A SULPHUR DEFICIENCY IN SUGARCANE

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Abstract

A very large (250%) response in sucrose yield/acre was obtained by the application of a moderate quantity of sulphur (20-40 lb. S/acre) on a sandy loam soil. Cane yield and sucrose % cane were both increased, as were stalk population and foliar sulphur and potash contents. Threshold levels appeared to be about 0.16% S and a N:S ratio of 17 for the TVD leaves. Foliar aluminium content was substantially reduced by application of sulphur. Visual symptoms were an overall yellowish unthrifty appearance of the foliage, which could easily be mistaken for a nitrogen deficiency.

Introduction

The continued use of high analysis fertilizers such as urea and triple superphosphate, especially under irrigation, carries with it the inherent danger of creating a sulphur deficiency. However, sulphur deficiencies have only occasionally been reported in sugarcane in the field (Dutt 1962[3], Bonnet 1965[1], Sedl 1968[8]) and it was not expected that a major sulphur deficiency would develop within four years of developing caneland from virgin bush.

Description of experiment

Bush was cleared on Section 24, Triangle Sugar Estates and N:Co.376 was planted in April 1964. Fertilizer given during the plant crop and first two ratoons totalled 386 lb. N, 192 lb. P_2O_5 and 162 lb. K_2O per acre applied in the form of urea, triple superphosphate and muriate of potash respectively.

The 2nd ratoon was harvested in December 1967 and an experiment comprising eight nutrient treatments was established on 1st February 1968.

The treatments were as follows, all fertilizers being applied to the soil adjacent to the cane row.

The experiment was an 8 x 4 randomized block design with plot size of 45 ft. x 30 ft. (6 rows). The following fertilizers were applied to all plots: 184 lb. N/acre as urea and 44 lb. P_2O_5/acre as triple supers.

Heavy rain followed the application of fertilizers and two weeks later there was a marked visual difference between those treatments containing appreciable quantities of sulphur (G, S, Mg) and the remainder. The former were much darker green and slightly taller.

Twenty top visible dewlap (TVD) leaf samples were taken from each plot at two months, aggregated by treatments and analysed spectrographically.

Soil samples were also taken and the mean analysis over four replications was:

pH ($CaCl_2$)	6.0
Available P_2O_5 (resin extract)	5 ppm
Ex. K (m.e. %)	0.23
Ex. Ca (m.e. %)	7.3
Ex. Mg (m.e. %)	3.0
Exchange Capacity (m.e. %)	14.1
Total N%	0.063
Mineral N initially	9
(ppm) after incubation	21
Total S (ppm)	104
Adsorbed S (ppm)	3.5

The soil analysis showed a low phosphate and potash status in the soil as well as low available sulphur content. The total sulphur content was moderate, but mineralization was probably slow.

Part of the experiment was frosted during June 1968, and the low temperatures resulted in unusually slow growth during winter. In spite of this, conspicuous visual differences were observed throughout the crop between treatments with and without sulphur application. Figure 1 shows the effect of sulphur treatments on height growth during the crop.

TABLE I
Details of fertilizer treatments

Treatment	Fertilizer	Composition	Level lb./acre	% S	Nutrients applied lb./acre S	Other
G	Gypsum	$CaSO_4.2H_2O$	240	18	43	Ca 55
Mg	Magnesium sulphate	$MgSO_4.7H_2O$	150	13	20	Mg 15
S	Rock Sulphur	S	50	90	45	—
Cu	Copper sulphate	$CuSo_4.5H_2O$	18	13	2	Cu 4.5
Zn	Zinc sulphate	$ZnSO_4.7H_2O$	20	11	2	Zn 4.5
B	Fertilizer borate	$Na_2B_4O_7$ (14.3%)	40	—	—	B 5.7
Mo	Sodium molybdate	$Na_2MoO_4.2H_2O$	1.5	—	—	Mo 0.6
Nil	Control	—	—	—	—	—

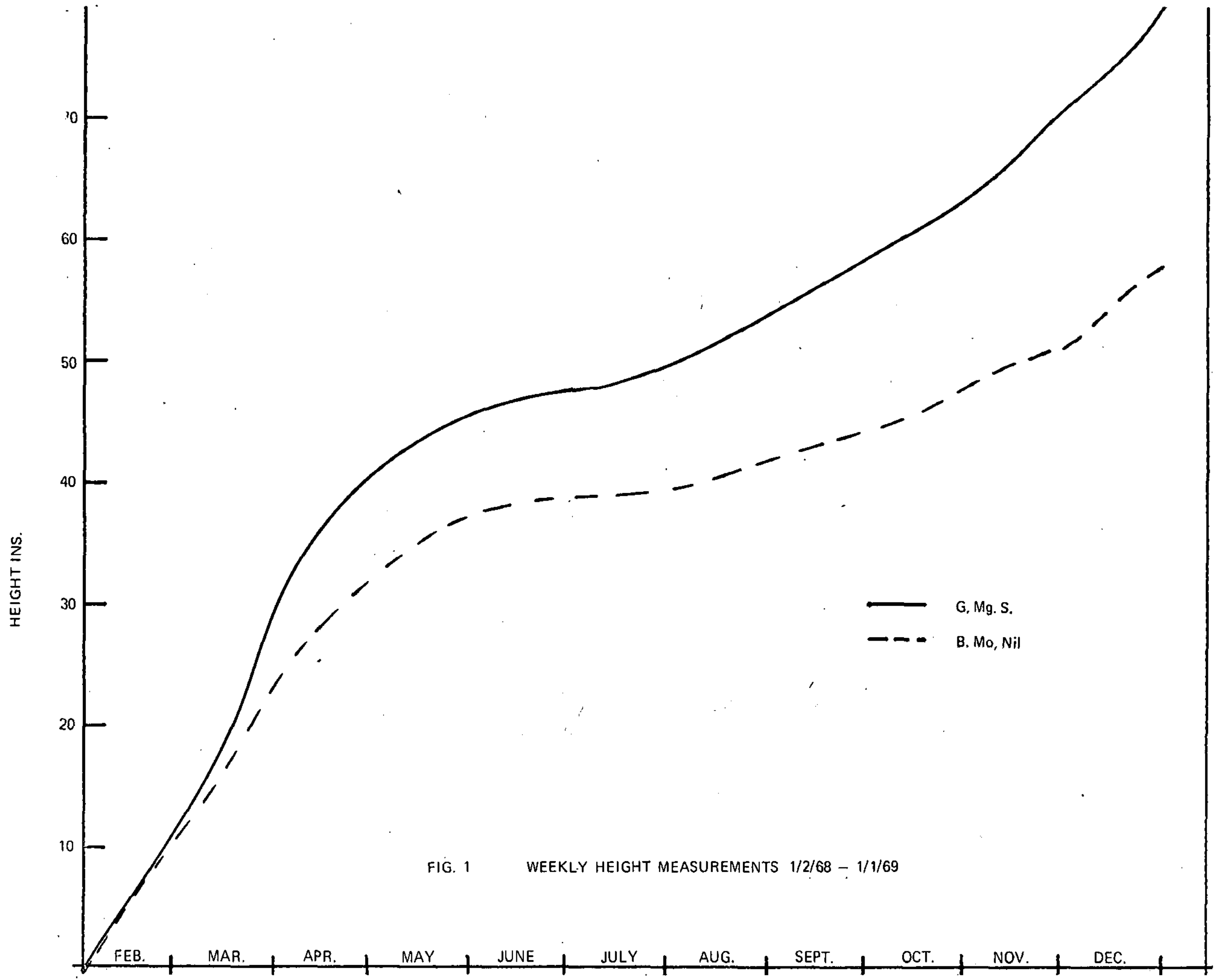

FIG. 1 WEEKLY HEIGHT MEASUREMENTS 1/2/68 – 1/1/69

Harvest results

The experiment was harvested in January 1969 at 12½ months. Cane yield, sucrose content and stalk population were ascertained, with the following results:

The Coefficients of Variation were quite high, mainly due to variable growth caused by frost. In spite of this, treatment differences were large.

TABLE 2
Yield response to sulphur treatments

Treatment	Tons Cane Per Acre	Sucrose % Cane	Tons Sucrose Per Acre	Stalk Count '000s/ acre
Mg Magnesium sulphate	40.8	13.8	5.72	69.7
G Gypsum	41.2	13.8	5.70	70.8
S Rock Sulphur	38.3	13.6	5.20	68.9
Zn Zinc sulphate	22.0	13.8	3.04	67.9
Cu Copper sulphate	21.5	13.7	2.97	64.5
Mo Sodium molybdate	19.5	12.9	2.54	65.0
B Fertilizer borate	16.8	13.0	2.23	63.5
Nil Control	18.5	11.4	2.21	61.0
L.s.d. (5%)	10.3	1.5	1.68	7.1
(1%)	14.0	2.0	2.29	9.6
C. V. (%)	25.6	7.7	30.9	7.2
Mean Mg, G, S	40.1	13.7	5.54	69.8
Mean Zn, Cu	21.8	13.7	3.01	66.2
Mean Mo, B, Nil	18.3	12.4	2.33	63.2

The treatments fall naturally into three groups: those containing appreciable quantities of sulphur, those containing very small amounts (2 lb. S/acre) and those with no sulphur.

Treatments containing appreciable amounts of Sulphur (Mg, G, S) produced far higher cane yields than the remaining treatments. Those containing a small amount of S (Zn, Cu) appeared to be slightly better (NS) than those containing no sulphur (Mo, B, Nil).

All five treatments containing sulphur produced a higher sucrose content than control.

Yields of sucrose per acre in the three high sulphur treatments were about 2½ times those of the control treatments. There was no apparent difference between the application of 20 lb. S in magnesium sulphate and 45 lb. S in rock sulphur or 43 lb. S in gypsum.

The stalk populations in the three high sulphur treatments were higher than those in the control treatment.

Deficiency symptoms

These comprised an overall yellowish appearance of the foliage especially the young leaves, very similar to that of a nitrogen deficiency, together

TABLE 3
Foliar analyses of TVD Leaves

Treatment	Ash %	N %	P %	K %	Ca %	S %	Mg %	Fe ppm	Al ppm	Mn ppm	B ppm	Cu ppm	Zn ppm	N:S ratio
G	5.80	2.5	0.32	0.92	0.24	0.27	0.19	80	49	50	13	13	21	9.3
Mg	6.27	2.6	0.33	0.92	0.24	0.17	0.20	89	60	51	17	10	20	15.3
S	5.97	2.6	0.36	0.92	0.24	0.16	0.18	113	84	56	13	14	22	16.2
Cu	4.97	2.6	0.33	0.67	0.20	0.14	0.18	103	84	49	14	8	18	18.6
Zn	5.17	2.6	0.34	0.72	0.21	0.17	0.17	140	160	49	12	9	25	15.3
B	5.05	3.1	0.33	0.49	0.21	0.13	0.16	105	123	44	12	9	36	23.8
Mo	5.09	2.9	0.32	0.54	0.21	0.14	0.17	158	204	44	7	6	21	20.7
Nil	4.76	2.8	0.27	0.53	0.19	0.11	0.16	107	120	41	9	11	22	25.4
G, Mg S	6.01	2.6	0.34	0.92	0.24	0.20	0.19	94	64	52	14	12	21	13.0
Cu, Zn B, Mo	5.07	2.6	0.34	0.70	0.21	0.16	0.18	122	122	49	13	8	22	16.2
Nil	4.97	2.9	0.31	0.52	0.20	0.13	0.16	123	149	43	9	9	26	22.3
Threshold Level*		2.1	0.21	1.10	0.12	0.16†	0.08	5	—	30	1	4	15	17†

* Mostly from Evans (1959)[4]
† Proposed Levels

with a reduction in leaf size, tillering and plant height. No other specific symptoms could be detected.

Foliar analysis

Table 3 shows the analyses of the TVD leaf samples for each treatment, together with approximate threshold values.

The sulphur content of the Top Visible Dewlap (TVD) leaves in the control treatment (0.11%) was substantially increased to 0.20% in the three main sulphur treatments (Mg, S, G). The N:S ratio dropped from 25 in the control treatment to 13 for the treatments containing sulphur.

An interesting feature of the sulphur containing treatments was that they permitted considerably greater uptake of K than the control treatments (0.92% and 0.52%). Both these values are below the threshold value and it appears that the sulphur deficiency was retarding potash uptake and accentuating potash deficiency on a soil with low inherent potash content.

Nitrogen and phosphate levels in the leaf were well above threshold requirements, as were those of Ca, Mg, Fe, Mn, B, Cu and Zn.

There was a marked reduction in the aluminium content of the leaves in the S treatments (64 ppm) compared with control (149 ppm), and the possibility of an aluminium toxicity cannot be excluded, as the threshold toxicity level may be in the region of 60 ppm Al (S.A.S.A. 1968[7]).

There was no indication that any other applied nutrient affected the foliar composition.

Discussion

According to Pumphrey and Moore (1965)[6], the N:S ratio is a more useful criterion of sulphur deficiency than the S content for lucerne foliage because it is less affected by age. Where the ratio was wider than 11, a response to sulphur could be expected; the S content was less than 0.22% in such cases. Dijkshoorn and Van Wijk (1967)[2] found that the organic N:organic S ratio of sulphur deficient plants was wider than 40.

It appears from the data in this paper and those of Sedl (1968)[8] and Malavolta *et al.* (1962)[5], that the threshold value for sulphur in 3rd or TVD leaf of sugarcane could be taken as about 0.16% while an N:S ratio wider than 17 might be expected to produce responses to sulphur. The threshold level in the 3-6 sheath is reported as being around 0.2-0.5% (Bonnet 1965[1]).

Correction of a sulphur deficiency can be achieved in several ways: the use of sulphate of ammonia instead of urea, single superphosphate instead of double or triple superphosphate, sulphate instead of muriate of potash, or the use of gypsum, rock sulphur or mixtures. Based on a requirement of about 30-40 lb. S/acre per year (Sedl 1968[8]), the most economical method in Rhodesia is to use about 300 lb. single supers/acre which supplies 36 lb. S in addition to 57 lb. P_2O_5, a typical maintenance dressing of phosphate. The cost is only 3/- per acre greater than that of using double superphosphate.

Acknowledgements

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Discussion

Mr. Odendaal: Were the treatments applied to the surface of the soil or were they incorporated in the soil? Has any work been done on spraying magnesium sulphate onto the leaves of ratoons?

Dr. Gosnell: All fertilizers were applied in solid form to the side of the cane row and irrigation followed immediately. There was some wash of fertilizer from the treated field.

We have not sprayed magnesium sulphate, but as over a hundred pounds of magnesium sulphate per acre is required in order to show response it does not seem a reasonable proposition.

Mr. du Preez: During a leaf survey in the Midlands, on one type of soil, it was noticed that when aluminium was high growth was designated as poor at the time of sampling.

The high level was of the order of 60 ppm aluminium in the leaves. At lower levels cane growth was better.

Subsequent analyses of leaves from other areas have shown normal cane to contain up to 150 ppm. From Dr. Gosnell's figures the iron to aluminium ratio is approximately one. However, addition of sulphur decreased the aluminium relative to the iron, by 30%, whereas in the control plot the aluminium was higher than the iron content.

Mr. Wardell: Is Dr. Gosnell satisfied that conversion to single supers is adequate to make up for sulphur deficiency? Would it not still be advisable to use filter press, which has a fairly high sulphur content?

Dr. Gosnell: We have worked on a figure of 30 to 40 pounds elemental sulphur per acre per annum on a 50 ton cane crop and three hundred pounds of single supers per acre should supply this amount of sulphur.

The amount of sulphur in filter cake presumably depends on the area from which the cane comes to the mill, i.e. if from a sulphur deficient area then the filter cake will be low in sulphur.