CHAPTER 7

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Nutrition Efficiency

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Nutrients and soil constraints that impact cotton

Crop nutrition management not only requires a sound knowledge about plant nutrient requirements and demands but also requires an understanding about soils, soil chemistry, soil health and the complex interaction between the plant and soil.

Nitrogen

Nitrogen is a mobile nutrient both in the soil and in the plant and should be monitored throughout the production season to maximise production. Deficiency symptoms include stunted plants with pale yellow leaves, few vegetative and fruiting branches. Excessive supply of N will induce rank vegetative growth, shed young bolls, delayed fruiting and crop maturity, hamper defoliation and reduce lint yield and profit.

Cotton sources most of its N as nitrate-N from the mineralisation of soil organic matter. Mineralisation is a biological process within the soil which results in the release of nutrients in a form which is available for crop uptake. Only about 1/3 of the crop's N needs are derived from N fertiliser but this is critical to maximising production.

Nitrogen can be lost from the system in several ways and must be considered when preparing a nitrogen management plan. These include:

- **Denitrification –** A biological process especially under low oxygen conditions such as during water-logging where nitrate N is converted into a nitrogen gas and lost to the atmosphere.
- **Leaching and runoff –** Nitrates can be washed through the soil profile and out of the root zone or removed in runoff water.
- **Volatilisation –** Nitrogen in the form of ammonia is lost to the atmosphere. Particularly important when solid fertilisers are applied and are not incorporated properly or in a timely manner.
- **Removal of seed cotton –** most of the crop N removed from the system is found in the cotton seed and can be significant, particularly in high yielding crops.
- **Burning stubble –** The heat from fire destroys organic matter in the surface soil, and much of the N, P and S contained in the soil organic will be lost to the atmosphere during burning. Burning stubble is not common in modern cotton farming systems.

Excess nitrogen can have a detrimental impact.

While insufficient nitrogen will impact on yield, excess nitrogen can also have significant detrimental impacts on cotton. Rank vegetative growth, boll shedding, delayed full boll load and crop maturity, small fruit, increased disease problems such as boll rots, difficulties in defoliating, harvesting problems and reduced fibre quality are all problems associated from over fertilising. All these impacts have considerable economic costs associated with them and result in reduced yields, quality down grades, increased production costs as a result of increased use of growth regulators and defoliants, higher fertiliser costs and reduced N efficiencies. Recent research on Nitrogen Use Efficiency (NUE) by Dr Ian Rochester has identified that there may be opportunities to improve NUE in the cotton industry. www.mybmp.com.au has useful strategies to assess nitrogen use

Anhydrous ammonia (82% N) and Urea (46% N) are the two major nitrogen fertilisers used in the cotton industry. The N released from both fertilisers become available to plants within days, depending on the amounts applied. Urea has the advantage of being able to be applied in different ways using different application methods and at different times. It does need to be incorporated quickly after application to prevent significant losses through volatilisation.

There are several different approaches to how and when N is applied. If all N is applied prior to planting:

- Apply after July to reduce substantial losses through denitrification and leaching.
- Allow sufficient time after application and before planting (3 weeks) to prevent seedling damage.
- Depth and position is also critical to prevent unnecessary losses and seedling damage.
- If N applications are to be split there are two main methods (side-dressing and water run) of application in crop. Side-dressing should occur prior to flowering to help reduce crop damage through root pruning and allow sufficient time for the N to become available to the plant. Water run urea provides more flexibility and reduces crop damage, however in really wet years, opportunity to get nitrogen on may be limited..

Anhydrous ammonia (NH_3) is the most popular option for irrigated cotton, especially where high rates of N are required. Specialised equipment and training is required when applying NH_3. It must be applied deeper than 15 cm to reduce losses however soil conditions impact greatly on this. Very dry soils will allow gas to escape through voids and air spaces while very wet soils will allow gas to escape through the application furrow if it is not closed properly.

Legumes

Incorporating a legume into your crop rotations can significantly improve soil nitrogen fertility through their capacity to fix atmospheric nitrogen into a plant available form. Legumes can also have beneficial effects on soil structure and plant disease management. The amount N fixed and residual soil N of various legume crops can be seen in NUTRIpak.

Recent work has shown significant financial and agronomic benefits of including legumes into the rotation.

Phosphorus

Phosphorus (P) plays an important role in the energy transfer process in plants cells, used in DNA and RNA and some regulation of plant metabolism. Plant deficiency causes reduced seedling vigour, poor plant establishment and root development, delayed fruiting and maturity. Plants will appear stunted and with red/purplish colour.

Phosphorus is a highly immobile nutrient in the soil and despite many soils having a high total P content they can have very low P availability especially under alkaline conditions. P in soils can be classified into 3 pools:

- Available P (phosphate in soil solution that can be used by plants, limited in quantity but readily replenished from labile P).
- Labile P (moderately available P that move in and out of solution, acts to buffer the available P in solution).
- Non labile P (very insoluble P unavailable to plants).

Actively growing cotton plants take up available P from the soil solution. As this supply is depleted, labile P replenishes and maintains the available P. i.e. acts as a buffer. With continued cropping, the level of labile P declines and is less able to replenish and maintain available P. When P fertilisers are applied to soils, much of the P ends up as labile P. P is normally applied pre plant as a starter with N to enhance growth and increase efficiency.

Mono Ammonium Phosphate, MAP (N:P:K – 9:22:0) and DiAmmonium Phosphate, DAP (N:P:K – 18:20:0) are the most commonly used P fertilisers. Banding of these fertilisers is the preferred method of application as the P remains in solution for a longer period. Although it is considered that P fertilisers are only 30-50% efficient, it is not lost to the system but is immobilised or fixed and may become available later.

P is relatively immobile within the soil so increasing soil-root contact can increase the uptake of P by the crop. Mycorrhizal fungi (VAM) found in the soil have an association with cotton and assist in accumulating and making P available to the plants. Low VAM populations have been attributed to long fallow disorder and need to be considered when growing cotton following long fallow periods or after non-mycorrhizal crops such as canola. Tillage is the main contributor to low VAM populations.

Potassium

Potassium (K) is a mobile nutrient within the plant and has a role in energy transfer, osmotic regulation (maintaining turgor), protein synthesis and nitrogen metabolism. Adequate K nutrition has been linked to reducing the incidence or severity of plant diseases and improving yield and fibre quality.

Deficiencies are first seen in the lower leaves as necrotic lesions and leaf death which moves up the plant, bolls don't develop and fail to open, and as premature senescence can occur.

There are several forms of K in the soil with varying levels of availability to the plant.

Potassium chloride (muriate of potash) is the most widely used fertiliser. It should be banded away from the seed row to prevent seedling damage. Foliar fertilisers can be effective when deficiencies have been identified in petiole and leaf analysis.

Other essential nutrients

Zinc: Zinc is essential in small amounts for enzymes and plant harmony. Deficiencies can be seen as interveinal chlorosis, stunting, and will affect yield, maturity and fibre quality. Zinc sulphate is the most effective and inexpensive form to apply zinc to soil or crop, whereas zinc oxide is very insoluble in the soil but can be dissolved by plant roots. Zinc can be broadcast and worked into the soil, with shallow cultivation. Zn can also be successfully applied to crops as a foliar spray; it can alleviate symptoms and supply sufficient zinc to meet crop needs.

Iron: Iron is an essential nutrient required in very small amounts in chlorophyll synthesis and some enzymes. Plant symptoms include interveinal chlorosis of the young growth and yellowing of the leaves. Most of the iron in soils is unavailable to plants. Availability is greatly affected by the presence of manganese and P and Zn fertiliser can also reduce iron uptake. Water logging can also lead to deficiencies in alkaline soils. Deficiencies can be managed through both foliar and soil applications.

Other essential nutrients such as copper, boron, calcium, magnesium, sulphur, manganese and molybdenum all have very specific roles to play in meeting the nutritional needs of a cotton crop. Required in very small amount, deficiencies are very rare.

For more information the following resources and tools are available at https://www.mybmp.com.au/auth_user/grower_tools_and_resources.aspx

- **NUTRIpak**
- **FIBREpak**
- **SOILpak**
- **Vetch Fact sheet**
- **Nutrients removed in harvested seed-cotton**
- **CottASSIST Nutrilogic**

Subsoil constraints

Soil provides the cotton plant with water, oxygen, nutrients and support. An ideal soil would have good infiltration and internal drainage, high plant available water capacity (PAWC), good soil structure for root growth and development, optimum pH, low salinity, balance nutrient availability, low sodicity and adequate soil mycorhiza and other soil biota. Subsoil constraints are those soil properties or characteristics which limit or restrict the cotton plant in meeting its requirements. Problems associated with subsoil constraints include compaction, soil dispersion, high or low pH, water logging and erosion. These soil related problems can result in poor seedling emergence, poor plant growth, loss of bolls and poor boll set, reduced yields, erosion, increased land management costs and other management issues.

Understanding how modern farming practices impact on and effect the soil, it's chemical and physical properties, is a critical role in how we develop and manage our production systems. For example, as much as 1.5 tonnes of salt per ha is deposited onto soil and into the root zone each time a crop is irrigated. This can be significantly higher when bore water is used rather than river water. The accumulation of salts in the root zone can lead to sodic soils causing soil structural problems, soil dispersion, water logging and hard setting soils.

What is a sodic soil?

A sodic soil is one which has too much sodium associated with the negatively charged clay particles. Large quantities of sodium in soil, reduces the strength of bonds holding clay particles together in aggregates. The sodium also attracts large numbers of water molecules helping to force the clay particles apart. This is known as dispersion and causes the soil structure to collapse. The level of sodicity can be quantified by determining the exchangeable sodium percentage (ESP) during a soil test.

Many of the soils used for cotton production in Australia, are sodic or strongly sodic below a depth of 0.5 m. This affects root growth and water and nutrient uptake. Ground water, used for irrigation can cause sodicity problems particularly when the water contains high sodium levels relative to calcium.

What is a saline soil?

A saline soil is one with excess salts in the soil solution. Soil solution is the liquid in soils held between the soil aggregates. When the concentration of salts in the soil solution exceeds that found in the plant roots, water flows from the roots back into the soil. In this situation the plant is unable to meet its water demands even though the soil is moist. Salinity occurs as a result of ground water rising to within 2mtr of the soil surface, or by irrigating with saline water, or by applying salts via: fertilisers; lime or gypsum. Salinity is measured by testing the soil solutions electrical conductivity (EC).

Meeting the challenge of sodic soils

Calcium can be applied to soils to ameliorate sodic soils. The best form of calcium to use is determined by the pH of the soil. If the soil is alkaline, gypsum will give the best results while if the soil is acid, lime should be used. In this case, lime also has the added benefit of raising the pH of the soil.

The addition of organic matter to soil can also help to reduce the effects of soil sodicity. Organic matter helps hold the soil aggregates together, stabilises soil chemistry, reduces dispersion and improves soil structure.

Source: "Salinity and Sodicity – what's the difference?" By David McKenzie *The Australian Cottongrower* Feb-Mar 2003

Other important soil constraints

Compaction: Soil compaction restricts root growth, reducing the availability of nutrients and water to the cotton plant. It can also increase denitrification, further reducing the availability of nitrogen. Some compaction is an inevitable consequence of using heavy machinery on soils, however by implementing good management practices, minimal tillage systems and guidance systems, the impact can be minimised.

Waterlogging: Water logging particularly following surface irrigation can impact significantly on cotton production. Denitrification, boll shed and reduced boll set are some of the impacts of water logging, resulting in yield loss. refer to Chapter 8 for more information on waterlogging.

Soil pH: Soil pH is a measure of the acidity, neutrality or alkalinity of the soil solution. It directly influences the availability of soil nutrients to the cotton plant. Most cracking clay soils are alkaline (pH 8.0 to 8.5) affecting the availability of many micronutrients. This should be considered when calculating fertiliser programs.

Soil mycorrhiza: Soil mycorrhiza (also referred to as AM), are beneficial soil-borne fungi that attach themselves to the

Alternative crop rotations can increase organic inputs.

growing roots of crops. They allow roots to scavenge more effectively for nutrients especially those nutrients which are immobile in the soil and have poor solubility such as P and Zn. Low AM levels are associated with long fallow disorder when cotton crops perform poorly particular in long fallow dryland cotton systems or following non mycorrhizal crops such as canola. Refer to Chapter 16.

For more information the following resources and tools are available at https://www.mybmp.com.au/auth_user/grower_tools_and_resources.aspx

- **WATERpak**
- **NUTRIpak**
- **SOILpak**

Soil organic matter and soil carbon

Soil organic matter is composed of dead and decomposing plant material, litter, soil biota (fungi, bacteria, earthworms etc) and decomposing animals and their waste material. It includes everything that is of biological origin; by definition, soil organic matter is rich in carbon.

Soil organic carbon can be divided into four fractions.

1. **Crop residue and particulate matter:** Organic materials which have started to quickly decompose.
2. **Microbial biomass:** Microscopic living organisms that decompose organic materials.
3. **Humus:** Organic material whose structure is unrecognisable from its original form. Changes it form slowly.
4. **Charcoal:** Stable organic material and relatively inactive and unlikely to undergo further decomposition.

Soil organic matter is normally quantified by measuring the soil organic carbon content of the soil. An assumption is made that organic matter contains ~60% carbon. Hence, a soil containing 1% carbon will have approximately 1.7% organic matter. The soil carbon content reflects both the organic and inorganic carbon sources. In alkaline soils, carbon is found in inorganic forms as $CaCO_3$ (limestone) and as $CaMgCO_3$ (dolomite) but these carbon forms are normally excluded from soil carbon analyses.

Importance of soil organic matter

Soil organic matter plays an important role in all three aspects of soil fertility:

1. **Biological functions:** Supplies nutrients for plant growth and provides energy and nutrients for soil micro-organisms.
2. **Physical functions:** Stabilises soil structure and promotes soil aggregation, improves soil water storage and infiltration.
3. **Chemical functions:** Increases soil cation exchange capacity, buffers soil pH, reduces effects of salinity and sodicity.

Organic matter losses

Organic matter can be quickly depleted if soils are not managed carefully. Soil organic matter losses result from excessive cultivation, excessive nitrogen fertiliser application, wind and water erosion of top soil, crop stubble removal (silage, hay or burning), and high soil temperatures (bare fallow in summer).

Managing soil organic matter

Soil organic matter levels in many cotton fields have declined significantly since the fields were developed. Arresting the decline and rebuilding soil organic matter should be an important consideration to ensure soils remain fertile into the future. This means balancing the addition of organic materials with their decomposition, by either adding more organic matter (crop residues and other organic materials) and or reducing the loss of carbon from the soil.

Inputs of organic materials can be increased by:

- Retaining stubble;
- Growing cover crops and green manure crops;
- Alternative crop rotations;
- Adding composts;
- Animal manures; and,
- Bio-solids.

Losses can be reduced by changing management practices:

- Reduce tillage operations;
- Employ controlled traffic and use permanent bed systems; and,
- Stop burning or baling crop residues.

It may be difficult to achieve this balance in every cotton production system, due to soil type, environmental conditions and agronomic constraints.

Some of these practices may have conflicting impacts. For example, retaining crop stubble on the surface increases soil water infiltration and storage, reduces soil erosion and protects the soil. However, a significant amount of carbon is lost to the atmosphere as carbon dioxide (CO2) as soil organic matter decomposes. In contrast, stubble incorporation can increase organic carbon retention and may be combined with pupae busting operations. Cultivation can promote loss of soil water and expose the soil to erosion. Research has shown that a strategic, targeted tillage operation to incorporate stubble and control pupae, can help increase soil carbon.

Most of a crop's nutrient requirements are met from the recycling of soil organic matter and the nutrients released during the decomposition of this material. Inorganic fertilisers are required when the soil is unable to meet a crops nutrient demand and are critical in optimising production. Manures and composts can be a very important source of organic matter for soils as well as a valuable supply of nutrients. However there is a time lag between the applications of these materials and when nutrients become available to the crop. The nutrients are slowly released to the soil and assist the supply of nutrients to the crop.

In irrigated cotton systems, research has shown that soil organic carbon levels can increase with changes to conventional cropping systems. By eliminating deep tillage operations, soil structure can be maintained and by incorporating stubble, soil health is promoted. Other management practises including reducing fallow periods and optimising water and nutrient applications can also play important roles.

Monitor to manage – nutrition efficiency

Application of fertilisers to meet crop demand is only a part of developing a crop nutrition plan. Consideration must be given to other very important factors such as crop rotations, fallows, stubble management, tillage practices, legumes, manures and composts, soil chemistry, salinity, sodicity and irrigation water. The development of a considered, balanced nutrient management plan for the crop will maximise yields, optimise nutrient use efficiencies, minimise nutrient losses and improve soil health and physical properties.

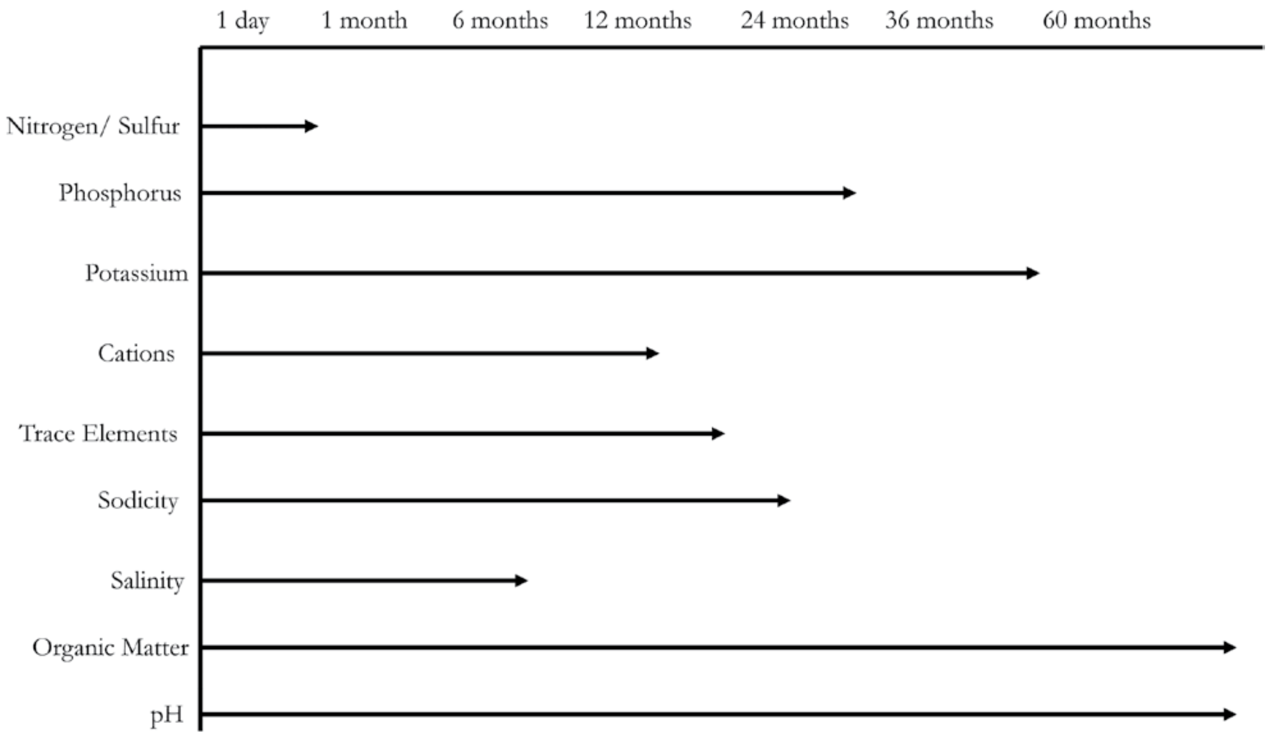
Most of the nutrients taken up by cotton from the soil are derived from the decomposition of previous crop residues, soil microorganisms and soil organic matter. Nutrients are continually being cycled between the crop and soil, as occurs in all biological systems. However, because of the high rates of nutrient removal in seed cotton (Table 1), our inherently fertile cotton-growing soils can become depleted in nutrients.

The removal of nutrients depletes soil fertility and fertiliser application may be needed to increase the supply of these nutrients to subsequent cotton crops. Hence, we can either replace these nutrients as they are removed or wait until each nutrient successively becomes limiting to cotton production, then commence a fertiliser program to overcome the nutrient deficiency. It is important that this program begins before nutrient supply limits crop production.

TIME TO DETECT SIGNIFICANT CHANGE IN SOIL PROPERTIES FROM TYPICAL FERTILISER APPLICATION

When developing a crop nutrition plan, consider how frequently should soil be tested for different nutrients.

Source: Healthy soils for sustainable Farms, Understanding Soil Testing short course. (Source: Cotton CRC Healthy Soils for Sustainable Farms, Understanding Soil Testing Short Course)



In developing a fertiliser program a grower needs to consider the following strategies and integrate them according to their own farm's needs:

- Determine soil nutrient status using pre-season soil testing.
- Calculate expected crop nutrient requirement taking into consideration expected yield, cropping history, cropping system and nutrient losses, crop use efficiencies, plant nutrient recovery and uptake, soil condition and characteristics – decision support programs such as NutriLOGIC can assist here.
- Develop a fertiliser use plan that minimises nutrient losses.
- Monitor crop through petiole (early season) and leaf analysis (flowering to defoliation) to determine if the crop has sufficient or inadequate nutrient levels.
- Develop a long term management program which maintains or improves soil health.

Determine soil nutrient status: soil sampling and analysis

A fundamental requirement in meeting the nutritional needs of a cotton crop is determining nutrient level in the soil before planting. By using soil analysis as a routine part of management, it can provide an indication of the fertility level in your soil at that point in time. Do-it-yourself soil sampling kits are commercially available through accredited laboratories or, service providers can be engaged to sample, analyse and provide recommendations for fertiliser application.

Soil sampling kits provide instructions on how and where to sample the soil in order to provide a representative sample. There are often differences in soils and soil types within any given field. To gain the most benefit from soil tests it is important to take these differences into account when sampling. Precision Ag technology such as EM surveys can assist to understand this variability. Crop performance throughout the season can also provide insight into areas worthy of investigation. Good records can allow for the monitoring of nutrient status over time. Follow sampling instructions carefully; accuracy of the results can be impaired if the samples are not taken and handled correctly.

Refer to the Precision Ag section of this book for more details on EM surveys.

When choosing a laboratory to conduct your testing, ensure that it is accredited to Australian Standards and registered by the Australian Association of Testing Authorities. Unfortunately laboratories express results differently so it is important that the tests being conducted are going to provide the information that is required and in a form that can used.

Calculate expected crop nutrient requirement

Interpreting soil tests can be complicated and it is recommended to seek professional advice from service providers or use an interpretation program such as NutriLOGIC to determine fertiliser requirements. NutriLOGIC is a user friendly decision aid for fertiliser management. It is a component of CottASSIST, a suite of web tools developed by CSIRO, Cotton CRC and CRDC to provide the cotton industry with access to the latest research.

NutriLOGIC provides an assessment of nutrient/fertiliser requirements, independent of fertiliser manufacturers and resellers.

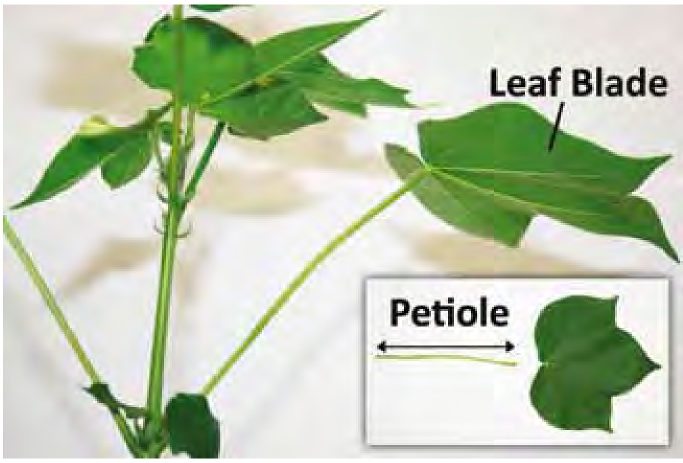
NutriLOGIC estimates the fertiliser required for a cotton crop based on years of field experiments conducted in Australian conditions, supported by industry funding. Inputs required are soil test data, the cotton growing region and the month the sample was taken. The program makes allowance for soil factors (texture, compaction and predisposition to water logging). Losses of N through denitrification and leaching during the crop-growing season are also built into the web tool.

Develop a fertiliser management plan

A fertiliser plan outlines how, when and in what form the fertiliser inputs that are required by cotton crops are managed. This requires working through a number of considerations, all of which depend on each other.

Which fertiliser to apply: There different types or forms of fertiliser that can be used i.e. manures and composts, granular fertilisers, anhydrous ammonia (gas), liquid fertiliser or foliar fertiliser. The type of fertiliser may be limited by the capacity to apply it. Composts and manures need to be spread and incorporated, anhydrous ammonia (gas) needs to be applied using specialized equipment by trained staff, and foliar fertilisers need to be applied evenly and in a timely manner, i.e. in response to nutrient crop demand

When to apply: The timing of fertiliser application is determined by the production system and the type of fertiliser being used. Composts and manures need to be spread and incorporated in advance of planting and when used in minimum tillage systems may need to be combined with other processes. Anhydrous ammonia (gas) fertiliser cannot be applied too close to planting



Leaf and petoile testing can inform cotton nutrient status.
(Photo: Duncan Weir, Qld DAFF)

as seedling damage may occur from ammonia burn. When applying all the nutritional requirements "up front" there are reduced efficiencies and greater losses from the system to be considered. Split applications can improve efficiencies and the application rates can be adjusted to meet changing crop demands. Timing of split applications is critical, irrigation and rain can impact on the capability to apply fertilisers in a timely manner hence increasing the risk of crops being nutrient deficient at a critical time.

What rate to apply: The fertiliser rate will depend on the type of fertiliser being used and when it is being applied. The composition of the fertiliser (percentage of each nutrient in the fertiliser) will dictate just how much of the product needs to be applied to meet the crop requirement. If all the fertiliser is being applied up front, an adjustment must be made to take into consideration losses and inefficiencies. On the other hand, if a starter fertiliser is being used at planting with later in-crop applications, the rate of fertiliser must be adjusted. The rate is determined by soil analysis in the winter prior to planting the crop and can be modified by leaf and petiole analyses performed in-crop.

Where to apply it: Most fertilisers are best applied to the soil. This normally occurs pre-plant, at depth, off the plant line. Applying fertilisers too close to the plant line may cause seedling damage due to the salt or toxicity effect. Nitrogen, contained in fertilisers can be lost to the atmosphere through ammonia volatilisation and should be applied below the surface and buried. Other fertilisers e.g. P, K, Zn etc can be broadcast and then incorporated later to maximise contact between the roots and fertiliser. The amounts of nutrients that can be applied to the foliage is quite limited and the benefit short term. Foliar fertilisers can be used to help meet crop nutrient requirement when a nutrient has been identified and the quantity of nutrient required is small.

Fertiliser plans need to be flexible and have the capacity to be modified through the season if conditions change or if leaf and petiole analyses identify a problem and indicate a change to the nutritional requirement of the crop and subsequent fertiliser program.

Monitor the crop

Often, nutrient deficiencies are not identified until symptoms appear, by which time, some yield reduction will have occurred despite remedial fertiliser application. Plant analyses can provide information about the nutritional status of a crop and indicate nutrient deficiencies which, if identified early enough, may be rectified by applying the appropriate fertiliser with little or no impact on the crop.

Petiole analysis is ideal for monitoring nitrate-N and potassium concentrations up to flowering. For Australian cotton, petiole tests have been calibrated for nitrate and potassium but are not recommended for other nutrients. Three samplings approximately 10 days apart (600, 750 and 900 day degrees) are required to give a good indication of the rate of change in the nitrogen and potassium in the petioles.

Leaf analysis can be used to monitor all nutrients including micronutrients. Sampling leaf tissue twice (at flowering and cut out) produces the most useful information.

Follow sampling direction carefully, results can only be as good as the sample provided. Tips for leaf blade and petiole sampling:

- Ensure samples are taken at a similar soil moisture and time of day and record stage of growth (day degrees).
- Do not sample when the crop is not stressed (eg. during water logging or cloudy weather).
- Sample at least 50 petioles or 50 leaf blades from the youngest mature leaf, normally 4th or 5th unfolded leaf from the top of the plant.
- Leaf blades must be immediately removed from the petiole
- Collect samples with clean, dry hands or clean gloves, as sweat and sunscreen can contaminate.
- Samples should be loosely packed in a paper bag and stored in a cool place (refrigerator) immediately and transported to laboratory as soon as possible.

NutriLOGIC can be used to assess both petiole analysis (early crop nutrient monitoring) and leaf analysis (flowering to defoliation crop nutrient monitoring).

Develop a long term management program which maintains or improves soil health.

Compaction, sodicity, poor soil structure, low fertility and salinity are just some of the critically important reasons to develop long term production programs and systems. Sodicity and salinity are naturally accruing constraints in many soils used for cotton production. They are covered in more detail in the Subsoil Constraints section below.

Reduced, minimal or zero tillage practices, crop rotations, cover crops, legumes, composts, stubble incorporation, manures and controlled traffic are just some of the management practices which can be introduced into a cropping system that can have beneficial impacts on soil health and soil fertility as well as reduce costs and improve productivity.

For more information the following resources and tools are available at https://www.mybmp.com.au/auth_user/grower_tools_and_resources.aspx

- **NutriPAK**
- **SoilPAK**
- **Nutrients removed in harvested seed-cotton**
- **CottASSIST NutriLOGIC**
- ***Cotton Symptoms Guide***