Back to soil chemistry basics

Background

Tea Tree will uptake available chemical nutrients from the soil, in varying amounts, according to stage of tree development and seasonal conditions. While the base chemical composition of soil will depend upon the materials from which it was formed, and the environmental processes that occurred during its formation, the soil chemistry can be manipulated to some extent through the supply of inorganic fertilisers, organic inputs, and soil ameliorants. But simply incorporating, broadcasting or fertigating sources of nutrients does not mean the tree will use them immediately. We also need to consider how the soil's environmental processes will store, cycle, and release the nutrients.

In order to optimise the availability and uptake of soil nutrients to the tree crop, the 4Rs strategic approach is important to adopt:

- The *right* source- match product to crop requirement;
- at the *right* rate- match amount to crop uptake demand;
- at the *right* time- nutrients available when the crop needs them; and
- in the *right* place- match applications to soil type and where the crop needs it.

There has been limited specific research undertaken on the relationship between soil chemistry/ nutrient supply and Tea Tree physiology (uptake demand, cycling, storage and use within the tree), and the subsequent influence upon tree development and growth. This is an area that will develop as the industry matures. In the meanwhile, reliable principles researched and used in other tree crops and industries operating on the same soil types, in Tea Tree growing regions, are certainly applicable.

Why is good soil chemistry beneficial?

The soil holds the majority of nutrients that are needed by plants for growth, but these are not always available in the right form, at the right time, for plant uptake. Soil inputs such as inorganic fertilisers, organic materials, and ameliorants such as lime, are ways in which chemical nutrient availability can be manipulated within a season or across seasons. When applying fertiliser, it is important to consider that the tree crop may not uptake that application immediately.

Key points

- The base chemical composition of a soil is determined by the rock from which it was formed and the environmental processes to which it has been subjected.
- Soil chemistry will influence the supply of nutrients that are required for optimal plant growth.
- Adoption of the 4Rs strategy will maximise nutrient input efficiency:
  - *Right* source
  - *Right* rate
  - *Right* time
  - *Right* place
- Soil and leaf testing will determine whether there are any deficiencies or toxicities within the soil.

There are processes in the soil that may convert these into stored forms for release later in the season, or often months later. While these processes are undertaken, losses can occur if application is undertaken at vulnerable times, such as when heavy rainfall is forecast. For this reason, it is important to continuously monitor the nutrient status of your soil through soil testing and apply according to the 4Rs.

There are 14 soil nutrients that are essential for tree growth and each of them has a critical role to play in the development of the plant (Table 1). Trees will struggle to reach their maximum yield potential, and there may be costly fertiliser waste to the environment, if the soil chemistry is unbalanced.

By undertaking a leaf analysis of Tea Tree and comparing results to the ranges outlined in Table 2, you can assess whether the plant is lacking essential nutrients and work to correct imbalances. At this time, the industry is working towards conducting further work to readdress optimal nutrient ranges and further define nutrient best management practices to maximise tree growth and production.

Table 1

Macronutrients and their role in plant growth (Source: NSW LLS, 2020)

Nutrient	Role in plant growth
Nitrogen (N)	Needed for photosynthesis and protein formation
Phosphorous (P)	Stimulates early growth, Essential for energy formation
Potassium (K)	Disease resistance, Regulation of enzyme functions
Sulfur (S)	Energy processes, Formation of chlorophyll, protein production
Calcium (Ca)	Plays a role in metabolic processes, Plant structure and movement of nutrients
Magnesium (Mg)	Essential for photosynthesis, Enzyme activation, Production of carbohydrates, amino acids, sugars fats, etc.
Sodium (Na)	Essential for osmosis
Zinc (Z)	Needed for the uptake of phosphorus, energy production and water uptake
Manganese (Mn)	Required for Nitrogen and C02 uptake
Iron (Fe)	Chlorophyll function
Copper (Cu)	Photosynthesis, respiration, and enzyme processes, Protein and carbohydrate metabolism, Disease resistance
Boron (B)	Movement of sugars around the plants and roots, Disease resistance and plant resilience, Cell division, Nitrogen Uptake
Molybdenum (Mo)	Protein Production
Silicon (Si)	Strengthens plants, Improves photosynthesis, Increases drought tolerance

Table 2

Optimal levels of Leaf and soil analysis for a healthy Tea Tree Crop (Source: Drinnan, 2000)

Leaf			Soil		
Nutrient	**Range**	**Healthy**	**Nutrient**	**Range**	**Healthy**
N (%)	1.3-2.1	1.8	**pH (Water)**	4.9-6.1	5.8
P (%)	0.07-0.23	0.15	**N (mg/kg)**	2-10	10
K (%)	0.27-1.1	1.1	**P BRAY (mg/kg)**	7.7-40	40
Ca (%)	0.4-0.8	0.5	**K (meq/100g)**	0.3-0.8	0.8
S (%)	0.11-0.22	0.2	**Ca (meq/100g)**	6-16	8
Mg (%)	0.18-0.38	0.22	**S (mg/kg)**	4-13	10
Cu (mg/kg)	4-45	20	**Mg (meq/100)**		4
Zn (mg/kg)	14-70	40	**Cu (mg/kg)**	4-10	5
Fe (mg/kg)	60-170	100	**Zn (mg/kg)**	0.4-5.0	5.7
Mn (mg/kg	100-1000	200	**Fe (mg/kg)**	0.3-5.7	20
B (mg/kg)	25-45	35	**Mn (mg/kg)**	11-33	15
			B (mg/kg)	0.62.0	1

Healthy soil chemistry is also essential for the structure and friability of the soil (*See Back to Soil Structure Basics*). For example, the ratio of Ca and Mg that is present within the soil can affect the soil structure. Once the Mg percentage of exchangeable cations exceeds 20%, the soil will become increasingly difficult to work. Mg and Na will cause clay particles to disperse, whereas in soils that have the exchange dominated by Ca the clay platelets will aggregate to form peds. These soils are easier to work, have better internal drainage are easier to cultivate and as a result naturally encourage higher levels of soil biology (*See Back to Soil Biology Basics*).

What are the management practices known now to encourage improved soil chemistry?

Adopting the 4Rs strategy will help maximise nutrient use efficiency within the crop.

Right Source

There are various sources that can provide nutrients to the soil and to the plant ranging from traditional granular fertilisers, liquid fertiliser, spent leaf mulch, chicken manure, and other organic amendments. When choosing which source of nutrients to apply to your tree crop, consider the availability of the product, labour required to apply the product, and the equipment needed. Chicken manure can be difficult to source, and nutrient composition and rates vary greatly across batches. Spent leaf mulch is a great source of organic matter but is costly and time-consuming to reapply. Granular fertilisers are composed of different sources of base fertiliser products and can be tailored to your soil type.

For example, if your soil is often waterlogged, then using an ammoniated source (e.g., urea, ammonium sulfate) is better than using a nitrate source (e.g., urea ammonium nitrate) (Dairy Australia, 2020). If salt levels within your paddock are high, using sulfate of potash will be more suited than using muriate of potash.

Right Rate

The right rate to apply on the Tea Tree crop is calculated through soil testing and leaf sample analysis. By understanding how much biomass has been removed through the harvesting process we can begin to work out how much to apply the following year.

For example, if leaf N is 0.9% and our harvested biomass is 15 tonnes (dry weight), then N removal rate is 135 kgN/ha (15 000kg*0.9%= 135) (Drinnan, 2000). Allowances need to be made for N stored in the soil, as well as leaching, erosion, volatilisation, and nutrient tie-up. Calibration of your fertiliser box is also important to make sure the target rate is actually being applied and is distributed evenly across the block.

Right Time

The fertiliser that is used should be applied split throughout the growing season in smaller amounts as shown in Table 3. By splitting the application of fertiliser, nutrients are targeted to the needs of the crop throughout its different growth stages.

For example, only a small proportion of the fertiliser is applied during the first 2 months after harvest while coppicing is starting, and plant growth is slow.

Table 3

Nutrient application timing for Tea Tree (Source: Drinnan, 2000)

Months from harvesting	% of total nutrients
0-2	10%
2-4	20%
4-6	20%
6-Harvest	50%

If fertiliser is broadcast on top of the soil surface, applying it before a small rainfall event is ideal to minimise the risk of N loss via volatilisation and denitrification.

Right Place

Spatial Placement: When blanket rates of fertiliser are applied across blocks over-supply can occur, resulting in economic losses, and under-supply in other areas, leading to lower yield potential.

By grouping blocks into different soil types and/or areas of known production variation for soil sampling and leaf testing, nutrient recommendations can be tailored to suit each unique management area (Figure 1).

In-crop placement: At this point in time, there is very little research completed on the benefits of different nutrient placement strategies (foliar applied, solid granular broadcast, solid granular incorporated) pre-plant, during growth and post-harvest. In a recent report (Kristiansen et al., 2021), subsurface application was highlighted as beneficial in reducing nutrient loss compared to surface application.

Standard practice of subsurface mineral fertiliser application in Tea Tree is to apply along the center of the inter-row. Incorporation depths vary from 50-200mm dependent upon equipment and soil type.

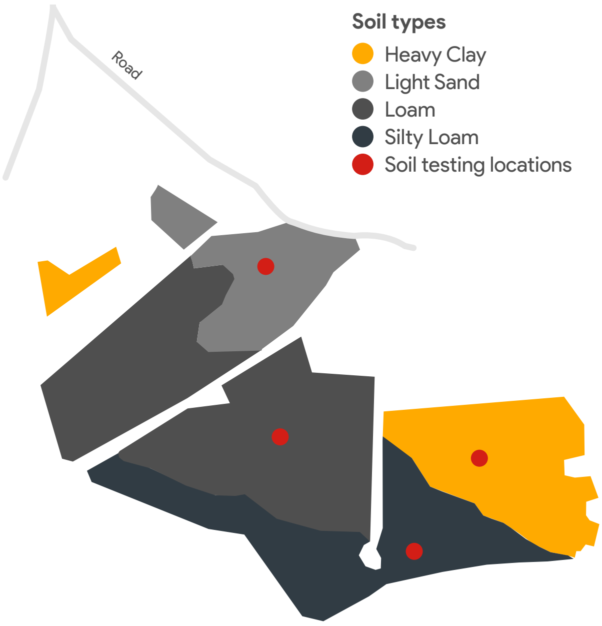

Figure 1. Soil testing locations grouped by soil types across paddocks

Monitoring soil health for improved chemistry management

The first step to managing soil chemistry is to take both soil tests and leaf tests to understand whether your soil is experiencing any deficiencies or imbalances. Sampling location and paddock history are important to help understand the results. A local agronomist is best placed to advise on where to take samples within each of your soil types/ management areas, and to organise laboratory testing and analysis. The next step is to work with your agronomist to develop a nutrient plan that will keep your soil chemistry well-balanced without loss to the environment.

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