A COMPARISON OF THE EFFECTS OF UREA AND SULPHATE OF AMMONIA ON SUGARCANE

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Abstract

Urea resulted in lower cane yields and higher sucrose % cane than did sulphate of ammonia and the two carriers produced virtually identical yields of sucrose per hectare. There was significantly less lodging in the urea treatments, which might account for the higher sucrose content. These effects occurred in N:Co.376, but not in N:Co.310 or C.P.29/116. Similar responses took place at a level of 101 kg N/ha and at the mean of 5 levels between 101 and 258 kg N/ha. The reduction in flowering which occurred with increasing levels of nitrogen was much more marked with sulphate of ammonia than with urea.

Introduction

Numerous experiments have been carried out in various parts of the world comparing the use of urea and sulphate of ammonia on sugarcane. In a comprehensive review, du Toit (1967) concluded that in the majority of countries, little or no difference had been found between the two carriers, but that sulphate of ammonia produced higher yields of cane than urea on a number of occasions. In many of the experiments quoted, sucrose analyses were not carried out but on several occasions it appeared that urea caused less depression of sucrose than did sulphate of ammonia. However it was not possible to identify or describe the conditions under which these results occurred and the conclusions regarding differential sucrose content between the carriers were challenged by Parish (1967) who contended that a higher sucrose content with urea must have been the result of less efficient utilization of nitrogen. More recently, Gill et. al. (1968) summarized results from over 50 trials in India, and found that sulphate of ammonia produced slightly more cane but lower sucrose content than urea to give equal yields of sucrose per hectare, thus confirming du Toit's conclusions.

Two experiments were established in 1966 at Chiredzi in which a comparison of urea vs. sulphate of ammonia was combined with other treatments in order to ascertain whether some of the factors affecting the comparison of the carriers could be identified. In trial No. 1, three varieties (N:Co.310, N:Co.376 and C.P.29/116) were treated with 5 levels of N (101, 140, 179, 219, 258 kg/ha) applied in both forms. Optimum irrigation was given throughout. In trial No. 2, N:Co.376 was subjected to 6 levels of irrigation ranging from 1.0 x Class "A" Pan evaporation to 0.37 x Pan, and the comparison of urea and sulphate of ammonia was factorially arranged with a burning vs. trashing comparison.

The soil on which both trials were established was a PE 1 red brown sandy clay loam, recently cleared from virgin bush, with the following mean analysis:-

Clay	20%
pH ($CaCl_2$)	6.7
Sp. Conductivity (mmho/cm.)	0.120
Carbon %	0.68
Total N %	0.053
Mineral N p.p.m. initially	17
Mineral N p.p.m. after incubation	28
Available P_2O_5 (p.p.m.)	13
Ex. K (m.e. %)	0.89
Ex. Ca (m.e. %)	9.1
Ex. Mg(m.e. %)	3.5

The urea and sulphate of ammonia were applied on the surface over the cane row and immediately irrigated in to prevent losses of N through volatilization. Applications were split in the plant crop but a single application was made in the ratoons.

TABLE 1

Effect of N carrier on yield and sucrose content

Experiment	Crop		Urea	Sulphate of Ammonia	L.s.d. (5%)
1	P	T.C.H.	139.9	144.1	4.9
		S. % C.	14.36	14.14	0.39
		T.S.H.	20.00	20.29	0.74
1	1R	T.C.H.	155.3	158.5	4.4
		S. % C.	13.74	13.23	0.45*
		T.S.H.	21.22	20.83	0.87
1	2R	T.C.H.	127.5	129.1	3.9
		E.R.S. % C	12.75	12.15	0.41**
		T.E.R.S.H.	16.23	15.63	0.71
2	P	T.C.H.	115.0	118.1	2.5*
		S. % C.	14.36	13.98	0.32*
		T.S.H.	16.43	16.52	0.49
2	1R	T.C.H.	117.7	121.9	4.0*
		S. % C.	12.89	12.61	0.32
		T.S.H.	15.38	15.42	0.67
Mean		T.C.H.	131.1	134.3	—
		S. % C.	13.98	13.58	—
		T.S.H.	18.32	18.22	—

N.B. T.C.H. = Metric tonnes cane per hectare
T.S.H. = Metric tonnes sucrose per hectare
E.R.S. % C. = Estimated Recoverable Sugar % Cane = S—0.451 (B—S) — 0.077F where S= Sucrose % cane, B = Brix and F = Fibre by direct analysis.
T.E.R.S.H. = Metric tonnes Estimated Recoverable Sugar/hectare = T.C.H. x E.R.S. % C. x 10^{-2}

TABLE II
Effect of N carrier on cane quality (Expt. 1, 2R)

	Urea	Sulphate of Ammonia	L.s.d. (1%)
Sucrose % Cane	14.56	13.97	0.53**
Brix % Cane	16.29	15.76	0.53**
Fibre % Cane	13.32	13.07	0.69 NS
E.R.S. % C.	12.75	12.15	0.54**
Purity	89.4	88.6	—

All crops were cut at 12 months in November and results from Plant, 1st and 2nd ratoon (1967-69) are available from Trial No. 1, together with Plant and 1st ratoon (1967-68) from Trial No. 2.

At harvest, cane weights and numbers of stalks per plot were determined, together with sucrose % cane. Visual estimates of lodging were also carried out in all plots at harvest.

Results

Overall comparison of urea and sulphate of ammonia

The main results of the trials are shown in Table I.

From these results it is apparent that urea has resulted in consistently higher sucrose % cane (significant in three instances) with somewhat lower cane yields (significant in two cases) to give virtually identical yields of sucrose per acre. A more detailed analysis of cane quality was carried out in Expt. 1, 2nd ratoon and the results are shown in Table II.

Brix and sucrose % cane were both far higher with urea than with sulphate of ammonia, while purity was slightly higher. Fibre was not significantly affected, and the Estimated Recoverable Sugar % Cane was significantly higher with urea ($P < .01$) than with sulphate of ammonia.

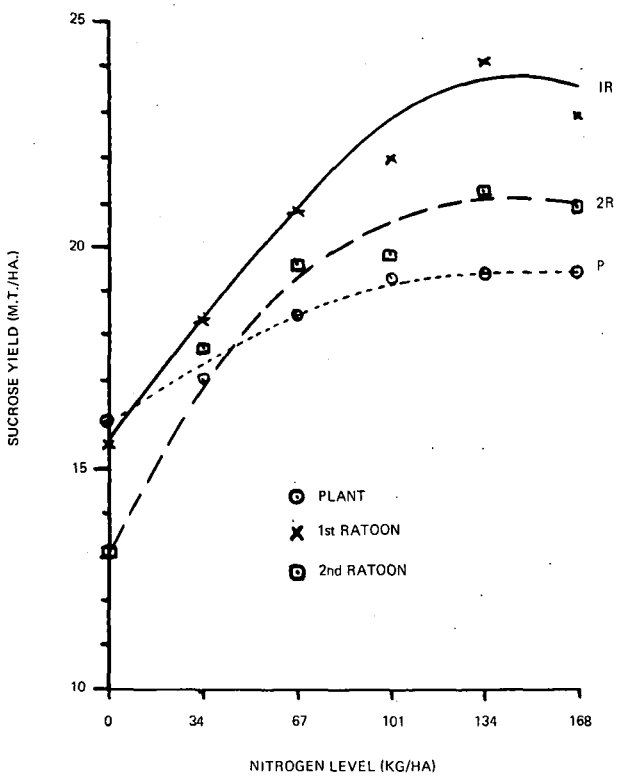

FIGURE 1: Response of N:Co.376 to levels of nitrogen between 0 and 168 kg/ha.

Effect of Level of Nitrogen

In any comparison of N carriers it is important that (a) there is a response to nitrogen and (b) that the comparison be made in the region of the optimum level and also below it at a fairly steep part of the response curve, in order to provide maximum practical usefulness as well as maximum sensitivit yof the comparison. In Expt. 2 all comparisons were made at 157 kg N/ha. in the plant crop and 179 kg N/ha. in the ratoon. In Expt. 1, levels of nitrogen ranged from 101 to 258 kg N/ha. The shape of the response curve to N in the range 0 to 168 kg N/ha. is given in results from an adjacent experiment where six levels of N were tested in this range. The responses are shown in Fig. 1.

From this it may be seen that the 101 kg/ha. level satisfies the requirements for a valid comparison of N carriers and in Table 3, comparisons have been made at this level only.

TABLE III
Effect of N carriers at the level of 101 kg N/ha.

		Urea	Sulphate of Ammonia	L.s.d. (5%)
Plant	T.C.H.	132 5	142.3	11.1
	S. % C.	14.79	13.99	0.86
	T.S.H.	19.52	19.75	1.66
1R	T.C.H.	148.7	151.2	10.0
	S. % C.	13.59	13.54	1.00
	T.S.H.	20.00	20.32	1.97
2R	T.C.H.	126.9	124.4	8.8
	E.R.S. % C.	13.15	12.03	0.91*
	T.E.R.S.H.	16.65	14.87	1.59*
Mean	T.C.H.	136.0	139.3	—
	S. % C.	14.46	13.79	—
	T.S.H.	19.53	19.10	—

It is clear that the comparison of urea and sulphate of ammonia was in general similar at 101 kg/ha. to that over all levels shown in Table I.

Effect of Variety

In Expt. 1, it was observed that N:Co.376 consistently produced lower cane yields and higher sucrose content with urea than with sulphate of ammonia, while this effect was not observed with N:Co.310 and C.P.29/116. This is shown in Tables IV and V.

TABLE IV
Effect of N carrier on yield and sucrose content of N:Co.376

		Urea	Sulphate of Ammonia	L.s.d. (5%)
T.C.H.	Plant	136.3	145.3	8.5*
	1st Ratoon	159.6	167.0	7.6
	2nd Ratoon	128.0	137.0	6.7*
S. % C.	Plant	14.49	13.69	0.67*
	1st Ratoon	13.41	12.69	0.78
	2nd Ratoon	14.97	13.72	0.69**

TABLE V
Effect of N carrier on yield and sucrose content of varieties (Mean Plant, 1st and 2nd ratoons)

Treatment	N:Co.310	N:Co.376	C.P.29/116
	TONS CANE/HECTARE		
Urea	127.3	141.2	154.7
Sulphate of ammonia	127.1	149.7	155.1
	SUCROSE % CANE		
Urea	14.82	14.29	13.55
Sulphate of ammonia	14.64	13.36	13.32
	TONS SUCROSE/HECTARE		
Urea	18.83	20.08	20.87
Sulphate of ammonia	18.58	19.97	20.56

TABLE VI
Effect of N carrier on % lodging

Experiment	Crop	Urea	Sulphate of Ammonia	L.s.d. (5%)
1	P	81.3	90.6	7.3*
	1R	89.2	94.1	7.4
2	P	37.5	57.5	15.9*
	1R	52.8	70.3	16.7*
Mean	—	65.2	78.1	—

Effect of N Carrier on Lodging

The visual assesssments on lodging are summarized in Table VI.

In three out of four crops in which lodging was assessed, urea resulted in significantly less lodging ($P<.05$) than sulphate of ammonia, and in the remaining case there was a similar trend. In Expt. 2, there was little or no lodging in the drier treatments, and the results quoted above are the means of the two wettest treatments (1.0 and 0.84 x Pan).

Effect of N Carrier on Flowering

The incidence of flowering in the Rhodesian Lowveld varies considerably from year to year; in 1969 it was fairly high, and regular flower counts were taken in all plots of Expt. 1. These showed that the application of urea produced significantly ($P<.01$) more flowers (6250/hectare) than did sulphate of ammonia (4500/hectare).

It was observed that this increase in flowering with urea only occurred with N:Co.310; as shown in Table VII. This effect may be due to the fact that N:Co.310 consistently flowers much more heavily than the other varieties.

TABLE VII
Effect of N carrier & variety on number of flowers/hectare

Treatment	N:Co.310	N:Co.376	C.P.29/116	L.s.d. (1%)
Urea	14,180	1,580	2,940	3,190
Sulphate of ammonia	9,510	1,630	2,250	

Effect of N Carrier on Stalk Population

In the 2nd ratoon of Expt. 1, urea resulted in significantly ($P<.01$) more stalks per hectare (126,000) than did sulphate of ammonia (121,000). This was consistent over all levels of nitrogen and in all three varieties. However, no difference between carriers was observed in the other four crops and it must be presumed that this was a chance effect.

Irrigation and Burning vs. Trashing

No consistent interactions between N carrier and level of irrigation or trash management could be detected.

Discussion

In general, it has been shown that sulphate of ammonia has given slightly higher yields of cane than urea and also produced significantly greater lodging. Other experimental work in Rhodesia (Anon 1969a) has shown that lodging results in a highly significant reduction in sucrose content, and it is therefore probable that the greater depression in sucrose content observed with sulphate of ammonia is due to the greater amount of lodging produced by the latter.

Any comparison of sulphate of ammonia and urea must recognise the possible beneficial effect of sulphur in sulphate of ammonia. Although sulphur deficiencies in cane have been discovered on certain soils in the Rhodesian Lowveld (Gosnell & Long 1969), there is no reason to believe that a deficiency occurs on the soil of these experiments. The fact that sulphate of ammonia did not outyield urea in yield of sugar per hectare is a good indication that sulphur deficiency was not present.

Some of the conflicting results in past comparisons of the two nitrogen carriers may possibly be resolved in terms of variety. It was found in Experiment 1 that in the case of N:Co.376, sulphate of ammonia produced on average some 8.5 tonnes/hectare more cane with 0.93% lower sucrose % cane than did urea; on the other hand there were no significant differences between the two N carriers with N:Co.310 and C.P. 29/116.

No explanation for these varietal differences was forthcoming, but differential varietal responses to nitrogen levels and to herbicides have been observed in the past, so differential responses to N carriers cannot be ruled out.

Another curious difference between urea and sulphate of ammonia was their effect on number of flowers produced. Experiments have shown a marked reduction in flowering with increasing levels of nitrogen (Anon 1969b), and it now appears that this reduction is greater with sulphate of ammonia than with urea in the case of N:Co.310.

No explanation for the differential behaviour of urea and sulphate of ammonia is at present available as it is generally accepted that urea is converted rapidly in the soil to the ammonium ion, following which it should presumably behave similarly to sulphate of ammonia.

Urea

$CO(NH_2)_2$ urease $\longrightarrow$ NH_4^+ $\longrightarrow$ $NO_2/$ $\longrightarrow$ $NO_3/$

Sulphate of ammonia

$(NH_4)_2SO_4 \longrightarrow$ $NH_4^+ \longrightarrow$ $NO_2/ \longrightarrow$ $NO_3/$

The main practical conclusion from these trials is that there was no difference between the two carriers in yield of sucrose per acre; however urea is the recommended carrier because it has a lower cost per unit nitrogen. In addition, the higher sucrose content combined with lower yields obtained with urea results in lower costs in transporting cane to the mill. These conclusions are only valid, however, where urea can be irrigated in or cultivated, in order to prevent volatilization losses of nitrogen.

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Discussion

Mr. du Toit: We have noticed that when ammonium sulphate is used the cane has a better appearance — it looks greener — than when urea is used.

I have always thought that very soon after the application of either urea or ammonium sulphate the nitrogenous form would always be in the form of a nitrate. Therefore why do these differences persist?

Dr. Gosnell: We have observed no colour differences at all.

Professor Orchard: In any comparison where sulphate of ammonia is involved, the final cost must be kept in mind.

It is all right in a neutral soil with 20% clay, but with sandy, less buffered soils that are slightly acid, if sulphate of ammonia is used the soil will eventually become acid and have to be limed.

Mr. du Toit: I understand that Iran is using urea on an alkaline soil with irrigation.

Have experiments comparing urea and ammonium sulphate been carried out in Iran?

Mr. Abbassi: In Iran we found urea gave a better yield and better sucrose on the ratoon crop. There was no difference in the plant cane crop.

Mr. d'Hotman de Villiers: Will not continued use of urea result in sulphur deficiency in the soil?

Dr. Gosnell: We have found sulphur deficiencies in Rhodesia due to use of urea and double and triple supers. By returning to the use of single supers we have corrected this.

Dr. Cleasby (in the chair): In Natal, where urea has been used for a long time, there are signs of sulphur deficiency.

Mr. Odendaal: Did Dr. Gosnell notice a difference in lodging between the various varieties?

Also, why does ammonium sulphate cause more lodging than urea.

Dr. Gosnell: CP 29/116 lodged more than the other two varieties.

I do not know why there is more lodging with ammonium sulphate .

Mr. Wood: We are carrying out a comprehensive nutrient survey at present throughout the industry and sulphur is one of the elements being considered.

Mr. Moberly: Are there any third leaf differences in content, particularly in respect of varieties?

Dr. Gosnell: We have not yet analysed many third leaf samples and so far results are confusing.

Mr. Alexander: Our main reason for recommending urea is that sulphate of ammonia at present prices is about 10% per unit of N higher than urea, apart from higher transport and storage costs.