Managing Your Crop's Nitrogen

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Overview:
Nitrogen is needed in much greater quantities than other nutrients to produce high wheat yields and proteins. In lower rainfall areas, most of this nitrogen comes from the mineralisation of soil organic matter. A range of nitrogen indicators such as paddock history, preceding crop yield and protein, deep soil tests, shoot density and sap nitrate and NIR tests are available to help fine tune nitrogen management. Deep soil nitrogen tests combined with simple nitrogen budgeting show promise for deciding on the best crop type for a paddock and for pre-plant nitrogen application rates. In-crop shoot and nitrogen measurements can aid topdressing decisions. Worthwhile responses to topdressing can be achieved in wetter years even in lower rainfall areas.

Background

Nitrogen is a major crop nutrient for cereals, required in much larger quantities than nutrients such as phosphorus and sulphur. For example, a 3 t/ha crop removes 50-70 kg of nitrogen compared to 8-9 kg of phosphorus and 4.5 kg of sulphur, yet many paddocks receive little fertiliser nitrogen. Applying DAP fertiliser at 80 kg/ha supplies only 14 kg/ha of nitrogen. Most of the nitrogen therefore comes from decomposing soil organic matter.

More than 90% of the nitrogen in the soil is in, the organic form which is unavailable to plants. A typical red soil in the lower rainfall area contains about 1.5 t/ha in the surface 10 cm out of a total of about 3 t/ha in the root zone. This material has accumulated over many years and if it is to be maintained then nitrogen inputs are required from fixation by legumes and from fertiliser. The wheat plant obtains its nitrogen from the soil as mineral nitrogen, particularly nitrate. This mineral nitrogen is produced by soil microbes breaking down organic matter, a process which is fastest in warm and moist conditions. Mineralisation occurs predominantly in the surface soil because it contains most of the organic matter and in average years about 2-5% of the organic nitrogen is mineralised. Rates are usually highest after rain in spring, summer and autumn and mineralisation occurs during plant growth if soil moisture is available. The nitrate produced can be leached by heavy rainfall deeper into the soil profile and this, together with mineralisation at greater depths means that shallow soil tests will underestimate the amount of nitrate available.

Nitrogen is required for all aspects of wheat growth and severely deficient crops are often yellow and stunted with small leaves and few tillers. Adding nitrogen to deficient sites will increase leaf area development, the number of fertile tillers and the number of grains per hectare. Mineral nitrogen can be taken up by the roots of the wheat crop throughout its growth. For maximum yield, nitrogen supply from tillering to ear emergence is critical as this period sets the upper limit to the number of grains per ha. For grain protein, nitrogen supply after ear emergence is important as soil nitrogen absorbed during this period is transported largely to the developing grain. The other source of grain protein is nitrogen compounds translocated from other parts of the plant such as senescing lower leaves. The relative contribution of these two sources to grain protein varies but typically 70-80% comes from plant parts and 20-30% from soil uptake and plant roots.

Nitrogen Indicators

Managing nitrogen is crucial to achieving crops of the desired yield and protein. A number of indicators are available to help decision making as to the crop type most suited to a paddock, the likely requirement for pre-sowing nitrogen fertiliser and the likely response to topdressing.

1. *Paddock history*

The value of farmer and adviser experience based on paddock history should never be underestimated. However, this knowledge can be hard to transfer between farms and adapt to new rotations.

2. *Preceding crop yield and protein*

The protein level of the preceding crop can be a useful indicator of soil nitrogen status. This approach has been useful in northern NSW where a number of cereal crops are grown in succession. Protein levels below about 11% indicate inadequate nitrogen supply for maximum yield in that crop. Grain yield should also be considered as high proteins can result simply from low yield caused by poor early weed control or unusually low rainfall.

3. *Calculated mineral nitrogen supply*

In southern and western Australia nitrogen calculators have been developed which estimate mineral nitrogen based on paddock history, organic carbon and average rainfall. These have proved useful but are less suited to central NSW where mineralisation is much more variable. Computer models which use actual daily rainfall appear more promising.

4. *Deep soil tests*

Soil mineral nitrogen can be measured prior to sowing or even in crop, but sampling needs to be deep enough to estimate the nitrogen which the crop will recover. Sampling should be to at least 60 cm and preferably deeper if soil moisture extends deeper than this. Samples must be kept cool or quickly dried at moderate temperature before testing. Allowance must be made for further mineralisation between sampling and sowing time and for in-crop mineralisation. A sufficient number of cores must be taken to properly represent the paddock.

5. *Sap nitrate tests*

Once the crop is growing, plant tests can be used to estimate nitrogen status and likely response to topdressing. Basal stem sap nitrate gives a good "snapshot" of nitrogen status at the time of testing but levels fluctuate due to current weather conditions, herbicides etc. Best results come from measurements taken at least twice in a two week period and calculating the rate of decrease.

6. *Shoot density*

The number of shoots (tillers) per square metre at the end of tillering is a useful tool for estimating the likely response to nitrogen topdressing. The number is related to nitrogen uptake provided tiller number is not restricted by other factors. In the medium rainfall (450-650 mm) zone, yield responses are likely where there are less than 500 shoots per square metre. There is little information for the lower rainfall areas.

7. *Crop nitrogen concentration (NIR)*

The nitrogen concentration of the whole plant can be used as an indicator of nitrogen status, and this can be accurately assessed using near infra-red reflectance. The total nitrogen content does not show the short term fluctuations seen with sap nitrate, but conversely it is less indicative of current nitrogen supply. The fructan content of the plant is also measured and this value can be useful in identifying other limitations to crop growth. As with sap nitrate, crop growth stage should be accurately determined. The value of this test is likely to be improved if combined with a dry matter or shoot density value.

Nitrogen Budgeting

A useful approach to nitrogen management is nitrogen budgeting. This involves selecting a target yield and grain protein, calculating the nitrogen required to achieve this, and then comparing this with the nitrogen available. A target yield can be selected based on past experience or calculated using stored moisture, decile rainfall and water use efficiency. Target protein is set in a similar way. However, these estimates need to be realistic.

Nitrogen requirement.

Once these targets have been set, the amount of nitrogen in the grain and the available soil nitrogen needed to attain these yield and protein levels can be determined from Table 1. N-rem is the nitrogen removed in the grain and N-Req is the soil nitrogen required. For example, a 3.0 t/ha crop at 11% protein removes 58 kg of nitrogen and requires 120 kg/ha of soil nitrogen. Note that the efficiency of nitrogen removal decreases as the protein level increases. Therefore high levels of nitrogen are required for 13% protein and higher. *Nitrogen supply.*

The nitrogen supply can be calculated using a deep soil nitrogen test, an estimate of mineralisation between sampling and crop maturity, and any nitrogen fertiliser applied. An example of such a calculation is shown in Table 2. The soil test value is converted to kg/ha of nitrogen using bulk density (assume 1.4 if no better estimate) and the depth of sampling. An allowance for mineralisation is used based on organic carbon. Some budgets also use average growing season rainfall to calculate this as it is usually higher in wetter areas. For much of the lower rainfall central west an allowance of 30 to 40 kg is appropriate depending on deep sampling time. To this is added the nitrogen applied as fertiliser which is generally quite small unless urea is used. These values are then totalled, giving a value of 137 Kg/ha of nitrogen in the example. From Table 1, this would be sufficient for almost 4 t/ha at 10% protein or 3 t/ha at 12 % protein but only 2.0 t/ha at 14% protein.

If the calculated nitrogen supply exceeds that required for the target yield and protein then no action is required if the crop is milling wheat. While the figures would need adjusting for barley, a high value here would suggest growing some other crop. If the calculated nitrogen supply is less than the required nitrogen level then the options could be

- reduce your yield or protein expectations
- consider the economics of pre-plant urea
- delay a decision and, depending on the season, topdress urea - this is less reliable in lower rainfall areas.
- Change crop type to a malting barley or a pulse crop.

Table 1. Guide to Nitrogen Content in Wheat Grain at Various Yield and Protein Levels

The following table is a guide to nitrogen in grain at various yield and protein levels of wheat versus the available soil nitrogen required to attain these yields and protein levels.
(Nitrogen removal figures are in light type and **soil N requirement figures are in bold type)**

Wheat Protein (%)

Wheat Yield	8		9		10		11		12		13		14		15	
	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req	N-Rem	N-Req
1.0	14	28	16	32	18	35	19	40	21	47	23	59	25	71	26	82
1.5	21	42	24	47	26	53	29	60	32	71	34	88	37	106	39	123
2.0	28	56	32	63	35	70	39	80	42	94	46	115	49	141	53	184
2.5	35	70	39	79	44	83	48	100	53	115	57	147	61	176	66	206
3.0	42	84	47	95	53	105	58	120	63	141	68	176	74	212	79	247
3.5	49	98	55	111	61	125	68	140	74	165	80	206	86	247	92	288
4.0	56	112	63	128	70	140	77	160	84	188	91	235	98	282	105	329
4.5	63	126	71	142	79	158	87	180	95	212	103	265	111	317	118	370
5.0	70	140	79	158	88	175	97	201	105	236	114	294	123	353	132	411
5.5	77	154	87	174	96	193	106	221	116	259	125	323	135	388	145	452
6.0	84	168	95	189	105	211	116	241	126	283	137	353	147	423	158	493

Nitrogen removal efficiencies generally decrease with increasing grain protein.

* Guidelines for soil nitrogen removal efficiency figures for increasing grain protein in wheat At a given yield derived from nitrogen research trials 1966-1991, conducted jointly by Incitec and NSW Agriculture in Central and Northern NSW. These figures should be used as a guide only - various factors may alter these efficiencies, such as seasonal conditions, plant disease, P & Zn deficiencies, soil acidity and soil sodicity.

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Table 2 Calculating nitrogen supply - Add up the amount of N from all sources:

Example ____ *N kg/ha*

1 **Soil test result in kg/ha of nitrogen** (N): to convert N in mg/kg concentration to kg/ha content

N kg/ha = N mg/kg X bulk density of soil (usually 1.4) X number of 10 cm layers in the depth of soil sampled

12.0	**1.4**	**6**	say **100**

2. **Expected amount of N which will be mineralised** between the time of sampling & when the crop starts drying off in October:
   This relates to the organic carbon content of the soil since organic matter contains about 58% carbon and 5% nitrogen, then 0.6% carbon translates to 21 kg/ha N becoming available
   0.8% carbon translates to 29 kg/ha N becoming available **say** 30
   1.0% carbon translates to 38 kg/ha N becoming available

3. **Fertiliser rate used in kg/ha of N:** * pre sowing nb. urea is 46% N
   * at sowing nb. MAP is 10% N **say** 7
   nb DAP is 18% N

   No more than 25 kg/ha of N can be applied in contact with the seed at sowing time (ie 140 kg/ha of DAP or 54 kg/ha of urea is the maximum rate).

Actual N available to crop during its growing season : **137**

Timing of Nitrogen Application

The relative advantages of pre-plant and topdressed nitrogen application are listed in Table 3. In lower rainfall areas, pre-plant nitrogen application is generally more reliable and should be used for at least part of the extra nitrogen required on low fertility paddocks. However, trials in the Condobolin area have shown excellent responses to topdressing in wetter years when the nitrogen requirement of the crop is higher than initially expected.

Table 3. **Advantages And Disadvantages Of Applying Nitrogen At Different Stages**

Crop Stage	**Impact**	**Advantages**	**Disadvantages**
Pre-sow **or** at sowing.	More tiller production, less available for protein.	Cheap application. Machinery availability. Yield increase 5% higher than topdressing.	Cashflow (high costs at sowing). Extra cultivation. Unknown paddock performance, seasonal conditions. Haying-off.
Topdressing for Yield	Increased tiller survival, some effect on grains/ear and protein.	Able to assess season, prices etc. Less risk of haying-off. Less weeds than pre-sow.	Ground application difficult. Not as uniform.
Topdressing for Protein	No effect on tillers, some effect on grains/ears, most effect on protein.	Opportunity to assess premium, season and crop conditions.	Expensive by air. Losses unknown with infrequent rainfall. Poor application techniques.