CROP NUTRITION
- THE BEST OF 2018

GRDC COMMUNITIES

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NSW GOVERNMENT Department of Primary Industries

Crop Nutrition

- the best of 2018

GRDC's Crop Nutrition Community of Practice continues to be an invaluable extension initiative for industry.

The CoP's core mission to provide the broader cropping and advisory sector with reliable, credible information on crop nutrition has resulted in ongoing collaboration between key research scientists to produce an esteemed collection of extension resources. Since its establishment in 2015, the CoP has developed and shared articles, videos, and eBooks aimed at enhancing productivity and inspiring innovation amongst industry organisations, advisors, public and private sector specialists, and growers alike. This eBook features a collection of 2018's most-read articles, reflecting the year's seasonal conditions and emerging issues in crop nutrition.

As it stands today, the Crop Nutrition Community of Practice has a total of 44 members including individuals representing government, not-for-profit and private Research Development & Extension organisations. Each member plays a pivotal role in contributing to the knowledge and information shared to support industry, including current crop nutrition issues, guidance for management decisions, and additional sources of peer-reviewed research and information. The focus of 2019 is to develop awareness amongst industry of the decision support tools available to them, as well the importance of a planning and evaluation cycle to enable better cropping decisions and outcomes for all involved.

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Contents

Try these new decision support tools to do better in the HRZ

PUBLISHED - 28 FEBRUARY 2018
BY MALCOLM MCCASKILL, ELLY POLONOWITA, AGRICULTURE VICTORIA

Making fertiliser decisions can be difficult. Paddocks in the HRZ have high yield potential. Actual yields often fall short even in high input cropping systems.

Fertiliser decisions in the HRZ:

- Under-fertilising appears to be a major cause of yield gaps in the HRZ.
- You get the best return on nitrogen (N) investment with enough phosphorus (P), potassium (K) and sulphur (S).
- Critical values for nutrient levels in soil need to be re-aligned for the HRZ.

Developing new tools to help

Three tools in development could help estimate the most economic rates of fertiliser. The tools support decisions for wheat and canola crops during the growing season. They allow for first-rate decisions at sowing. Then at early stem elongation, you can check top-up rates when yield outlook is clearer.

Fertility response relationships are based on nutrient response trials across the Southern Region. Researchers will continue field trials and gather feedback from advisers and growers. They'll refine the critical nutrient soil levels and crop yield responses in the tools. In time the tools will become more specific to the HRZ.

These tools are in a pilot phase and only 5 sites are available. More sites will be added in August. They have not been reviewed by the GRDC Communities Crop Nutrition CoP. The developers would like your feedback (see below)

Tool 1: Awareness

A quick first look to see how current P, K or S levels could limit crop response to N. It uses input data to estimate how profitable it is to apply N to wheat or canola with different:

- P, K & S levels
- seasonal outcomes
- market prices.

Feedback questions: Do you consider the estimates it provides are reasonable? Is the information easy to follow? Are the terms explained well? Is this useful?

DOWNLOAD THE HRZ NUTRIENTS 'AWARENESS' TOOL (1) AS AN EXCEL FILE.

Tool 2: Planning and Evaluation

Note that the "Planning" and "Evaluation" tools have now been combined.

Plan for macro-nutrients (N,P,K,S) to apply at sowing using commodity prices and climate forecasts. The tool offers the opportunity to "top-up" in-crop N application as the season develops.

Assess whether nutrients were under or over applied at the end of the season. Look back at the N, P, K and S applications for a crop to check if you used the most profitable combination of nutrients.

Feedback questions: Feedback questions: Do the at-sowing rates seem reasonable? Are the soil test values appropriate or is there missing information? Is it too simple or too complicated? Is it easy to follow? Does it reflect the responses you have seen in the HRZ? Is this useful? Does this seem reasonable? Is it close to the sorts of application rates used? Are the soil test levels used reasonable from your experience? Is it easy to follow? Is this useful?

DOWNLOAD THE HRZ NUTRIENTS 'PLANNING & EVALUATION' TOOL (1) AS AN EXCEL FILE.

Help improve the fertiliser decision tools

We want your feedback on how the tools perform. Did they aid your fertiliser decision making? Share your feedback at communities.grdc.com.au/crop-nutrition

The Excel tools are at present only populated for 4 sites in south-western Victoria, and one site in the SE of South Australia. More sites will be added in the near future, including Skipton (Vic), Seaspray (Gippsland, Vic) and Campbell Town (Tas).

If you have other suggestions of sites in the high rainfall zone to add that are relevant to you, please contact
Dr. Malcolm McCaskill, Research Scientist – Soils.
Email: malcolm.mccaskill@ecodev.vic.gov.au
Phone: (03) 5573 0957

These decision tools are part of the project: Optimising yield and economic potential of high input cropping systems in the high rainfall zone (HRZ).

More information:

GRDC

- GRDC update paper
- GroundCoverTM: Yield potential rises in the high-rainfall zone
- Production Economics: Are you maximising your profits?

CropPro

- CropPro
- CropPro wheat nutrition
- CropPro canola nutrition
- Economic Videos: Diminishing Marginal Returns

PLANNING THE SEASON ARTICLE 2

How to keep bulk fertiliser deliveries safe

PUBLISHED - 13 JUNE 2018
BY JEFF KRAAK, FERTILISER AUSTRALIA

Photo: Silo collapse – Jeff Kraak

Bulk fertiliser deliveries can cause accidents and near misses. Overhead obstacles, unsafe access, and dumped product are potential hazards.

Fertiliser safety is everyone's responsibility. The Heavy Vehicle National Law (HVNL) will soon be amended to reflect this. The changes mean that every party in the supply chain – not just the driver – has a duty to ensure safety.

How to organise a smooth bulk delivery

For growers, this means making sure truck access, unloading, and cleaning activities are safe. When organising a bulk delivery, think about:

Access:

- Can farm roads handle heavy trucks?
- Are there creek crossings, and are they safe for a truck?
- Are there any low branches or powerlines that might be in the way of a 4.3 m high truck?
- Make sure you inform the delivery driver of any concerns.

Unloading:

- Unload on flat ground away from trees and powerlines.
- Make sure people and animals are clear of the tipper.
- Don't unload near watercourses, even if they are dry.
- Make sure silos are strong enough to hold the fertiliser. Most fertilisers weigh more than the same volume of grain.

Cleaning

Most fertiliser depots have an area to clean out trucks. However, it is best if the driver cleans the truck out on farm before leaving. This helps prevent product being dumped on the roadside and cross contamination of the next load.

About 15% of Australian cereal or canola crops use fungicide - treated fertiliser. Blending fungicide with fertiliser can make it easier to apply. After carrying chemically treated fertilisers, trucks need to be washed out with a food grade cleaning product, particularly if the truck will then carry grain. When treated fertiliser is delivered, growers should provide a suitable wash down area on-farm.

FOR A MORE COMPREHENSIVE LIST SEE THE FERTCARE® GUIDELINES (SEE BELOW) ON UNLOADING BULK SOLID FERTILISER ON FARM.

More information:

- Fertcare® guidelines on unloading bulk solid fertiliser on farm.
- How to protect your grain – prevent contamination
- Fertiliser handling code of practice
- Truck washing fact sheet
- National Heavy Vehicle Regulator – changes to chain of responsibility

How much nitrogen can pulses supply to the next crop?

PUBLISHED - 4 JULY 2018
BY HOWARD COX, DAF QLD

Growing pulses can increase soil nitrogen (N) stocks. Researchers in QLD have developed some rules of thumb to estimate pulse-N contribution to the next cereal crop. The rules apply to chickpeas and faba beans.

Calculating N from pulses

Good crops

In a good chickpea or faba bean crop:

Extra N (kgN/ha) = grain yield (t/ha) * 20

For example, a good chickpea crop yielding 3 t/ha will supply an extra 60 kgN/ha.

Another rule of thumb from southern NSW suggests using grain yield (t/ha) * 18 to calculate additional N contribution.

Poor crops

In a semi-failed crop:

Extra N (kgN/ha) = crop biomass (t/ha) x 10

For example, a frost-affected crop with a biomass of 1 t/ha will supply 10 kgN/ha.

Should you change your N rate?

Consider reducing N fertiliser if the pulse crop has supplied more than 40 kgN/ha. Consider N contributions less than 40 kg/ha a boost to soil reserves. The next crop probably still needs normal N rates.

Use soil tests as well

Always check soil N stocks with soil tests. The amount of N a pulse fixes varies, and is affected by:

- crop species
- soil conditions (moisture, organic matter, N levels)
- seasonal conditions
- crop performance.

If available soil N is > 100 kg/ha, pulses are unlikely to have fixed much N. In high N soils, pulses take advantage of the existing N rather than fixing their own.

More information:

- Webinar: How to check your pulse-N
- The best resource on fertiliser N and legumes in the northern region
- Think twice before sowing chickpeas into high nitrogen soils
- Adding N with Legumes
- How effective are high nitrogen rates for canola wheat rotations?
- How to account for stubble nutrients next season

SOIL TESTING ARTICLE 1

Soil testing

PUBLISHED - 8 FEBRUARY 2018
BY ROB NORTON, ANZ IPNI

Soil testing informs crop nutrition decisions. Collecting representative samples is the most important step in getting useful information.

Plan your soil sampling

- Map non-uniform paddocks into zones. Base the zones on observed soil differences (or EM38 maps if available), and sample them separately.
- Use a sampling plan within zones. Grids, zig zags and randomised are the common styles. Taking more samples within each zone improves the reliability of the analysis – and fertiliser recommendations.
- Use a consistent method to take samples.

Tips for collecting soil samples:

- Sample at the same time each year, as many soil properties change with the season. Sampling each year is ideal, but you can often get away with sampling paddocks every 2-3 years. Soil test values for immobile nutrients change slowly.
- Map sampling areas. Keep GPS records of collection sites.
- Collect more than 20 cores or sub-samples from the sampling zone.
- Use a sampling tool e.g. soil probe, tread sampler, auto-corer. A shovel is not a good collection tool as depth is hard to control. Tapered tools (such as a trowel) bias the sample with more soil from upper layers.
- Place samples into clean plastic bags, or a clean plastic bucket. Metal containers can contaminate the sample, especially for micronutrient tests.
- Avoid areas that may have abnormal soil nutrient levels (e.g. headlands, old fertiliser dumps, areas near trees, fence lines, roads, tracks and stock camps).
- Sample to the correct depth for the information you need:
  - 0-10 cm is the most common depth for samples (P, K, S, micros)
  - 10-60 cm for deep samples (N, K, S)
- Subsoil samples (>10 cm) can examine chemical constraints limiting root depth, such as pH (v. high or v. low), sodicity, salinity, and boron
- Obtain more precise information on nutrient distribution by sampling depth intervals separately (e.g. 0-10, 10-20, 20-30, 30-60cm).

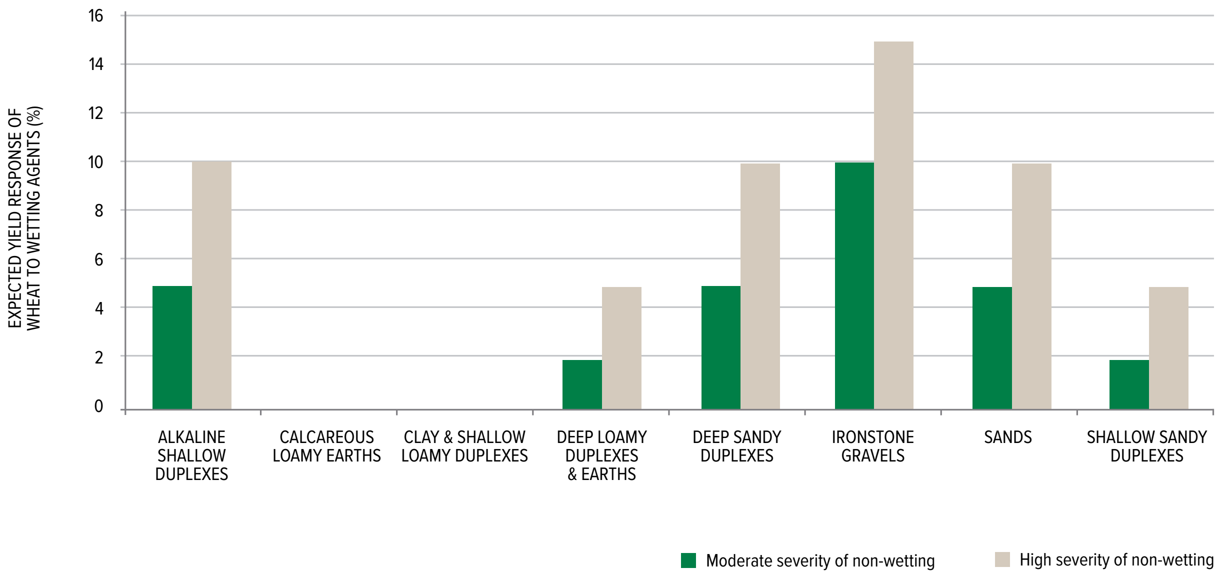
Look after your samples:

- Keep samples cool in an esky or fridge – important for N in moist soils.
- Thoroughly mix the cores from a sample area, breaking up clods. DON'T ASSUME THIS WILL BE DONE AT THE LAB.
- Check with the lab you are dispatching to on how to pack the sample. Some laboratories provide bags or containers. Make sure your packing containers or bags are new and clean.
- Fill out the lab's information sheet completely and keep a copy.
- Dispatch samples as soon as possible.
- Use ASPAC/Fertcare accredited laboratories. These labs use methods accepted in Australia and have demonstrated that they achieve accurate results.

Which soil problem should you fix first? Ask ROSA

PUBLISHED - 15 NOVEMBER 2018
BY JEREMY LEMON, DPIRD

Western Australian growers with multiple soil constraints can check which one is costing them the most. The WA tool, Ranking Options for Soil Amelioration (ROSA), assesses which soil management options will give the biggest return on investment. WA croppers lose $4.3 billion each year from soil constraints. Most losses are in the central and northern grainbelt.



How does ROSA work?

ROSA addresses the five most common soil constraints:

- topsoil acidity
- subsoil acidity
- non-wetting
- subsoil compaction
- soil structure decline.

Users enter data on their soil, rotations, current and expected yields, and budget. ROSA then estimates potential yield after improving the soil. The tool considers both single soil amendments and combinations, now and for the next 10 years.

Soil amendment options include:

- claying
- deep ripping (>40cm)
- gypsum
- liming to address topsoil acidity
- liming to address subsoil acidity
- soil mixing (<40cm)
- wetting agents.

Each soil amendment or combination is assessed with a Benefit Cost Ratio (BCR), estimating the return on dollars spent. A BCR summarises the overall 'value for money' of a project. The higher the BCR, the better the return on investment.

Default model data comes from WA growers, advisors, and research. You can adjust grain yield responses and costs to reflect conditions on your farm.

ROSA is a ranking tool

It is important to remember that ROSA is a ranking tool. It is designed to group and rank options, not give precise amendment rates or savings. ROSA helps identify which soil constraint(s) are costing growers the most.

Want to try ROSA out?

Contact Jeremy Lemon at jeremy.lemon@dpird.wa.gov.au.

ROSA is a spreadsheet tool, best used in the office or on a laptop.

More information:

- How soil inversion can turn the tables on soil constraints
- Looking for better yields from sandy soils?
- Compaction concerns showing up in soil pits

SOIL TESTING ARTICLE 3

What is the DGT Phosphorus test and when should you use it?

PUBLISHED - 2 AUGUST 2018
BY SEAN MASON, AGRONOMY SOLUTIONS

The Diffusive Gradient in Thin-films (DGT) Phosphorus is an alternative P soil test. Colwell-P can overestimate available P on calcareous soils, and acid gravel soils.

How does the DGT test work?

The DGT is a cylindrical plastic device that uses an iron oxide gel as a P-sink, which attracts available P through a membrane. To run the test, a soil sample is moistened to 100% water holding capacity. The DGT device containing a clear membrane, followed by the P-sink, is placed on top of the soil. The test measures how much P diffuses through the soil and into the gel. The membrane controls P movement into the gel. After 16-24 hours, the amount of P bound to the gel is measured.

The DGT test can be a better predictor of plant P requirements because it mimics the action of plant roots. It accounts for both:

- the initial soil P concentration, and
- the ability of the soil to resupply P as it moves into the gel.

When to use the DGT test

Consider DGT-P if you have calcareous soil and/or your Colwell-P values are odd. Colwell P doesn't always provide data that makes sense based on responses seen in the paddock. DGT-P might also offer greater accuracy on gravel, high PBI soils. Initial isotopic studies in WA suggests DGT-P outperforms Cowell on these soils.

Using DGT for the first time

If you haven't used DGT before, test both DGT and Colwell P / PBI. Pay attention to areas where DGT and Colwell P recommendations are conflicting. Test strips will confirm which test method was more accurate for your site. When using P test strips:

- Make sure there is a zero P strip.
- If using MAP or DAP, make sure N is not limiting so any response is from P.
- If you can, use the recommended rate and a higher rate to check.
- Grain yield data is key, as critical values are based on grain responses to P.

Interpreting DGT Values

Soilquality.org has some information on interpreting values and application rates for different crops. As this research is ongoing, contact Agronomy Solutions for more updated data as it comes out.

DGT for other nutrients

The DGT method is being trialled on other nutrients. Research is underway on DGT for potassium and aluminium.

More information:

- DGT proves worth on calcareous soils
- Soil phosphorus availability by DGT
- Older soil test methods hold ground
- Variable soil demands a flexible fertiliser program

FERTILISER ARTICLE 1

Chicken manure improves sandy soils

PUBLISHED - 1 NOVEMBER 2018
BY SAM TRENGOVE, TRENGOVE CONSULTING

Chicken manure is helping to ameliorate sandy soils on South Australia's Yorke Peninsula. Trial results over three years indicate that high-rate surface applications, combined with deep ripping, are delivering the highest marginal returns.

Positive results

The marginal returns from applying chicken litter (or a comparable, inorganic fertiliser), and deep ripping, ranged from $934 per hectare to $1249/ha. This was cumulative over the three seasons. Depending on treatment cost, these delivered a return on investment ranging from 142 per cent to 521 per cent.

Agronomist Sam Trengove, Trengove Consulting, began the trials at Bute in 2015 with funding from GRDC. The trials were continued in 2016 and 2017 with funding from NLP and South Australian Grain Industry Trust. Common constraints experienced at the trial site included low plant available water holding capacity, low organic matter, low nutrient availability, compaction, non-wetting and high risk for wind erosion. Annual rainfall average is 390mm and about 280mm for the growing season.

Trial details

The trials tested applications of the following treatments:

Trial 1

- Deep ripping
- Annual fertiliser
- Clay (130 tonnes per hectare)
- Chicken litter – 0, 5 or 20t/ha.

Trial 2

- Placement of chicken litter or fertiliser, either on the surface or in subsoil at 30-40cm deep
- Spading
- Matching the nutrition of 20t/ha chicken litter with 1,026 kilograms per hectare urea, 800kg/ha mono-ammonium phosphate, 420kg/ha sulphate of ammonia and 704kg/ha muriate of potash.

The crops trialled were barley, wheat and lentils. The trials were repeated in 2016 and 2017, and will continue until 2020.

More information:

GRDC Update Paper Amelioration of sandy soils

FERTILISER ARTICLE 2

Give seeds the best chance in a dry start – how to avoid fertiliser burn

PUBLISHED - 23 APRIL 2018
BY ROB NORTON, IPNI, & GRAEME SANDRAL, NSW DPI

Seeds can be damaged by fertiliser placed too close or at too high rates. Dry soils increase the risk of harm to germinating seeds from fertilisers. Take extra care with fertiliser and seed placement this year. The dry lead to 2018 winter sowing means last year's strategy might not be safe this year.

Use the seed damage calculator to check how much fertiliser you can apply with seed through the same chute.

The calculator doesn't address fertiliser placed below or to the side of seed. With separation of seed and fertiliser, around 3–5 cm is usually enough distance to protect the seed.

Safe fertiliser rates with seeds depend on:

Soil texture and conditions

The risk of fertiliser damage increases with drier and sandier soils. Conditions that cause stress or slow germination prolong fertiliser-seed contact. This increases the chance of damage.

Crop type

Canola and lentils are more sensitive. Wheat and barley are relatively tolerant. The sensitivity of crop species crop species can vary according to fertiliser type. In general the order from most to least sensitive in major grain crops is: canola > lentil > peas > oats > wheat > barley.

Fertiliser type

Fertilisers can affect germinating seeds in at least two ways:

Salt Index

Most fertilisers are salts. Too much fertiliser salt can 'burn' the seedling or stop seedlings from absorbing water. N and K fertilisers tend to have a higher salt index than P fertilisers. Sulphate forms tend to have lower salt indexes.

Ammonia formation potential

Free ammonia can be toxic to seed. Placing urea-containing fertilisers in-furrow is risky because they produce ammonia. A fertiliser with polymer coatings or urease inhibitors may slow the rate of ammonia production enough to protect seed. These fertilisers are still considered risky to place near seeds.

Placement and machinery configuration

Row spacing

The safe rate of fertiliser per hectare increases as row space narrows – all else being equal. Closer row spacing 'dilutes' fertiliser over the length of row.

Twin chuting systems

Twin chuting systems separate seed and fertiliser. Fertiliser is placed in bands to the side or below the seed bands. Usually, separation of 3–5 cm is enough to protect seed.

Seed Bed Utilisation

The more scatter there is between seed and fertiliser, the more fertiliser can be safely applied. The concept of Seed Bed Utilisation (SBU) addresses this factor. SBU is the proportion of row width occupied by seed row. It's the seed row width divided by the tyne spacing or row width. The wider the seed row for a specific row width, the greater the SBU. As SBU increases so does the safe rate of in-furrow fertilisation. Tables for fertiliser/crop combination thresholds are available from the IPNI website.

What about fluid fertilisers?

The seed damage calculator includes several fluid fertilisers. As a general rule, use the same maximum N or P rates as for solid products, based on nutrient concentration. Treat urea/ammonium nitrate like urea. Treat ammoniated phosphoric acid the same as MAP.

PHOTO COURTESY OF GRDC
THIS ARTICLE IS A REVISION OF OUR 2016 POST GIVE SEEDS THE BEST CHANCE BY AVOIDING FERTILISER DAMAGE.

FERTILISER ARTICLE 3

What is the fate of nitrogen fertiliser?

PUBLISHED - 8 MARCH 2018
BY ROGER ARMSTRONG, VIC DEDJTR

Do you know the fate of nitrogen (N) fertiliser that's applied to cropping paddocks? How much ends up in the crop, soil or lost? Victorian researchers have been working with a traceable N fertiliser to find out. The standard assumption is the crop takes up half the fertiliser N in the year it's applied. Crop uptake across a range of farming systems showed closer to one third in the plants and grain.

Tracking the fate of nitrogen

Several field trials have used N fertiliser with a specific amount of the isotope N-15. Researchers can track where the fertiliser ends up – in the straw, grain or soil. N-15 occurs naturally in soil-crop systems as 0.36% of total N. N-15 levels higher than background levels show the fate of the fertiliser.

How much nitrogen could be recovered?

Soil, grain and straw analysis showed where the N fertiliser ended up. Not all the applied N was recoverable in any of the N15 trials. The amount varied between trial sites and application methods in one trial (see figure below). In another project, 71% of fertiliser N was recovered from the crop and soil.

Nitrogen losses

Some of the applied N couldn't be recovered from grain, straw or soil. We presume this N moves out of the cropping system. That's a cost to growers and the environment.
It doesn't look like the losses happen through leaching. Measuring N15 through the profile didn't show much downward movement of N.

How much fertiliser nitrogen is in the crop?

Most of the recoverable fertiliser-N ended up in grain. More fertiliser-N in grain and straw meant less remained in the soil. Average uptake of fertiliser N by the crop was low. Growing season rainfall influenced uptake more than soil N status. There were differences in N-fertiliser uptake between farming systems:

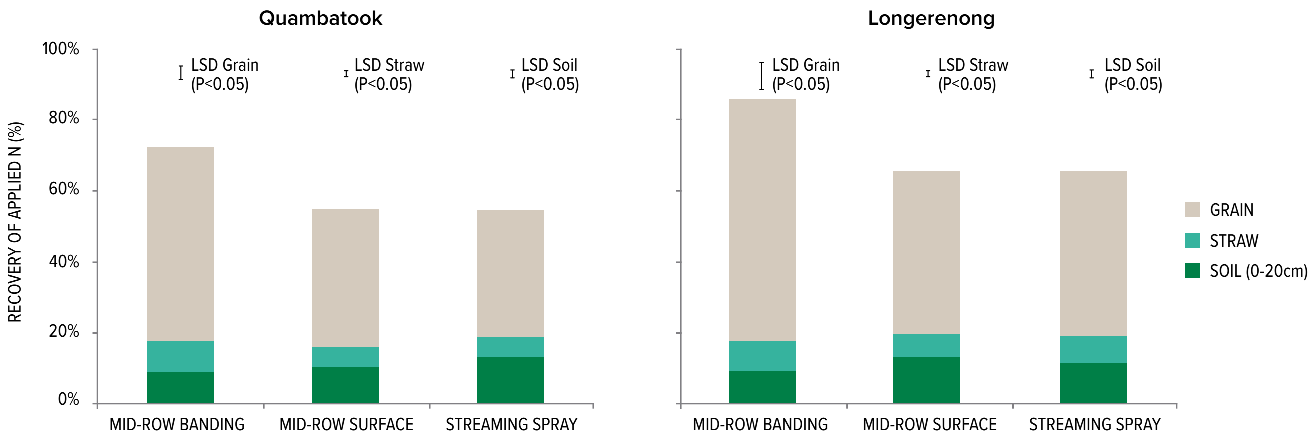
- 42% in irrigated
- 32% in low/medium rainfall
- 30% in high rainfall.

In the mid-row banding trials, site and application methods also made a difference to N uptake.

What affects the fate of nitrogen?

Application method

Application method caused the most variation in fertiliser fate in Victoria. Placing N fertiliser in the soil (compared to topdressing) will reduce losses via volatilisation. With mid-row banding (MRB), crops took up about 20% more N compared to surface methods. MRB showed the most fertiliser-N ending up in the grain.



The recovery of fertiliser N in the grain, straw and soil. The difference between total recovered and applied represents N losses from the system.
Source: Mid-row banding nitrogen fertiliser in-season.

Timing

Timing of application affected fertiliser-N uptake. For MRB, August applications followed by low rainfall produced the greatest grain uptake. Banding N below the soil surface might reduce volatilisation in low rainfall conditions.

Soil Moisture

Researchers recovered less N fertiliser as soil moisture increased above optimal. Between 2014 and 2016, average N recovery from soil + crop was 78%, 75% and 63% in low, medium and high rainfall zones. Note the lowest recovery was in the high rainfall zone. With waterlogging, denitrification can cause significant N losses.

What can you do?

The best strategies to reduce fertiliser costs and N losses are to:

- Predict soil N status with deep soil testing before sowing
- Match N applications to crop demand.

More information:

GRDC Communities

- Mid-row banding promising for in-crop Nitrogen
- How good are in-crop mineralisation predictions?
- Improving nitrogen use efficiency of cropping systems in southern Australia by mid-row banding nitrogen fertiliser in-season
- Reducing on-farm nitrous oxide emissions through improved nitrogen use efficiency in grains

Agriculture Victoria

- Improving the bottom line through improved nitrogen fertiliser use efficiency?
- Improving nitrogen use efficiency to reduce nitrous oxide emissions in Victoria’s grains industry?

NUTRITION AND DROUGHT ARTICLE 1

What nutrients are lost when making hay from failed crops?

PUBLISHED - 18 SEPTEMBER 2015
BY GRDC COMMUNITIES

Cutting for hay is an option to get some economic value from a failed crop. Growers with an eye to the long term productivity of their paddocks weigh the value of the hay against the value of leaving the crop material in the paddock. Nutrients that would otherwise be recycled in the soil are lost when crop material is removed from the paddock.

One-off hay cutting of a crop that has failed due to drought can prompt some changes in your crop nutrition program and paddock management into the next season.

How much material is removed?

Typical yields of stressed cereal or canola crops would yield 1.0 to 3.0 t/ha of hay.

A rule of thumb for unstressed cereal hay is that with a good plant density (~200 plants/m^2), each 30cm of growth above the cutting height will yield 2.5 t/ha of hay.

Nutrients removed with hay

Cutting hay will remove 2 to 3 times more nitrogen, and up to 10 times more potassium than if the crop was left for grain, and maybe 5 times more sulfur in both canola and cereals. This is talking in ballpark figures; nitrogen is always quite

	WHEAT CROP THAT WOULD YIELD 1.0 t/ha grain		CANOLA CROP THAT WOULD YIELD 0.6 t/ha grain	
Nutrient removed	**with grain (kg/ha)**	**with hay (kg/ha)**	**with grain (kg/ha)**	**with hay (kg/ha)**
Nitrogen	25	50	18	65
Phosphorous	3	3	3	8
Potassium	5	50	6	85
Sulphur	3	4	3	15

variable, as are phosphorous, sulfur and potassium, as all depend on soil nutrient status. In the table above, there are indicative values from a number of sources, including Rob Norton's experiments in the Wimmera and Mallee during the period 1990 to 2003 with wheat and canola.

Crop nutrition issues in the following season:

Potassium deficiency in soils with low K reserves

If concerned, apply a test strip of muriate of potash (MOP) pre-sowing and monitor. Used at sowing, MOP can cause salt damage to the seed, so separate seed and fertiliser. Low soil K levels are a greater risk in sands or light textured soils, acid soils, high rainfall zones, and in paddocks with history of hay cutting. Wheat critical levels for Colwell K are 40 mg/kg on Tenosols and Chromosols, 50 mg/kg on Kandosols, and about 65 mg/kg on Brown Ferrosols (Brennan and Bell 2013).

Sulfur deficiency following canola hay cutting

Consider sulfur supplementation of the following crop, such as using S fortified fertilisers or gypsum applications.

Acidification and lime requirements

Hay cutting is considered the most acidifying of agricultural practices, and on acid soils can make the issue worse. The removal of cereal or canola hay requires 25 kg/ha of lime for each tonne of biomass removed, or 45 kg/ha for each tonne of annual legume hay removed, to neutralise the resulting acidity.

Soil carbon

Cutting hay reduces inputs of organic matter into the soil for that season. The size of the effect when the hay is cut from a failed crop might be roughly similar to organic matter lost from burning stubble residues from a good crop, compared to retaining the stubble. The importance depends on the soil carbon status of the paddock and the goals of the grower.

Erosion can lead to more nutrients lost

Following hay cutting as there is little residue cover (maybe 0.4 t/ha of residue after hay cutting versus 2.0 t/ha after harvest). Reduce grazing and traffic across these paddocks to reduce the hazard of wind and water erosion. Nutrients are lost with eroded soil.

More information:

- IPNI: Nutrients removed in hay crops
- GRDC: Canola hay and silage fact sheet
- VIC DEDJTR: Soil acidity (see table 4 for replacement liming rates for product removal)
- Crop & Pasture Science: Soil potassium—crop response calibration relationships and criteria for field crops grown in Australia, Ross Brennan and Michael Bell, 2013.

ACKNOWLEDGEMENTS

Rob Norton, IPNI & Roger Armstrong, VIC DEDJTR.
Photos provided by GRDC.

NUTRITION AND DROUGHT ARTICLE 2

What to do with a failed crop

PUBLISHED - 9 NOVEMBER 2017
BY TIM WEAVER, CSIRO & EDDY POL, SUMMIT FERTILISERS

Failed crops can still be an asset to the farm. This year many areas are facing the results of not enough rain. Severe frosts have hit some crops hard too. Failed crops are caused by weather, weeds, pests and disease. Legumes can fail when growers don't use inoculants or wait too long to plant inoculated seed. If a crop looks like it's failing, there are some important decisions to make.

When to call it a failed crop

A crop 'fails'' when it will cost more to harvest and sell than what you can earn from the sale. To decide if the crop is a failure, consider:

- cost of harvesting
- grain price
- potential weed seed set
- feed value for livestock.

What to do with a failed crop

The three main options are cutting for hay, grazing, and spraying out. Each has pros and cons and can affect next season's crop.

1. Cut for hay

Start with crops that have some bulk, but are least likely to respond to rain. Bear in mind that very drought stressed crops are difficult to turn into hay. Cutting further dries the leaf which reduces hay quality and makes it harder to bale. For a canola crop, the best time to cut is late flowering. Cutting earlier improves quality but lowers yield.

Cutting hay will change crop nutrition requirements next season. Hay removes 2-3 times more N and up to 10 times more K than if a crop is left for grain. It also makes the soil more acidic. This is worth thinking about if acid soils or subsoils are an issue already. Removing cereal or canola hay requires 25 kg lime/ha for each tonne of biomass removed.

Also, think about soil cover, the crop residue will help protect the paddock from erosion by wind or water when rain comes. If soil carbon levels are already low, consider keeping the crop residue in place. The amount of carbon lost when hay is cut is similar to burning stubbles.

Cutting for hay might not be the most cost-effective option. Consider the costs of cutting, curing, logistics, storage – as well as the price you'll get for it.

2. Spray it

Spraying the crop can be like a chemical fallow. If weeds are becoming a problem, you might spray out the crop and weeds. This can mean a 'cleaner' crop with fewer chemical costs in the future. A WA grower saw a 700 kg/ha yield increase in the next year's crop from less weeds, more soil nitrogen and moisture.

Another option is to 'crop top'. This means applying herbicides late to stop weed seed-set. Crop topping costs less than spraying out and leaves more ground cover to protect the soil. It's not as effective as spraying out, but is better than harvesting and returning weed seeds to the soil.

3. Graze it

Livestock can benefit from a failed crop and help keep weeds down. Check:

- whether the soil can handle the erosion and compaction risk.
- what chemicals have been used on the crop.
- grazing withholding periods to observe.

Whatever you decide, make protecting the soil until next season a priority. Every millimetre of soil lost to erosion can reduce future crop yields.

More information:

- Tips to tweak your crop nutrition program following drought
- To cut for hay or not?
- What nutrients are lost when making hay from failed crops?
- What's the minimum Phosphorus rate if you are following a poor crop?

What happens in the year after a hayed-off crop?

PUBLISHED - 21 MARCH 2018
BY CLAIRE BROWN, BIRCHIP CROPPING GROUP

A hayed-off crop can make estimating available nitrogen (N) trickier than usual. Deep N testing is the best way to assess N resources. Estimates and actual results from deep soil testing were very different in recent research by Birchip Cropping Group.

After haying off there's potential yield benefit next season from leftover nitrogen. But the benefit may not be proportional to the amount of N applied in the previous season.

The dry limited yields in 2015

Trials in Victoria's Wimmera region looked at soil N and wheat yields after a hayed-off barley crop. The 2015 trial had six barley varieties and five N rates (0, 30, 60, 90, 120 kg N/ha). 2015 was a very dry year – decile 1 rainfall. The trial yields averaged only 0.7 t/ha in 2015. In that year, Barley did best with zero N applied. Higher N rates yielded less.

2016 yields and nitrogen rates

Clearfield wheat was sown in 2016. The 2015 N applications influenced the wheat yield. As the 2015 N rates increased, so did the wheat yield in 2016. Half of each wheat plot received 40 kg N/ha. The yield varied less between plots with different 2015 N rates where N was applied in 2016. The 2015 N rate affected yield more than N applied in 2016.

How does a hayed-off crop affect soil N?

Estimates of residual soil N, based on a simple nitrogen balance calculation, were very different to 0–70 cm soil test results. The nitrogen balance calculations overestimated available N.

Use deep N testing for an accurate picture of soil N reserves. There might be more error from the 'N balance calculation' as the severity of 'haying off' increases.

In both 2015 and 2016, there was a strong mid-season biomass response to N rates. As well as pre-season soil testing growers can watch in-crop N response. Crop signs can help guide topdressing rates to avoid over or under fertilising.

More information:

- Dig deeper if you really want to know about Nitrogen
- Using deep soil cores for Nitrogen, Potassium & Sulfur
- What nutrients are lost when making hay from failed crops?
- Tips to tweak your crop nutrition program following drought
- What's the minimum Phosphorus rate if you are following a poor crop?

STUBBLE MANAGEMENT ARTICLE 1

How to account for stubble nutrients next season

PUBLISHED - 22 NOVEMBER 2017

BY ROB NORTON, ANZ IPNI GRAEME SANDRAL, NSW DPI

Stubbles can be a source of nutrients for next season. Different crops grown under different conditions have varying amounts of nutrients in their stubbles. Nutrient budgets can consider the amount and type of stubble.

How much stubble?

Stubble loads can be estimated from grain yield and the amount of growth. For cereals, there is usually a ratio of grain to stubble of 1:1.5. So, a 4 t/ha wheat yield means around 6 t/ha of stubble. This is a harvest index of 0.4. The Harvest index is the ratio of grain to total biomass (the stubble plus the grain). For canola and some legumes, the ratio is 1:2. A 3 t/ha canola yield comes with around 6 t/ha of stubble. That's a harvest index of 0.3.

With good finishes, there's a bit more grain relative to stubble, and the harvest index comes up a bit. Droughted or frosted crops tend to have less grain relative to stubble and lower harvest index scores.

Nutrients in stubble

Depending on the crop, stubbles contain different amounts of nutrients. The table below gives estimates of the nutrients present in crop stubbles. It comes from the Canola best practice management guide for south-eastern Australia. See "More Information".

CROP	NUTRIENT (kg/ha per tonne of stubble)			
	Nitrogen (N)	**Phosphorus (P)**	**Potassium (K)**	**Sulfur (S)**
Canola	10*	2	26	3.2
Wheat	8	0.7	21	1.5
Barley	7	0.7	18	1.5
Oats	7	0.6	18	1
Lupins	10	0.4	16	2.5

** The amount of N in canola stubble varies with time of windrowing. The value of 10 kg N/t is at the high end of the range. More mature crops might have 5 kg N/t.*

When are stubble nutrients released?

Retaining stubbles for soil fertility is a long-term strategy. The rate stubbles break down is influenced by:

- crop type – legumes are fastest, cereals slowest, canola in the middle
- soil moisture – wetter is generally faster
- Temperature – warmer is generally faster
- degree of incorporation into soil – more mixing leads to faster breakdown
- carbon (C): nitrogen (N) ratio – lower C:N breaks down faster
- other nutrients present – sufficient nutrients speeds breakdown
- the amount of stubble – more stubble takes longer.

What is the fate of these nutrients?

Soil organic matter includes charcoal, humus, microbes, and decomposed organic residues less than 2mm. Microbes form organic matter by breaking down the stubble, which is mostly carbon. The microbes need adequate amounts of nitrogen (N), phosphorus (P) and Sulfur (S). Most stubbles have a low C:N ratio. All the nitrogen in the stubble is consumed by the microbes to break down only part of the stubble. In rough terms, soil microbes need an additional 3 to 5 kg N from the soil for each tonne of stubble. The tie-up of soil N in the breakdown of stubble is called immobilisation. It's likely that most of the N in cereal and canola stubbles will be tied up in the short term (months rather than weeks).

Most of the P, K and S in crop residues are present in soluble forms. They get washed out of the stubble and into the soil with rain, soon after crop maturity. So most of the nutrient release occurs in the first month. These nutrients may not be available in the short term (several months) if summer weeds take them up.

Positive Priming

Positive priming is when crop residues mobilise soil nutrients. Stubbles can interact with soil organic matter to increase mineralisation and nutrient availability. For example crop residues with a higher C:N ratio, such as grain legumes, can increase soil mineral N by 18 +/- 9 kg N/ha for each t/ha of grain harvested (Peoples et al., 2017).

Studies on P and S have found that P bound to the soil may be mobilised by working crop residues into the soil. In South Australia, more P was detected in the crop and soil when stubble was incorporated into the soil. Canola released about 20% more sulfur (S) than wheat. Most of the nutrient release occurred in the first month after stubble incorporation. After four months, up to 30% more nutrients were released.

Stubbles and nutrients

Retaining stubbles is an important part of a crop management system, to protect soil and reduce erosion risk. Managing nutrients in these systems is part of a long-term strategy. Some nutrients – particularly N – get tied up in the short term, but become available later in the cropping cycle.

Burning stubbles results in nutrient losses. About 80% of N, 44% of P, 40% of K, 50% of S, and 80% of carbon from stubbles is lost. Over the longer term, the losses add up, becoming a significant difference between burnt and retained stubble systems.

More information:

GRDC Communities

- When do retained stubbles increase the need for nitrogen?
- What happens to urea with high residue loads?
- What happens to nutrients when stubbles burn?

GRDC

- Canola best practice management guide for south-eastern Australia
- Managing stubble

What happens to nutrients when stubbles burn?

PUBLISHED - 13 MARCH 2017
BY ROB NORTON, ANZ IPNI

Most of the nitrogen (N) and carbon (C) contained in crop stubbles is lost when they are burnt. Around 100 kg/ha of urea could be needed to replace the N lost from burning stubble from a high yielding wheat paddock. Substantial amounts of stubble sulfur (S), phosphorous (P) and potassium (K) are also lost.

The nutrients are lost via smoke, airborne ash, and later via losses of windblown and waterborne ash. How much nutrient is lost depends on the stubble load and extent of ash movement. The significance of the loss depends on the paddock's nutrient status.

Some nutrients from retained stubbles can also be lost, especially P and K when there is rainfall. However, these losses will be smaller than losses from burning stubbles without significant rainfall. Nutrients washed from retained stubble will be in the topsoil. These nutrients may later become available to the next crop.

STUBBLE NUTRIENTS AND AMOUNTS LOST FROM A HOT BURN (for a wheat crop – yielding 5 t/Ha, produces 7.5 t stubble per Ha)

	Nutrient	Amount
Amount of nutrients in stubble (kg/Ha)	N	56
	P	5.9
	K	109
	Carbon	3450
Amount lost during a hot burn (kg/Ha)	N	46
	P	2.6
	K	44
	Carbon	2760
Percentage lost (%)	N	82%
	P	44%
	K	40%
	Carbon	80%
Amount of fertiliser to replace lost nutrients (kg.Ha)	Urea	100
	Single Super	30

How much is lost?

Nutrient loss increases with higher stubble loads and hotter burn temperature. Higher yielding crops produce more stubble. This formula can estimate the stubble load:

Amount of stubble (t/ha) = grain yield (t/ha) / harvest index

The harvest index value is around 0.4 to 0.5, depending on the season. Reference values for the crop can give a general indication of nutrient concentrations in stubbles. The best way to estimate nutrient concentrations is to tissue test the specific stubble. Cut and collect stubble from several small areas that reflect majority paddock conditions.

What happens to nutrient availability?

Burning converts most nutrients into more available forms. Nutrients remaining in ash are around 80% available to crops grown in the next season. Despite nutrient losses, burning stubble may lead to an increase in immediate nutrient availability to emerging crops. Burning prevents the tie-up of soil N in the decomposition of retained stubble.

The carbon in crop stubble provides a food resource for soil micro-organisms. Ash carbon is relatively inert ; the carbon that remains after burning bypasses the labile carbon pool.

Bad or good?

Repeated stubble burning can run down soil fertility. Occasional burning can have management benefits, but the nutrient loss should be factored into nutrient budgets.

More information:

- Managing stubble

When do retained stubbles increase the need for nitrogen?

PUBLISHED - 6 APRIL 2017
BY ROB NORTON, ANZ IPNI & TIM WEAVER, NSW DPI

Microbes use nitrogen (N) from the soil to decompose stubbles. When stubbles have a high carbon: nitrogen (C: N) ratio, soil mineral N is tied-up. Cereal stubbles have a high C: N ratio of around 80:1. Canola stubble C:N ratios are higher and legume stubbles are lower.

As stubbles break down soil mineral N is immobilised until crop residues decompose to have a C: N ratio of around 15:1. The question is if immobilisation of N will coincide with the early growth of the following crop.

If it does, extra N fertiliser may be needed to get the following crop off to a good start. Approximately 10 kg of additional N is required to break down one tonne of cereal stubble. A 6 t/ha wheat crop, leaving about 8t/ha of stubble, may require up to an extra 80 kg N/ha at sowing to ensure the young crop can access enough N.

In time, the N becomes available as the stubble decomposes. Rootzones with good microbial activity can hold up to 40 kg/N/ha in the root zone for later release. Healthy root zones also reduce N leaching, keeping it where the plants can use it.

Burning stubbles makes some N available immediately, however up to 80% of the stubble N content is lost during the burn.

You may need to apply a similar amount of N fertiliser to compensate for immobilisation of N as to replace N lost through burning. Applying N to compensate for temporary immobilisation builds up paddock nitrogen stocks. Replacing N lost through burning maintains nitrogen levels.

Retaining stubbles also improves soil carbon levels and helps soil biological fertility.

More Information:

- What happens to nutrients when stubbles burn?
- What happens to urea with high residue loads?

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