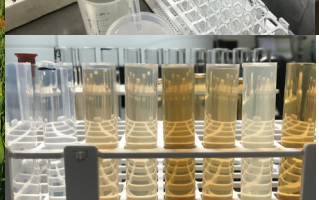
Project adviser Sean Mason, of Agronomy Solutions
Photo: AgCommunicators



GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

SOIL AND PLANT TESTING FOR PROFITABLE FERTILISER USE

Protocol for selecting monitoring sites and soil sampling procedures for project participants

Purpose of this Guide

This guide has been developed as one of the outputs of the Grains Research and Development Corporation (GRDC) investment,

"Using soil and plant testing data to better inform nutrient management and optimise fertiliser investments for grain growers in the southern region"

which focuses on increasing growers' use of soil and plant testing data to better inform their fertiliser decision making.

This guide is designed to provide growers and advisers involved in the project a clear protocol for selecting sampling sites and best practice soil and plant sampling procedures. The approach to sampling can affect data accuracy so adhering to the protocol is recommended.

The three-year investment, led by Agronomy Solutions in conjunction with Australian Precision Ag Laboratory (APAL), CSIRO, Nutrien Ag Solutions, Hart Field-Site Group and AgCommunicators, is working to collect soil and plant tissue test data and quantify the likely returns from improved nutrient management techniques.

For more information, please contact the project management team for more information.

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The soil and plant testing protocol involves several key steps:

Developing a Soil Testing Strategy to determine sampling zones, collecting the soil samples from the pre-determined zones, determining fertiliser treatment levels from the soil testing, completing strip trials and collecting plant samples for plant testing and biomass and yield estimations.

DEVELOPING A SOIL TESTING STRATEGY

- Zoning
- Sampling frequency
- Paddock information

SOIL TESTING

- Soil sampling collection
- Tests completed

FERTILISER STRIP TRIALS

- Fertiliser recommendations
- P Test Strips
- N Test Strips

PLANT TESTING

- Plant sample collection
- Tests completed

Contents

Background

Fertilisers are one of the biggest input costs for grain growers, so a carefully considered soil and plant testing strategy is essential.

Strategic and best practice soil testing ensures optimal nutrient balance for maximised yields.

DID YOU KNOW?

In most soils, phosphorus and potassium are best added at seeding. Without soil testing it's not possible to identify if the soil is deficient until yield is compromised.

Soil tests can be used to determine the nitrogen (N) application budget for the season, ensuring N is prioritised to the soils that will be most responsive.

If soil tests show nutrient levels are increasing, fertiliser application can be reduced, saving time and associated costs.

Developing a Soil Testing Strategy

Before any soil testing is completed it is important for growers and agronomists to work together to develop a soil testing strategy.

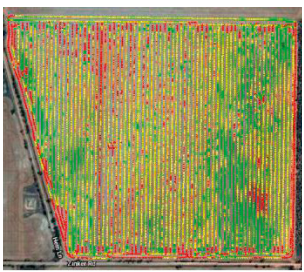
You should first understand the variability within your paddocks and identify production zones. All paddocks have varying areas of production and this can change between years depending on season and crop type.

Zoning

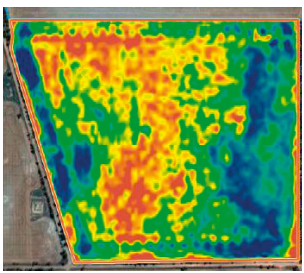
Zoning involves splitting areas of the paddock into sections depending on yield or other soil performance factors.

While most growers have a good sense of high and low yielding parts of their paddocks, tools including yield maps, in-season NDVI maps or mapping technologies like EM38 can provide a more accurate picture.

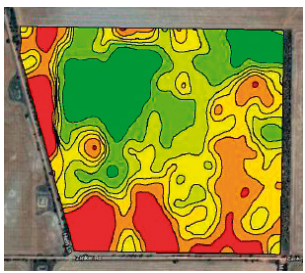
These tools can be utilised to set production zones for soil sampling. For this project yield data will be used as the primary data set, however NDVI will be a backup option if yield data cannot be obtained.



Yield map



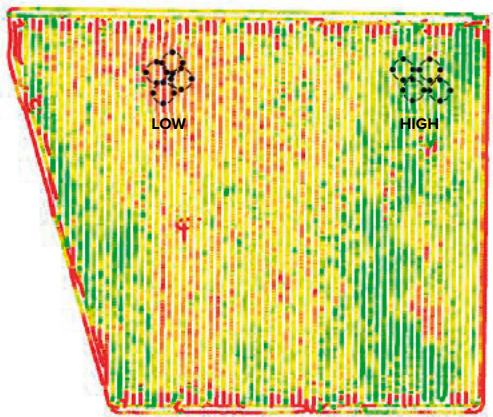
NDVI map



Soil Surveying map

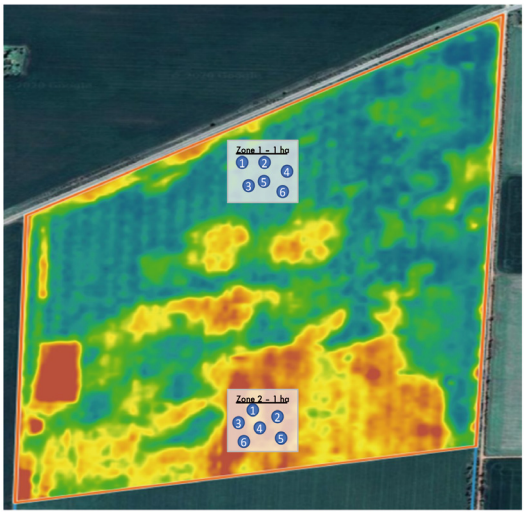
Testing in different production zones can help identify the causes of variable crop growth and performance.

When deciding where to sample within a paddock, it's advised to target the different production zones that present themselves to ultimately achieve a better paddock overview and target fertiliser application strategy. Generally selecting two production zones per paddock is effective, however it does not have to be restricted to this.



Using mapping data, production zones throughout the paddock can be determined.

High production Mid production Low production



Ensure there is minimum of **three years' paddock history**, including crop/pasture type and yield, fertilisers applied and the intended fertiliser rate is recorded for the paddock this season prior to soil sampling. The paddock must be planted to wheat in the year of experimentation.

In each production zone, identify **two areas of one hectare each** for soil sampling. The soil sampling plots must be in line of sowing.

Record the coordinates for each corner of the soil sampling zones (or just the midpoint of the one-hectare zone, specify which).

Paddock informaton

Paddock information that needs to be collected for each site:

- row spacing (to determine dry matter/m^2)
- stubble type, stubble management (slashed, standing) and approximate amount of stubble present when soil sampling
- sowing date (or emergence date if sown dry), variety, sowing rate, fertiliser used at sowing (type, rate), emergence date (if no soil moisture at seeding), herbicides applied in the previous 10 days
- sowing equipment (tyne, disc), row spacing
- in-crop fertilisers (type, rate and date of application)
- daily rainfall for 4 weeks post N spreading
- during flowering to grain fill record frost and heat shock events

Sampling Frequency

Growers and agronomists should work together to decide which paddocks to test and how often. Many opt to test each paddock every four or five years on a rotational basis, or when a paddock is going to be planted to wheat. Individual needs and factors should be considered in this process.

The best time to take soil samples can vary depending on what nutrients you wish to gauge. For more stable nutrients, including phosphorus, sampling can be undertaken anywhere between harvest and sowing time.

For nutrients which are sensitive to mineralisation, including nitrogen and sulphur, testing is recommended prior to sowing to gain a more accurate idea of what nutrients will be available to the crop at sowing.

Consult your agronomist about the best course of action for your particular cropping rotation.

Frequently Asked Questions

Please summarise the protocol for the sampling strategy?

Each grower/agronomist will select six paddocks to be sown into wheat, with two sampling zones selected in each paddock.

Within the two zones, a one-hectare (100mx100m) area should be sampled. 100m should cover about three seeder widths.

What is the sampling intensity and sampling depth?

Sampling intensity is the numbers of cores taken from within each zone. When deep sampling, six cores will be taken within each zone. When shallow sampling, six small cores (0-10cm) should be taken around each deep core (total 36 topsoil samples).

Sampling depth is the depth under the paddock surface at which soil samples are collected. The sampling depths in this project are 0-10cm, 10-30cm, 30-60cm and 60-90cm.

Depth sampling by horizons – what is the standard?

Some agronomists are keen to perform sampling by changes in soil colour or texture with depth to better capture soil constraints. This is fine as long as the N bucket is captured. The sample set from this is expected to be small.

Why are we soil testing six paddocks when we are only required to do trials on three paddocks?
The fertiliser strip trials are validating the soil test recommendations but the data will also help build a data set to see where nutrients are sitting and get an organic carbon and acidity status. This data will be helpful for future trial use and recommendations.

Do all paddocks need to be going into wheat?
Wheat is the preference, though barley is another option but it needs to be reported so recommendations can be altered slightly. Non-cereal paddocks can be sampled for soil test data only, but these paddocks cannot be used for fertiliser strips. In this case, try to pick paddocks going into wheat next year where we can re-sample.

Form of wheat – durum vs spring vs soft:
It is suspected that soil test interpretation won't change much for different wheat types so for flexibility any type is acceptable, just as long as it is noted.

When should I test?

The best time to take soil samples can vary depending on which nutrients a grower wants to check. For more stable nutrients, including phosphorus, sampling can be undertaken anywhere between harvest and sowing time. For nutrients which are sensitive to mineralisation, including nitrogen and sulphur, testing is recommended in March or a few weeks before sowing to allow for laboratory analysis to gauge what nutrients will be available to the crop at sowing time.

What information should I make my agronomist or the soil testing laboratory aware of when I submit a soil sample for testing?

The person making the recommendation on fertiliser applications should be made aware of the paddock history and planting intentions for the coming season. This can assist in making a more accurate fertiliser recommendation.

Soil Testing

Soil testing measures nutrients and physio-chemical parameters in the soil. These measurements indirectly influence how plant growth and quality will respond to additional nutrient supply throughout a growing season.

Deep core sampling is important for mobile nutrients such as N, K and S as well as pH, salinity and sodicity.

Sample Collection

Unless using wide rows, a ratio of one sample on-row to six samples inter-row is recommended, as the crop is normally planted between rows and ultimately where the crop's roots will grow and take up water and nutrients.

Samples from 0-10cm below the soil surface can be collected using a 'pogo stick' sampler, while a soil sampler with a hydraulic ram setup is the most effective way to take deep soil samples.

Sample six sites per one-hectare area and complete:

- **A deep nitrogen (N) core (segmented 0-10, 10-30, 30-60, 60-90cm)**
- **Six topsoil (0-10cm) samples for phosphorus**

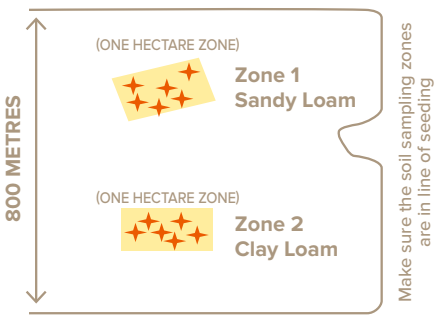
Altogether, for each one hectare sampling zone there should be

(i) a combined topsoil sample from the 36 topsoil cores; and

(ii) combined samples for each depth from the segmented deep cores for N

Avoid areas such as stock camps, old fence lines, watering troughs, any old lime or fertiliser dumps and crop headlands.

Do not sample in very wet conditions and avoid contaminating the sample, sampling equipment and sample storage bag.



Step-by-step

Topsoil samples

- In each one-hectare soil sampling zone, collect six topsoil (0-10cm) samples with a pogo stick sampler within a two-metre radius of the deep soil core.
- Push aside any plant residues on the soil surface before inserting the pogo.
- Take six samples between last year's crop row for every sample on the rows.
- Put the six samples in a clearly labelled bucket (0–10cm).
- In dry sandy soils, make sure none of the sample falls out of the pogo before it goes into the bucket
- Mix soil well before going to the next sampling site.

Preparation for deep sampling

- Log the GPS location of all deep soil cores in each zone (using a program such as Echelon or a handheld GPS logger). There should be 12 soil sampling locations in total (six in zone 1 and six in zone 2)
- Before taking a deep soil core, dig down to 10cm with a spade and remove the topsoil (making a clean surface area to take your deep core samples).
- Only take deep cores between last year's rows.
- Do NOT use the deep soil corer for collecting 0-10cm soil. Topsoil is often high in mineral N and contaminating topsoil with the subsoil needs to be avoided. Dry topsoil can easily fall down the sides of the tube when extracting a core.

Remove deep core and cut in half length ways

- Sample to 90cm depth, remove tube and slowly push soil core out into collection tray (try keeping the core intact). Separate the 10-30, 30-60, 60-90cm sections.
- With a knife cut the core lengthways in half to reduce the amount of soil that is sampled for each depth for ease of mixing.
- Place soil for each 10-30, 30-60 and 60-90cm depths in separate buckets.

Continue and repeat at next sampling site

Sample preparation

- When you have completed sampling six sites in a zone, mix the contents of each bucket thoroughly, breaking up any large clods (mixing is very important to get a representative sample). Put a sub-sample in an APAL soil sampling bag.
- Discard the rest of the soil in the buckets
- Log sample using the APAL Farm2Lab app, inclusive of scanning the bar code on the sample bag. If you do not have an APAL soil sample bag, use clear plastic snap lock bags and mark clearly with a texter.
- Keep soil samples cool while storing and taking other samples.
- Send to APAL as soon as you can (this is very important – mineralisation can occur in warm moist soils which will change the mineral N values)

Sending soil samples

Submission forms are available on the APAL website or you can enter your information using the APAL Farm2Lab app or APAL Online account.

Post samples to:
APAL, PO Box 205,
Hindmarsh, SA, 5007

or courier
U 3, 11 Ridley St,
Hindmarsh, SA 5007

Note: send samples Express Post – regular mail takes too long to get to the lab in Adelaide

Tests

Soil tests that can be performed on all samples:

- Soil depth: 0-10cm. Analytes measured: pH, EC, Mineral N, OC, Colwell P, PBI, DGT P. Extras (if applicable): Aluminium (if pH < 5), Chloride (high EC), texture (Sand, Silt, Clay), Carbonate
- Soil depth: 10-30cm. Analytes measured: pH, EC, Mineral N. Extras (if applicable): Aluminium (if pH < 5), Chloride (high EC), texture (Sand, Silt, Clay), Carbonate
- Soil depth: 30-60cm. Analytes measured: pH, EC, Mineral N, texture (Sand, Silt, Clay), Carbonate
- Soil depth: 60-90cm. Analytes measured: pH, EC, Mineral N, texture (Sand, Silt, Clay), Carbonate

Frequently Asked Questions

Why should I soil test?

Soil testing can be helpful for monitoring soil fertility and identifying any subsoil constraints. Soil tests can also determine which nutrients are likely to limit yield, while also measuring pH, sodium and salinity levels which can affect a crop's ability to access nutrients and identify reasons for poor crop performance. It can also help guide management decisions such as application rates, the creation of paddock zones for variable application and application timing and placement.

Should we be sampling on the inter-row, on the row or a combination?

It is suggested that you concentrate on the inter-row when sampling because that is where the crop is normally planted. Soil testing protocols suggest a 1:6 ratio of row to inter-row sampling.

What will be measured?

Analytes to be measured at each depth include pH, EC and Mineral N, as well as nutrients N, P, K, Ca, Mg, Na, S, Cu, Mn, Zn, B, Fe and Al.

At soil depths 0-10cm and 10-30cm, aluminium will be measured if pH is less than five, while chloride will be measured if high EC is recorded.

Further analysis of soils – some agronomists and growers are interested in further analysis at their own cost.

For soil testing promotion purposes, all project samples will be archived in the case further analysis is requested by agronomists or growers.

Grain protein measures – will this be done?

Grain protein measures are not included in the project but can be measured on request.

For those with protein sensors on headers, collecting protein data is encouraged.

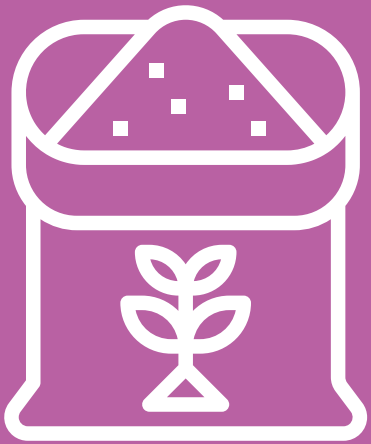
Do we need to take photos of deep cores taken?

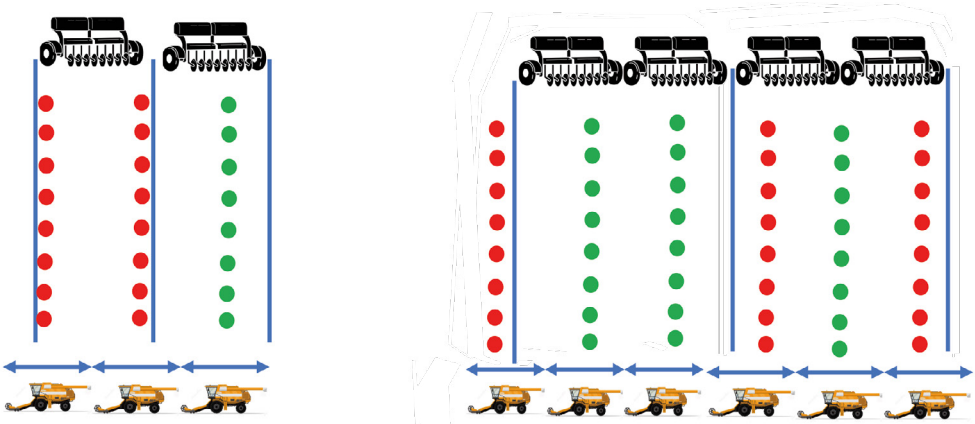
This is a suggestion which will help with interpreting soil test results at depth. Take photos of deep cores if possible.

Fertiliser Recommendations and Strip Trials

Fertiliser strip trials are a useful way to show the effects of nitrogen and phosphorus inputs on crop growth and development.

Strip trials are the process of placing a high nutrient rate strip next to a nil fertiliser strip, to show crop responses to different nutrients.





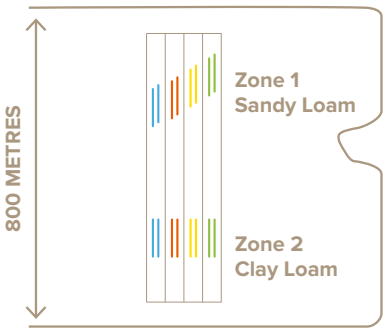
Each rate should be applied as two to three seeder widths.

Tip: most modern variable rate seeders and technology can be pre-programmed to implement fertiliser strip trials

As a grower involved in the ***Soil and Plant Testing*** project, soil analysis results will be forwarded to a Fertcare accredited agronomist to provide a fertiliser recommendation. These recommendations will be reviewed by the project team.

The rates should be sown across sampling zones by either:

- Along the length of the paddock (e.g. 800 metres in the image below) – This is the preferred option
- For the soil sampling zones only (beginning minimum 50 metres before the zone and finishing 50 metres after the zone)
- Record the exact location of the strip trial on Google Earth as a kml or kmz file and provide to the farmer. A sign on the fence also helps determine location



P rates kg/ha

0P **4.5P** **9P** (paddock rate) **18P**

Note these rates are indicative only and are based on the results of the soil test

After all results and recommendations have been received, the project team will select appropriate sites for fertiliser strips to demonstrate the benefit of soil testing pre-sowing.

Trial category	Proposed strip			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4 (optional)
N Non responsive (Poor season)	Nil N (Starter)	Grower rate (IBS or GS30)	1/2 x Grower rate (IBS or GS30)	2 x Grower rate (IBS or GS30)
N responsive (Good season)	Nil N (Starter)	Grower rate (IBS or GS30)	2 x Grower rate (IBS or GS30)	1/2 x Grower rate (IBS or GS30)
P responsive	Nil P	Grower rate	2 x Grower rate	
P Non responsive	Nil P	Grower rate	1/2 x Grower rate	
			Soil test recommendation	

The locations of each fertiliser test strip MUST be logged, using one of the following methods:

- Using a mapping program (e.g. Echelon) where fertiliser strips can be drawn as polygons within each paddock.
- A prescription map for fertiliser applications that will ID the locations of the strips.
- Log the GPS coordinates for the four points at the start / end of each strip with a hand held logger. Or log at least one side of the fertiliser strips and then provide the width of each fertiliser strip (i.e. how wide three seeder passes were and therefore the location of the next fertiliser strip). Do a self-check on these data points by plugging them into Google Earth Pro

P Test Strips

Locate P strip trials across the paddock in line with the selected soil testing areas.

For P responsive trials, apply each treatment with **2 adjacent widths of the seeder** (this is a MUST to get 1 clean harvester width out of each strip) – treatments are 0P (no P fertiliser), 1P (farm applied rate) and 2P (double the farm rate or DSS determined rate).

For P non-responsive sites apply each treatment with 3 adjacent widths of the seeder – treatments are 0P (no P fertiliser) and 1P (farm applied rate).

N Test Strips

The timing of N trials is dependent on grower practice. Some growers apply the bulk of N fertiliser at seeding, whereas others apply a starter-N rate and the bulk of N during the season after assessing conditions. The following timing of application applies to the latter (i.e. in season).

For N responsive trials apply each treatment with **2 adjacent widths of a spreader** (this is a must to get one clean harvester width out of each strip) – treatments are 0N (no N fertiliser), 1N (farm applied rate) and 2N (double the farm rate). N treatments to be applied between GS16 to 30.

For N non-responsive sites apply each treatment with 2 adjacent widths of a spreader – treatments are 0N (no N fertiliser) and 1N (farm applied rate). N treatments to be applied between GS16 to 30.

Frequently Asked Questions

Do application decisions vary depending on whether liquid or granular set ups are used?
The type of fertiliser application setup is something that should be taken into account when P recommendations are made. Discuss with your adviser or agronomist.

Is there any compensation for farmers who need to purchase a fertiliser to suit the trial recommendation?
At this stage, no. If you can send through the product information being used we can try and tailor the fertiliser strip trial with that product. We can look at what the farmer is doing and try to tailor things to suit their needs.

I'm worried about loss of production by running nil strip trials?
If this is a concern, growers do not have to run full strip. The nil strip only needs to be in the soil sampling zones. Another option is to just use half of the grower application rate.

Do project growers or agronomists have access to the Echelon system?
Yes, growers and agronomists can get access to the Echelon system. Nutrien Ag Solutions is happy to give everyone access and Nutrien Ag Solutions PA Training Lead Dan Bell would be the best person to contact in regards to this on 0439 668 192. Clients can get access even if they're not Nutrien Ag Solutions clients. If growers or agronomists do have their own software platform, they are welcome to use those as well.

Plant Testing

Soil analysis is not particularly accurate for trace elements, but plant tissue testing is a much more reliable option.

Plant testing can check the uptake of other nutrients during the season, including those not measured in soil tests, and the effectiveness of fertilisers applied at or near sowing time.

When conducting plant tissue testing, it is advised to collect samples at growth stage 30, or the end of tillering. This stage is just prior to a crop's peak nitrogen demand so growers can often decide on the rates of in-season nitrogen.

Unfortunately, phosphorus deficiencies cannot be fixed in-season, but tissue testing will provide useful information for P application decisions in later seasons.

When collecting plant samples for nutrient levels, take whole plants cut off at ground level for simplicity and to ensure accuracy.

Plant sampling should not be conducted within 36 hours of a frost or heat shock event, or herbicide application.

Sample Collection

For P trials, take tissue samples in each testing zone at GS30 for each P treatment. For N trials take samples prior to N application.

- Place a 30cm ruler in between crop rows and cut at ground level (where the plant stem changes from white to green) in these zones on rows both sides side of the ruler.
- Use clean scissors or secateurs.
- Include all above ground shoot material in the sample
- Repeat this process three times in each of the pre-determined monitoring zones, while avoiding the best or the worst patches.

Sending tissue samples

Record:

- Growth stage of crop
- Time between emergence and sampling
- Row spacing and seeding rates
- Combine the three cuts and place in a well labelled paper bag (not plastic as the plants tend to sweat and decompose)

Note: send samples Express Post – regular mail takes too long to get to the lab in Adelaide

Plant tests completed

- Phosphorous, Potassium, Calcium, Magnesium, Sodium, Sulfur, Copper, Manganese, Boron, Iron, Aluminum
- Total Nitrogen

Frequently Asked Questions

When should plant tissue samples be taken?

Growth stage 30 is the recommended time to take plant tissue samples for general purposes. Please note that you should not conduct plant tissue sampling within 36 hours of a stress event such as frost or extreme heat.

Why is plant tissue sampling completed at GS30?

Two plant tissue timings for P and N is not practical. Given they are both only contributing data to the project and not affecting recommendations for that season, we have agreed that GS30 is most sensible.

What about K and S trials?

Protocols will be abided by and if any deficiency symptoms are found in paddock inspections or tissue sampling, we will explore the possibility of looking at K and S next year.

There is potential for samples to be archived and K and S studies to be conducted if budgets permit.

Contact Information

For any questions or more information, please contact the project management team for more information.

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