HRDC Project number FR98061

Completion Date 01/01/00 Resubmitted June 2000

Title **The Potential of Petiole Sap Analysis in Bananas.**

Objective: To examine the validity of petiole sap nitrate analysis as a guide to nitrogen application in North Queensland banana.

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Fitz Gerald Horticultural Consultancy wishes to thank the Queensland Fruit and Vegetable Growers and the Horticultural Research and Development Corporation for jointly funding this project.

Queensland Fruit & Vegetable Growers

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Contents Page

- Industry Summary P2
- Technical summary P 3
- Introduction, literature review. P 4
- Materials and methods P 4-5
- Results P 5-7
- Discussion P 7-8
- Recommendations-scientific and industry combined. P 8
- Acknowledgments P 8
- Bibliography of literature cited. P 9

Industry Summary.

Frequent sampling trial

- Petioles of the first fully expanded leaf of large non-flowering banana plants were collected on three commercial banana plantations. These were taken at approximately 3 day intervals over a 26 week period in 1999.
- Sap was extracted from samples diluted 10-1 with water and analyzed for nitrate nitrogen and potassium using a Merck RQflex reflectometer.
- Sap nitrate readings ranged from 0-890ppm, potassium 1200-5000ppm.
- Readings were compared with nitrogen and potassium inputs. Rises and falls in the sap nitrate reading correlated strongly with N inputs. Sap potassium levels correlated poorly with K inputs.

Correlation of sap nitrate against dry matter total N.

- Four sap samples were taken at 10 sites over a 13-day period.
- On the final sampling date lamina was taken from the third fully expanded leaf of the plant which was petiole sampled.
- Sap Nitrate taken on the earliest date had the strongest correlation with dry matter data. (r^2=0.53). Sap potassium correlated poorly.
- Established dry matter critical level of 2.6% correlated to 90ppm nitrate in the sap. Recommended levels of 3-3.5% total N correlated to 200-350ppm.

Project Outcomes Recommendations

- All of the surveyed plantations had sap nitrate readings well above and below suggested optimum levels at various times throughout the trial.
- Inexpensive rapid sap nitrate readings appear to have a role to play in fine tuning nitrogen management of far north Queensland banana plantations.
- A reliable rapid method for determining the potassium status of banana plants will be required for industry adoption and is suggested as the focus for future research.

Technical Summary

Nitrogen inputs in the North Queensland banana industry vary from 100kg/ha/annum to 1100kg/ha/annum (1994 Daniells). There is a level of dissatisfaction with traditional soil and leaf analysis as a guide for fertilizer application. This project assessed the potential of petiole sap analysis for use as a monitoring tool to adjust fertilizer programs.

Frequent sampling trial

Petioles of the first fully expanded leaf of large non-flowering banana plants were collected on three commercial banana plantations. These were taken at approximately 3 day intervals over a 26 week period in 1999. Sap was extracted from samples diluted 10-1 with water and analyzed for nitrate nitrogen and potassium using a Merck RQflex reflectometer. Sap nitrate readings ranged from 0-890ppm, potassium readings ranged from 1200-5000ppm. Readings were compared with nitrogen and potassium inputs. Rises and falls in the sap nitrate reading correlated strongly with N inputs. Sap potassium levels correlated poorly with K inputs.

Correlation of sap nitrate against dry matter total N.

Four sap samples were taken at 10 sites over a 13-day period. On the final sampling date lamina was taken from the third fully expanded leaf of the plant which was petiole sampled. Sap nitrate taken on the earliest date had the strongest correlation with dry matter data. (r^2=0.53). Sap potassium correlated poorly. Established dry matter critical level of 2.6% correlated to 90ppm nitrate in the sap. Recommended levels of 3-3.5% total N correlated to 200-350ppm.

Major findings

All of the surveyed plantations had sap nitrate readings well above and below suggested optimum levels at various times throughout the trial. Inexpensive rapid sap nitrate readings appear to have a role to play in fine tuning nitrogen management of far north Queensland banana plantations. A reliable rapid method for determining the potassium status of banana plants will be required for industry adoption and is suggested as the focus for future research.

Introduction

Nitrogen inputs vary over a wide range in the North Queensland banana industry. In a survey conducted in 1994 Daniells found application rates varied from 100 to 1100 kg/ha/yr. The industry average was 519kg/ha/yr with many growers applying nitrogen above or below optimum rates. The same survey found dissatisfaction with traditional soil and leaf analysis as a guide for fertilizer application.
The low cost and fast turn around of petiole sap testing means it has potential to be used as a frequent monitoring tool to adjust fertilizer programs rather than a diagnostic tool to correct deficiencies. Sap nitrate testing has been found useful in other horticultural crops such as, potatoes (Williams and Maiers 1990), tomatoes, (Huet and Rose 1988), lettuce, (Huet and White 1991) and zucchini (Huet and White 1992).

Sap testing does offer certain advantages over traditional dry matter analysis. The method is simple and is able to measure nitrate nitrogen, which is much more sensitive to changes in nitrogen in the plant than the measurement of total leaf nitrogen. (D J Lyons). Lahav (1983) found there was a good basis for using N-NO_3 to evaluate the N status of the banana sucker. Advantages over traditional dry matter total N analysis were stated as being physiologically more sensitive and easier to perform in the laboratory. However Lahav found lamina analysis for NO3 gave a clearer picture of the N status of the plant than petiole analysis.
The main perceived disadvantage of petiole sap measurement in much of the relevant literature is variations in sap nutrient levels over short time periods, (D J Lyons). Armour and Daniells 1998, found large variations in petiole sap nitrogen levels depending upon the age of the plants in small plot work conducted in Innisfail. This following work aimed to determine whether the variation in petiole sap nitrate was meaningful and potentially useful. Petiole sap potassium data was also collected. There are two sections of the work, part 1 the frequent sampling trial, determines the amount of variation in sap nitrate levels over short time periods and response in sap nitrate to fertilizer application. Part 2 of the work is an attempt to correlate sap nitrate levels with dry matter analysis to establish tentative critical limits.

MATERIALS AND METHODS

Frequent sampling trial

Three commercial plantations were monitored approximately every three days for six months. Sites were selected to include a site with high nitrogen application rates, a site with nitrogen applications close to industry standard and a site with nitrogen applied through trickle irrigation.

Six plants were sampled at each site. The petiole from the first fully expanded leaf of a large nonflowering plant were sampled. In an attempt to limit variation within each treatment, the sample area was restricted to an area of approximately 50m x 50m. Samples were refrigerated if not analyzed within 2 hrs. Sap was extracted from the leaf petioles using a mechanical press. This was then diluted 5:1; a Merck nitrate test strip with a range of 5-225ppm was used to measure nitrate concentration. Potassium levels were measured using Merck Kalium test strips with a range of 0.25-1.20g/l K^+. These strips were read on a Merck RQflex reflectometer (TUV, Germany).
Two forms of nitrogen were applied, urea and calcium ammonium nitrate (CAN). C.A.N. was broadcast and used at all three sites. Urea was broadcast at Site 2 and

applied in the irrigation at Site 1. The form of nitrogen applied is represented by a C or U on the sap nitrate curves.

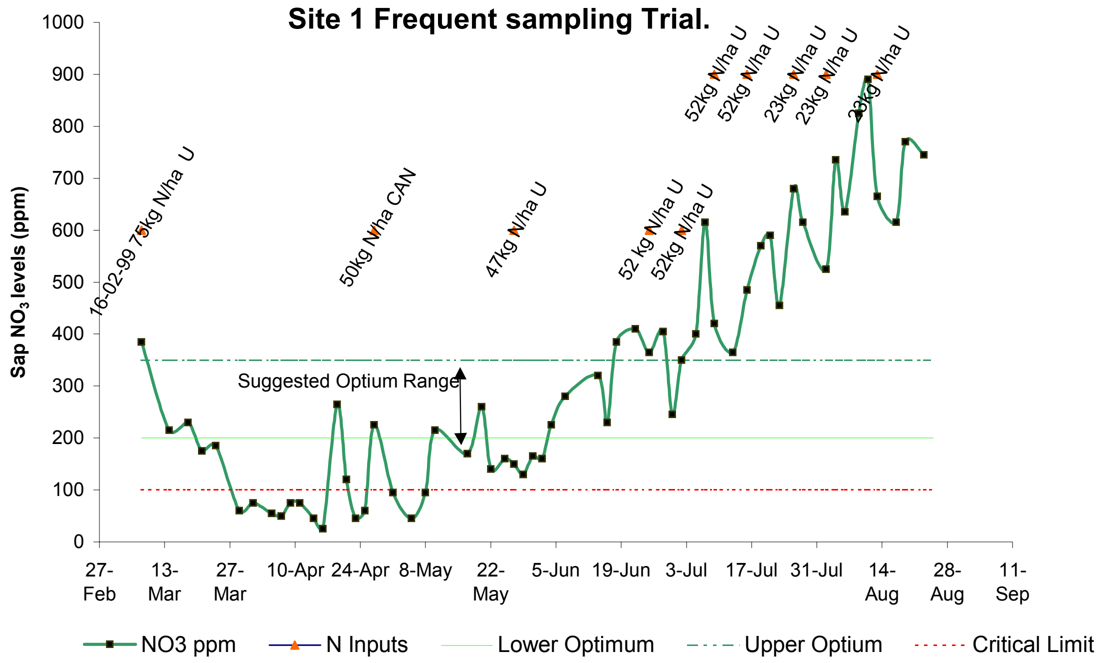
Correlation of sap nitrate against dry matter total N.

Sites were selected in an attempt to encompass a wide range of nutrient levels. Sap samples were collected and analyzed using the procedure outlined in part 1. Four sap samples were taken at 10 sites over a 13-day period. Samples were collected on 11, 16 18, 23 November. This was done as sap nutrient levels are perceived to be a “snap shot” or a reflection of what is taking place at that point of time, and dry matter data contains “history”, or is influenced by prior nutrient availability. For this reason a range of sampling times was used to establish if dry matter total N would show stronger correlation to a sap nitrate level taken earlier. On the final sampling date lamina was taken from the third fully expanded leaf of the plant which was petiole sampled. This was sent to Agritech laboratories Pty Ltd for dry matter analysis. The lamina was oven dried at 80° C, treated with an acid digest and analyzed using an ICP. Total N was measured using the Kjeldah method. Water-soluble Nitrate was measured using an UV vis spectrometer.

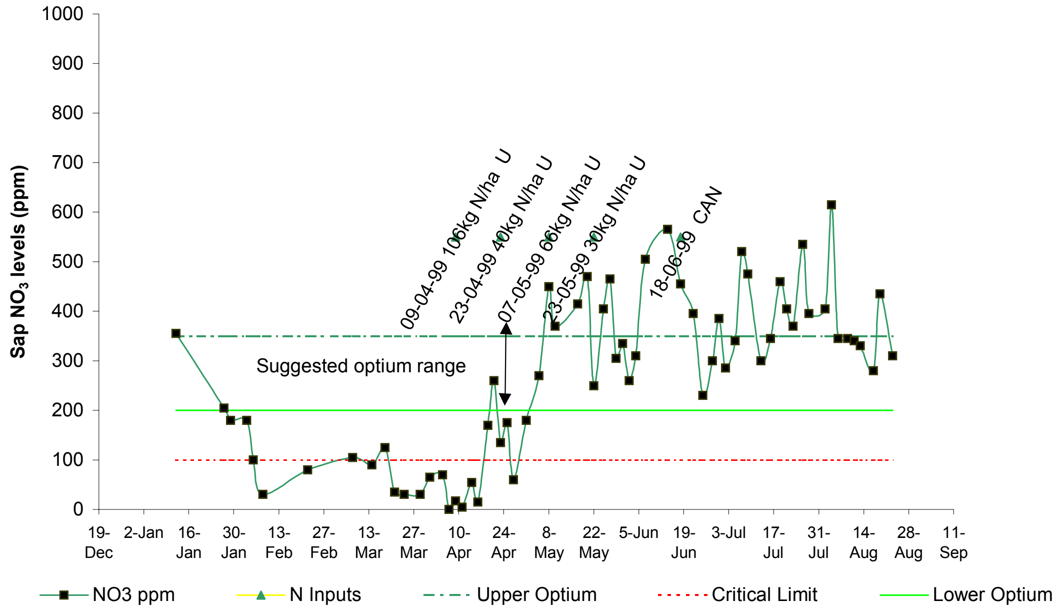
RESULTS

Frequent Sampling

Nitrogen recorded as nitrate nitrogen ranged from 0-890 ppm over the three sites. At all sites fertilizer inputs ceased in February 1999 due to extensive flooding and record rainfall. This was well reflected in the measured sap nitrate levels. When fertilizer applications resumed in late April petiole sap nitrate levels increased at all sites.

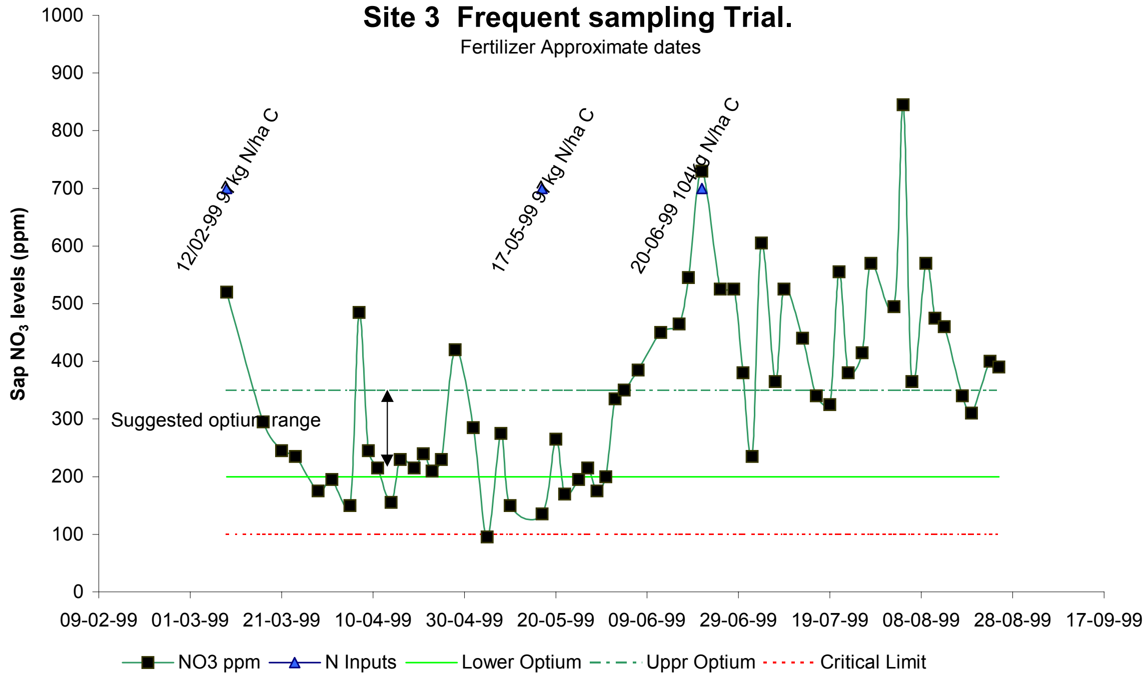


Site 2 Frequent sampling Trial.



Site 3 Frequent sampling Trial.

Fertilizer Approximate dates

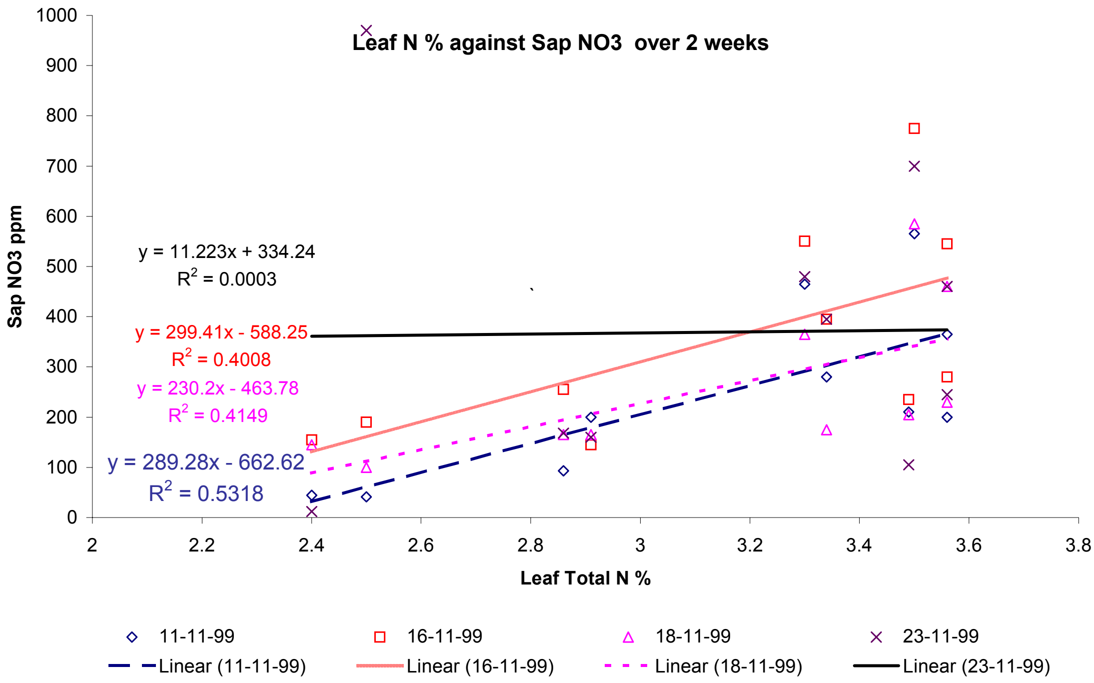


Frequent sampling Potassium

The levels of potassium over the three sites ranged from 1200-5000 ppm. A much greater level of variation occurs with sap potassium in comparison with sap nitrate. There is appears to be a poor direct relationship between petiole sap potassium and applied K.

Correlation of Sap readings against Dry Matter

A relationship was found between sap nitrate and total leaf N. Dry matter total N correlated strongest (r^2 0.53) with the petiole sap taken 13 days earlier.



Discussion

Frequent Sampling

The sap nitrate levels at site 1 show the strongest relationship to applied nitrogen. This is particularly noticeable in the later part of the survey period where nitrogen is applied frequently with the trickle irrigation. There are two unexplained peaks on this curve which occurred on April 19 & 27 prior to the C.A.N. application on the April 29. These points represent 3% of the data collected at this site. Site 2 data follows a similar pattern. The applications of N are closer together and larger in volume initially than in comparison with Site 1.

At site 3 there were only 2 applications of N in the survey period. Following the first application there is a slow but consistent increase in nitrate levels in the sap about the 20/6/99 a further N application is made but the same trend is not repeated. This may be as the result of the fertilizer being broadcast as no irrigation was used at this site.

Yield was not recorded in this trial, however there is general agreement site 3 was the highest producing of the three sites over the surveyed period. While nitrate levels did not reach the peaks seen at sites one and two, they did not fall below 100ppm while sites 1 & 2 both experienced close to zero readings. Armour and Daniells 1998 suggest 300ppm as a tentative optimum level for petiole sap nitrate, the findings in this survey support this. This also suggests that nitrate in the sap was at luxury levels following high nitrogen applications at site 1.

Correlation of Sap readings against Dry Matter

Using the strongest relationship a petiole sap level of 90ppm correlates with the 2.6% total N critical level, (Robinson & Reuter 1986). Suggested optimum levels are 200-350ppm which correlates to 3.0%-3.5% in dry matter total N. Independent data obtained in a separate trial run in conjunction with Incitec laboratories gave a similar relationship with 253-442ppm correlating with the 3.0-3.5% total N range and 97ppm equivalent to the 2.6% dry matter critical limit. The r^2 of the regression in this case was 0.55. To establish the accuracy of the Merck system, sap nitrate was measured on the Merck system, then samples were frozen and sent to Incitec laboratories, the r^2 of a linear regression on the two measuring systems was 0.93.

Technology Transfer.

A summary of this paper was published in the January 2000 edition of Bananatopics which was distributed to every Queensland banana grower.
The project results to May 1999 were displayed at the FHC stand at the third national banana growers congress.
Two commercial banana plantations are monitoring sap nitrate levels. The current limitations on a reliable rapid potassium test are restricting wider adoption of the technique.

Recommendations

Petiole sap nitrate levels do exhibit higher variability than dry matter total N. It has been demonstrated this variability is strongly related to nitrogen applications. This makes the variability useful, providing the data is collected continuously, and inputs reviewed prior to making recommendations. One off sap nitrate samples would have limited interpretive value. While a higher r^2 value on the dry matter correlation would allow more confidence in the thresholds, a relationship does exist. A similar relationship has been determined from two independent data sets. It may be possible to increase yield with decreased nitrogen inputs if petiole sap nitrate levels can be maintained within the suggested optimum range. A reliable rapid method for determining the potassium status of banana plants will be required for industry adoption as nitrogen and potassium are applied in conjunction. This is suggested as the focus for future research.

Acknowledgements

Fitz Gerald Horticultural Consultancy wishes to thank the Queensland Fruit and Vegetable Growers and the Horticultural Research and Development Corporation for jointly funding this project. The Tully Banana grower's contribution in promotion of the project is gratefully acknowledged. The trials would not have been possible with out grower co-operators Dore's Bananas, Jackson Farming Company and ATM Bananas.

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