NITROGEN USE EFFICIENCY - THE PATH TO HIGH YIELDS AND PROTEIN

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The Water Use Efficiency (WUE) concept introduced by French and Schultz in the mid-eighties paved the way to systematically improve yields. Growers who used the principles of Water Use Efficiency were able to set targets for production based on the Growing Season Rainfall. Those growers, who were also part of crop monitoring programs such as MEY-Check, were able to identify the factors limiting production and were thereby able to adapt their cropping practices and achieve higher yields. Many growers are now achieving Water Use Efficiencies for wheat in the potential range of 14 to 16 kg/mm/ha. The next step for these growers is continue with the practices which have resulted in high yielding crops but to also start paying attention to Nitrogen Use Efficiency. Grain protein levels, in Victoria, are generally low (<9.5%) and now that the AWB are starting to pay for protein it is essential that simple to use models, similar to WUE, are developed for Nitrogen Use. This paper outlines the concept for Nitrogen Use Efficiency (NUE) and how it can be used on the farm to optimise yield and protein. The model is based on the work done in the last four years by Peter Ridge, PIVOT and the Department of Conservation and Natural Resources. The information presented is based on the trial work undertaken by DCNR in the FAST (FM500 And Sustainable Technology), MEY-Sites and Crop Water Use projects. The first two of these projects are supported, in part, by the GRDC.

Growers are now able to receive significantly higher prices for high protein wheat. The protein premiums paid for quality wheat are likely to be even larger next year. The Wheat Board have also suggested that wheat below 10% protein may not make ASW grade in the future.

Growers now face the challenge to produce high protein wheat at high yields, or make the decision to grow quantity for feed rather than ASW or AH. Either way, the decision must be based on a knowledge of what can be produced. When making the decision growers will have to consider:

1. the soil water storage at sowing
2. available soil nitrogen at sowing
3. choosing the right variety for the type of wheat to be grown
4. the market for the variety selected

Nitrogen is the most difficult variable for growers to handle. Nitrogen fertilisers are not cheap and growers must make the decision to use a nitrogen fertiliser, such as Urea, on a knowledge of:

1. the amount of available nitrogen in the soil at sowing
2. an estimate of the amount of available nitrogen to be mineralised over the growing season
3. the amount of nitrogen required to grow a crop of maximum potential at the required protein level

Trial Site Results - 1993

At optimum conditions (minimal disease levels, low competition of weeds, adequate nutrition) grain yield is a function of Growing Season Rainfall plus the amount of water stored in the soil at sowing. Figure 1 illustrates the yields obtained on the FAST and MEY trial sites during the 1993 season as a function of the water available during the growing season.

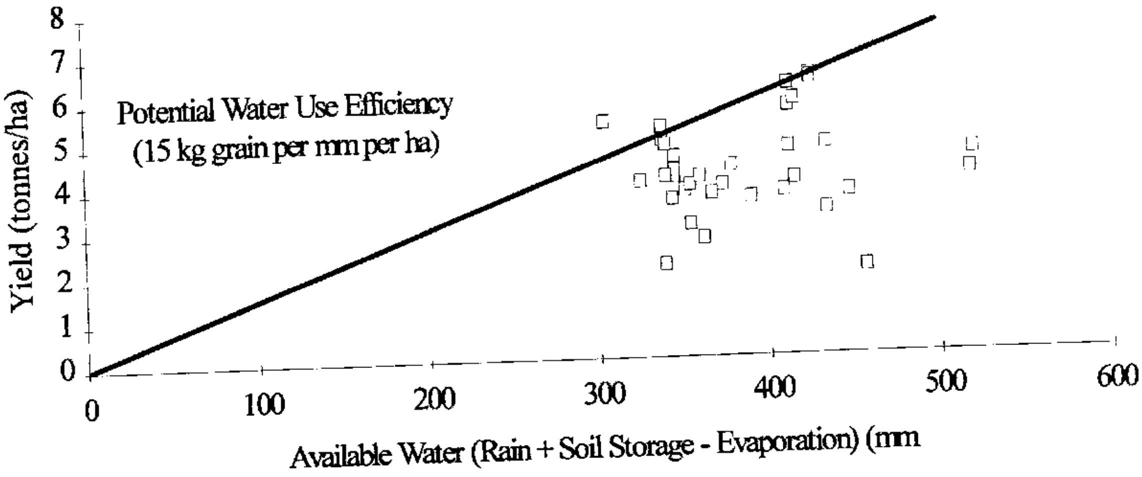

Figure 1. Yield (t/ha) as a function of available water (GSR + soil water stored - evaporation)

Nitrogen use at each trial site was calculated from the yield and grain protein content obtained. The equation used was:

N-used (kg/ha) = yield (t/ha) x (grain protein/5.7) x 20

where grain protein/5.7 is equal to the grain nitrogen content

Nitrogen use was strongly correlated to the Water Use Efficiency obtained (Figure 2). As expected the amount of nitrogen used by the crop increased as the water use efficiency of the crops improved.

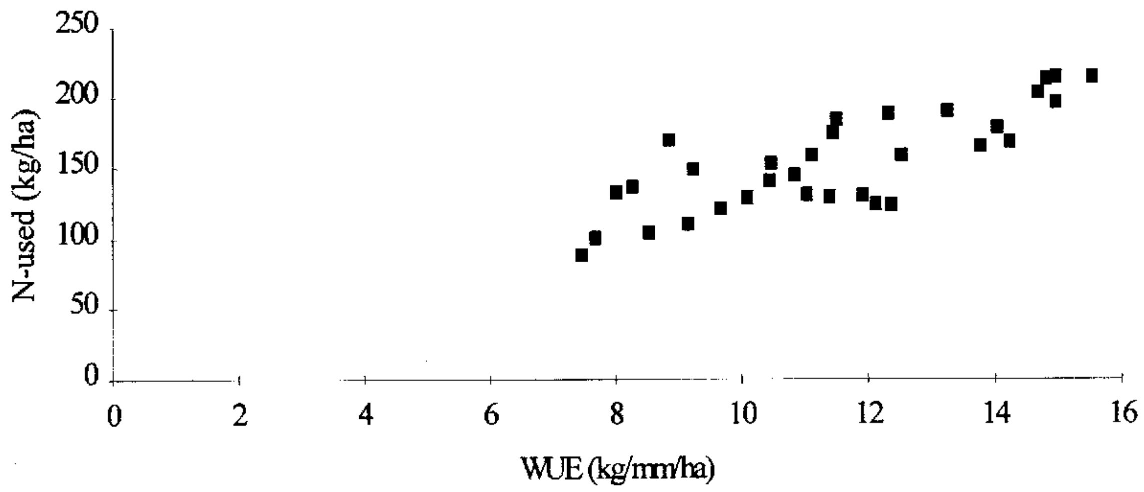

Figure 2. Nitrogen used (kg/ha) as a function of Water Use Efficiency (kg/mm/ha)

The Nitrogen used also increased as a function of the amount of water available for crop growth (Figure 3). As the crop yields increased the amount of nitrogen used also increased. Note the similarity of this curve to the WUE curve, as presented in Figure 1. The potential Nitrogen Use Efficiency for a crop grown at a WUE of 15 kg/mm/ha, at 11.5% protein is **0.6 kg of Nitrogen per mm of water**. The potential NUE of 0.6 kg of N/mm/ha should be used during the 1994 season to test the validity of the model.

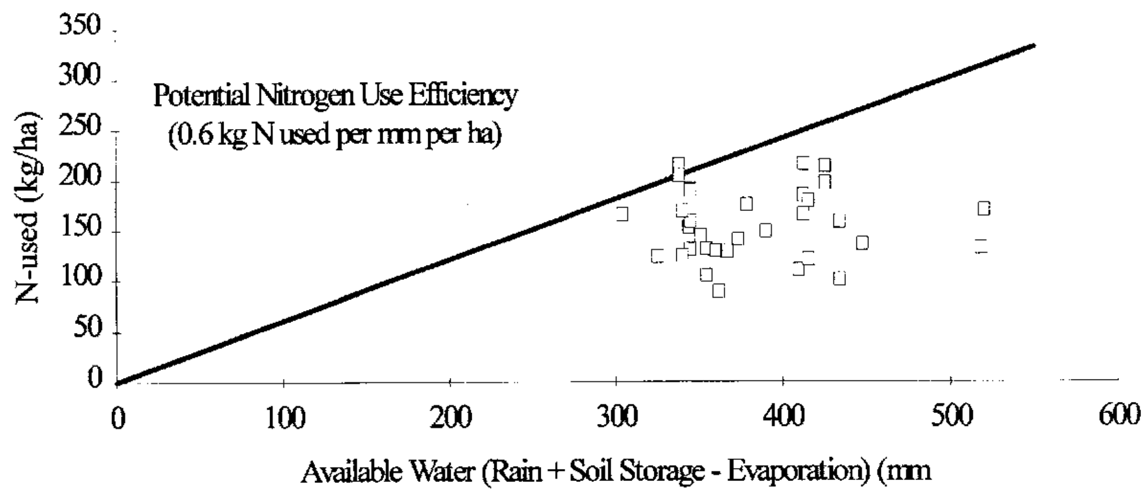

Figure 3. Nitrogen used (kg/ha) as a function of available water

The amount of Nitrogen used by the crops (N-used) increased as the amount of Nitrogen available increased (Figure 4). The amount of Nitrogen available was calculated from:

N-available (kg/ha) = Available Nitrogen measured in the soil at sowing (kg/ha over 60cm depth)
+
Available Nitrogen Mineralised over the Growing Season (kg/ha)
+
Nitrogen supplied in fertiliser

where: the Available Nitrogen Mineralised over the Growing Season is calculated from the mineralisation model developed by Peter Ridge (N mineralised = 0.15 x Organic Carbon (%) x GSR).

Figure 4 clearly illustrates that for several crops Nitrogen use was not optimised and that there was still nitrogen left behind after the season. In other words, not all crops utilised all of the available Nitrogen. The next challenge is to find out why some crops, even if they have reached potential WUE, do not use all of the available Nitrogen.

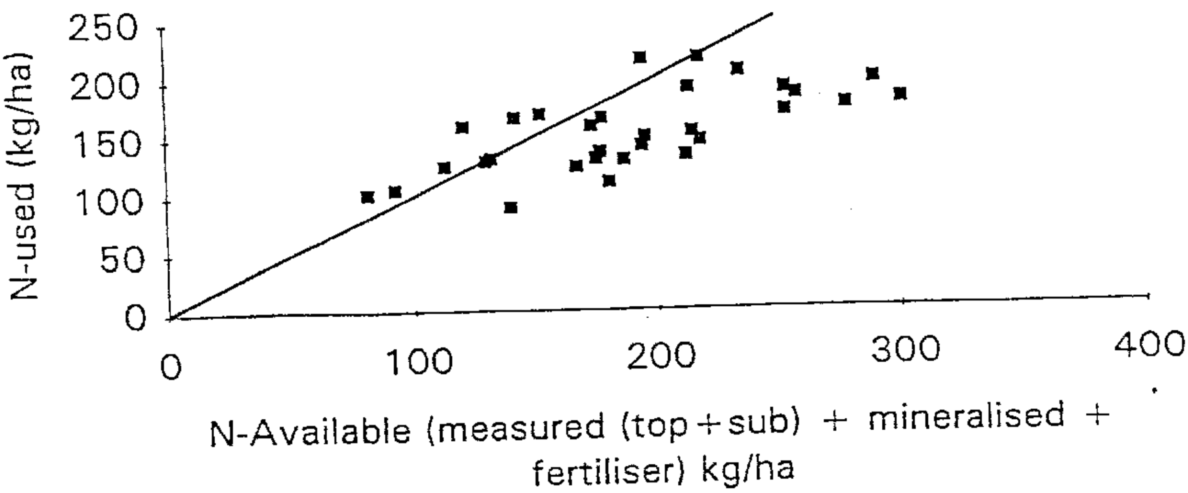

Figure 4. Nitrogen used (kg/ha)as a function of Nitrogen available (kg/ha).

How to use NUE

1. measure soil available nitrogen at sowing (soil test)
2. calculate nitrogen mineralisation based on Organic Carbon content for an average GSR
3. calculate the grain yield for an average GSR based on the WUE model
4. calculate the amount of Nitrogen required to grow a crop of that size with a protein content of 11.5%
5. work out the difference between the Nitrogen required (as in point 4) from the amount of Nitrogen calculated in points 1 and 2.
6. the value calculated in 5 is the amount of nitrogen required as fertiliser.

Example:

1. soil available nitrogen as determined from the soil test at sowing was 80 kg/ha
2. for a soil at 1.4% OC and a average GSR of 300 mm:
   N mineralisation = .15 x 1.4 x 300 = 63 kg/ha
3. grain yield for a GSR of 300 with 100mm storage and 110mm evaporation = 15 x (300 + 100 - 110) = 4.4 t/ha
4. Nitrogen required for a 4.4 t/ha crop at 11.5 % protein:
   N required = 4.4 x (11.5/5.7) x 20 = 177 kg/ha
5. N required - N mineralised - N measured at sowing = 177 - 63 - 80 = 34 kg/ha
6. The amount of Urea required is 34 x (100/46) = 74 kg/ha
   (note: Urea is 46% nitrogen)

Acknowledgements

The data used in the model was provided by John Williamson, Matthew Macmillan, Anne Jackman and Heather Anderson from DCNR. The trial work in the FAST and MEY projects included more than 15 sites. Neil Sutton helped with the analysis.

Note: the model outlined above is still in the initial stages of development. The model will be further tested in 1994. Consequently when using the model due care should be taken in interpreting the Nitrogen fertiliser requirements.

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REMEMBER: BCDS Field Day - 14 September