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RATES OF BIODUNDER FOR SUGARCANE

by

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1.0 SUMMARY

The BSES recommendation for a maximum application rate of biodunder at 4 m^3/ha (120 kg K/ha) is considered adequate to maximise returns and production for ratoon crops on the majority of Mackay soils. In one experiment conducted on a black earth soil with 2:1 layered clays, cane yield was in excess of 140 t/ha and an application of 5 m^3 of biodunder per hectare (150 kg K/ha) was justified. The possibility of K fixation on these soils requires further evaluation. This in no way condones *carte blanche* increases in biodunder application rates, but recognises that higher K application rates are justified when very high yielding ratoon crops are produced on 2:1 layered clays.

As the experiments were conducted only on ratoon crops, no evidence is available to allow comment on the fertiliser K requirement of plant cane, which remains at up to 3.3 m^3 of biodunder per hectare (100 kg K/ha). The mineralisation of K during a long fallow increases the availability of natural K from soil, thus reducing the dependency of plant cane crops on fertiliser K sources.

There was no difference in the ability of biodunder to provide K for cane growth compared to muriate of potash.

Sulfur, copper and zinc are nutrients in biodunder which were shown to be taken up by the cane crop. These nutrients did not affect cane growth in the experiments but they could be of value if the nutrients were deficient in soils. Other nutrients present in biodunder; namely, nitrogen, phosphorus, magnesium, calcium, iron and manganese, were not significantly increased in concentration in sugarcane where biodunder was applied. However, the application of these nutrients in biodunder is considered a positive attribute in maintaining fertility.

The use of biodunder on caneland is highly recommended as an environmentally friendly way of recycling plant nutrients, thereby reducing fertiliser costs, reducing imports of fertilisers, and increasing cane production and profitability.

2.0 OBJECTIVE

To evaluate the rate of biodunder for maximum return for canegrowers.

3.0 INTRODUCTION

CSR ferments molasses and distils industrial alcohol at Sarina. The by-product of this process is biodunder which has a potassium content of at least 3% w/v. Biodunder also contains other valuable plant nutrients. The viability of distilling depends on the disposal of biodunder in an environmentally acceptable manner. Canegrowers have welcomed biodunder as a source of plant nutrients. A total of 45,000 ha of caneland at Mackay was fertilised with 180,000 m^3 of biodunder during 1994. The application rate varied around 4 m^3/ha, which provided 120 kg K/ha. This rate of usage conforms with BSES advice

(Anon, 1985). The potassium content of biodunder is water soluble and therefore readily available for sugarcane.

Soil growing sugarcane operates on a potassium deficit, for the fertiliser application of 120 kg K/ha is less than the average above-ground crop removal of 203 kg K/ha for an 84 tonnes per hectare crop of cane (Chapman *et al.*, 1981). Fortunately, there are large reserves of non-soluble K in most soils and these reserves, after they are mineralised into a soluble form, are utilised to maintain production. Evidence of the capability of soil to mineralise K is available from a long-term potassium experiment at the Sugar Experiment Station, Mackay. Here, 27 crops of cane were grown without fertiliser K applications. Cane yields were below optimum in plots receiving no potassium fertiliser, but the reserves of K in the soil were not seriously depleted (Chapman, 1995).

There have been changes in the varietal composition of crops, cultural methods (for example, reduced cultivation, herbicide use for weed control) and an increase in yields since BSES advice was formulated.

This program of three experiments was conducted to evaluate the current advice for biodunder and potassium application rates.

4.0 METHODS AND MATERIALS

Three cane fields were selected to represent a range of soil types. The soils were black earth (self mulching, grey, cracking clay); non-calcic brown (acid to neutral, red brown, duplex soil); and yellow-red podzolic soil (acid, bleached, yellow-red, duplex soil) (Stace *et al.*, 1968). These cane fields were on properties owned by H and A Barfield, Victoria Plains, J McKay, Racecourse and B Jansen, Yakapari, respectively. Full details of analyses of soil samples taken from each replicate (10 cores to 250 mm deep from interrow) are in Appendices 1, 2 and 3. The soils had exchangeable K and nitric acid K, respectively, (as me%) of 0.23 and 1.06 (Barfield), 0.13 and 1.10 (McKay) and 0.11 and 0.50 (Jansen) in the 0-25 cm sampling zone. The fields were planted with the variety Q124, first ratoon (Barfield), Q124, first ratoon (McKay) and Q124, second ratoon (Jansen).

Potassium treatments were applied to the young ratoon crops as either biodunder or muriate of potash at the rates of 0, 50, 100, 150 and 200 kg K/ha. Biodunder had the analysis of 3.4% K, 1.00% N, 0.04% P, 0.8% Ca, 0.6% Mg and 0.4% S on a weight/volume basis. Thus, increasing quantities of N, P, Ca, Mg and S were applied as the biodunder application rate increased; namely, 1.5, 2.9, 4.4 and 5.9 m^3/ha, to supply 50, 100, 150 and 200 kg K/ha, respectively. The biodunder was banded onto the cane row. On one site (Jansen), green cane harvesting with trash conservation was practised, but in the other two sites burnt harvesting was practised. The muriate of potash treatments were blended with urea and trifos to apply 200 kg N/ha and 20 kg P/ha. Only N and P were applied at the same rate when the treatment included biodunder. These fertiliser treatments were applied with a stool splitter and buried 100 mm in the centre of the row on 14 October 1993 (Barfield), 29 October 1993 (McKay) and 11 November 1993 (Jansen).

The treatments were set out in a split block design with rates of K as the main treatment. For each rate, the plot was split into two and muriate of potash or biodunder applied. There were three replicates and each split plot was four rows (1.5 m) by 15 m long. The treatments were applied four weeks after ratooning. Barfield's site was irrigated before and after applying the treatments. The other two sites were rainfed. Rainfall for the crop period was lighter than normal, but well distributed and totalled 1,203 mm. Monthly totals (as mm) were October 74, November 100, December 154, January 123, February 276, March 247, April 78, May 85, June 24, July 32, August 5 and September 5, so soil moisture levels were adequate for most of the season.

First exposed dewlap leaves were collected from each plot of each trial on 23 December 1993. Thus samples were collected 1.5 to 2.5 months after fertilising or approximately 2.5 to 3.5 months after ratooning. Samples comprised 20 leaves (200 mm of the middle section with the midrib removed). These were analysed for total N, P, K, Ca, Mg, S, Cu, Zn, Fe and Mn.

Cane was harvested (10 August 1994, Barfield; 24 October 1994, McKay; 13 October 1994, Jansen) with a chopper harvester and the billets from each plot weighed in a truck-mounted weighing machine. Six stalk samples were collected from each plot and, after crushing in a small mill, the juice was analysed by industry methods. A deduction of 1.5 units of ccs was applied to each analysis to compensate for the low extraction (50%) of the small mill.

Conductivity measurements (an index of the ash content of raw sugar) were made on each juice sample from Barfield's and McKay's experiments.

Return per hectare was calculated for each plot using the formula below.

Return ($) = [(0.009 price of sugar (ccs - 4) + 0.5) x cane yield] - cost of fertiliser K - cost of harvesting

assuming: price of sugar $350/t, harvesting cost of cane $6/t, biodunder $21/m^3 and muriate of potash $437/t.

All data were analysed for variance using Statistix V.4.1.

5.0 RESULTS

5.1 Yield

Yield data are presented in Tables 1, 2 and 3.

Rates of potassium fertiliser increased cane yield by 17, 3 and 17 t/ha for Barfield's, McKay's and Jansen's experiments, respectively. The probabilities that the linear components of these trends were significant, were 0.00, 0.33 and 0.11, respectively. No quadratic components were significant.

Sugar content was not significantly affected by rate of K fertiliser and sugar yield therefore followed cane yield trends.

Returns, based on sugar yield trends, sugar price and cost of inputs, showed significant linear trends in only one experiment (Barfield). Rates which gave the highest returns were 200, 0 and 100 kg K/ha for Barfield's, McKay's and Jansen's experiments, respectively.

There were no significant differences between biodunder and potassium fertiliser for cane yield, ccs, sugar yield or return in any of the experiments, nor were there any significant interactions between rates and form of K fertiliser.

5.2 Conductivity of juice

Rates of K had a significant linear effect on conductivity of juice in both Barfield's and McKay's experiments (Tables 1 and 2). Conductivity of juice was higher in the potash than in the biodunder treated cane in Barfield's experiment, but there were no significant interaction effects between rate and form of K fertiliser.

5.3 Soil analyses

BSES advice on fertiliser K requirements is based on results of soil samples collected in the interrows, thus avoiding positions where residual K may affect levels of soil K. A comparison of soil analyses at establishment and harvest indicated levels were little changed by treatment levels of K fertiliser (Table 4). When samples were collected in the rows rather than the interrows, 200 kg K/ha increased soil K levels from 0.07 to 0.10 me% in Jansen's experiment.

5.4 Leaf analyses

Data are presented in Tables 5, 6 and 7. Concentrations of nutrients in leaf samples were in excess of accepted critical levels established in 3 to 4 month old cane (Chapman and Haysom, 1984), except for K in Barfield's and Ca in Jansen's experiments. Increasing K fertiliser rates showed a significant linear increase in K concentrations in all three experiments and a significant linear decrease in Mg concentrations in Barfield's and McKay's experiments.

Biodunder, compared to potash, increased concentrations in leaves of Mg, S and Cu in Barfield's; S in McKay's; and Cu in Jansen's experiments; but decreased K in Barfield's experiment.

There were significant linear interactions between rate and form for S in Barfield's; S in McKay's; and Cu and Zn in Jansen's. An example of these interactions is illustrated in Figure 1. Here muriate of potash applications had no effect on the concentration of S in leaves but biodunder increased S concentrations from 0.17 to 0.23 mg/kg. All these concentrations are above the critical value and this increase would not affect cane yield. In Jansen's experiment, the age of cane at sampling was only 2.5 months which was slightly younger than the cane used to establish critical levels. This earlier sampling does not appear to have seriously affected the interpretation of the results.

6.0 DISCUSSION

The prediction of K fertiliser requirements by soil analysis has large errors (Chapman, 1971). The results from these experiments also had poor correlations between the K requirements predicted by soil analyses at the time of fertilising and the actual amount of K fertiliser to give maximum return (Table 8).

K fertiliser requirements of 50, 100, and 100 kg/ha were predicted by the use of soil analyses for Barfield's, McKay's and Jansen's experiments, respectively. The actual amounts of K fertiliser for maximum returns were 200, 0, 100 kg/ha, respectively (Table 8). Rates of K for maximum cane production were 200, 150, 150 kg/ha, respectively.

Rates of K fertiliser were predicted by fitting yield data for cane, sugar and returns to quadratic and square root production functions for Barfield's and McKay's experiments. These rates of K fertiliser were not acceptable, because of the large P value for the fit of the models. Some refinement of the prediction of K requirements was possible for Jansen's experiment (Table 8) by using the quadratic model.

Weather conditions for these experiments were ideal for growth.

Soil analysis for exchangeable K and nitric K were in the adequate range for Barfield's site. The large yield response to K fertiliser at this site is therefore unexpected, particularly as yield was increasing linearly at the maximum rate. Conductivity levels in the juice were low compared to those at McKay's site. Leaf K values were less than optimum, even after applying 200 kg K/ha. The cane yield on this irrigated site was 140 t/ha while the mill area average for this season was 104 t/ha. It is therefore not clear why the higher than recommended rate of K fertilisation was required in Barfield's experiment.

The failure of McKay's experiment to have a significant growth response to K fertiliser is also unexpected. Conductivity levels in the juice and leaf K concentrations were both high. The crop obviously obtained an adequate supply of K, mineralised from the K reserves (nitric K = 1.10 me%), for the exchangeable K levels were only in the medium range (0.13 me%). A long-term K experiment, conducted on a similar soil type at the SES, Mackay, has demonstrated the varying capacity of this soil type to mineralise K under different weather conditions (Chapman, unpublished data). Rate of K required for maximum yield is not directly related to rainfall patterns in the SES experiment. During the 1993/4 season, maximum yield was achieved with an application of 180 kg K/ha in a 5th ratoon crop. Yet in McKay's experiment, there was no yield response from potassium fertiliser. The high yield was apparently produced from mineralised K.

Jansen's experiment represented a site with low exchangeable K (0.11 me%) and low nitric K (0.5 me%). This site also produced a large crop without the addition of K fertiliser. Although there was some variation in the yield results, and despite the low probability of a linear response ($P = 0.11$), it is likely there was a yield and return response from K fertiliser. The leaf K concentrations were increased from just below the critical level to adequate levels by the application of K fertiliser.

This site had low calcium concentrations in leaves and in soil samples, thus liming would have been beneficial to yield.

Results again demonstrated that biodunder is as effective as muriate of potash in providing K for cane growth. Increasing K levels of fertiliser reduced Mg concentrations in leaves in Barfield's and McKay's experiments. As Mg concentrations were above the critical level, cane growth was probably not affected.

These trials produced conclusive evidence that the use of biodunder can provide sulfur, copper and zinc for plant growth. The availability of these nutrients had no effect on yield in these experiments, but in other sites where these nutrients are deficient, cane growth could be increased.

7.0 CONCLUSIONS

The results from these experiments demonstrated that:

- soil analyses for exchangeable K and nitric acid K are not completely reliable indicators of amounts of potassium fertiliser required for maximum production and returns;
- application rates of K fertiliser in excess of BSES recommendations (up to 150 kg K/ha) may be necessary on the black earths where production is in excess of 140 tonnes of cane per hectare;
- there is no convincing evidence that BSES maximum recommendation of 120 kg K/ha should be increased on average production sites;
- biodunder is as effective as muriate of potash in providing K for cane growth;
- biodunder contains plant nutrients not present in muriate of potash, and applications of biodunder increased the concentrations of sulfur, zinc and copper in cane plants;

- conductivity of cane juice was increased by application of K fertiliser, and biodunder and muriate of potash generally had equal effects.

8.0 ACKNOWLEDGMENTS

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Table 1

Effect of rate and form of K fertiliser on cane, sugar yields, ccs and return for Barfield's experiment, harvested 10/8/94

Variable	Rate of K (kg/ha)	Form of K	Cane (t/ha)	ccs	Sugar (t/ha)	Conductivity (dS/m)	Return ($/ha)
	0		125.3	14.3	17.9	1.05	3389
	50		122.3	14.2	17.4	1.15	3247
Rate	100		130.8	14.7	19.2	1.18	3620
	150		138.3	14.5	20.0	1.37	3688
	200		142.4	14.5	20.6	1.35	3758
	P linear		0.00	0.12	0.00	0.01	0.02
	P quadratic		0.40	0.14	0.64	0.83	0.81
Form		Biodunder	131.0	14.4	18.8	1.18	3500
		Potash	132.7	14.5	19.2	1.26	3580
	S.E.diff		3.1	0.1	0.5	0.03	104
	P		0.59	0.55	0.43	0.05	0.46
	0	Biodunder	126.5	14.4	18.2	1.06	3461
	0	Potash	124.1	14.2	17.6	1.04	3316
	50	Biodunder	122.8	14.2	17.4	1.12	3227
	50	Potash	121.8	14.3	17.5	1.18	3268
Rate*Form	100	Biodunder	127.4	14.8	18.8	1.22	3559
	100	Potash	134.1	14.6	19.6	1.14	3681
	150	Biodunder	134.4	14.4	19.3	1.23	3552
	150	Potash	142.1	14.6	20.7	1.50	3823
	200	Biodunder	143.6	14.2	20.4	1.29	3701
	200	Potash	141.2	14.7	20.7	1.42	3814
	P linear		0.70	0.19	0.39	0.06	0.34
	P quadratic		0.28	0.73	0.39	0.89	0.49

Table 2

Effect of rate and form of K fertiliser on cane, sugar yields, ccs and return for McKay's experiment, harvested 24/10/94

Variable	Rate of K (kg/ha)	Form of K	Cane (t/ha)	ccs	Sugar (t/ha)	Conductivity (dS/m)	Return ($/ha)
	0		104.2	16.2	16.8	1.57	3426
	50		98.2	15.9	15.6	1.62	3097
Rate	100		104.3	16.0	16.6	1.75	3283
	150		107.0	16.1	17.2	2.01	3386
	200		106.2	15.8	16.8	2.24	3210
	P linear		0.33	0.33	0.45	0.00	0.73
	P quadratic		0.63	0.98	0.64	0.24	0.65
Form		Biodunder	103.5	16.0	16.6	1.81	3280
		Potash	104.4	16.0	16.7	1.87	3280
	S.E.diff		5.3	0.1	0.9	0.08	176
	P		0.86	0.70	0.90	0.46	1.00
	0	Biodunder	103.1	16.3	16.8	1.40	3429
	0	Potash	105.3	16.0	16.9	1.74	3423
	50	Biodunder	98.4	15.8	15.6	1.54	3100
	50	Potash	97.9	15.9	15.6	1.70	3094
Rate*Form	100	Biodunder	108.6	16.0	17.4	1.71	3444
	100	Potash	99.9	15.9	15.9	1.79	3121
	150	Biodunder	105.6	16.2	17.1	2.02	3384
	150	Potash	108.3	16.0	17.4	2.00	3389
	200	Biodunder	101.7	15.7	15.9	2.36	3043
	200	Potash	110.6	15.9	17.6	2.12	3376
	P linear		0.67	0.12	0.59	0.04	0.59
	P quadratic		0.42	0.49	0.41	0.91	0.40

Table 3

Effect of rate and form of K fertiliser on cane, sugar yields, ccs and return for Jansen's experiment, harvested 13/10/94

Variable	Rate of K (kg/ha)	Form of K	Cane (t/ha)	ccs	Sugar (t/ha)	Return ($/ha)
	0		101.5	15.3	15.5	3047
	50		107.6	15.4	16.6	3242
Rate	100		115.5	15.1	17.4	3332
	150		118.3	14.7	17.4	3242
	200		112.7	15.2	17.1	3210
	P linear		0.11	0.38	0.15	0.56
	P quadratic		0.22	0.61	0.27	0.34
Form		Biodunder	112.0	15.2	76.4	3276
		Potash	110.2	15.1	63.7	3154
	S.E.diff		5.7	0.2	0.9	192
	P		0.75	0.56	0.64	0.54
	0	Biodunder	99.9	15.4	15.4	3043
	0	Potash	103.1	15.1	15.6	3051
	50	Biodunder	113.0	15.6	17.6	3473
	50	Potash	102.2	15.2	15.6	3012
Rate*Form	100	Biodunder	117.2	15.4	18.0	3475
	100	Potash	113.8	14.9	16.9	3189
	150	Biodunder	114.1	14.7	16.8	3115
	150	Potash	122.5	14.8	18.1	3370
	200	Biodunder	116.0	15.1	17.5	3274
	200	Potash	109.3	15.4	16.8	3146
	P linear		0.99	0.35	0.80	0.75
	P quadratic		0.96	0.59	0.82	0.75

Table 4

Soil exchangeable K and nitric K in samples at establishment and, exchangeable K at harvest for different fertiliser applications, at Jansen's, McKay's and Barfield's experiments (as me%).

Fertiliser K kg/ha	Jansen		McKay		Barfield	
	Est.	Harv.	Est.	Harv.*	Est.	Harv.
0	0.11(0.50)**	0.09	0.13(1.10)	0.07	0.23(1.06)	0.17
100		0.09		-		0.17
200		0.10		0.10		0.18

Est. = Sampled at establishment.
Harv. = Sampled after harvest.
* Sampled in row, others sampled in interrow.
** Nitric acid extractable K in brackets.

Table 5

Effect of rate and form of K fertiliser on the analysis of first exposed dewlap leaves, in Barfield's experiment, 23/12/93

Variable	Rate of K (kg/ha)	Form of K	N (%dm)	P (%dm)	K (%dm)	Ca (%dm)	Mg (%dm)	S (%dm)	Cu (mg/kg dm)	Zn (mg/kg dm)	Fe (mg/kg dm)	Mn (mg/kg dm)
	0		1.94	0.32	0.62	0.29	0.65	0.16	7.3	22.3	74.8	48.0
	50		2.01	0.31	0.77	0.28	0.51	0.18	7.2	23.1	70.2	47.5
Rate	100		2.00	0.33	0.89	0.25	0.49	0.17	6.9	22.2	70.5	39.5
	150		1.94	0.30	0.86	0.23	0.41	0.16	6.9	25.1	69.0	39.0
	200		2.04	0.32	0.94	0.25	0.44	0.17	6.8	22.6	71.8	41.2
	P linear		0.44	0.72	0.02	0.16	0.01	0.55	0.07	0.67	0.67	0.08
	P quadratic		0.93	0.91	0.34	0.47	0.05	0.95	0.71	0.68	0.52	0.36
Form		Biodunder	1.97	0.32	0.74	0.27	0.53	0.18	7.2	22.2	71.3	42.4
		Potash	2.00	0.31	0.89	0.25	0.46	0.16	6.8	23.9	71.2	43.7
	S.E.diff		0.03	0.01	0.04	0.01	0.02	0.00	0.19	1.19	5.72	1.50
	P		0.35	0.94	0.01	0.11	0.02	0.01	0.05	0.19	0.98	0.42
	0	Biodunder	1.95	0.32	0.64	0.30	0.64	0.16	7.7	21.6	86.0	49.0
	0	Potash	1.92	0.32	0.60	0.29	0.66	0.17	6.9	23.0	63.7	47.0
	50	Biodunder	1.93	0.31	0.01	0.27	0.57	0.18	7.2	23.2	66.3	45.7
	50	Potash	2.08	0.31	0.83	0.28	0.45	0.17	7.2	23.0	74.0	49.3
Rate*Form	100	Biodunder	2.01	0.32	0.77	0.27	0.54	0.18	7.2	21.2	66.7	40.0
	100	Potash	1.99	0.33	1.01	0.23	0.43	0.16	6.7	23.1	74.3	39.0
	150	Biodunder	1.92	0.31	0.75	0.22	0.41	0.17	7.2	24.5	66.0	36.7
	150	Potash	1.96	0.30	0.97	0.23	0.41	0.16	6.5	25.6	72.0	41.3
	200	Biodunder	2.03	0.32	0.83	0.27	0.51	0.19	6.8	20.5	71.7	40.7
	200	Potash	2.05	0.31	1.04	0.23	0.37	0.16	6.7	24.6	72.0	41.7
	P linear		0.95	0.77	0.08	0.68	0.28	0.02	0.69	0.44	0.31	0.52
	P quadratic		0.55	0.72	0.25	0.42	0.57	0.48	0.89	0.53	0.16	0.52

Table 6

Effect of rate and form of K fertiliser on the analysis of first exposed dewlap leaves, in McKay's experiment, 23/12/93

Variable	Rate of K (kg/ha)	Form of K	N (%dm)	P (%dm)	K (%dm)	Ca (%dm)	Mg (%dm)	S (%dm)	Cu (mg/kg dm)	Zn (mg/kg dm)	Fe (mg/kg dm)	Mn (mg/kg dm)
	0		2.55	0.37	1.32	0.23	0.21	0.17	6.6	26.6	82.8	165.7
	50		2.48	0.36	1.51	0.23	0.20	0.17	6.5	27.6	82.3	176.2
Rate	100		2.58	0.34	1.66	0.25	0.20	0.19	6.3	27.8	85.8	187.7
	150		2.63	0.35	1.77	0.21	0.19	0.20	6.8	30.8	92.8	170.7
	200		2.56	0.34	1.78	0.21	0.19	0.19	6.4	25.8	84.2	180.7
	P linear		0.08	0.05	0.00	0.22	0.02	0.00	0.98	0.84	0.28	0.47
	P quadratic		0.77	0.31	0.12	0.35	0.60	0.39	0.90	0.35	0.37	0.46
Form		Biodunder	2.59	0.35	1.64	0.23	0.19	0.20	6.5	27.2	87.2	181.9
		Potash	2.53	0.35	1.58	0.23	0.20	0.17	6.5	28.3	84.0	170.4
	S.E.diff		0.02	0.01	0.03	0.01	0.00	0.00	0.09	2.07	3.22	8.27
	P		0.01	0.97	0.11	0.69	0.11	0.00	0.94	0.62	0.34	0.19
	0	Biodunder	2.54	0.39	1.43	0.24	0.21	0.17	6.5	27.2	82.3	175.3
	0	Potash	2.56	0.35	1.21	0.23	0.22	0.17	6.6	25.9	83.3	156.0
	50	Biodunder	2.55	0.34	1.47	0.23	0.19	0.18	6.4	27.8	86.0	192.7
	50	Potash	2.41	0.37	1.54	0.23	0.21	0.17	6.6	27.4	78.7	159.7
Rate*Form	100	Biodunder	2.59	0.35	1.70	0.24	0.19	0.20	6.3	28.1	82.7	175.0
	100	Potash	2.56	0.34	1.62	0.26	0.20	0.17	6.4	27.6	89.0	200.3
	150	Biodunder	2.69	0.35	1.81	0.21	0.19	0.23	6.8	26.4	102.3	179.7
	150	Potash	2.57	0.35	1.73	0.21	0.18	0.17	6.7	35.2	83.3	161.7
	200	Biodunder	2.59	0.33	1.78	0.21	0.19	0.22	6.5	26.5	82.7	187.0
	200	Potash	2.54	0.35	1.79	0.22	0.19	0.17	6.3	25.2	85.7	174.3
	P linear		0.48	0.08	0.23	0.49	0.10	0.00	0.19	0.54	0.74	0.64
	P quadratic		0.17	0.33	0.40	0.75	0.61	0.16	0.53	0.49	0.44	0.38

Table 7

Effect of rate and form of K fertiliser on the analysis of first exposed dewlap leaves, in Jansen's experiment, 23/12/93

Variable	Rate of K (kg/ha)	Form of K	N (%dm)	P (%dm)	K (%dm)	Ca (%dm)	Mg (%dm)	S (%dm)	Cu (mg/kg dm)	Zn (mg/kg dm)	Fe (mg/kg dm)	Mn (mg/kg dm)
	0		2.17	0.28	1.08	0.14	0.25	0.14	5.4	27.0	73.0	129.8
	50		2.20	0.29	1.33	0.14	0.23	0.15	5.6	25.3	75.3	131.7
Rate	100		2.21	0.29	1.41	0.13	0.25	0.15	5.6	25.1	72.4	131.3
	150		2.27	0.28	1.47	0.13	0.23	0.15	5.5	25.9	72.2	146.5
	200		2.21	0.28	1.49	0.13	0.24	0.15	5.4	27.5	75.8	138.8
	P linear		0.40	0.52	0.01	0.43	0.73	0.11	0.85	0.75	0.83	0.45
	P quadratic		0.50	0.15	0.21	0.98	0.61	0.10	0.13	0.22	0.69	0.94
Form		Biodunder	2.23	0.28	1.35	0.13	0.24	0.15	5.4	26.6	74.5	139.1
		Potash	2.19	0.28	1.36	0.14	0.24	0.15	5.6	25.8	73.0	132.1
	S.E.diff		0.04	0.01	0.06	0.01	0.01	0.00	0.07	1.28	1.82	4.24
	P		0.39	0.71	0.90	0.72	0.34	0.08	0.00	0.55	0.44	0.13
	0	Biodunder	2.20	0.28	1.00	0.12	0.27	0.14	5.5	29.4	76.3	139.7
	0	Potash	2.14	0.28	1.17	0.15	0.23	0.14	5.2	24.6	69.7	120.0
	50	Biodunder	2.23	0.29	1.35	0.15	0.23	0.16	5.3	26.3	74.7	141.7
	50	Potash	2.17	0.29	1.32	0.13	0.23	0.15	6.0	24.3	76.0	121.7
Rate*Form	100	Biodunder	2.21	0.30	1.45	0.12	0.25	0.16	5.5	25.4	74.3	129.0
	100	Potash	2.21	0.29	1.37	0.13	0.25	0.14	5.7	24.9	70.4	133.7
	150	Biodunder	2.28	0.28	1.46	0.14	0.23	0.16	5.4	26.5	71.3	147.7
	150	Potash	2.25	0.27	1.47	0.13	0.23	0.15	5.5	25.3	73.0	145.3
	200	Biodunder	2.22	0.28	1.52	0.13	0.24	0.16	5.1	25.2	75.7	137.7
	200	Potash	2.19	0.27	1.47	0.13	0.25	0.14	5.7	29.9	76.0	140.0
	P linear		0.71	0.51	0.31	0.51	0.05	0.16	0.03	0.05	0.29	0.07
	P quadratic		0.78	0.95	0.37	0.22	0.43	0.55	0.20	0.72	0.62	0.55

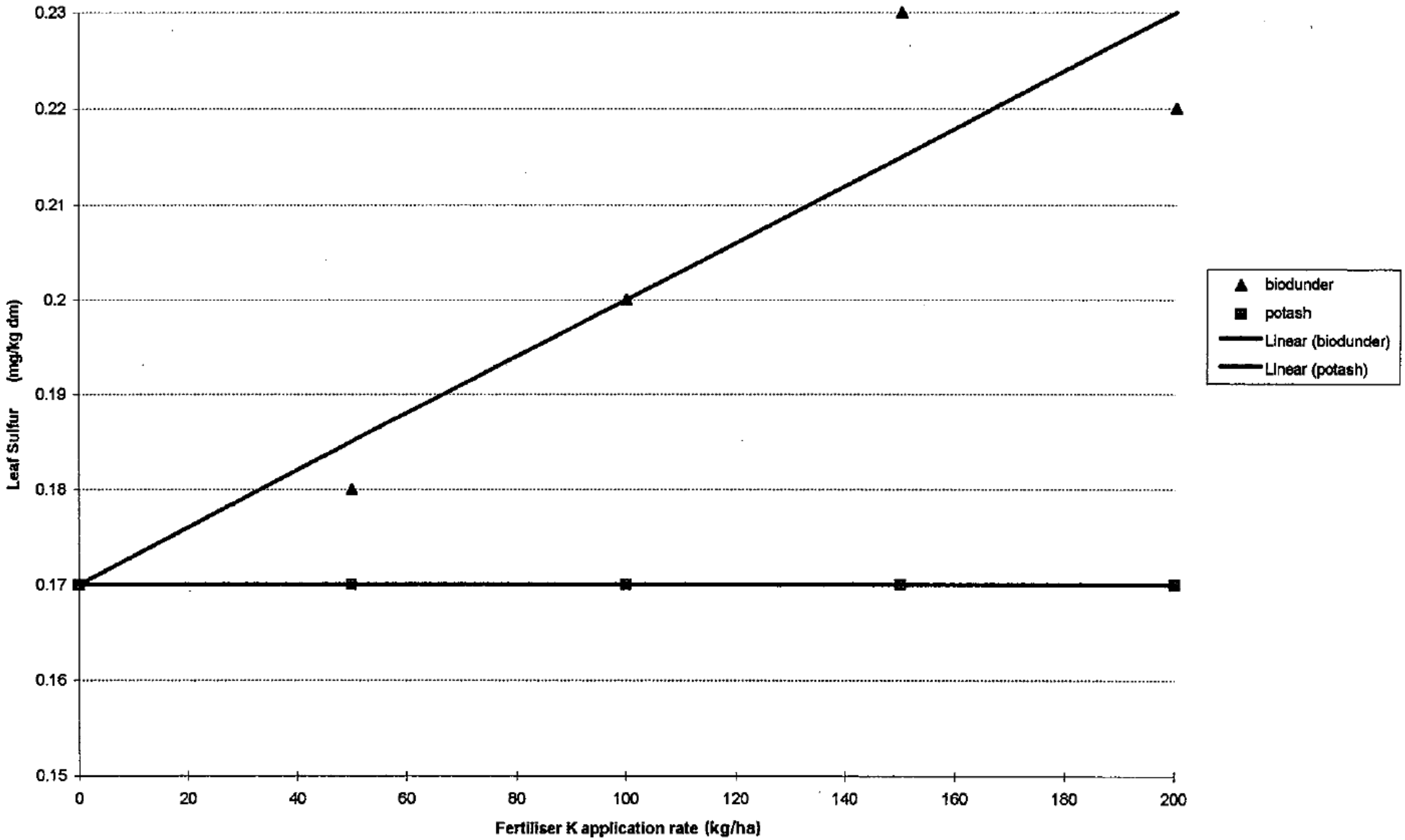
Table 8

Predicted K fertiliser requirements (as kg/ha) based on soil analysis, actual fertiliser treatment to give maximum, and estimate of K maximum from the fit of the quadratic model ($Y = b_0 + b_1 K + b_2 K^2$) to the data (for cane, sugar and return).

Experiment	From soil analysis	Cane	Sugar	Return
Barfield	50	A* 200 Q N/A†(0.08)**	200 N/A(0.12)	200 N/A(0.24)
McKay	100	A 150 Q -††(0.58)	150 - (0.79)	0 - (0.92)
Jansen	100	A 150 Q 140(0.05)	150 140(0.00)	100 118(0.09)

*A = Actual fertiliser rate giving maximum.
Q = Estimate of maximum from quadratic model.
** P value for fit of quadratic model
† N/A = predicted value from quadratic model was a minimum and not acceptable.
†† - = regression model was not an acceptable fit.

Figure 1 Effect of biodunder and muriate of potash on the concentration of sulfur in cane leaves at Barfield's experiment, sampled 23/12/93



Appendix 1

Samples: Soil

Project: Rates of biodunder for sugarcane
H Barfield 18/10/93 (Establishment)

Ref: 199-0007

Sample identification	Laboratory number	Water pH	SEC dS/m @ 25°C	Ca me%	Mg me%	Na me%	K me%
Rep 1	93/3293	7.92	0.073	9.92	9.28	0.399	0.225
2	3294	8.12	0.075	9.01	10.74	0.406	0.199
3	3295	8.05	0.084	9.33	9.90	0.307	0.261

Sample identification	Laboratory number	0.1M HCl				BSES P mg/kg	S mg/kg
		Cu mg/kg	Zn mg/kg	Fe mg/kg	Mn mg/kg		
Rep 1	93/3293	4.29	1.78	50	131	27	2
2	3294	4.86	1.38	77	140	26	2
3	3295	4.67	1.39	76	153	23	3

Sample identification	Laboratory number	Nitric K me%	Organic C %	Total N %	Available NO_3-N
Rep 1	93/3293	1.074	2.16	0.133	2.21
2	3294	0.999	2.34	0.146	3.33
3	3295	1.107	2.07	0.141	1.50

Appendix 2

Samples: Soil

Project: Rates of biodunder for sugarcane
J McKay 29/10/93 (Establishment)

Ref: 199-0007

Sample identification	Laboratory number	Water pH	SEC dS/m @ 25°C	Ca me%	Mg me%	Na me%	K me%
Rep 1	93/3296	5.13	0.038	1.42	0.37	0.075	0.135
2	3297	5.17	0.035	1.46	0.44	0.084	0.137
3	3298	5.11	0.035	1.31	0.35	0.088	0.130

Sample identification	Laboratory number	0.1M HCl				BSES P mg/kg	S mg/kg
		Cu mg/kg	Zn mg/kg	Fe mg/kg	Mn mg/kg		
Rep 1	93/3296	1.45	2.03	342	26	174	5
2	3297	1.47	2.21	343	26	173	4
3	3298	1.40	2.12	307	23	210	6

Sample identification	Laboratory number	Nitric K me%	Organic C %	Total N %	Available NO_3-N
Rep 1	93/3296	1.116	1.31	0.050	4.47
2	3297	1.069	1.60	0.064	2.39
3	3298	1.102	1.53	0.066	2.12

Appendix 3

Samples: Soil

Project: Rates of biodunder for sugarcane
W Jansen 11/11/93 (Establishment)

Ref: 199-0007

Sample identification	Laboratory number	Water pH	SEC dS/m @ 25°C	Ca me%	Mg me%	Na me%	K me%
Rep 1	93/3402	5.09	0.059	0.732	0.573	0.176	0.119
2	3403	5.40	0.044	0.870	0.410	0.138	0.106
3	3404	5.43	0.035	0.790	0.420	0.099	0.112

Sample identification	Laboratory number	0.1M HCl				BSES P mg/kg	S mg/kg
		Cu mg/kg	Zn mg/kg	Fe mg/kg	Mn mg/kg		
Rep 1	93/3402	0.223	0.623	193	34	21	6
2	3403	0.195	0.791	201	28	57	7
3	3404	0.213	1.165	146	29	44	7

Sample identification	Laboratory number	Nitric K me%	Organic C %	Total N %	Available NO_3-N
Rep 1	93/3402	0.489	0.98	0.068	0.58
2	3403	0.505	1.35	0.052	0.71
3	3404	0.505	1.11	0.057	0.48