

Project: Assessing NIR method for improved petiole model accuracy. Collection of leaf and petiole for determination of macro and micronutrients.

Report: Validating NIR in NutriLOGIC model

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Hone Red HLORA-0010
used to validate the Petiole
model during the 2022-23
season.



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1 Summary

During the 2022/23 cotton season at the Australian Cotton Research Institute, Myall Vale, a field experiment was established in A3 (see Figure 1) to validate a previously built NIR model to determine nitrate-N (ppm) in cotton petioles. Petioles were scanned using the Hone HLROA-0010 NIR instrument and the previously built model used to estimate the nitrogen required calculated by the crop model NutriLOGIC (to determine the N recommendation rate in kg N/ha). A comparison was then made with an industry standard average of 270 kg N/ha applied and a statistical comparison (in bales per hectare) made with the NutriLOGIC recommendation. The petioles collected after the treatments were applied, were scanned with the HLROB instrument to contribute 120 samples to the total team (ie. AMPS, CSD, Incitec) for potential micronutrient models comparing petioles scanned in parallel or cross section (see Figures 8 and 9). The following report outlines the results of the validation of the NutriLOGIC model using the HLROA instrument. The data collected with the HLROB instrument was added to the pooled dataset. The spectra from the HLROB data has been reported by Hone, showing that scanning petioles in cross section (see Figure 9) improved the accuracy of modelling.

1.1 Experimental Field Trial for Validation of NutriLOGIC

A Field Trial was sown on the 18th Oct. 2022 in Field A3 at the Australian Cotton Research Station with two varieties, Sicot 748 B3F and Sicot 606 B3F (see Figure 2), and five N decision treatments (see Figure 1 and Table 1) with four replicates (a total of 40 plots in a randomised complete block design). Soil samples were analysed for nitrate-N to a depth of 120 cm (see Figure 4) across the site prior to the applications of urea showed an increase with depth ie. 3 kg N/ha in the surface 0-15 up to 25 kg N/ha at 90-120 cm.

Two of the treatments were controls; (T1) with a zero application of Urea and another with 270 kg N/ha (T5) applied at 600 DD (industry average) on the 21st December 2022. The other three treatments utilised the Hone HLROA-0010 device to scan petiole N concentration at 600, 750 and 900 DD and received the recommended nitrogen rate as calculated by NutriLOGIC (see Figure 5). The first scan at 600 DD (T2) with the Hone HLROA-0010 device (using the petiole model) predicted a value of 16849 ppm. This was then substituted into NutriLOGIC that recommended a range of 191 to 211 kg N/ha to be applied (see Figure 5). A mid-rate of 200 kg N/ha was then applied in treatments 2,3 and 4. Urea was applied (side-dressed with double disc opener and press wheel – see Figure 6) to treatments 2,3 and 4. At 750 DD and 900 DD the results from the Hone device were then substituted into NutriLOGIC to check if further applications of nitrogen were required. The results from the Hone device indicated that no more nitrogen was required at 750 and again at 900 DD.

Note: The recommendation generated by NutriLOGIC compares the petiole input with the optimum petiole nitrate-N status according to the stage of the crop development. Crop development is determined by the number of day degrees calculated. The recommendation is then adjusted according to the region.

Field A3 2022/23

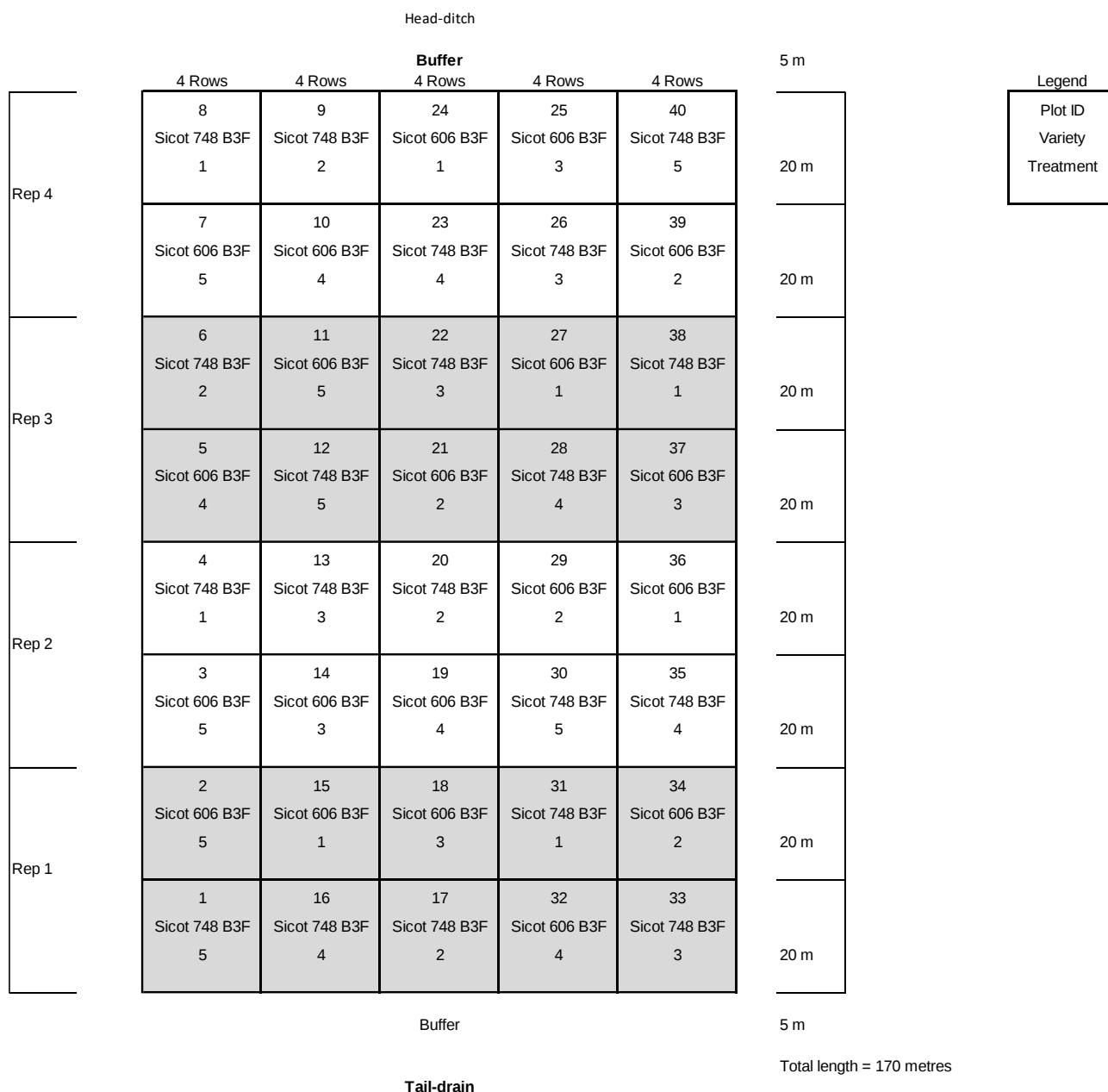


Figure 1. Trial layout for 2022/23. Randomised complete blocked design (4 Replicates x 2 varieties x 5 Treatments (see Table1)). Control = 0 N kg/ha applied (Treatment 1).

Table 1. Treatments applied in the Validation of NutriLOGIC experiment using NIR at the ACRI during the 2022/23 season.

1	0	no applied Urea (kg N/ha) (control)
2	600 DD	0 kg N/ha applied at sowing, NIR of petioles at squaring 600 DD and the NIR nitrate-N (ppm) results substituted in NutriLOGIC. The N rate (kg N/ha) recommendation from NutriLOGIC applied following analysis.
3	750 DD	0 kg N/ha applied at sowing + recommended rate from NutriLOGIC applied at 600 DD. NIR of petioles at flowering 750 DD and nitrate-N (ppm) results substituted in NutriLOGIC. The N rate (kg N/ha) recommendation from NutriLOGIC is then applied following analysis (if required).
4	900 DD	0 kg N/ha applied at sowing + recommended rate from NutriLOGIC applied at 600 DD and 750 DD (If required). NIR of petioles at boll fill 900 DD and the nitrate-N (ppm) results substituted in NutriLOGIC. The N rate (kg N/ha) recommendation from NutriLOGIC is then applied following analysis (if required).
5	Industry Ave.	0 at sowing + Side dressed @ 600 DD at 270 kg N/ha (industry average. Dec)



Figure 2. Sowing the Field Trial in Field A3 at the Australian Cotton Research Institute on the 18th October 2022 with two varieties: Sicot 748 B3F and Sicot 606 B3F.

1.2 Soil Coring

Soil cores were removed from each plot (40 in total) prior to fertiliser application and analysed in increments: 0-15, 15-30, 30-60, 60-90 and 90-120 cm for nitrate-N (see Figure 3 and 4).



Figure 3. Soil coring the field experiment on the 29th November prior to the fertiliser being applied on the 21st December in Treatment 5.

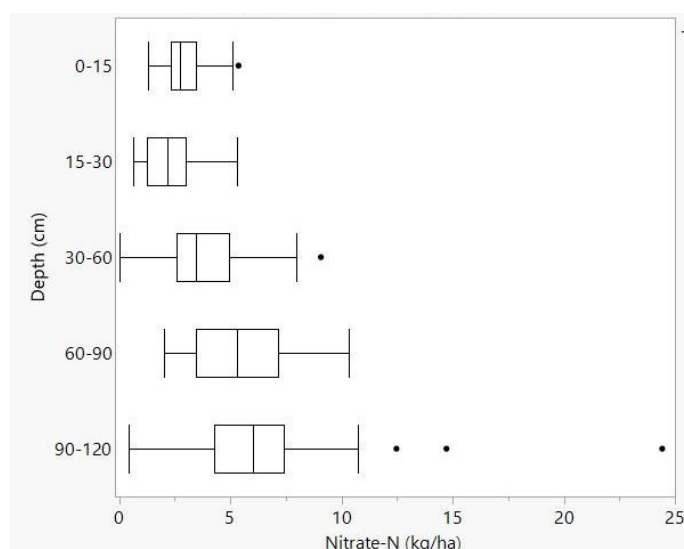


Figure 4. Soil (grey vertosol) nitrate-N (kg/ha) status across the site (40 cores) from 0 to 120 cm before nitrogen was applied to the trial site. There was no significant differences in nitrate-N variability in the 0-60 cm depth. Boxplot shows the data distribution - outer lines are the maximum and minimum values with visible data points indicating outliers. The line in the middle of the box is the median value.

1.3 Petiole Scans

The NIR scan dates were taken during squaring on the 19th Dec 2022, at flowering on the 3rd Jan 2023 and during boll fill on the 16th Jan 2023.



Sample Date	Day Degrees	NO3 Reading (ppm)
19/12/2022	600	16849

Recommendations

PETIOLE tests indicate that you need to apply between 191 and 211 kilograms of Nitrogen per hectare.
NOTE: After early January (approximately 1200 Day Degrees), Leaf Analysis provides more reliable data for crop Nitrogen management. A more accurate Nitrogen recommendation is achieved with 3 or more petiole tests.

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Climate Data provided courtesy of the Bureau of Meteorology and the Queensland Climate Change Centre of Excellence
CottASIST has been developed by CSIRO, supported by CRCs and the former Cotton Catchment Communities CRC Ltd.

Figure 5. Entering the NIR nitrate-N results from the Hone device into the NutriLOGIC model with a recommendation range between 191 to 211 kg N/ha.



Figure 6. Applying fertiliser on the 21st December at 600 DD (Base 12) in Treatment 5 (270 kg N/ha) and treatments 2,3 and 4 as recommended by the NutriLOGIC model (200 kg N/ha applied) using NIR to determine petiole nitrate-N in ppm.

1.4 Comparison of Petiole Scanning Methods with the HLORB Hone Device

The field trial was also used to capture a second dataset using the HLORB Hone instrument. The method of clamping the petioles in cross section is shown in Figure 7, 8 and 9. The validation of the petiole nitrate-N model used the HLORA-0010 instrument and scanned the petioles in parallel as shown in Figure 8. It was evident that the zero applied plots produced very thin petioles and thus required significantly more samples to sufficiently clamp firmly for scanning (see Figure 9). This would need to be considered in future experiments when capturing spectra in low N plots.



Figure 7. Preparing petiole samples for scanning in cross section with Hone Red HLORB.



Figure 8. Jig to hold petioles in parallel and in clamped cross-section for accurate capture of spectra. (Developed by Dave McRae)

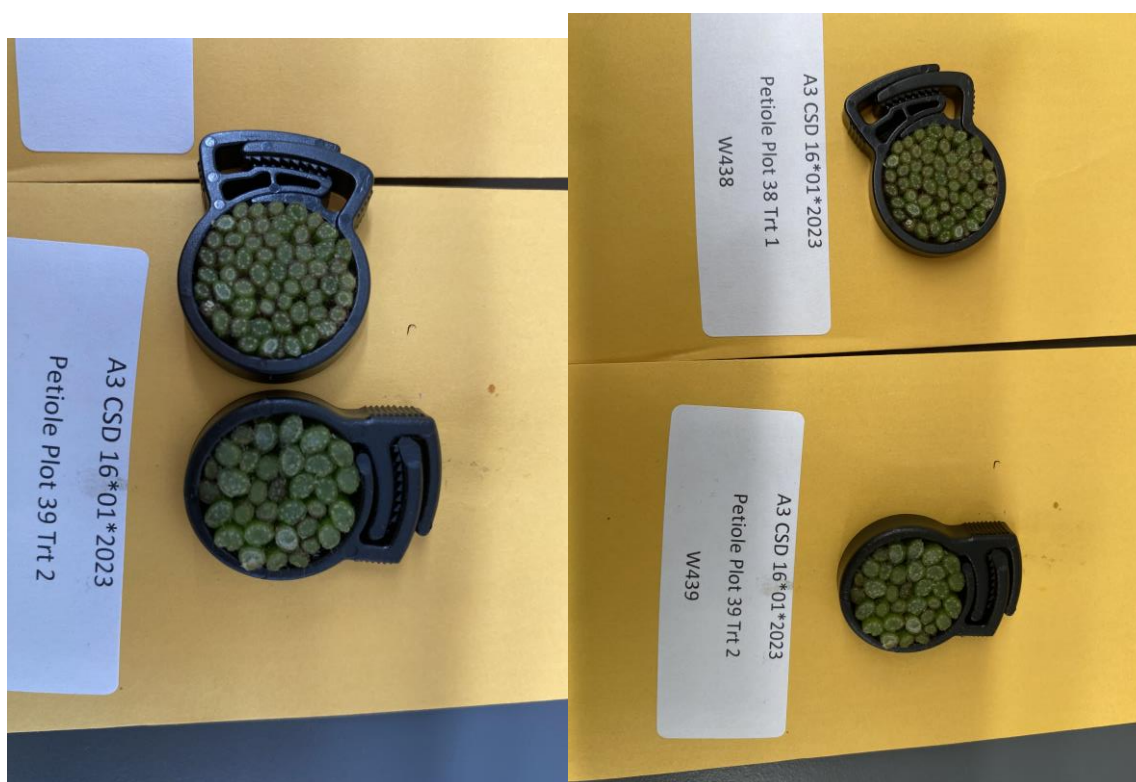


Figure 9. Petioles sampled on the 16/1/2023 from the Treatment 1 (0 kg N/ha applied) and Treatment 2 (200 kg N/ha applied). It was obvious that more petioles were required to clamp in the zero applied plots.

1.5 Picking the Field Trial

The experiment was picked on the 24th May 2023. The trial received eight irrigations and a total of 426 mm of rainfall.

1.6 RGB Drone Images of the Field Trial

Images of the experiment were captured in a time series from December 2022 to May 2023 (see Figure 10). The zero treatment plots were visible from January 2023 onwards.

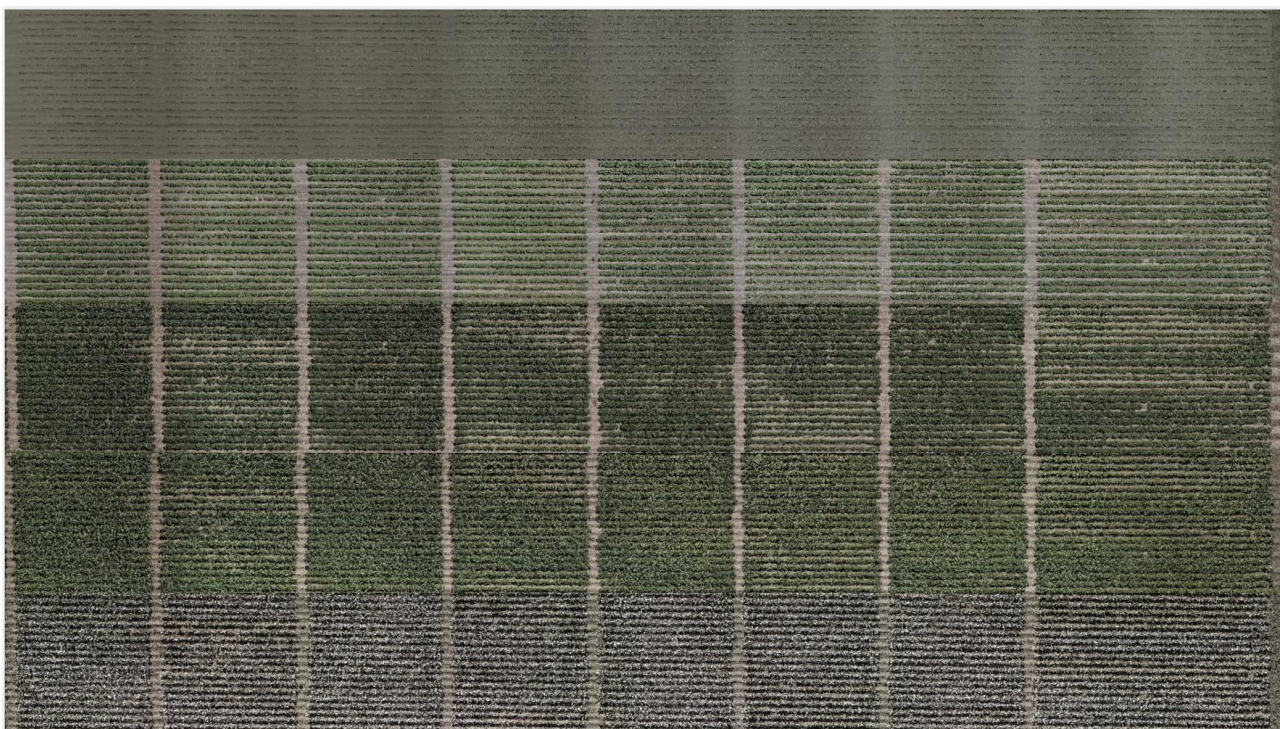


Figure 10. RGB of the field experiment in Field A3 at Myall Vale. The experiment was imaged on the 16/12/2022 (top), 24/1/2023, 17/2/2023, 16/3/2023 and 5/5/2023 (bottom).

1.7 Yield Results

The experiment was picked on the 24th May 2023 and the yields are shown in Figure 11. The highest yield was observed in Treatment 3 at 15 bales/ha (Sicot 606 B3F) where the use of the Hone NIR device with NutriLOGIC model supported a nitrogen application recommendation of 200 kg N/ha following timely petiole measurements at 600 DD. It did not require any further applications of N based on subsequent and timely petiole measurements. Importantly the results showed the need for N compared to the nil N treatment and matched the industry applied rate. There were no indications that additional N was increasing yields and there were no statistical differences at the 99.9 confidence level.

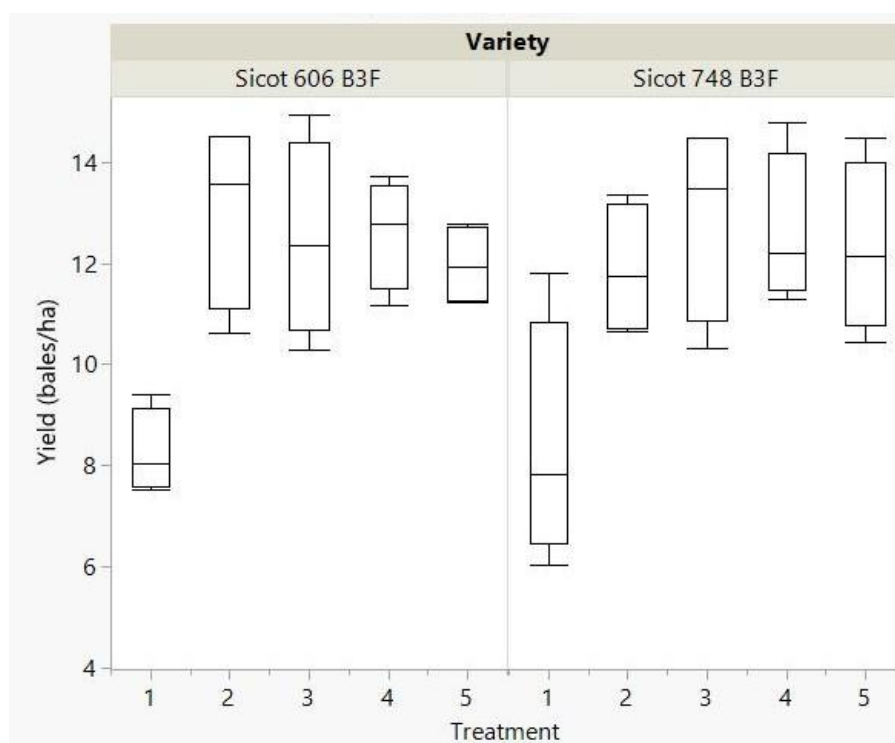


Figure 11. Yield (bales/ha) for Sicot 606 B3F and Sicot 748 B3F for the Validation of NutriLOGIC using NIR Hone Device. Treatments 2,3 and 4 received only 200 kg N/ha and Treatment 5 received 270 kg N/ha side dressed.

1.8 Conclusion

Although a very preliminary (less calibrated) model was used with the Hone handheld NIR device and NutriLOGIC, this study demonstrated the value of timely access to crop nutrition status to improve crop N management (saving 70 kg/ha in this study). Opportunities to improve the calibration of models across the industry (more regions for instance) would improve recommendations. The results of timely crop nutrition statuses can be used with crop nutrient recommendation models like NutriLOGIC or other tools available to crop managers.

Summary

- A very preliminary petiole nitrate-N model (used along with the Hone handheld NIR HLROA-0010 and NutriLOGIC) was able to provide sensible agronomic N recommendation rates demonstrating the value of having timely results from petiole samples.
- Appropriate application of urea at 200 kg N/ha using NIR and NutriLOGIC for N management in-crop produced yields up to 15 bales/ha with no upfront application and a starting nitrate-N in the 0-60 cm depth of 10 kg N/ha. A saving of 70 kg N/ha when compared to an industry average rate of 270 kg N/ha which was assessed.
- Handheld NIR technology coupled with cloud-based models is a promising solution to real-time in-situ analysis of petioles for optimum nitrogen management.

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