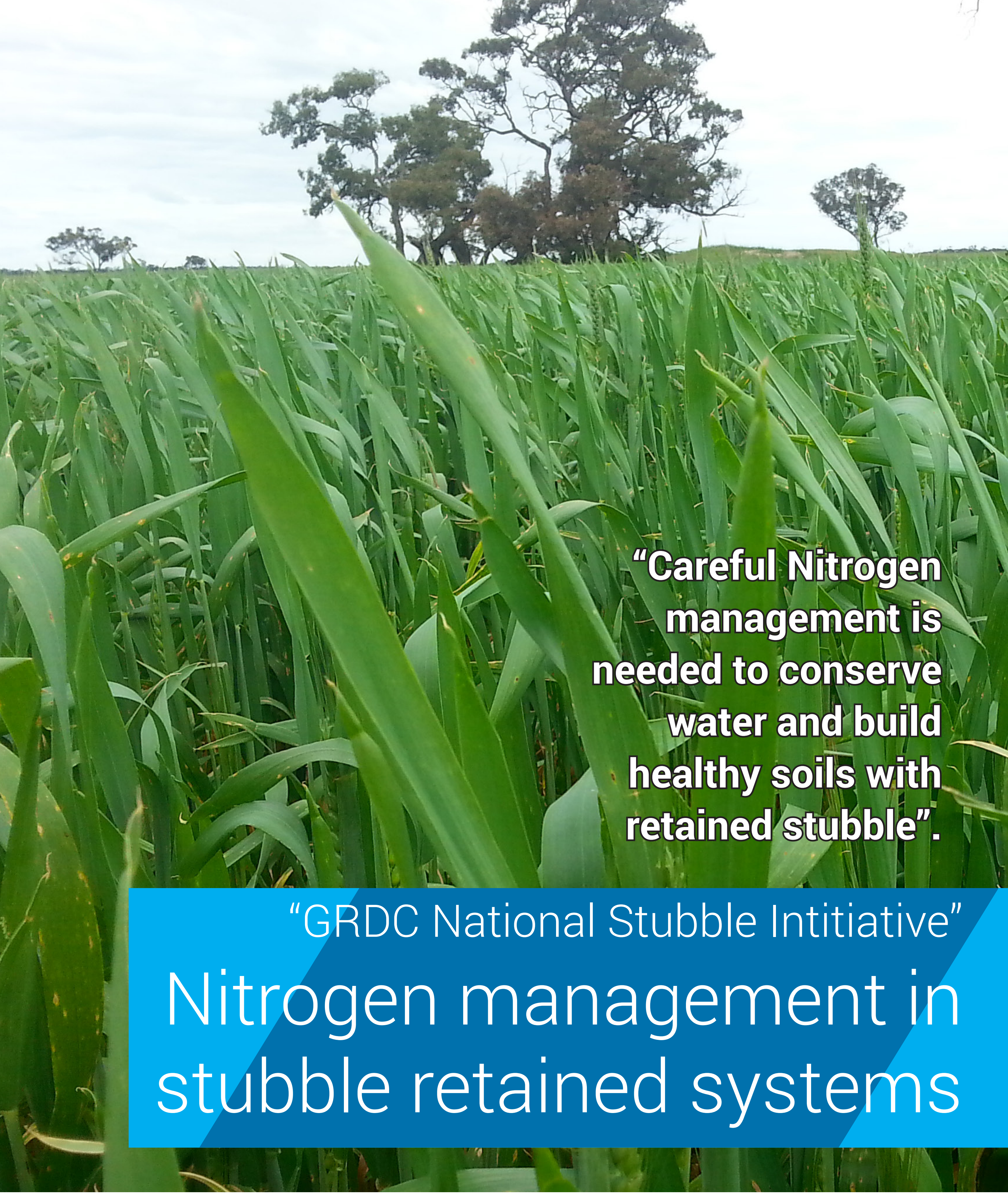

“Careful Nitrogen management is needed to conserve water and build healthy soils with retained stubble”.

“GRDC National Stubble Intitiative”

Nitrogen management in stubble retained systems

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Stubble retained systems need more N and need it earlier

Stubble retained, no-till systems need more N than systems where stubble is removed and soil cultivated prior to sowing. Soil bacteria and fungi that break down retained stubble compete with crop plants for N, and this has to be taken into account when budgeting N in stubble retained systems. A rough rule of thumb is that every tonne per hectare of cereal or canola stubble will tie-up (immobilise) 5 kg/ha of N. This means that in a paddock with a typical SE NSW cereal stubble load of 5 t/ha, 25 kg/ha of N will be tied up if the stubble is retained, and this must be compensated for with fertiliser N if yield is to be maintained.

Also, retaining stubble during the summer fallow and direct drilling can make more water available to crops compared to cultivated systems, and N must be added to turn this extra water into yield.

Crop plants grow slower in uncultivated soil, particularly when it is cooled by surface retained stubble. Wheat grown in stubble retained systems typically have higher incidence of yellow leaf spot which also reduces early plant growth. Providing up-front N increases early growth and can help alleviate these constraints.

Managing N in stubble retained systems

The process for managing N in stubble retained systems is relatively simple, and there are good rules of thumb to help with decision making, which are outlined below;

1. Soil test in March-April

2. If soil test results show less than 40 kg/ha N in the top 60 cm then apply some N at sowing. If there is more than 40 kg/ha mineral N then wheat and barley will make it to Zadoks stage Z30 (start of stem elongation) and canola will get to 6-leaf without losing yield potential.

3. Top-dress the majority of N at Z30-31 (mid-July – early August) based on your best assessment of yield expectations. Add 40 kg/ha N per tonne of anticipated wheat grain yield, 80 kg/ha N per tonne of canola and 35 kg/ha N per tonne of barley. In SE NSW this can be done 'by the calendar' without waiting for a rain event.

4. If conditions are favourable top-dress more N at Z39 in cereals (flag leaf emergence, early September) but at this time of year a rain after application is required to ensure plant uptake.

1. Soil Testing

You can't manage what you don't measure and soil testing is a vital first step in N management. This can be done by an advisor with appropriate soil coring equipment. Make sure samples are taken to at least 60 cm and as a bare minimum segmented into two depths (0-10, 10-60 cm). Segmenting the top soil away from the subsoil minimises the chances of measurement error cause by poor mixing of the N rich top-soil with the lower N sub-soil. Typically 6-8 cores are taken across a paddock and bulked into depths for analysis. Ensure bulked samples are very well mixed, and kept cool following sampling (keep in an esky in the ute, then transfer to a fridge/freezer back at the office). When sending samples away for analysis do this by express post, and send early in the week so that samples do not sit around in a hot post office over the weekend.

2. Soil Test Results

Soil tests report two forms of plant available N – nitrate (NO3) and ammonium (NH4). These need to be expressed as kilograms per hectare of N (kg/ha N). If they are reported as mg/kg (or parts per million, PPM) this number can be converted to kg/ha N by multiplying by bulk density of the soil (1.4 is a good rough value for SE NSW) and the sampling depth in decimetres (1 decimetre = 10 cm) over which the sample was taken, see worked example below.

Nitrate (NO3) value should always be much higher than ammonium (NH4) values on the test. If this is not the case, regard the results with extreme suspicion. Ask the lab to retest the samples, and if they are still high it is likely that samples got hot between sampling and analysis and results should be ignored.

EXAMPLE

Soil test results:

Depth (cm)	Nitrate NO3 (mg/kg)	Ammonium NH4 (mg/kg)
0-10	10	3
10-60	5	1

Calculate total soil mineral N by adding nitrate and ammonium;

Depth (cm)	Nitrate NO3 (mg/kg)	Ammonium NH4 (mg/kg)	Total mineral N (mg/kg)
0-10	10	3	13
10-60	5	1	6

Convert mg/kg to kg/ha N by multiplying by bulk density (1.4 kg/ha) and depth increment in decimetres (1 decimetre = 10 cm).

Depth (cm)	Nitrate NO3 (mg/kg)	Ammonium NH4 (mg/kg)	Total mineral N (mg/kg)	Depth Increment (dm)	Total mineral N (kg/ha)
0-10	10	3	13	1	18 (13 x 1.4 x 1)
10-60	5	1	6	5	35 (5 x 1.4 x 5)

Total mineral N = 18 + 35 = 53 kg/ha N

3. Applying N at Sowing

If soil tests results show that there is less than 40 kg/ha of mineral N (nitrate + ammonium) in the top 60 cm of soil, some N (at least 20 kg/ha N) should be added at sowing. If there is more than 40 kg/ha N then cereal crops will make it to Z30 and canola crops to 6-leaf without losing yield potential. If the soil test is less than 60 kg/ha N then you may want to add some N as the chances of getting a yield response are high.

There are different ways of adding N at sowing all of which are effective and have various pros and cons;

a. At sowing with the seed. Fertiliser products with a higher N content (e.g. 27:12) can be used to do this, urea blended with MAP or in air-carts with three bins urea added independently of seed and MAP. Be aware that higher rates of N fertiliser with the seed will reduce crop establishment, particularly with wide row spacing and low seed-bed utilisation (SBU) and particularly in canola (See table below).

b. At sowing deep- or side- banded. Same as above but higher rates can be applied as the fertiliser is separated from the seed and any effect on crop establishment is reduced.

c. Pre-drilled prior to sowing. This puts the N away from stubble and safe from gaseous loss and can be done well in advance of sowing, but requires another pass which is expensive and has the potential to delay sowing.

d. Spread and incorporated by sowing. Fast and cheap, but should be done close to sowing to avoid gaseous losses.

Approximate safe rates of N as urea, mono-ammonium phosphate (MAP) or di-ammonium (DAP) with the seed of cereal grains if seedbed has good soil moisture (at or near capacity).

	Row Spacing 25 mm seed spread			Row Spacing 50mm seed spread		
Soil Texture	180mm	229mm	305mm	180mm	229mm	305mm
SBU[3]	14%	11%	8%	29%	22%	17%
Light (sandy loam)	20	15	11	40	30	22
Med-Heavy (loam to clay)	25	20	15	50	40	30

4. Top Dressing

The most reliable time to top-dress N in cereals is at early stem elongation (Z30-31) which in SE NSW typically happens from mid-July to mid August depending on sowing time, variety and temperature. At this stage of development, tillering has largely finished and the risk of producing excessive tillers and 'haying off' cereal the crops has passed. Temperatures are still low, showers are frequent and on acid soils chances of gaseous losses are low. Consequently, urea can be safely spread 'by the calendar' at this time of year without waiting for a rain event to put it out in front of. The majority of the crops anticipated N supply should be added at this time.

If seasonal conditions are favourable N can be 'topped up' up until flag leaf emergence (Z39) in cereals (typically early September in SE NSW), but at this time of year rain is required to ensure plant uptake and prevent gaseous losses.

Canola can be top-dressed earlier than

cereals without risk of haying off, and this can be done by the calendar in June-July when temperatures are low, rain more frequent and chances of gaseous losses very low.

There is no Australian data that suggests any yield benefit of different forms of N for top-dressing (liquid vs. granules) and urea is by far the cheapest and most cost-effective source of N.

5. N budgeting-N requirement

The following are handy rules of thumb for calculating N requirement of a crop;

Wheat (11% protein): 40 kg/ha N per tonne of grain yield
Canola: 80 kg/ha N per tonne of grain yield
Barley: 35 kg/ha N per tonne of grain yield

In wheat, grain protein less than 11% indicates that crop yield was probably nitrogen limited. Targeting 11% protein will ensure yield is maximised and APW protein levels are achieved. The extra N required to achieve H1, H2 or APH may or may not be worth it, depending on the spread in prices and cost of urea.

6. N budgeting–N supply

The supply of N available to a crop consists of ;

1. Soil N available at sowing (as measured with soil test)
2. Net mineralisation in-crop (mineralisation – immobilisation)
3. Applied fertiliser N

Estimating net mineralisation in the N supply is tricky because it varies greatly depending on season and paddock history. Net mineralisation is a function of temperature, water availability, organic carbon and stubble type and amount. The majority of mineralisation happens in spring, and can vary from negative values in cold, dry years in paddocks with heavy stubble loads to more than 80 kg/ha in paddocks with a legume history during wet springs. Fortunately this component of N budgeting is 'self correcting' in that more N becomes available in higher yielding seasons. What figures you end up using are very much a personal choice. However, allowing for mineralisation in N budgets means that reserves of soil organic N and carbon will decline over time. In the case of stubble retained systems (particularly if continuous cropping without legumes) it is probably best to assume no net mineralisation when calculating N budgets, as N tie-up cancels out any mineralisation.

7. Estimating likely yield

Estimating likely yield is the trickiest part of N management and there is no perfect way to do it, as in SE NSW yield greatly depends on weather in September and October. Simple rules of thumb based on water limited yield potential can be useful, as are moisture probes and 'gut feel'. Yield Prophet® is able to give probabilities of different yields occurring based on seasonal conditions to date and historic climate, but it is not a perfect forecast and growers still have to decide what level of probability they are willing to accept. At the end of the day, growers and advisors still need to take a punt on what they think the season will bring and manage accordingly. The uncertainty associated with yield forecasting means that in practice N management has more to do with farm finances than agronomy. How much N fertiliser the farm business can afford to purchase and apply in any given season, and the business consequences of not getting the money back in the current season if targeted yields are not achieved should drive decision making. If N top-dressing decisions are made in conjunction with a farm adviser, they should be aware of financial position when making recommendations.

Given that cash flow and attitude to risk generally limit N application, inputs should be targeted to crops where a return on investment is most likely. Weed-free crops sown on time following a break crop or well managed pasture will have the highest yield potential. APH varieties that are better able to withstand weather damage (e.g. Ellison, Spitfire) are also less of a risk as there is a greater chance of receiving a premium for high protein if spring turns hot and dry.

8. Putting it all together

Once you have an estimate of anticipated yield that you are comfortable with, the maths of N budgeting are simple.

Total N requirement (kg/ha N) = 40 x anticipated yield (t/ha)

Top-dressed N requirement (kg/ha N) = Total N requirement – soil mineral N prior to sowing – starter N – mineralisation

See the worked example for wheat below.

EXAMPLE

Anticipated wheat yield = 4 t/ha

Total N requirement (kg/ha N) = 4 x 40 = 160 kg/ha N

Soil mineral N prior to sowing (from soil test) = 30 kg/ha N

N applied at sowing = 27 kg/ha N (applied as 35 kg/ha MAP (20% N) and 43 kg/ha of urea (46% N)

Mineralisation = assumed 0 kg/ha (many years of canola-wheat sequence with retained wheat stubble in current season)

Top-dressed N requirement (kg/ha N) = 160 – 30 -27 – 0

= 103 kg/ha N (223 kg/ha urea)

Author: DR James Hunt, CSIRO

GRDC Project: CSP00174 - Maintaining profitable farming systems with retained stubble in NSW south-west slopes and Riverina

Nitrogen banding

In 2016 and 2017, we investigate the potential role of nitrogen tie-up in the growth and yield penalties associated with cereal stubble. What we found was that deep-banding the N fertiliser had no impact on wheat biomass or N% at GS 30, but increased both the biomass and N content of the wheat tissue at anthesis more in the retained-stubble than in burnt stubble (Table 2).

Retaining stubble decreased biomass overall but not tissue N. N uptake (kg/ha) at anthesis was significantly increased by deep-banding in both stubble treatments, however the increase was substantially higher in the stubble-retain treatment than in the burn treatment (38 kg N/ha cf 15 kg N/ha). The overall impact of deep-banding on yield persisted at harvest, but there was no effect, nor interaction with stubble retention, presumably due to other interactions with water availability. However the fact that deep-banding N has had a bigger impact in the stubble retained treatment provides evidence of an N-related growth limitation related to retained stubble. It's appearance at anthesis, and not earlier, presumably reflects the high starting soil N levels which were adequate to support early growth but the cold dry winter generated N deficiencies as the crop entered the rapid stem elongation phase. The increased protein content related to both burning and deep-banding and its independence from yield, suggest on-going N deficiencies generated by those treatments.

Table 2 — Effect of surface-applied and deep-banded N on wheat response in stubble-burnt and stubble-retained treatments at long term Harden trial in 2017.

Treatment		Anthesis			Harvest (@12.5%)	
Stubble	100 N	Biomass (t/ha)	Tissue N (%)	N Uptake (kg N/ha)	Yield (t/ha)	Protein (%)
Retain	Surface	8.1	1.1	91	4.5	9.3
	Deep	9.1	1.4	129	5.1	10.2
Burn	Surface	8.9	1.2	104	4.5	10.3
	Deep	9.5	1.3	119	5.0	10.8
LSD (P<0.05)	*Stubble*	*0.6*	*ns*	*ns*	*ns*	*0.8*
	N	*0.2*	*0.1*	*8*	*0.2*	*0.4*
	Stubble x N	*0.6*	*0.2*	*12*	*ns*	*ns*