Plant nutrient analysis *in established* leucaena

Leucaena is a highly productive perennial forage legume suitable for tropical and sub-tropical regions of Australia.

Growth and forage quality of established leucaena can be constrained by low nutrient supply due to naturally low soil nutrient levels or induced deficiencies from previous land uses that removed nutrients (e.g. grain cropping).

Monitoring nutrient levels in the soil or plant tissue is important for maintaining high productivity from established leucaena stands. Plant tissue testing measures the concentration of nutrients in a leucaena stand to determine if levels are sufficient for optimal growth. Sampling and testing plant tissue nutrients can sound complicated, but following a few simple steps can ensure reliable results.

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Why measure nutrient levels in leucaena?

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Leucaena is highly responsive to fertiliser when available soil nutrient levels are low, especially phosphorus. Plant tissue testing is the best way to determine if established leucaena is nutrient deficient (Figure 1) and therefore whether productivity can be improved through the application of fertiliser. Tissue testing provides a direct measure of whether leucaena is extracting an adequate nutrient supply from the soil.

There are two main reasons for using plant tissue testing in leucaena:

1. **Diagnostic testing.** Used to determine the reason for poor growth.
2. **Monitoring.** Used to assess whether nutrient supply has changed over time.

Figure 1. Healthy leucaena *(left)*, and sulfur-deficient leucaena *(right)*.

Diagnostic testing

Plant tissue testing can be used to help determine what factors are limiting plant growth or causing nutrient deficiency symptoms in a leucaena stand. Ideally, soil testing should be conducted in conjunction with plant tissue testing to determine soil-nutrient reserves, and whether any soil constraints such as pH, salinity or sodicity, or physical subsoil barriers are limiting root exploration and nutrient uptake.

Plant samples (and soil samples) should be taken from both good and poor growth areas of the paddock and analysed separately for comparison.

Monitoring

Regular plant tissue testing is a useful tool for monitoring nutrient status over time as the leucaena stand ages. Soil nutrient supply generally declines with increasing age of leucaena since establishment; tissue testing is a useful tool for deciding whether aging leucaena stands require fertiliser to maintain high production levels. Tissue testing can be used for monitoring whether fertiliser programs are supplying an adequate nutrient level to support optimal leucaena growth.

How to collect plant samples in leucaena

Plant samples need to be collected in the correct way to be useful for nutrient analysis. Youngest fully expanded leaves (YFEL) need to be collected only during active vegetative growth from more than 30 representative plants at representative locations in a paddock. Sampling older leaves; after vegetative growth has stopped, or flowering has commenced; or from unrepresentative locations will produce meaningless results. The samples need to be handled to avoid contamination or spoilage for delivery to a laboratory.

When to sample

Nutrient levels vary in stressed plants (e.g. moisture stress). Collect your plant tissue samples from young leaves on actively growing leucaena. When collecting your sample, the leucaena plant needs to be:

- in a vegetative growth state i.e. not heavily flowering or producing pods and seeds
- actively growing, and without water, heat or cold stress for at least 28 days before sampling, and
- not under heavy grazing pressure

Sample during summer. The best time of year for sampling is during summer when leucaena is vegetatively growing without significant limitation to nutrient uptake from water or heat stress. Sampling during this period also allows sufficient time for fertiliser application and for a response to occur before the end of the leucaena growing season (typically around May depending on location).

Sample mid-morning. The best time of the day for sampling is mid-morning, after any dew has evaporated but before the midday heat causes temporary moisture stress.

Sample early in the week. Samples should be collected early in the week (e.g. Monday or Tuesday) for timely arrival to the laboratory before the weekend.

Do not sample for at least 3 months after applying fertiliser. Rainfall is required to dissolve the fertiliser into the soil before the plant is able to extract the nutrients from the soil.

Where in the paddock to sample

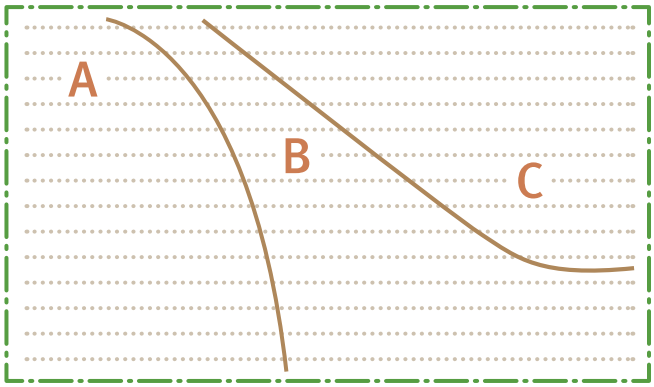
It is essential to collect plant samples from locations that are representative of the paddock or of the area in question (such as a poor growth zone). Unusual areas that are not representative need to be avoided such as stock camps, near troughs, end of rows, edges of paddocks, waterlogged patches or other areas that are growing differently.

Leucaena growth can vary across paddocks due to differences in soil type, location in the landscape (e.g. soil depth, elevation) or other factors. Samples should be collected and analysed separately from different production zones if the paddock has variable growth, especially if diagnostic testing is the aim. Samples from across the whole paddock can be analysed together if leucaena growth is uniform, and if monitoring nutrient supply over time is the aim. The main sampling strategies for paddocks are to sample either across the whole paddock or in defined zones.

Whole paddock. Where the leucaena stand is relatively consistent, with uniform plant growth and soil type, samples should be collected randomly across the whole paddock, avoiding end of rows, edge of paddock and atypical areas. This sampling strategy is effective when monitoring nutrient supply over time.

Defined zone. This sampling strategy should be used where there are different production zones or trends across a paddock (Figure 2). This sampling strategy is used where different soil types, landscape features (e.g. change in soil depth down a hillslope) or poorly growing areas occur in a paddock. Production zones should be sampled and analysed separately to determine if there are differences in leucaena nutrient status in different parts of the paddock. The sampling zones should be clearly identified and recorded on a farm map to inform management decisions. This sampling strategy is effective when diagnostic testing even if there are no obvious soil type or other landscape differences.

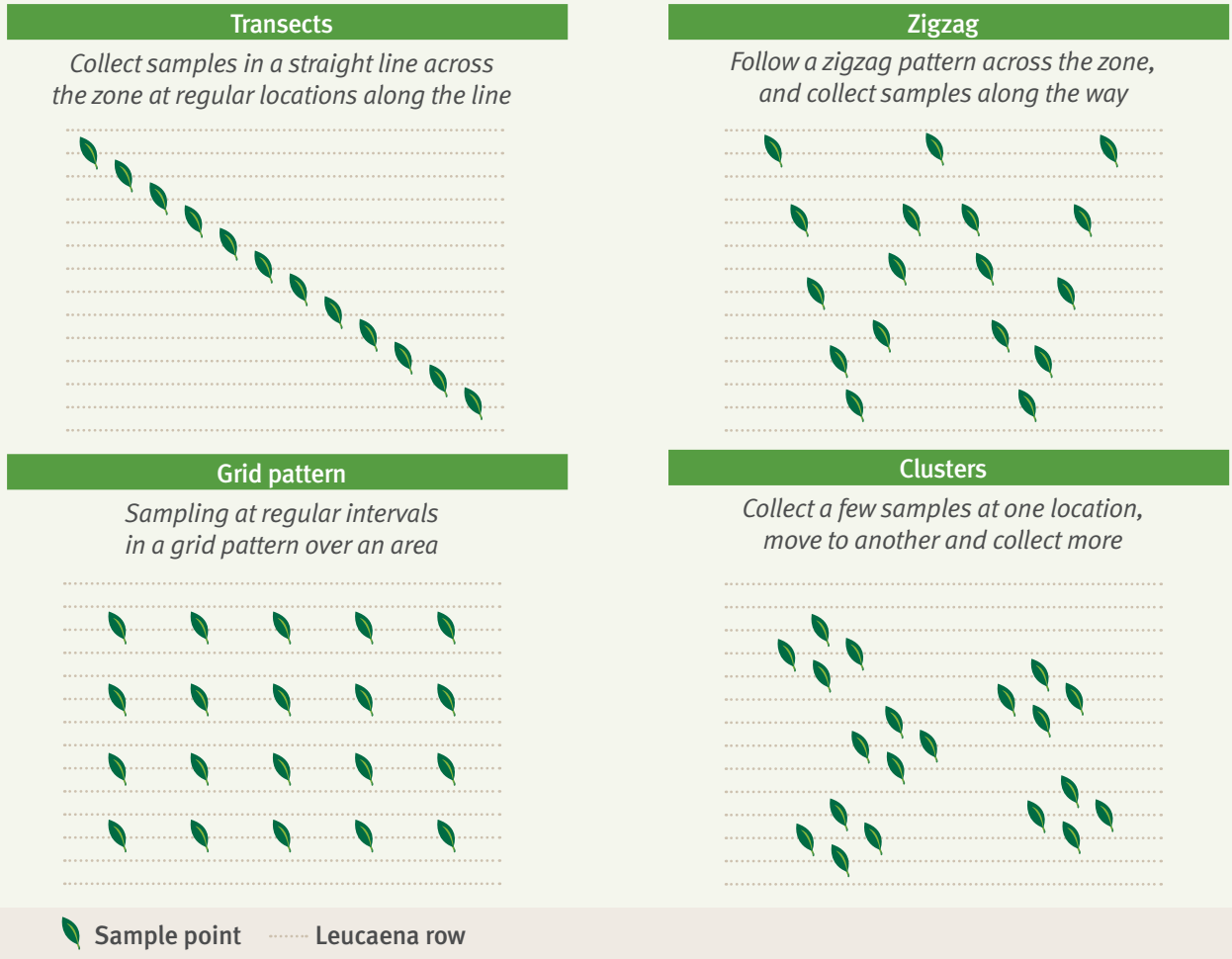
Figure 2. Example of defined zones in a paddock. Zone A (Brigalow box red soil), B (cracking clay alluvial) and C (Brigalow clay on gentle slope) within one paddock should be sampled and analysed separately. In this example all three zones are likely to have different nutrient status, and therefore fertiliser requirements.



Locating trees to collect samples

Within the whole paddock or defined zone, there are four main methods to ensure the area is sampled in an unbiased manner: transects, zigzag, clusters and grid pattern (Figure 3). Leaf samples should be collected from more than 30 leucaena trees located across each of the sampling zones.

Figure 3. Sampling pattern examples across a whole leucaena paddock or a defined zone within a paddock.



What part of the leucaena tree to sample

Collect your plant tissue samples only from young leaves on actively growing leucaena. Leaf samples should be collected from representative (typical) trees within a hedgerow.

Nutrient levels in leaves change as they age, so it is critical to only collect the youngest fully expanded leaves (YFEL). Leucaena has multiple leaflets that make up a leaf, the YFEL are located close to the end of the stem but not at the growing tip where the leaves have not yet unfurled or fully expanded (Figure 4).

Figure 4. Youngest fully expanded leaf (YFEL) held in hand.

Equipment for sampling

Gather all the equipment needed for sampling. Ensure that equipment and hands are clean from contaminants such as dust, oil or fertiliser:

- secateurs
- bucket
- paddock map
- pen
- gloves
- paper bags
- notepad

Handling samples

It is essential that samples reach the laboratory in a good, clean condition without spoilage to produce meaningful results. Place the freshly sampled leaves into a clean paper bag and label with date, paddock name and defined zone. Do not place samples into plastic bags as this will cause condensation and lead to decomposition of the plant sample.

It is critical that samples be cooled immediately to below 5°C in a fridge or esky. Fresh samples that are kept in warm, moist environments will spoil. Mould growth in a spoiled plant sample changes nutrient levels. Do not let the plant sample freeze as that will also damage the sample and affect results.

Washing samples

Leaves need to be clean and free from dust or other contaminants (e.g. insecticides, fertiliser). Dust or chemicals can affect laboratory results, especially for micro-nutrients. If necessary, wash samples with distilled water (or rainwater) and thoroughly and carefully dry with paper towel.

Drying samples

Plant samples can be dried before dispatch if delivery to the laboratory is likely to be delayed. Plant samples can be dried between 40°C to 60°C. Drying at these temperatures can be achieved during summer by laying samples in the sun or leaving them in a car in a paper bag. The paper bag should be opened at one end to assist with drying if in a location free from dust or contaminants.

Laboratory analysis

Sending samples to the laboratory

Plant samples should be collected early in the week (e.g. Monday or Tuesday) for timely arrival of fresh samples to the laboratory before the weekend. Where possible, it is best to send samples via express post or overnight courier to ensure samples do not deteriorate during transit. Samples should be dried if any delay between collection and laboratory analysis is likely to occur.

Laboratories have sample submission forms that need to be filled out before sending samples. Get in contact with the laboratory to make sure that you have the correct forms completed and delivery instructions before sending. Often these forms and instructions can be downloaded from the company website. The paperwork is essential for the laboratory to undertake the correct analysis and provide meaningful results. Keep a copy of the sample submission form for your records to aid in result interpretation.

Which laboratory should I use?

Multiple laboratories across Australia provide plant sample analysis services. Ensure the laboratory you choose a) provides analysis of the specific nutrients required, b) is accredited for reliability of results (i.e. National Association of Testing Authorities (NATA) and membership of the Australasian Soil and Plant Analysis Council (ASPCA)), and c) can provide timely reporting of results with good customer support and value for money.

What nutrients should I test for?

Requesting analysis for multiple nutrients is recommended. Plant tissue nutrient analyses are generally offered in package options by laboratories. These packages usually offer a range of macro-nutrients and micro-nutrients (Table 1).

Nitrogen, phosphorus, sulphur, and potassium are the nutrients that most commonly limit leucaena growth, however all nutrients can influence plant growth and should be assessed for individual paddocks.

It is usually worthwhile investing in a comprehensive analysis which includes multiple nutrients to determine whether fertiliser is required.

Table 1. Nutrients typically available for plant tissue analysis by laboratories.

Macro-nutrients	Nitrogen (nitrate-N and ammonium N), phosphorus, potassium, sulphur, calcium and magnesium
Micro-nutrients	Sodium, chloride, copper, manganese, iron, zinc, boron, molybdenum, cobalt, selenium

How to interpret the results?

To interpret plant tissue analysis, the results are compared to known concentrations required for optimal leucaena growth. The optimal levels in leucaena have been determined from research trials by testing the response to specific nutrients.

Compare results with look up tables

Table 2 and Table 3 outline the nutrient concentrations required for optimal growth for leucaena YFEL collected from actively growing plants. Compare your test results with these look up tables to determine whether your leucaena has any deficiencies or toxicities and target the 'Adequate' range.

Address deficiencies first

Any results in the 'Deficient' range should be addressed first. Interpreting nutrient test results can be complicated as many of the nutrients interact with each other. When deciding which fertiliser product is needed, it's important to know there are many products available for different situations. Obtaining professional advice from a trained agronomist is recommended, especially when deciding which fertiliser product to apply, how much to apply, and how often.

Special mention about nitrogen in test results

A deficiency in nitrogen does not mean that nitrogen fertiliser needs to be applied. Leucaena is capable of producing its own nitrogen (i.e. nitrogen fixation through rhizobia in root nodules) and adding nitrogen fertiliser only limits that ability. Low nitrogen values in a plant tissue test might indicate other associated problems such as limited or no nitrogen fixation due to inadequate nodulation, waterlogged soil conditions, or low availability or supply of other nutrients that are essential for nitrogen fixation such as phosphorus, sulphur and molybdenum.

Table 2. Macro-nutrient concentration values (%DM) in leucaena YFEL.

Nutrient	Deficient	Marginal	Adequate	High
Nitrogen (N)	‹3.50	3.50 – 4.00	4.00 – 4.50	›4.50
Phosphorus (P)	‹0.18	0.18 – 0.20	0.20 – 0.28	›0.28
Potassium (K)	‹0.80	0.80 – 1.00	1.00 – 2.00	›2.00
Sulfur (S)	‹0.20	0.20 – 0.24	0.24 – 0.30	›0.30
Calcium (Ca)	‹0.30	0.30 – 0.40	0.40 – 1.50	›1.50
Magnesium (Mg)	‹0.18	0.18 – 0.20	0.20 – 0.30	›0.30
Ca:Mg ratio			›2	

Source: Shelton et al. 2021 and Radrizzani et al. 2011.

Table 3. Micro-nutrient concentration values (mg/kg) in leucaena YFEL.

Nutrient	Deficient	Marginal	Adequate	High	Toxic
Zinc (Zn)	‹8	8 – 12	12 – 24	›25	
Copper (Cu)		‹2	2 – 10	‹10	
Iron (Fe)	‹20	20 – 40	40 – 100	›100	
Manganese (Mn)			20 – 100	100 – 325	›325
Boron (B)		‹20	›20	‹40	
Sodium (Na)			›20		
Aluminium (Al)			1 – 100	›100	

Source: Shelton et al. 2021.

Frequency of leaf testing

Monitoring nutrient levels in both the soil and leucaena plant should be undertaken on a regular basis. Regular testing ensures adequate nutrient supply over time and maximises the efficiency of converting water (rainfall or irrigation) into usable feed. Leaf testing should be conducted any time there is concern about the leucaena performance especially if nutrient supply is a likely cause of poor growth.

In established leucaena stands, testing every 4 to 5 years should be sufficient.

In new plantings, if a soil test was undertaken prior to planting and fertiliser was applied, the first leaf test should occur at about year 5. If no soil tests were taken and no fertiliser applied at planting, then a leaf test at about year 3 should be undertaken.

Testing frequency should increase in irrigated or high rainfall situations with high stocking rates and increased nutrient removal from stock.

More information

Gonzalez A, Andrew CS, Pieters WHJ. (1980). 'Foliar symptoms of mineral disorders in *Leucaena leucocephala*'. Division of Tropical Crops and Pastures. Technical paper No. 21. CSIRO, Melbourne.

Radrizzani A, Dalzell S, Shelton HM. (2011). Effect of environment and plant phenology on prediction of plant nutrient deficiency using leaf analysis in *Leucaena leucocephala*. Crop and Pasture Science. 62. 248-260.

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Leucaena tissue testing checklist

Plan

- [ ] **1. Develop a sampling plan that suits your situation:**
  - Reason for sampling: diagnostic or monitoring.
  - Representative of the paddock: defined zone, whole paddock.
  - Choose which laboratory and analysis to use and download their forms and sampling guides.
- [ ] **2. When to sample:**
  - During summer when leucaena is actively growing.
  - Mid-morning to avoid dew and midday heat.
  - Early in the week so samples arrive at the laboratory before the weekend.
- [ ] **3. Re-sample every 4 to 5 years as part of on-going monitoring.**

Sample

- [ ] **4. Gather appropriate sampling equipment.**
- [ ] **5. Collecting samples:**
  - Locate trees to sample in a representative pattern (e.g. transect).
  - Avoid unusual areas, sample from representative leucaena plants.
  - Collect YFEL from more than 30 trees into a clean paper bag.
  - Cool samples in an esky or fridge. Do not freeze.
- [ ] **6. Prepare samples for dispatch to laboratory (clean, and cool; dry if required) to avoid spoilage during transit.**

Send

- [ ] **7. Send samples to laboratory:**
  - Choose appropriate analysis package.
  - Complete submission forms and retain a copy.
  - Express or overnight courier to laboratory.

Interpret

- [ ] **8. Compare lab test results to look up tables for nutrient levels that optimise leucaena growth.**
- [ ] **9. Seek advice from a qualified agronomist for interpretation and fertiliser recommendations.**

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