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BSES PROGRESS REPORT

EVALUATION OF THE EFFECTS OF RARE EARTH ELEMENTS
ON SUGARCANE IN NORTH QUEENSLAND

by

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1. INTRODUCTION

During 1988 BSES submitted a proposal to the Australian Academy of Technological Sciences and Engineering for partial funding of a research project to investigate the response of sugarcane in north Queensland to rare earth elements.

Muswellbrook Energy and Minerals Ltd. agreed to provide the funding required and they succeeded in importing a sample of the Chinese soluble rare earth product, "Nongle". BSES received 200g of the imported product, which was sufficient to establish four field trials. An earlier 10g sample of "nongle" provided by Prof. C. Asher of the University of Queensland was used subsequently in the glasshouse studies.

2. PROJECT OUTLINE

The project was to progress in three phases:-

1. Field trials to determine the effect of RE foliar sprays on growth and yield at harvest.
2. Glasshouse studies to determine the effect of RE sett dips on germination and early root growth.
3. Glasshouse studies to determine the effect of sett/root RE dips, and foliar RE sprays on early shoot and root growth in pots.

3. CURRENT POSITION

3.1. Field trials

Four field trials were established toward the latter part of 1988. Soil samples were taken at establishment from 0-250 mm and 250-500 mm depths. A single bulk sample has been composited for each depth for each site. This sample awaits analysis pending details on suitable extractants for available RE elements.

There has been two site inspections since establishment. To date, soil moisture has not been a limiting factor at any stage and all sites have shown excellent growth.

3.2. Glasshouse germination studies

This trial was established on 1-3/3/89 and was evaluated for germination on 10/3/89 (8 days) 13/3/89 (11 days) and 14-17/3/89 (14 days). In addition, root number and average length were evaluated at 14 days, prior to plants being used in the glasshouse pot trial.

3.3. Glasshouse pot trial

This trial was established 14-17/3/89. Basal NPK and dip treatments were applied at planting. RE spray treatments were applied at two weeks post planting after satisfactory seedling establishment and a urea side dressing applied at 3 weeks.

4. TRIAL DESIGN

4.1. Field trials

Four field trials were established at even sites of plant cane, late in 1988. Figure 1 shows the location of sites in the northern cane growing region. Sites were chosen to represent a range of sugarcane varieties in a range of soil types.

A randomised complete block arrangement with four replicates of three treatments was used at each site.

Treatments:-

- 4 Sites
1. Mossman
 2. Babinda
 3. Tully
 4. Ingham

- 3 Treatments:
1. Control (water spray)
 2. Nongle - 400g product/ha
 3. Nongle - 800g product/ha

Plot size = 5 rows x 13.5m

Centre 3 rows will be used for yield estimation and evaluation of treatment effects.

Treatments were applied in a fixed quantity of double deionised water, sufficient to thoroughly wet the foliage. Because of variations in planting width, there were slight variations in the spray rate as follows:

Site	Spray rate L/ha
1	360.56
2	365.40
3	358.19
4	<u>383.41</u>
Mean	<u>366.89</u> L/ha

Solutions were made up to allow for the above variations and to account for a 300 ml portion which could not be sprayed from the applicator. Nongle had been placed in a dessicator for some time prior to use to

ensure it was thoroughly dry. These precautions ensured an accurate application rate of product per hectare.

Site and treatment details are listed in Table I. The canopy was well developed at all sites and conditions were ideal for active growth.

Plots were inspected at two monthly intervals for the following characteristics:-

1. Foliage motor activity (curling).
2. Foliage Disease, (3rd leaf). If necessary rated against standard charts. General observations on other disease symptoms.
3. Nutritional deficiency or toxicity symptoms.
4. Foliage colour (3rd leaf) rated with Munsell charts.
5. General field conditions in each plot (soil moisture).
6. Growth relative to adjacent plots. (Rated as greater than, equal to or less than.)

On the second inspection, 20 standard third leaf samples were collected per plot, for possible assay. A standard third leaf sample consists of a 200 mm section of leaf blade (mid-rib stripped away), taken from the centre of the third leaf. The first partially unrolled leaf was counted as number one.

The third leaf sample was weighed in the field prior to transport in insulated cooled containers to drying facilities. Leaf samples were dried at 70°C, prior to reweighing and grinding.

4.2. Glasshouse germination studies

The proposed design was altered to incorporate an artificial soluble RE treatment, by combining laboratory grade cerous and lanthanum nitrates.

The form of the trial was:-

$$[(3 \times 2) + 3] \times 3 = 27$$

Rates of RE	Forms of RE	Controls	Varieties	Treatments
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Plot size = 10 setts

Replication = 6

Treatments:-

3 Rates of RE	1.	0.1 mg (Ce + La)/L
Sett dip	2.	1.0 mg (Ce + La)/L
	3.	10.0 mg (Ce + La)/L

- 2 Forms of RE 1. Nongle
2. Ce and La nitrates laboratory grade.

Controls - dip in double deionised water.

- 3 Varieties - 1. Q117
2. Q124
3. Q138

As disease-free planting material was available from Tully Sugar Experiment Station, it was not necessary to hot water treat the setts. As sett position on the stalk can affect germination and root growth, setts were graded to replications, so that rep 1 setts came from the top of the stalk and rep 6 came from the bottom of the stalk. Damaged setts were discarded.

Setts were soaked for five hours in the respective treatment solution, prior to a short dip in a fungicide to protect cut ends from pineapple disease. Setts were placed in an upright position in trays containing vericulite. Buds were aligned with each other and pointing upwards.

Trays containing the setts were placed on an arc mesh bench under tap water sprays. Spray duty cycle was set to water four times during the day (6 a.m., 10 a.m., 2 p.m. and 6 p.m.), for five minutes. Germination was recorded at 8 and 11 days post planting, with an additional evaluation at 14 days when the root growth was evaluated. Selected plants were used to establish the pot trial.

Buds were evaluated for germination at the final inspection as follows:

1. Number of buds dormant.
2. Number of buds swelling (< 1 cm).
3. Number of buds germinated (> 1, < 5 cm).
4. Number of buds germinated (> 5 cm).

1-4 Above sums to 10 for each plot.
3+4 = No germinated.

Roots were evaluated for each sett (10 setts per plot) as follows:-

1. Total number of roots.
3. Mean length of roots per sett (cm).

Average number of roots, average root length and mean total root length was calculated for each treatment.

4.3. Glasshouse pot trial

The form of the trial was a factorial as follows:-

5 x 4 x 3 = 60
 RE Soils from
 treatments x field sites x Varieties = Treatments

Plot size = 200 mm polythene pot with two plants.

Replications = 4

Treatments:-

- 5 RE treatments
1. Control - Soaked in double deionised water.
 2. Nongle dip - 1.0 mg (Ce + La)/L soaked for 5 hrs.
 3. Ce and La nitrate dip - 1.0 mg (Ce + La)/L soaked for 5 hrs.
 4. Nongle - foliage spray - equivalent to mid-concentration applied in the field - i.e. 600g nongle in 400L.
 5. Ce and La nitrate foliage spray to apply Ce + La equivalent to treatment 4 above.

- 4 soils
1. Mossman
 2. Babinda
 3. Tully
 4. Ingham

- 3 varieties
1. Q117
 2. Q124
 3. Q138

Plants for treatments 1, 4 and 5 were soaked in double deionised water prior to planting. Plants for these treatments came from the control treatment of the germination study. Due to a favourable evaluation of the nongle and laboratory salts, 1.0 mg (Ce + La)/L germination sett dips, plants from the above sources were used to establish pot trial treatments 2 and 3 respectively. For the same reason, 1.0 mg (Ce + La)/L was the concentration used for the 5 hr soak for pot trial treatments 2 and 3.

Each 200 mm polythene pot was lined with a clean polythene bag and filled with 5 kg of soil. Basal NPK fertiliser was applied at planting as follows:-

K_2HPO_4 - 225 kg/ha (0.67 g/pot)
 NH_4NO_3 - 100 kg/ha (0.30 g/pot)

Nitrogen will be added at three week intervals as urea at 100 kg/ha (0.30 g/pot). Pots were placed in a glasshouse bench designed to cool the soil in the pot to approximately 28°C.

Foliage spray treatments 4 and 5 were applied at two weeks after planting of the pot trial. Pots to be sprayed with RE were removed from the bench prior to treatment application. They were returned to the bench after treatments 1, 2 and 3 were sprayed with double deionised water and all foliage allowed to dry.

5. RESULTS

5.1. Field trial results

Results of plot comparisons for the two inspections are listed in table II. Observations were made on plots in the field to determine if plot growth appeared greater than, equal to or less than the plots adjacent to it. The comparison was awarded a comparison index of +1, 0 or -1 accordingly. The mean comparison index was calculated for each treatment comparison by summing the individual indices and dividing by the number of comparisons. The number of comparisons depended on randomisation at each site.

Little can be said at this stage about relative differences between plots, as the data has not been subject to statistical analysis. It must be stated that differences, if present, are small and that the test is based on subjective assessment. In order to reduce operator bias, assessment was made by two operators, who were not aware of treatment identification.

The grand mean for treatment comparison may give an indication of trends. For instance, an index of -0.17 for treatment comparison 1/2 means that treatment one (control) was more frequently assessed as being smaller than treatment two (400 g nongle/ha). At about the same frequency, treatment 2 (400 g nongle/ha) was assessed as being larger than treatment 3 (800 g nongle/ha), with an index of +0.15. At a very low frequency, treatment one (control) was assessed as being larger than treatment 3 (800 g nongle/ha) as the 1/3 treatment comparison had an index of +0.05.

Treatment 1 (control) was more frequently assessed as being smaller than treatment 2 (400 g nongle/ha) at sites 2 (Babinda) and 3 (Tully). Of the four sites, these two have the highest annual rainfall.

Foliage colour has shown little variation due to site or treatment. The data on foliage colour are recorded in Table III. Munsell colour charts for plant tissue were used to evaluate foliage colour of the mid section of the third leaf. Value and chroma are recorded in the table for a hue

of SGY. Value notation indicates the degree of lightness or darkness of a colour in a range 0/ to 10/. The lower the value the darker the colour.

The Chroma notation of a colour indicates the strength (saturation) or degree of departure of a particular hue. The Chroma notation for the SGY chart ranged from /4 to /10. The lower the Chroma, the greater the gray component.

Data for percent moisture are presented in Table IV. Treatment effects were not significant, although it is interesting to note that the trend was towards higher moisture in the RE treated plots. Soil moisture has not been limiting since treatment of the field trials. There was a highly significant ($P < 0.01$) site effect. The variety Q124 at site three had a higher percentage moisture than varieties at other sites. The treatment x site term was not significant.

No other characteristics observed during inspections showed any consistent treatment effects.

5.2. Germination trial results

Data from this trial has been dispatched to BSES head office for statistical analysis using the genstat package. Preliminary data on the rare earth element main effect shows an encouraging trend.

Table V shows data on progressive germination of the trial. The RE sett dips seem to encourage a more rapid germination rate. The decision to use cane plants from the 1.0 mg (Ce + La)/L dip in the subsequent dip of equivalent strength for the pot trial, was based on encouraging results from the 11 day evaluation.

The final evaluation of germination and root growth was made at 14 days. The germination in the control setts had begun to catch up. Not presented here is the effect of variety and replication (stalk position) on early germination. From observation, it was evident that Q138 and Q124 were slower to germinate than Q117. It also appeared that setts from the top of the stalk germinated faster than setts at the bottom of the stalk.

Table VI presents the effect of Rare Earth sett dips on sett root emergence and growth. Total root length is the composite effect of these two factors. There appeared to be little effect on number of roots emerging however there may be a slight effect on mean root length and mean total root length, with 1.0 mg (Ce + La)/L showing a superior effect.

Statistical analysis of the data will provide information on the relative effects of nongle and laboratory RE salts, as well as data on varietal effect and the various interaction terms.

5.3. Pot trial results

This trial has been established for 3 weeks and data will not be available for another eight weeks. White lesions became evident on the foliage of RE sprayed plants (4 and 5) within one week of treatment application. There does not appear to be any other treatment effects at this stage.

6. CONCLUSION

Data on early season ccs and yields at harvest were the main objectives of the field trials and conclusions on this aspect of the project should be reserved until this data is available later in the year.

Data collected from the germination trial is encouraging. Faster germination is a useful characteristic, particularly during cooler weather or when there is a danger of flooding. At these times a more advanced plant may make better progress and have a better appearance. The worth to final sugarcane yield is less certain. Enthusiasm for the apparent germination response should be tempered pending statistical analysis of the data.

FIGURE 1 - LOCATION OF RARE
EARTH FIELD TRIALS

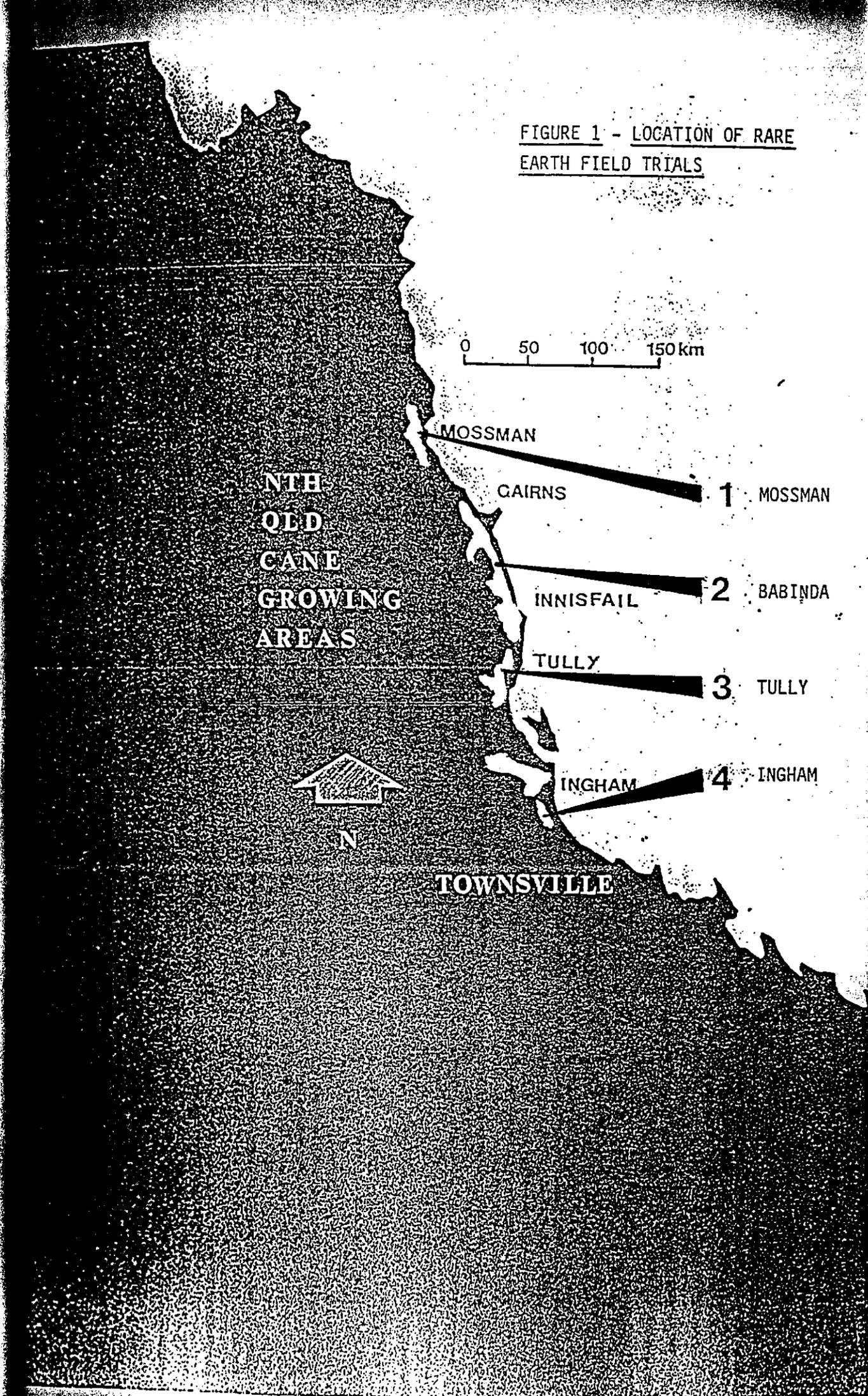


TABLE I FIELD TRIAL ESTABLISHMENT DETAILS

Site	Date Treated	Crop Class and Age	Mean Height to TVD mm*	Variety	Row Spacing (m)	Row direction (Degrees Magnetic)	Soil Classification
1. Mossman	14/11/88	Replant 3 mths	210.3	Q138	1.51	182	Brosnan
2. Babinda	11/11/88	Fallow plant 3 mths	239.3	Q117	1.49	270	Tyson
3. Tully	10/11/88	Fallow plant 4 mths	549.3	Q124	1.52	178	Coom
4. Ingham	28/10/88	Fallow plant 5 mths	160.0	Q115	1.42	178	Ashton

* TVD = Top visible dewlap. (Canopy height approximately 1m or less).

All sites had adequate nutrition, and satisfactory insect and weed control.

TABLE II: RARE EARTH FIELD TRIALS - COMPARATIVE GROWTH INDICES

		Mean Comparative Growth Index		
Treatment comparison		1/2	1/3	2/3
Site	Inspection			
1	1	0	-0.11	+0.33
	2	-0.25	0	0
	Mean 1	-0.13	-0.06	+0.17
2	1	-0.25	-0.30	+0.43
	2	-0.38	0	0
	Mean 2	-0.32	-0.15	+0.22
3	1	-0.46	0	+0.14
	2	-0.38	+0.80	+0.14
	Mean 3	-0.42	+0.40	+0.14
4	1	+0.66	-0.40	+0.14
	2	-0.26	+0.40	0
	Mean 4	+0.20	+0.05	+0.07
GRAND MEAN		-0.17	+0.05	+0.15

		Number of Comparisons per Trial		
Treatment Comparison		1/2	1/3	2/3
Site	Inspection			
1	1	12	9	6
	2	8	10	7
	3	13	5	7
	4	15	5	7
TOTAL		48	29	27

Key Treatment 1 = Control, 2 = Nongle 400 g/ha
3 = Nongle 800 g/ha

Site 1 = Mossman, 2 = Babinda
3 = Tully, 4 = Ingham

Inspection 1 - 20-21/12/88, 2 - 20-21/2/89

Treatment Relationship Comparative Growth Index

1>2, 1>3, 2>3	+1
1=2, 1=3, 2=3	0
1<2, 1<3, 2<3	-1

Mean comparative growth index = Sum of growth indices for treatment comparison divided by the number of comparisons.

TABLE III RARE EARTH FIELD TRIALS - THIRD LEAF FOLIAGE COLOUR

Hue = 5GY

Munsell Colour - Value/Chroma

Treatment		1	2	3
Site Inspection				
1	1	4.2/7.5	4.2/7.0	4.4/7.5
	2	5.0/5.5	5.0/6.0	5.0/6.75
2	1	4.0/6.2	4.0/6.5	4.2/7.5
	2	4.0/6.0	4.0/7.0	4.0/5.5
3	1	4.0/6.5	4.0/6.5	4.0/6.2
	2	5.0/4.5	5.0/4.0	5.0/4.0
4	1	4.0/6.0	4.25/6.5	4.0/6.0
	2	5.0/6.0	5.0/6.5	5.0/6.0
Mean		4.4/6.0	4.4/6.2	4.4/6.2

Each value in the body of the table is the mean of 4 replications.

Treatment 1 = Control 2 = 400g nongle/ha
3 = 800g nongle/ha

Site 1 = Mossman 2 = Babinda
3 = Tully 4 = Mossman

Inspection 1 = 20-21/12/88
2 = 20-21/2/89

TABLE IV RARE EARTH FIELD TRIALS - THIRD LEAF MOISTURE

Third leaf moisture as a percentage of oven dry weight

Treatment		1	2	3	Site Mean
Site	Variety				
1	Q138	219.5	220.8	225.2	221.8
2	Q117	214.7	217.1	212.3	214.7
3	Q124	236.3	233.9	234.9	235.1
4	Q115	213.0	228.0	228.9	223.3
Treatment Mean		220.9	225.0	225.3	223.7

- Highly significant site effect ($P < 0.01$)
site 3 > site 4, site 1, site 2.

- Treatment and treatment x site effects were not significant

Values in the body of the table are the means of four replications.

Dates sampled 20-21/2/89

Percent Moisture = $\frac{\text{Fresh weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$

Treatment 1 = Control, 2 = 400 g nongle/ha
3 = 800 g nongle/ha

Site 1 = Mossman, Q138, 2 = Babinda Q117
3 = Tully Q124, 4 = Ingham Q115.

Characteristics at 14 days

Treatment	Mean Number of roots per sett	Mean Sett Root length (cm)	Mean Total root length
Control	27.3	5.3	144.7
0.1 g/L + LaCl ₃	27.5	5.6	161.8
1.0 g/L + LaCl ₃	28.9	6.3	181.2
10.0 g/L + LaCl ₃	28.8	6.0	176.4

Values in the body of the table are the mean of 340 setts for the control treatment and 160 setts for other treatments.

TABLE V RARE EARTH GERMINATION TRIAL - EFFECT OF RARE EARTH SETT DIPS ON SUGARCANE GERMINATION

Treatment	Mean	Percent	Germination
	8	11	14
Control	27.2	64.6	88.9
0.1 mg (Ce + La)/L	30.3	71.9	94.4
1.0 mg (Ce + La)/L	30.6	78.1	93.9
10.0 mg (Ce + La)/L	28.9	71.9	93.6

Values in the body of the table are the mean of 54 plots for the control treatment and 36 plots for other treatments.

TABLE VI RARE EARTH GERMINATION TRIAL - EFFECT OF RARE EARTH SETT DIPS ON SETT ROOT GROWTH

Characteristics at 14 days

Treatment	Mean Number of roots per sett	Mean Sett Root length (cm)	Mean Total root length
Control	27.2	5.8	164.7
0.1 mg (Ce + La)/L	27.5	5.6	161.8
1.0 mg (Ce + La)/L	26.9	6.3	181.2
10.0 mg (Ce + La)/L	26.8	6.0	176.4

Values in the body of the table are the mean of 540 setts for the control treatment and 360 setts for other treatments.