CROP NUTRITION - SOIL TESTING AND PLANT ANALYSIS THRESHOLDS

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Proper nutrition is one of the many factors necessary in achieving the high yield and quality standards we have set for our cotton crop. Laboratory testing can reveal situations where more or new nutrients should be added to a crop. Unfortunately there have been bad experiences with predicting fertiliser use based on laboratory tests, but these experiences, plus research and new equipment should be used to our advantage.

Most cotton growing soils are relatively fertile. However there are three categories of deficiency where fertiliser use is necessary for maximum production:

a) The soil is incapable of providing the full crop requirements of the nutrient. Nitrogen is the best example of this category: virtually all irrigated cotton needs N fertiliser. Most areas north of Garah (NSW) require phosphate as well. With a high crop demand and depletion of nutrients with long-term cropping, other nutrients such as potassium and sulphur may become deficient.

b) Soil or other conditions do not favour release of nutrient at a time or rate required by the crop. Zinc can be an example in this category: high pH soils, cut areas, long fallow disorder etc, may create situations where this nutrient is unavailable to the plant.

c) Temporary imbalances between nutrients may occur during such events as waterlogging. Research is still scant on this subject.

Given these categories in most Australian cotton, the discussion should concentrate on the nutrients N, P, K, S and Zn.

Can tests help us determine these requirements?.

SOIL TESTS

Rather than complicate the issue I will present the opinion that soil tests as we know them are of little value in determining trace element (zinc etc) deficiencies. There are instances of successful calibrations of specific tests, in specific soils, for specific crops. There is little value in extrapolating from wheat to cotton or from USA to Australia.

Nitrogen

This nutrient is present in moderate levels in most soils, but it is very dynamic. Fluctuations in temperature, moisture and stubble can lead to large fluctuations in available soil nitrogen. It is common for soil N levels to drop by a half in the bare cotton fallow from June to September.

The most common soil test is for nitrate nitrogen. We have good correlations between this test and subsequent cotton crop nitrogen status for *samples taken in September to a depth of 30 cm in unfertilised soils.* With these methods, levels of 20-25 ppm nitrate are required before N fertiliser could be omitted from cotton. Generally levels are 5-10 ppm, indicating that 200 to 100 kg N/ha are required.

Because most growers apply N before September, it is necessary to leave nil strips in the field at the time of nitrogen application. These strips are sampled in September to determine whether sidedressing is necessary.

Phosphorus

There are numerous soil tests for this nutrient. One of the more common is the bicarbonate extraction; relationships between this test and phosphate nutrition in cotton are reasonable - but not perfect. A value below 10 ppm indicates P fertiliser should be tried.

Potassium

Australian clay soils are generally high in potassium, but with a high demand (see Table 1) and continued cropping, this nutrient could eventually become deficient. A soil test of less than 150 ppm K is commonly taken to indicate deficiency.

Sulphur

As with nitrogen, sulphur is in constant flux in the soil, so interpreting soil test data can be difficult. In general, a sulphate test less than 5 ppm would indicate deficiency. Most phosphate fertilisers add sulphur as well.

Physical status/gypsum requirement

The following soil tests indicate the most likely instances of obtaining a useful response to gypsum:

* On sodic soils where exchangeable sodium percentage (ESP) is greater than 5; particularly when ESP is greater than 10.

* When the Ca/Mg ratio is less than 2; particularly when the Ca/Mg ratio is less than 1 and ESP is greater than 5.

PLANT TESTS

There are many factors which can complicate the interpretation of plant tissue tests.

1. It is important to try and detect a deficiency in time to correct it. Hence there is a dilemma - the plant may not express the deficiency until it is too late to correct it. There are instances where a sidedressing or foliar application of a nutrient does not fully relieve the deficiency. Examples here are a late

sidedressing of N, most post emergent P applications and zinc. A nutrient stress is no different to water stress or cold shock: the plant may not fully recover.

2. Tissue tests on plants that have been under nutrient stress for some time may not detect that deficiency. This is because a tissue test is a concentration: a small plant may have the same or greater concentration as a large plant. It is therefore important to sample plants for tissue analysis when they first experience a nutrition problem - not after they have adjusted to it.

Therefore some tissue tests are more useful in indicating nutrient requirement in subsequent crops, rather than the present one.

Nitrogen

We have had the most success with monitoring plant N status with the petiole nitrate test. Levels of petiole nitrate less than 20,000 ppm at 750 day degrees from sowing indicate sidedressing may be necessary. The best scheme is to sample each field at regular intervals (say 500, 600 and 700 day degrees) and use these data to predict ahead and decide on whether the crop is approaching critical levels through time. This is the best way to try and ensure that N deficiency can be detected before any N stress occurs.

Plants undergoing a setback from cool weather, compaction, moisture stress, waterlogging, etc, may also show low levels of petiole nitrate. Therefore a full knowledge of all factors affecting the crop is necessary before reliable interpretation of petiole nitrate samples can be made.

Phosphorus

Both petiole and blade tests for phosphorus can be done. There has been little local calibration of either technique. Note that the response to P is greatest when it is applied before or at sowing.

Other elements

Table 3 presents approximate critical levels.

THE FUTURE

Soil and plant tests will not get any better without being used. Furthermore there are developments with research and with equipment which will improve our ability to predict crop nutrient requirements.

For soil tests (eg. P and K) there are other extractions being tested which better mimic roots removing nutrients from the soil. For soil N, we are studying the cycling of N in the soil as well as incubation tests. This work will improve our predictions from sampling at dates other than September for soil N.

For plant tests there is an approach to interpreting samples based on the balance between nutrients rather than the absolute level of each. One example of local relevance is that of zinc. Tissue levels of zinc less than 11 ppm may indicate deficiency of this nutrient. However if tissue P is high, the plant may still be under Zn stress at levels above 11 ppm. In other words if the ideal P/Zn ratio is about 110, a crop with a P level of 3000 ppm may have a critical Zn level of 27 ppm. Research is underway to examine this concept.

SUMMARY AND CONCLUSIONS

* Be representative with sampling in the field.
  Use standard sampling proceedures.
  The quality of results from testing will influence interpretation. Insist on accurate tests and standards.

* Soil testing for N, P, K and Na can help to identify fertiliser or gypsum requirement before sowing.

* Soil tests for trace elements have little use because there are poor correlations between soil tests and plant status.

* Petiole nitrate tests can be used as a guide to sidedressing requirement.

* Tests on leaf blades can be used as a guide to requirement of most elements, at least for subsequent crops in the same field. Future developments may allow for better interpretation of these tests - by establishing the balance between nutrients.

* Trial strips in suspect areas are an important method of determining response to fertilisers.

Further reading

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Table 1. Essential nutrients for cotton and typical values for total plant uptake or removal at harvest. Removal refers to that amount in both seed and lint, assuming 38% gin out-turn.

NUTRIENT		Typical uptake kg/ha	Typical removal kg/bale
Nitrogen	N	110	11
Potassium	K	125	6
Phosphorus	P	30	2
Calcium	Ca	90	1
Magnesium	Mg	30	1
Sulphur	S	10	0.1
Iron	Fe	0.600	0.066
Manganese	Mn	0.450	0.012
Boron	B	0.200	0.021
Zinc	Zn	0.060	0.013
Copper	Cu	0.020	0.003
Molybdenum	Mo	0.003	T

Table 2. Soil test values which may indicate deficiency for cotton growth. Different laboratories use different extraction methods.

NUTRIENT		Extraction method	Critical level ppm
Nitrogen	NO_3	Aqueous buffer	20-25
Phosphorus	P	Bicarbonate	10-20
Potassium	K	Ammonium acetate	100-150
Calcium	Ca	Ammonium acetate	400-700
Magnesium	Mg	Ammonium acetate	120-140
Sulphur	SO_4	Ca dihydrogen orthophosphate	5-10
Iron	Fe	DTPA	2
		EDTA	80
Manganese	Mn	DTPA	2
Zinc	Zn	DTPA	0.5
		EDTA	4
Copper	Cu	DTPA	0.3
		EDTA	2
Boron	B	Magnesium chloride	1.5
		Calcium chloride/Mannitol	0.4
		Hot water	0.15

Table 3. Plant tissue levels which may indicate deficiency for cotton growth.

a) LEAF BLADE DURING EARLY FLOWERING

NUTRIENT		UNITS	CRITICAL LEVEL	NORMAL RANGE
Nitrogen	N	%	3.0	3.0 - 4.5
Phosphorus	P	%	0.2	.3 - .5
Potassium	K	%	1.0	1.0 - 3.0
Calcium	Ca	%	0.4	.4 - 3.0
Magnesium	Mg	%	0.2	.4 - .9
Sulphur	S	%	0.2	.2 - .4
Iron	Fe	ppm	30	50 - 350
Manganese	Mn	ppm	13	50 - 350
Boron	B	ppm	10	20 - 60
Zinc	Zn	ppm	11	20 - 60
Copper	Cu	ppm	2	5 - 25
Molybdenum	Mo	ppm	0.4	.4 - .9

b) PETIOLE AT FIRST FLOWER

NUTRIENT		UNITS	CRITICAL LEVEL
Nitrogen	NO_3	ppm	20,000
Phosphorus	P	ppm	12,000
Potassium	K	ppm	10,000