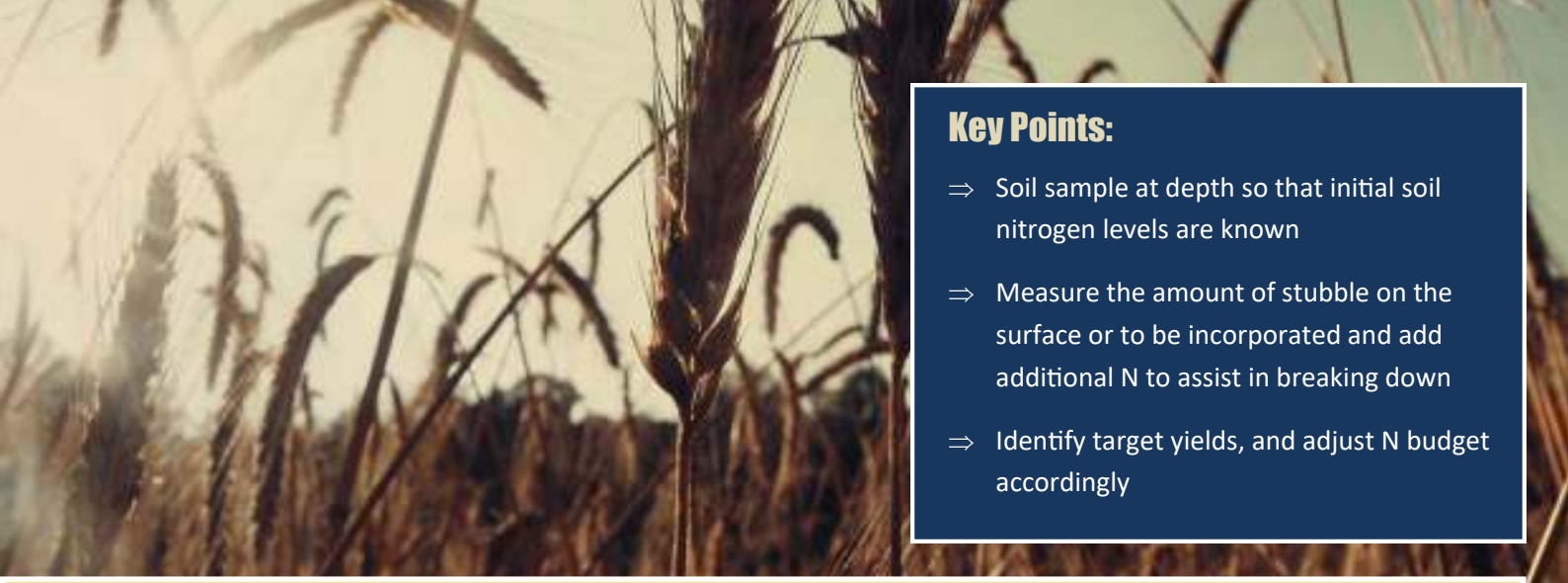


Key Points:

- ⇒ Soil sample at depth so that initial soil nitrogen levels are known
- ⇒ Measure the amount of stubble on the surface or to be incorporated and add additional N to assist in breaking down
- ⇒ Identify target yields, and adjust N budget accordingly

Nitrogen Management in Retained Stubble Systems

Background

Crop nutrition varies in stubble retained systems with more nitrogen (N) often being required early by the system to assist in breaking down the additional stubble load. A rough rule of thumb is that every tonne of canola or cereal grain will tie up (immobilise) approximately 5 kg N/ha. This is nutrient that is then not available to the crop until later in the season, once it has been mobilised or mineralised through microbial processes. This availability will depend on seasonal conditions, the soil type and other management factors such as crop type and time of sowing.

Knowing initial soil N levels and also the composition and quantity of the remaining stubble can assist in understanding what level of N is required to ensure good, early growth of the subsequent crop. Between 40-60 kg N/ha is required to get a cereal crop through to growth stage (GS) 30.

The incorporation of stubble with speedtillers or disc chains will increase the amount of nutrient that is tied up through immobilisation and if soil N levels are low, applying nutrients at the time of incorporation to increase the rate of humification may assist in reducing the amount of nitrogen that is immobilised (refer to Fallow Management Guideline[2]).

Introduction

This guideline has been developed for the MacKillop Farm Management Group (MFMG) as part of the project "Maintaining Profitable Farming Systems with Retained Stubble in the South-East and KI regions", funded by the Grains Research and Development Corporation (GRDC) as part of the Stubble Initiative.

The Stubble Initiative involves farming systems groups in South Australia, Victoria, southern and central New South Wales and Tasmania, collaborating with research organisations and agribusiness to address challenges associated with stubble retention, including weeds, pests, disease, nutrition and the physical aspects of managing stubble.

Nitrogen Processes

Immobilisation

Nitrogen immobilisation is the conversion of inorganic to organic N by microbes or plants. This occurs when the carbon/nitrogen (C:N) ratio of the plant residues in the soil exceed 30:1 (e.g. stubble) and the soil microbial population requires nitrogen in mineral forms (e.g. nitrate) to help break it down. This is commonly referred to as nutrient "tie-up" where soil N is being utilised to break down the high C:N ratio plant matter and isn't available to the growing crop potentially causing nitrogen deficiency.

Mineralisation

Is the reverse process of immobilisation. It is the conversion of organic N to plant available inorganic forms of N. It occurs with moisture, warm temperatures and a carbon source for the microorganisms. Mineralisation will occur during the growing season where soil temperatures are greater than 5°C, however the rate of mineralisation will increase with increasing soil temperatures.

Soil nitrogen levels

Understanding the initial soil N levels will assist in establishing the N requirements for the crop at sowing. These soil N levels combined with the stubble load and estimated amount of N required to minimise the impacts of immobilisation will determine the initial amount of fertiliser N that is required at the start of the season.

Soil tests typically provide an indication of nitrogen as mg/kg of soil. This figure needs to be converted into kg/ha to provide a meaningful measure for a paddock. To do this, the bulk density of the soil needs to be known. Figure 1 below shows a map of the South-East and location of sites where bulk density has been measured or estimated for use in APSIM modelling. There is currently only one soil characterised on Kangaroo Island – an Ironstone soil at Seddon. These figures are available through the CSIRO Soil Mapp App or online[3]. Identifying a soil with similar characteristics and utilising these will give an indication of the bulk density of your soil.

Figure 1. Location of characterised soils across the South-East of SA[4]

Soils with higher bulk densities are often sandier soils or those that are heavily compacted as there are less pore spaces. In clay soils with good structure, the bulk density is less with increased pore spaces. Soil Water Express[4] (SWE) is another tool developed by CSIRO, and if you know your soil texture through the profile, this data can be placed into SWE and an estimated bulk density can be obtained (but use with caution – particularly if the soil is compacted).

To accurately determine your soils bulk density, refer to the soil quality website www.soilquality.org.au.

Once the bulk density has been established, the amount of N can be converted from mg/kg to kg/ha using the process shown in Figure 2.

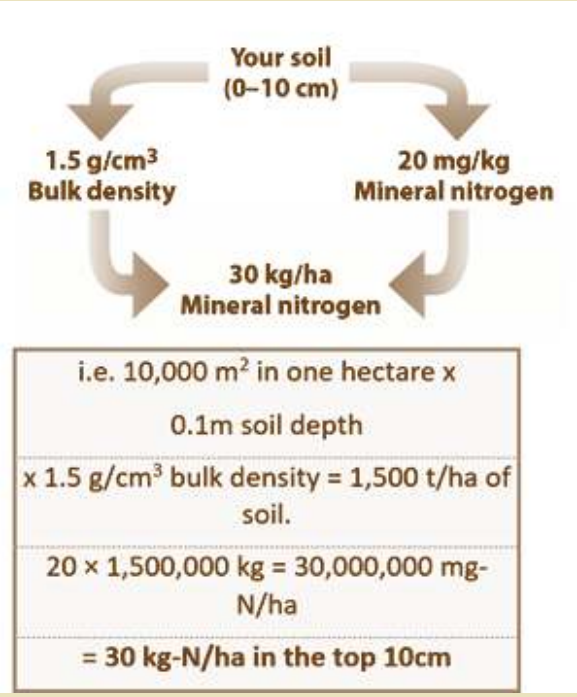
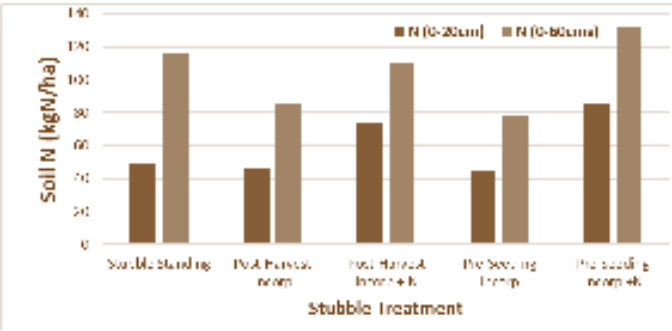


Figure 2. Converting soil test to actual kg/ha N (Source: Fraser, M, 2017 MFMG Field Day booklet)[5]

Effect of cereal stubble on soil N

The impacts of stubble on soil nitrogen levels were observed at Millicent in 2015. A speedtiller was used to incorporate wheat stubble either immediately post-harvest or pre-seeding with and without the inclusion of nitrogen. A comparison of soil nitrogen between five different stubble management treatments (standing stubble, post-harvest N incorporated, post-harvest incorporated, pre-seeding N incorporated and pre-seeeding incorporated) are shown in Figure 3.

Figure 3. Soil N levels two weeks post-sowing at 0-20cm and 0-60cm under different stubble treatments, Millicent 2015.



These results support the work conducted by CSIRO where they have shown that nitrogen tie-up by cereal residue is not just a problem following incorporation, it also occurs in surface-retained and standing-stubble systems[6].

The nitrogen tie-up is only a temporary constraint as the immobilised N will be released by microbial turnover later in the crop season (generally in spring).

The general recommendation to manage tie-up is to supply more N (5kg N for each t/ha of cereal residue) early in the crops life to avoid impacts of N tie-up on crop yield.

Cereal stubble should be thought of as a source of carbon (C) for microbes, not as a source of nitrogen (N) for crops. In no-till systems, only 1% to 6% of the N requirement of crops is derived from wheat stubble.

Break crops such as a legume or canola stubble have a lot lower C:N ratio and therefore tie-up less N.

The role of break crops is discussed further in the Break Crops Guideline[7].

Grazing stubbles

Research conducted by CSIRO has shown sheep grazing both stubbles and crops increased the availability of soil mineral N to subsequent crops which increased grain yield and protein in some seasons.

It was found to be important to maintain 70% stubble cover (2-3 t/ha cereal stubble) on the soil surface when grazing (refer to Fallow Management Guideline). Sheep grazing on stubble increased soil strength and bulk density and reduced water infiltration rates, but rarely to levels that impacted on soil water capture, crop growth or grain yield. Where infiltration rates did reduce soil water capture, it was due to removal of cover rather than compaction by hooves.

This suggests that livestock can be retained within modern conservation cropping systems without compromising crop performance, and continue to provide the production and business risk benefits providing grazing is monitored and areas are not over-grazed.

Figure 4. Sheep grazing cereal stubble, Upper South-East, 2018

Nitrogen budgeting

1. Know soil N available at sowing (as measured with a deep N soil test)
    - 0-10cm, 10-60cm
    - Convert to kg N/ha by using estimated (or measured) bulk density

2. Establish net mineralisation in-crop (mineralisation-immobilisation)
    - If incorporating cereal or canola stubble, may need to add some extra N to ensure soil levels are above 60kg N/ha to reduce impacts of tie-up (immobilisation early in the crop)
    - Mineralisation will provide additional N to the crop - particularly in spring when soil temperatures warm up. The amount will depend on soil type and crop rotation history (e.g. pulses in the rotation will generally result in more N being mineralised when compared with a canola-wheat rotation)

3. Applied fertiliser N - the additional amount of N required above soil N and mineralised N to provide crops with the amount required to achieve target yields
    - Wheat (11% protein) - 40 kg/ha N per tonne of grain
    - Canola - 80 kg/ha N per tonne of grain
    - Barley - 35 kg/ha N per tonne of grain

Acknowledgements

- Andrew Ware, Amanda Pearce and SARDI New Variety Agronomy Team, Struan
- Jenny Stanton, Keith Bolto, AgKI
- Vadakattu Gupta, John Kirkegaard, Therese McBeath, Tony Swan, CSIRO Sustainable Agriculture Flagship

References

[1]Vadakattu Gupta (CSIRO Agriculture and Food, Waite Campus), Personal communication, 2018
[2]Fallow Management in Retained Stubble Systems, MFMG, 2018
[3]https://www.csiro.au/en/Research/AF/Areas/Sustainable-farming/...tools/SoilMapp
[4]https://www.apsim.info/Products/APSoil.aspx
[5]Fraser, M, MFMG Field Day Booklet, 2017
[6]Vadakattu Gupta, Kirkegaard J, McBeath T, Richardson A, Swan A, Hunt J, 'The effect of stubble on nitrogen tie-up and supply' GRDC Update Papers, 2018
[7]Role of break crops in retained stubble systems, MFMG, 2018
[8]Swan AD, Hunt JR, Bresut PD, Pratt T, Rheinheimer B, Jones K, Kirkegaard J. 'The effect of grazing and burning stubbles on wheat yield and soil mineral nitrogen in a canola-wheat-wheat crop sequence in southern NSW'. Proceedings of the 18th Australian Society of Agronomy Conference, 2017

Further Information

Guideline produced by Felicity Turner for the MFMG
fturner@mackillopgroup.com.au
www.mackillopgroup.com.au