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Crop nutrition & soil health

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Managing good soil nutrition

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. 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.

BE AWARE OF

In developing a fertiliser program, a grower needs to

- Determine soil nutrient status – soil sampling
- Calculate expected crop nutrient requirement
- Implement a fertiliser use plan – fertiliser form, rate, application, frequency, timing
- Monitor crop nutrient status – leaf (and petiole) analysis
- Develop a long-term crop nutrition and soil health management plan
- It is important that the fertiliser program begins before nutrient supply limits crop production.

Soil Health module in *my*BMP contains further information to support crop nutrition management

TABLE 1.
The amount of each nutrient removed at various yield levels.

Yield b/ha	N	P	K	S	Ca	Mg	B	Cu	Zn	Fe	Mn
	kg/ha						g/ha				
4	35	10	15	4	2	5	13	12	53	85	6
5	50	12	18	5	3	7	20	14	63	98	8
6	65	14	22	6	3	8	28	16	72	112	9
7	80	17	26	7	4	10	35	18	82	125	11
8	95	19	29	8	4	11	42	20	91	138	12
9	110	21	33	9	5	13	49	22	100	151	14
10	125	24	37	10	6	14	56	24	110	164	15
11	140	26	41	11	6	16	63	26	119	178	17
12	155	28	44	12	7	17	70	28	129	191	18
13	170	31	48	13	7	19	78	30	138	204	20
14	185	33	52	14	8	20	85	32	148	217	21
15	200	35	55	16	8	22	92	34	157	230	22
16	215	37	59	17	9	23	99	36	166	244	24

http://www.cottoncrc.org.au/files/4eab6e0b-514a-4eeb-94e8-995a00f90139/CGNutRem.pdf

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.

Additional information is available in NUTRIpak, found on the Cotton CRC website. http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx

Leaf analysis is a good way to find out about the nutritional status of your crop.

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. (www.CottASSIST.org.au)
- 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.

NB. Link to soil sampling and analysis guidelines – CRC website http://www.cottoncrc.org.au/files/0b13f3af-7ac6-4c68-910f-995a00f901b3/SamGL06.pdf

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 computerised support system developed by CSIRO and Cotton CRC 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.

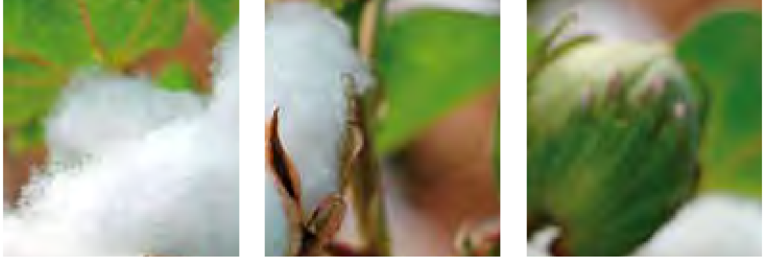
NutriLOGIC estimates the fertiliser required for a cotton crop based on years of field experiments conducted in Australian conditions, supported by industry funding. Inputs required are soil test data, the cotton growing region and the month the sample was taken. The program makes allowance for soil 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 program.

NutriLOGIC can be accessed through CottASSIST at: www.CottASSIST.cottoncrc.org.au/

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:** Different forms of fertiliser 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 specialised 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 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.





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Incitec Pivot

- **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.

NutriLOGIC can be used to assess both petiole analysis (early crop nutrient monitoring) and leaf analysis (flowering to defoliation crop nutrient monitoring). Follow sampling direction carefully, results can only be as good as the sample provided.

More information about Leaf and Petiole Sampling and analysis can be found at: http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx

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.

Nutrients

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. Insert Photos of deficiency symptoms

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.

Excess nitrogen can 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 Ian

Rochester has shown that many cotton crops are being over fertilised with nitrogen and significant improvements in NUE and the associated cost savings, could be achieved through the adoption of Best Management Practices. https://www.mybmp.com.au/home.aspx

For more detail of nutrient management and its impact on fibre quality: FIBREpak
http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx

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.

Anhydrous ammonia (NH3) is the most popular option for irrigated cotton, especially where high rates of N are required. Specialised equipment and training is required when applying NH3. It must be applied deeper than 15cm 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. http://www.cottoncrc.org.au/files/bc8dee8e-3f68-4b2c-8c30-995a00f8ff3a/03N.pdf

Recent work has shown significant financial and agronomic benefits of including legumes into the rotation. More detailed information can be found on the cotton CRC web site:

http://www.cottoncrc.org.au/files/c82c2fe2-f2c9-4c94-af82-9ad600bec0ca/Healthy%20Soils-VETCH%20(Low%20Res).pdf
and
http://www.cottoncrc.org.au/files/fae55662-754b-4a81-922d-9a9000b7ca02/Vetch%20profits.pdf

For more detail on the role of N, its importance, the nitrogen cycle and how it is managed follow the following links: http://web.cotton.crc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
http://web.cotton.crc.org.au/files/bc8dee8e-3f68-4b2c-8c30-995a00f8ff3a/03N.pdf
http://www.cottoncrc.org.au/files/4eab6e0b-514a-4eeb-94e8-995a00f90139/CGNutRem.pdf
http://www.cottoncrc.org.au/files/e481c4ad-3fe5-4f36-9d61-9c63010dbf4d/FIBREpakweb.pdf

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).

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.

For more details on Phosphorus, its importance, the phosphorus cycle and how it is managed follow the links below:
Home Page for NUTRIpak
http://web.cotton.crc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
Phosphorous specific pages:
http://www.cottoncrc.org.au/files/91625ea6-5d78-4ba7-8d38-995a00f8ff64/04P.pdf

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.

For more details on K, its importance, the K cycle and how it is managed follow the links:

Home Page for NUTRIpak
http://web.cotton.crc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
Potassium specific pages:
http://www.cottoncrc.org.au/files/cf72d5c7-b1c5-4e12-9abe-995a00f8ff85/05K.pdf
Related Topics:
Fibre Quality: http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx

Other essential nutrients

Zinc: An essential nutrient required in small amounts for enzymes and plant hormone synthesis. 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.

Dark spots on yellow areas on the leaves are a sign of zinc deficiency.

Zinc deficient young leaves 'cup upwards' and develop interveinal yellowing.

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 applicationsOther 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 details on any of these minor nutrients, their importance, and how to manage them, follow the links:
http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx

Important links

http://CottASSIST.cottoncrc.org.au/
http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy__Nutrition/Nutrition__NUTRIpak.aspx
http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton
http://www.cottoncrc.org.au/content/Industry/Publications/Soils.aspx
https://www.mybmp.com.au/home.aspx

Subsoil constraints

Soil provides the cotton plant with water, oxygen, nutrients and support. An idea 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 is 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.

Best Management Practices have been outlined in the *my*BMP program and can be easily accessed on line on http://www.bmpcotton.com.au/

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 sources of information on sodicity and salinity, their importance, impacts and management can be found on the Cotton CRC wed sites:
http://www.cottoncrc.org.au/content/Industry/Publications/Soils.aspx
http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton
http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy__Nutrition/Nutrition__NUTRIpak.aspx
www. mybmp.com.au

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.

Overcoming soil compaction – advice can be found in SOILpak, see Website below.
More detail on soil compaction can be found on the Cotton CRC web site: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/167501/SOILpak-cotton-Part-E.pdf

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. Water logging can be minimised by:

- Reducing irrigation times by increasing siphon flow rates
- Use shorter field lengths
- Have greater slopes in fields to increase the speed of the irrigation
- Insure beds in-field are raised
- Stop irrigation as soon as water reaches the tail drain
- Avoid soil compaction
- Use other irrigation systems i.e. lateral move or pivots

More details on water logging can be found on the Cotton CRC web site in SOILpak and NUTRIpak
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/167500/SOILpak-cotton-Part-D.pdf
http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx

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.

More details on soil pH can be found on the Cotton CRC web site in SOILpak and NUTRIpak
http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/167500/SOILpak-cotton-Part-D.pdf

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

More details on VAM can be found on the Cotton CRC web site in SOILpak and NUTRIpak
http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx
http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton
http://www.cottoncrc.org.au/files/f7c23902-844e-4a4a-b299-995c00488b84/Soilbiol.pdf