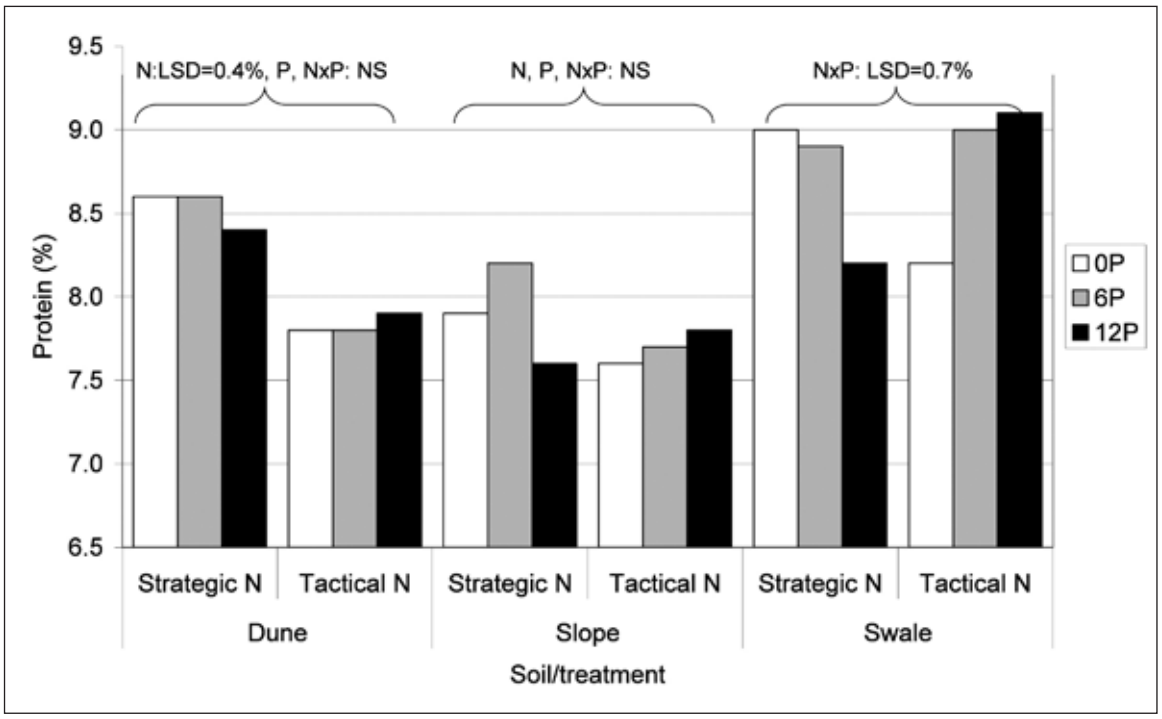


*Figure 2. Grain protein for nitrogen and phosphorus treatments on dune, slope and swale soils. Least Significant Difference (LSD) is given for significant (p<=0.05) treatments; NS = not significant.*

*Economics*

The generally low proteins meant that most wheat was ASW quality (only two swale plots made APW2; >10% protein). The only significant difference in gross return net of fertiliser and application cost was on the dune soil, between strategic and tactical N treatments (Figure 3, $94/ha averaged across P rates, p=0.014). This reflected the significant yield differences. The additional costs associated with higher P rates were not enough to be significant compared with variation on any soil type (at best p=0.198 on slope).

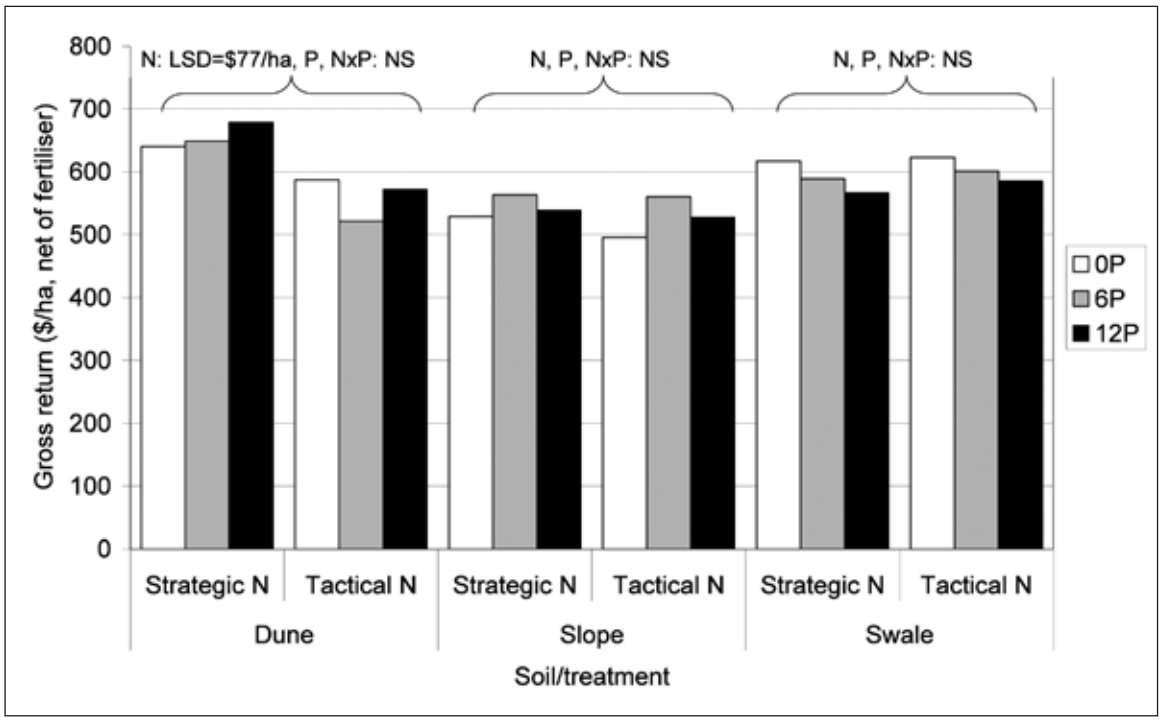


*Figure 3. Gross return net of fertiliser/application costs for nitrogen and phosphorus treatments on dune, slope and swale soils. Least Significant Difference (LSD) is given for significant (p<=0.05) treatments; NS = not significant.*

## Interpretation

*Strategic and tactical nitrogen*

The strategic approach with N was quite useful in 2010. Having N in the ground from the start of the season meant the pressure on top-dressing was reduced, and early crop growth was better. In hindsight, however, the slope soil probably should have received more N. Equally, the top-dressing in the tactical treatments was too little to late (GS32).

The tactical approach was hindered by not having full confidence in the soil characterisation (first year of the trial), and also being concerned about the impact of yellow leaf spot on the crop's ability to respond. These crops were not alone, however: decile 9 – 10 spring rainfall following a relatively dry winter (29mm in June – July combined) meant that sub-optimal N application was common across the district.

Debate within the team about interpreting Yield Prophet N reports may make a good discussion point on the usefulness of economic payback criteria (eg. 'must have 2:1 return'). The dune N report in August showed little probability of loss from top-dressing with 25 or 50 kg N/ha (Figure 4; near-100% probability of a 1:1 payback). On the same report, the 2:1 payback criteria is met in only 40-50% of years. On reflection, the 2:1 criteria is good protection for

decisions where there is a possible (and unknown) downside, but may not be appropriate where the probability of loss is very low, and/or where the probabilities and size of the downside are well known.

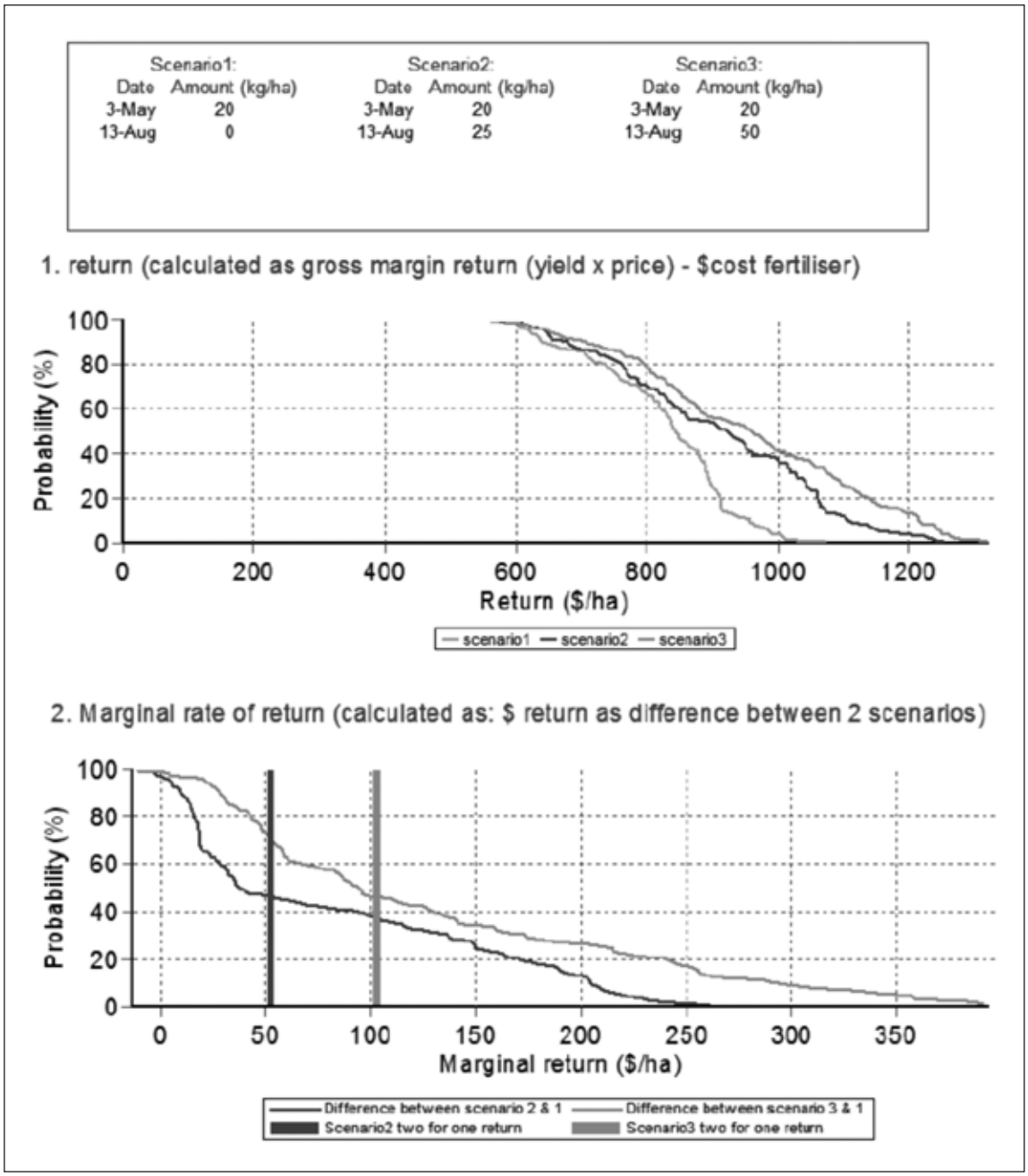


*Figure 4. Yield prophet N report for top-dressing 25 (scenario 2) and 50 (scenario 3) kg N/ha on the dune soil, compared to no top-dressing (scenario 1).*

*Phosphorus rates*

The lack of crop response to P is unsurprising, but also shows that maintenance P applications are unwarranted on continuous cereal paddocks when soil test P measurements are high and large amounts of N are unlikely to be applied. Yield will not be reduced in wet years, on any of these soil types, and it is likely with continuous cereal paddocks that other factors (N, disease) may become limiting.

Falling soil test P should be taken as an indication of the need to reintroduce maintenance P, and we hope to observe that in the next two years.

If large amounts of N are to be applied, the importance of adequate P is likely to increase, although it still may not be required due to good soil reserves. Previous work on N x P interactions (Holford *et al.,* 1992) showed these tend to occur at yield levels of 2t/ha or higher, on the 16% of paddocks that were P responsive. Yields in these experiments were just above this, but soil tests also indicate that the paddock would be unlikely to be P responsive.

## Commercial Practice

Fear of poor yields in a wet year should not be a reason to maintain P applications on continuous cereal paddocks when soil tests indicate it is unnecessary. Other factors (such as N or disease) may be a bigger issue on these paddocks in wet years.

Strategic (up-front) approaches with N naturally have advantages in a wet year, but farmers should wait for an assessment of residual benefits in a dry year before committing to a strategic approach.

## References

Holford ICR, Doyle AD, Leckie CC (1992) Nitrogen response characteristics of wheat protein in relation to yield responses and their interactions with phosphorus. *Australian Journal of Agricultural Research* **43**, 969-986.

## Acknowledgments

This project is funded by GRDC and the Victorian DPI.