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SOUTH AFRICAN SUGAR INDUSTRY
AGRONOMISTS' ASSOCIATION

4200/11 MOISTURE STRESS TRIAL

TERMINAL REPORT

Cat. 1432

Object: To determine the effect of moisture stress imposed for varying lengths of time during both the pre-canopy and full canopy phases of growth.

Duration of Investigation:

This trial was a 4th ratoon crop following the termination of projects 7300/13 and 14, and it lasted for 12,1 months (16.9.82 to 21.9.83).

Location: ZSA Experiment Station, Impala Block A5-10
Kudu Block G1-6.

Soil type: PE.1 sandy clay loam derived from gneiss.

Design: Randomised complete blocks, 6 replications.

Variety/Spacing: NCo 376 in 1,5m rows.

Fertiliser:

(1) Nitrogen: 180 kg/ha N applied as ammonium nitrate in two equal dressings at 3 and 10 weeks.

(2) Phosphate: 100 kg/ha P_2O_5 as single superphosphate applied at 3 weeks.

(3) Potash: 60 kg/ha K_2O as muriate of potash applied at 3 weeks.

Rainfall: 414mm

Irrigation treatments: (Treatments 1-5 irrigated to schedule pre-canopy).

1. Nett application of 51mm at 50mm accumulated pan deficit (Control - no stress).

2. Slight continuous stress with complete soil water replenishment when irrigated; 102mm applied at 100mm accumulated pan deficit (11 stress periods).

3. Alternate slight stress/no stress; 51mm applied at alternate pan deficits of 50mm and 100mm (8 stress periods).

4. One pre-canopy stress period of 100mm accumulated pan deficit, followed by two successive stress periods of 100mm accumulated pan deficit imposed on early full canopy phase; thereafter normal applications of 51mm at 50mm accumulated pan deficit were resumed. (3 stress periods.)

5. One pre-canopy stress period of 100mm accumulated pan deficit, followed by three successive stress periods of 100mm accumulated pan deficit imposed on early full canopy phase. Thereafter normal applications of 51mm at 50mm accumulated pan deficit were resumed (4 stress periods).

2/(Treatments....

(Treatments 1-6 Irrigated to schedule from full canopy)

6. Normal irrigation of 51mm at 50mm accumulated pan deficit from complete crop canopy.

7. Slight continuous stress from full canopy with complete soil water replenishment when irrigated; 102mm applied at 100mm accumulated pan deficit (9 stress periods from full canopy.

8. Alternate slight stress/no stress from full canopy, soil water not completely replenished in alternate irrigations; 51mm applied alternate pan deficits of 50mm and 100mm (7 stress periods from full canopy).

9. One 150mm stress period in early full canopy, with complete soil water replenishment (102mm irrigation. Three further stress periods in late summer with partial soil water replenishment; 51mm applied at 150mm accumulated deficit (4 stress periods from full canopy).

10. Continuous 200mm accumulated pan deficit from full canopy with complete soil water replenishment; 102mm irrigation (5 stress periods from full canopy).

11. Continuous 150mm accumlated pan deficit from full canopy with complete soil water replenishment; 102mm irrigation (6 stress periods from full canopy).

12. Continuous 250mm accumulated pan deficit from full canopy with complete soil water replenishment; 102mm irrigation (4 stress periods from full canopy).

<u>Conduct:</u>

(a) Overhead sprinklers were used to irrigate the trial, and an application efficiency of 85% was assumed. All treatments received two irrigations of 51mm after harvest of the previous crop, and 37mm after fertiliser application on 8th October, 1982. Treatment irrigations were imposed from then on until 13th June, 1983, after which all treatments received 3 irrigations of 51mm at 50mm accumulated pan deficit. The cane was dried-off by cessation of irrigation two months before harvest (the last irrigation was on 19th July, 1983). It should be noted that treatments which received 51mm irrigation were irrigated for seven hours, full circle. All treatments which received 102mm irrigation were irrigated over two days (2 x 7 hours full circle) with a rest period between irrigations which enhanced infiltration.

(b) After every irrigation the accumulated pan deficit was adjusted to the open pan reading for that day, regardless of whether the soil water had been replenished completely or not. Thus the accumulated pan deficit was a means of determining frequency of irrigation and was not related to soil water replenishment. This was particularly true of treatments 3, 4, 5, 8 and 9, where only 51mm was applied after periods of stress (see Table 1)

3/c)Gravimetric......

(c) Gravimetric soil moisture determinations were conducted periodically, but there was insufficient coverage to aid in interpretation of treatment responses and the data have not been presented in this report.

(d) Canopy cover measurements were taken regularly on treatment 1 from 5th November ot 9th December, 1982, after which the crop was considered to be at full canopy.

(e) At harvest stalk lengths, internode numbers and mid-point diameters of 24 stalks sampled for quality analysis were measured.

RESULTS:

a) Total precipitation: Table 2 shows the net effect of irrigation treatments in creating periods of stress and on the frequency of irrigations. Rainfall over the season was below average (414mm), and summer temperatures were high, creating ideal conditions for the stress treatments. The number of treatment irrigations varied from 4 (408mm) in treatment 12 (most severely stressed) to 21 (1 071mm) in treatment 1. Treatment 2 received the most water (1 763mm total) whilst treatment 12 received the least (1 063mm in total). It should be noted that although treatments 5 and 6 received the same amount of irrigation, as did treatments 9 and 11, treatment 5 was more severely stressed than treatment 6, as was treatment 9 compared with treatment 11.

b) Yield: (see Table 3).

i) Cane yield (t/ha)

The control treament (treatment 1) had the highest cane yield of 129,55 t/ha, whilst treatment 12 (most severely stressed) had the lowest yield of 71,07 t/ha (45,14% less than the control). Treatments 3, 5 and 8-12 had a significantly lower yield than the control. Water use efficiency values varied from 6,69 (treatment 12) to 8,63 (treatment 11) TC/ha/100mm of water(see Table 2). These values agreed well with values from previous experiments.

ii) ERC % cane

The decline in ERC % cane with stress was less marked than that for cane yield. The lowest ERC % cane value of 13,45 for treatment 12 was only 6,14% lower than the highest value of 14,33 for treatment 1. Only treatments 9-12 had significantly lower ERC % cane values than treatment 1. Treatments 6-12 had lower ERC % cane values than treatments 1-5, but the difference between corresponding treatments 1 and 6, 2 and 7, and 3 and 8 was not significant.

iii) TERC/ha

The variation of TERC/ha followed the same trend as TC/ha with the percentage decline in TERC/ha, with stress being more marked. The sugar yield of treatment 12 (9,56 TERC/ha) was 48,46% lower than treatment 1 (18,55 TERC/ha). The efficiency of all treatments in using water to produce sugar was almost constant at a mean value of 1,06 ± 0,07 TERC/ha/100mm of water (see Table 2).

c) Regression of yield on total precipitation: (See Fig.1 (a) - (c)): Cane yield (t/ha, ERC % cane, and TERC/ha were found to be linearly related to total precipitation(mm). The equations which best approximate the linear regressions are:

i) Cane yield (t/ha) = -2,48 + 0,0782(total precipitation); r = 0,93***

ii) ERC % cane = 12,21 + 0,0012(total precipitation); r=0,93***

iii) TERC/ha = -2,02 + 0,0121(total precipitation); r=0,95***

Despite the close correlation obtained, yield was also affected by frequency of irrigations and amount applied per irrigation. Treatment 6 (17,14 TERC/ha) outyielded treatment 5 (15,97 TERC/ha), even though both treatments received 1 522mm, total precipitation. The same applies to treatments 11 and 9 which both received 1 267mm total precipitation, but yielded 14,98 and 12,34 TERC/ha respectively (see Table 2).

d) Stalk characteristics: Table 4 shows that the main stalk characteristic which affected yield was stalk length. There was a decline in stalk length from 2,55m in treatment 1 to 1,34m in treatment 12. Stalk length was affected more by differences in internode length than by differences in internode number. Differences in mid-point diameter between treatments were negligeable, and stalk numbers varied slightly from 168,4 to 184,9 (x 10^{-3}) stalks per hectare. This variation appeared to have been randomly distributed, with no relation to treatments.

Severe lodging occurred in treatment 1 (93%), with 15% of the stalks producing flowers. There was a tendency for cane taller than 1,8m to lodge and to flower, whereas shorter cane did not.

DISCUSSION

Results may be more simply evaluated and explained by a consideration of ERC yields (t/ha) in relation to control yield, viz.

Treatment	ERC yield t/ha	% of control	Yield loss %
I1	18,55	100,0	-
I2	18,46	99,5	0,5
I3	16,29	87,8	12,2
I4	17,04	91,9	8,1
I5	15,97	86,1	13,9
I6	17,14	92,4	7,6
I7	17,26	93,0	7,0
I8	14,74	79,5	20,5
I9	12,34	66,5	33,5
I10	11,81	63,7	36,3
I11	14,98	80,8	19,2
I12	9,56	51,5	48,5

5/(a) Effect of.......

(a) Effect of irrigating at 100mm pan deficit.

Results showed that irrigating at a pan deficit of 100mm caused no appreciable yield loss when compared with irrigation at a deficit of 50mm, provided the estimated deficit was replenished, i.e. provided 100mm of irrigation water was applied. This is shown by the following comparisons:

I1 (50mm deficit) vs. I2 (100mm deficit): Yield loss 0,5%

I6 (" ") vs. I7 (" "): Yield loss 7,6-7,0=0,6%

It was apparent therefore that the total available moisture for thes soils was considerably greater than the 102mm measured in the top 90cm.

When the estimated deficit of 100mm was not fully replenished, as in the case of treatments 3 and 8 which were irrigated with 50mm at alternate pan deficits of 50mm and 100mm, then a significant drop in yield resulted, viz.

I2 vs. I3 : Yield loss 12,2 - 0,5 = 11,7%.
I7 vs. I8 : Yield loss 20,5 - 7,0 = 13,5%.

(b) Effect of irrigating at deficits greater than 100mm.

A comparison of treatments 7, 11, 10 and 12, which were irrigated with 102mm at cumulative pan deficits of 100mm, 150mm, 200mm, and 250mm respectively, is shown in Figure 2, where it can be seen that yield loss was directly related to cumulative pan deficit at the time of irrigation.

(c) Effect of stress 0-3 months after harvest.

Treatments 2 to 5 were without irrigation for 31 days from 8th October to 8th November, during which time an open pan deficit of 150mm was accumulated. There was no means of evaluating the effects of this early stress, but a comparison of treatment 2 with treatment 1 (which was not stressed) indicated that it had no marked effect on yield.

Treatments 6 to 12 were not irrigated from 8th October until late December, with cumulative deficits ranging from 116mm to 200mm at the time of irrigation. The effects of this prolonged stress period are shown by comparisons of treatments which were similar in all other respects viz:

I1 (No early stress) vs. I6 (early stress) Yield loss 7,6%
I2 (" " ") vs. I7 (" ") Yield loss 7,0-0,5=6,5%
I3 (" " ") vs. I8 (" ") Yield loss 20,5-12,2=8,3%

(d) Effect of stress at early full canopy

Assuming that the decline in yield due to the stress period from 8th October to 8th November was negligible (see para(c) above), then the yield reductions in treatments 4 and 5 may be attributed to stress that developed in December/January when only 51mm was applied at cumulative pan deficits of 100mm.

Two such stress periods (I4) reduced yield by 8,1% whereas three stress periods (I5) increased the yield loss to 13,9%.

6/(e) Effect of......

(e) Effect of stress at 6-8 months of age.

Treatment 9 was subjected to two major stress periods, the first during the pre-canopy period when it was not irrigated from 8th October to 28th December, and the second during March/April/May when three consecutive irrigations of 51mm were applied at cumulative pan deficits of 150mm. It was shown (para (c) above) that the effect of the early stress was an average yield loss of 7,5% (mean of 7,6, 6,5, and 8,3), and thus the effect of the stress at 6-8 months of age was a yield loss of 33,5 less 7,5 = 26,0%.

Treatment 11 was also irrigated at deficits of 150mm during this period, but irrigations of 100mm were applied as compared to the 51mm irrigations given to treatment 9. As a result of this the overall yield loss was much less severe at 19,2%, compared to the 33,5% loss recorded for treatment 9, in spite of these two treatments receiving the same total amount of irrigation water. Thus the timing of irrigations, and the amount applied per irrigation, had a greater effect on yield than the total amount applied over the growing season.

CONCLUSIONS

Post-canopy stress was more detrimental to yield than was pre-canopy stress, and stress at 6-8 months of age caused a greater loss in yield than stress in the early full canopy stage.

From field capacity and wilting point determinations carried out on the trial site, it was established that the total available moisture in the top 90cm of soil was 102mm. However, results showed that cane irrigated at a cumulative pan deficit of 100mm (equivalent to approximately 100% depletion of available moisture) sufferred no yield loss provided it was irrigated with an equivalent amount of water when the deficit was reached. Reserves of moisture below 90cm would account for this to some extent, but the matter requires further study before it can be fully explained.

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TABLE 1a) DATE OF IRRIGATION AND ACCUMULATED OPEN PAN DEFICIT ON THAT DATE

DATE OF IRRIGATION	DAYS AFTER HARVEST	TREATMENTS (Grouped according to similarity of Irrigation) 1	6	4	5	3	8	9
Sept 27	12	-	-	-		-	-	-
Oct 8	23	82	82	82		82	82	82
27	42	88						
Nov 8	54	70		158*		158*		
24	70	62		62		62		
Dec 3	79	56		56				
18	94		116*			100*	116*	
19	95	47						
28	104	66	75	113*		75		191**
Jan 7	114	73						73
12	119	40		113*		113*		40
20	127	61		61		61		61
26	133				104*			
28	135	58		58				58
Feb 2	140	44		44	60	102*		44
11	149					49		49
24	162		54					
Mar 2	168		46			100*		
18	184		47			47		147*
25	191		53					
30	196					84*		
Apr 4	201		61					
7	204					48		
14	211							144*
19	216		62					
28	225					96*		
May 3	230		66					
11	238					48		
17	244		47					
19	246							150*
27	254		45					
June 6	264					102*		70
13	271		52				21	
30	288				48			
July 19	307				43			

Legend: Tables 1a) and 1b)

* - accumulated pan deficit at the end of a stress period where 51mm was applied.

** - Accumulated pan deficit at the end of a stress period where 102mm was applied.

NB. Where accumulated pan figures for 2 or more treatments are grouped together in one column, it means that over that time period the treatments were irrigated identically.

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TABLE 1b) DATE OF IRRIGATION AND ACCUMULATED OPEN PAN DEFICIT ON THAT DATE

DATE OF IRRIGATION	DAYS AFTER HARVEST	TREATMENTS (Grouped according to severity of stress)						
		1	6	2	7	11	10	12
Sept 27	12							
Oct 8	23	82	82	82	82	82	82	82
27	42	88						
Nov 8	54	70		150**				
24	70	62						
Dec 3	79	56		118**				
18	94		116*		116**			
19	95	47						
28	104	66	75	113**		191**		
30	106						208**	
Jan 7	114	73			140**			
8	115							270**
12	119	40		113**				
20	127	61			101**	175**		
26	133			104**			207**	
28	135	58						
Feb 2	140	44			102**			
11	149	49		94**				
21	159					145**		241**
24	162	54						
28	166				115**			
Mar 2	168	46		100**				
8	174						200**	
18	184	47						
23	189				98**	155**		
25	191	53		100**				
30	196							
April 4	201	61						
7	204				93**			240*
14	211			92**			184**	
19	216	62						
22	219					140**		
28	225				96**			
May 3	230	66						
5	232			96**				
11	238							
17	244	47						
24	251				109**			
27	254	45		92**				
30	257					155**	190**	225**
June 13	271		52		63		43	
30	288				48			
July 19	307				43			

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TABLE 2: IRRIGATION, RAINFALL AND WATER USE

	TREATMENTS											
	1	2	3	4	5	6	7	8	9	10	11	12
I 0-3 months												
No. of irrigations (total)	6	4	4	5	5	2	2	2	2	2	2	2
No. of treatment irrigations	4	2	2	3	3	-	-	-	-	-	-	-
Irrigation (mm)	292	292	190	241	241	88	88	88	88	88	88	88
Rainfall (mm)	172	172	712	172	172	172	172	172	172	172	172	172
II 3-10 months												
No. of irrigations (total)	20	12	16	18	17	20	12	16	14	8	9	7
No. of treatment irrigations	17	9	13	15	14	17	9	13	11	5	6	4
Irrigation (mm)	1 020	1 057	816	918	867	1 020	1 071	816	765	663	765	561
Rainfall (mm)	242	242	242	242	242	242	242	242	242	242	242	242
Total irrigation (mm)	1 312	1 349	1 006	1 159	1 108	1 108	1 159	904	853	751	853	649
Total rainfall (mm)	414	414	414	414	414	414	414	414	414	414	414	414
Total precipitation (mm)	1 726	1 763	1 420	1 573	1 522	1 522	1 573	1 318	1 267	1 165	1 267	1 063
Yields												
TC/ha	129,55	129,46	114,76	120,28	112,44	123,49	122,01	105,79	89,39	86,83	109,40	71,07
TERC/ha	18,55	18,46	16,29	17,04	15,97	17,14	17,26	14,74	12,34	11,81	14,98	9,56
Water use efficiency												
TC/ha/100mm	7,51	7,34	8,08	7,65	7,39	8,11	7,76	8,03	7,06	7,45	8,63	6,69
TERC/ha/100mm	1,07	1,05	1,05	1,08	1,05	1,13	1,10	1,12	0,97	1,01	1,18	0,90

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TABLE 3: YIELD DATA

TREATMENTS	Cane Yield t/ha	ERC % Cane	TERC/ ha
1 - 5 : Irrigated to schedule pre-canopy			
1. Net 51mm @ 50mm deficit throughout (Control)	129,55	14,33	18,55
2 Net 102mm @ 100mm deficit throughout.	129,46	14,24	18,46
3 Net 51mm @ alternate 100/50mm deficit throughout	114,76	14,21	16,29
4 2 x 100mm deficit) early full canopy	120,28	14,19	17,04
5 3 x 100mm deficit) net 51mm @ 50mm thereafter	112,44	14,20	15,97
6 - 12 Irrigated to schedule from full canopy			
6 Net 51mm @ 50mm deficit	123,49	13,89	17,14
7 Net 102mm @ 100mm deficit	122,01	14,14	17,26
8 Net 51mm @ alternate 100/50mm deficit	105,79	13,93	14,74
9 Net 102mm @ 150mm deficit early full canopy 3 x 51mm @ 150mm deficit late summer.	89,39	13,78	12,34
10 Net 102mm @ 200mm deficit	86,83	13,56	11,81
11 Net 102mm @ 150mm deficit	109,40	13,68	14,98
12 Net 102mm @ 250mm deficit	71,07	13,45	9,56
Significance	P=0,001	P=0,01	P=0,001
L.S.D. P=0,05	12,69	0,49	1,84
P=0,01	16,89	0,65	2,46
S.E. single plot	10,97	0,42	1,59
S.E. treatment mean	4,48	0,17	0,65
C.V.%	10,01	3,01	10,38
Trial Mean	109,54	13,97	15,34

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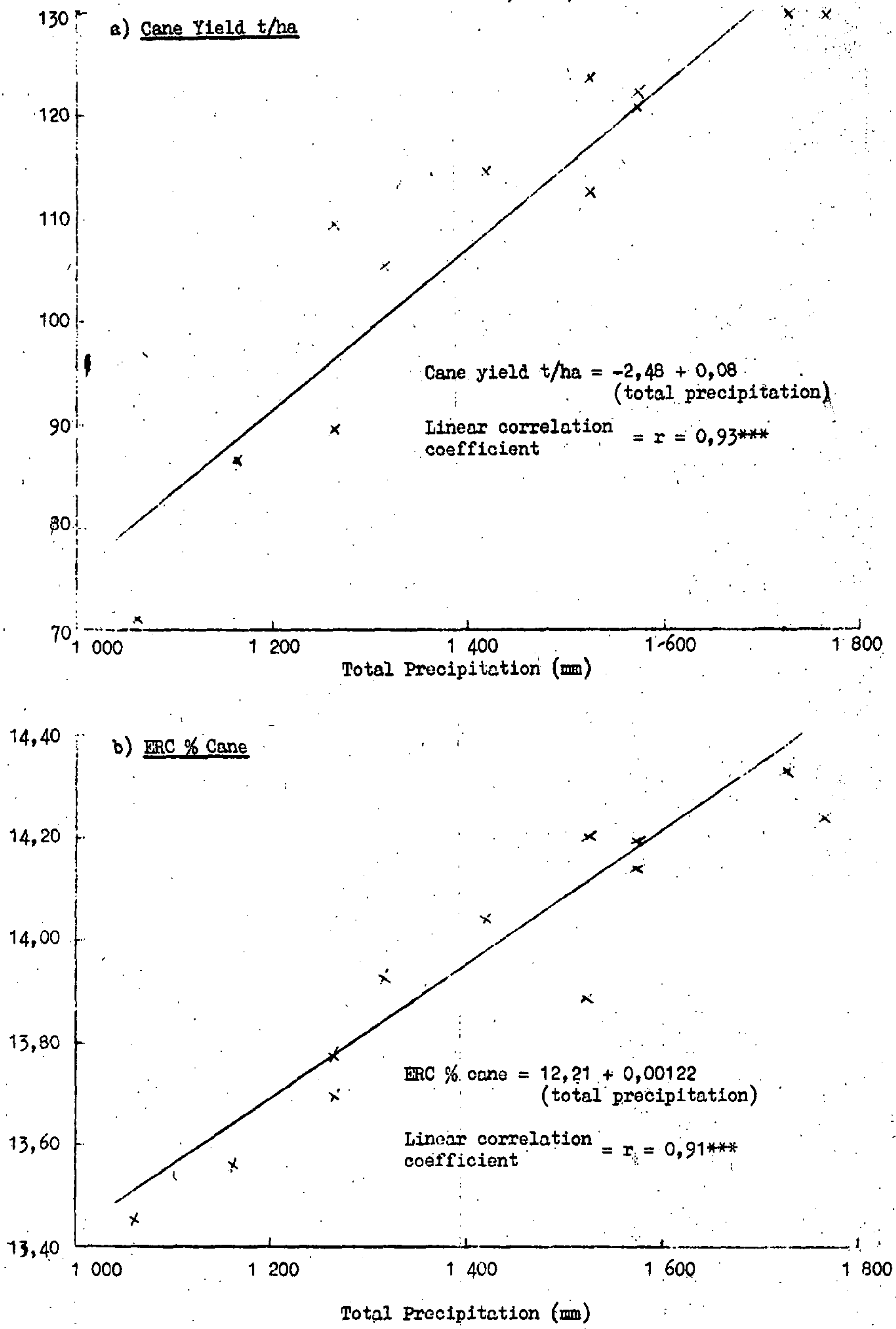
TABLE 4 STALK DATA

TREATMENTS	Stalk counts/ ha x 10^{-3}	Stalk ength m	Inter-node no.	Mean internode length cm	Stalk diameter cm	Lodging %	Flowering %
1 - 5 Irrigated to schedule pre-canopy							
1 Net 51mm @ 50mm deficit throughout (control)	170,1	2,55	20,1	12,7	1,8	93	15
2 Net 102mm @ 100mm deficit throughout	177,9	2,28	20,1	11,3	1,8	48	3
3 Net 51mm @ alternate 100/50mm deficit throughout	169,1	1,92	20,2	9,5	1,9	18	1
4 2 x 100mm deficit } early full canopy; net 51mm @ 50mm	169,9	2,15	20,3	10,6	1,8	37	3
5 3 x 100mm deficit }	174,8	2,02	19,9	10,2	1,8	30	1
6 - 12 Irrigated to schedule from full canopy							
6 Net 51mm @ 50mm deficit	182,4	2,14	19,7	10,9	1,7	33	0
7 Net 102mm @ 100mm deficit	181,9	2,12	19,9	10,7	1,8	43	3
8 Net 51mm @ alternate 100/50mm deficit	177,7	1,70	18,9	9,0	1,7	9	0
9 Net 102mm @ 150mm deficit early full canopy; 3 x 51mm @ 50mm deficit late summer	176,2	1,52	17,6	8,6	1,8	0	0
10 Net 102mm @ 200mm deficit	168,4	1,46	18,4	7,9	1,9	2	0
11 Net 102mm @ 150mm deficit	184,9	1,73	19,3	9,0	1,8	3	0
12 Net 102mm @ 250mm deficit	169,2	1,34	17,7	7,6	1,7	2	0
Significance		***					
L.S.D. P=0,05		0,24					
P=0,01		0,32					
S.E. single plot ±		0,21					
S.E. treatment mean ±		0,08					
C.V.%		10,75					
Trial mean	175,2	1,91	19,3	9,9	1,8	27	2

Figure 1

a) Cane Yield (t/ha)
b) ERC % cane
c) TERC/ha on total precipitation (mm)



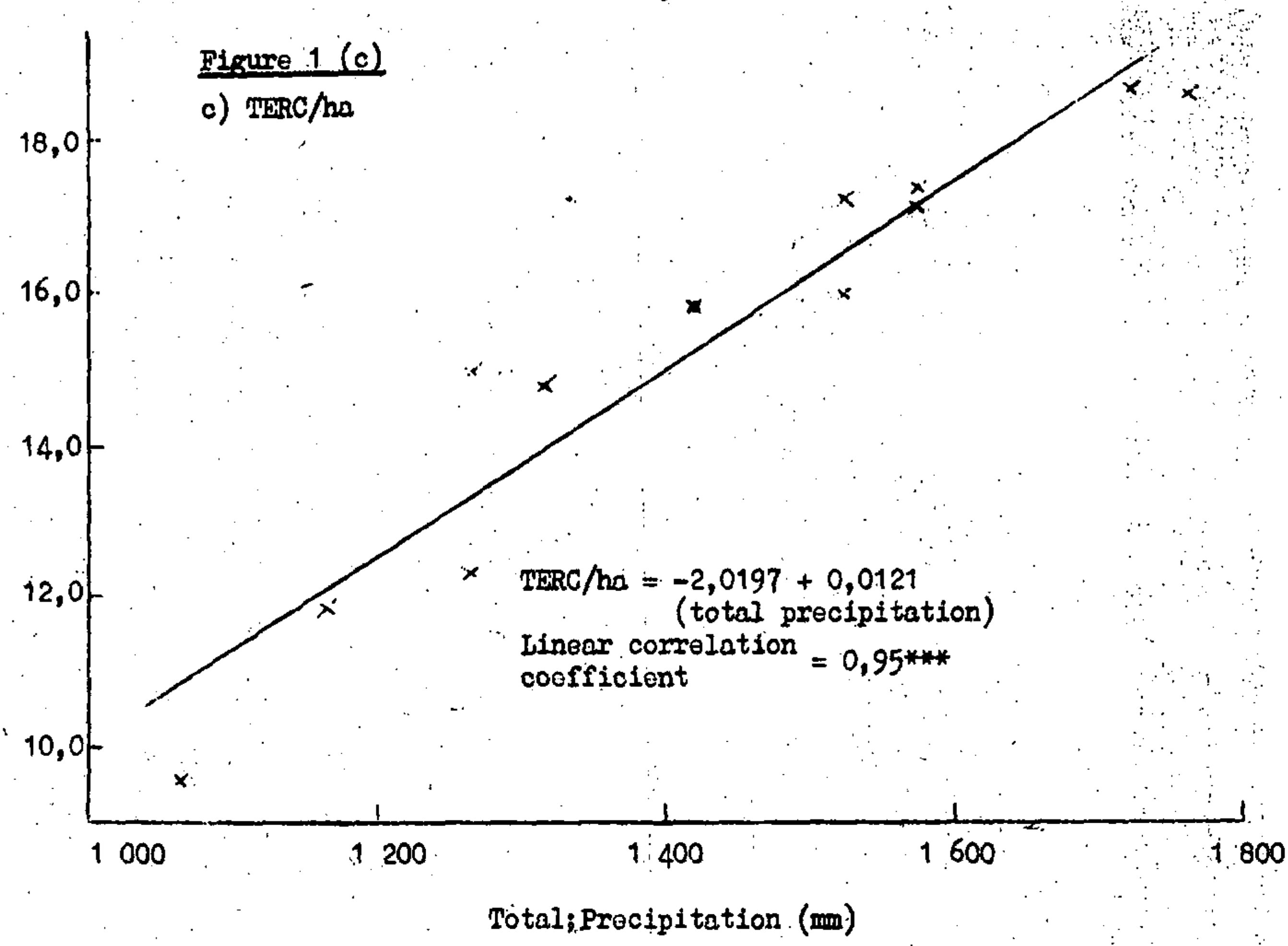
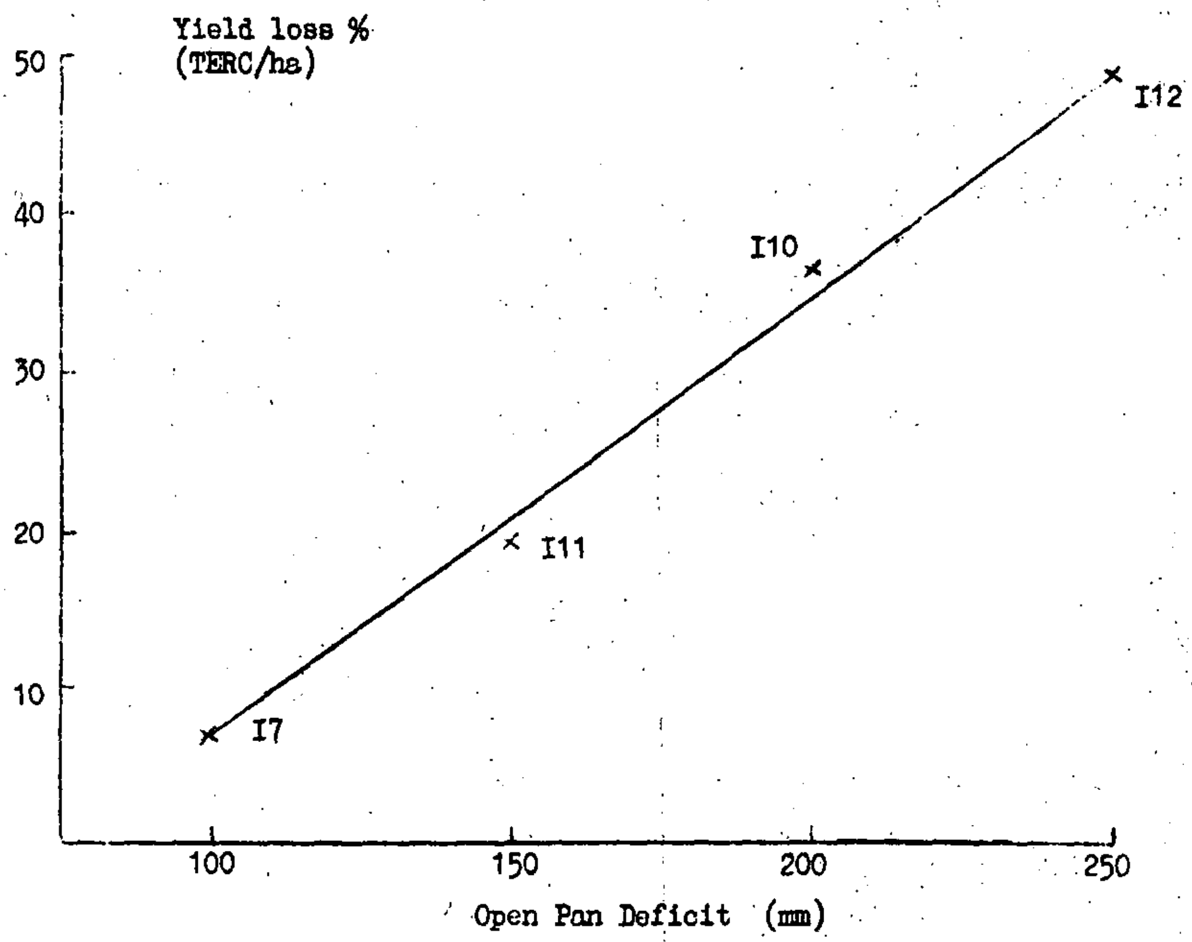


Figure 2. Effects of Irrigating at Different Deficits on Yield



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4. One pre-canopy stress period of 100mm accumulated pan deficit, followed by two successive stress periods of 100mm accumulated pan deficit imposed on early full canopy phase; thereafter normal applications of 51mm at 50mm accumulated pan deficit were resumed. (3 stress periods.)

5. One pre-canopy stress period of 100mm accumulated pan deficit, followed by three successive stress periods of 100mm accumulated pan deficit imposed on early full canopy phase. Thereafter normal applications of 51mm at 50mm accumulated pan deficit were resumed (4 stress periods).

2/(Treatments....

(Treatments 1-6 Irrigated to schedule from full canopy)

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(e) At harvest stalk lengths, internode numbers and mid-point diameters of 24 stalks sampled for quality analysis were measured.

RESULTS:

a) Total precipitation: Table 2 shows the net effect of irrigation treatments in creating periods of stress and on the frequency of irrigations. Rainfall over the season was below average (414mm), and summer temperatures were high, creating ideal conditions for the stress treatments. The number of treatment irrigations varied from 4 (408mm) in treatment 12 (most severely stressed) to 21 (1 071mm) in treatment 1. Treatment 2 received the most water (1 763mm total) whilst treatment 12 received the least (1 063mm in total). It should be noted that although treatments 5 and 6 received the same amount of irrigation, as did treatments 9 and 11, treatment 5 was more severely stressed than treatment 6, as was treatment 9 compared with treatment 11.

b) Yield: (see Table 3).

i) Cane yield (t/ha)

The control treament (treatment 1) had the highest cane yield of 129,55 t/ha, whilst treatment 12 (most severely stressed) had the lowest yield of 71,07 t/ha (45,14% less than the control). Treatments 3, 5 and 8-12 had a significantly lower yield than the control. Water use efficiency values varied from 6,69 (treatment 12) to 8,63 (treatment 11) TC/ha/100mm of water (see Table 2). These values agreed well with values from previous experiments.

ii) ERC % cane

The decline in ERC % cane with stress was less marked than that for cane yield. The lowest ERC % cane value of 13,45 for treatment 12 was only 6,14% lower than the highest value of 14,33 for treatment 1. Only treatments 9-12 had significantly lower ERC % cane values than treatment 1. Treatments 6-12 had lower ERC % cane values than treatments 1-5, but the difference between corresponding treatments 1 and 6, 2 and 7, and 3 and 8 was not significant.

iii) TERC/ha

The variation of TERC/ha followed the same trend as TC/ha with the percentage decline in TERC/ha, with stress being more marked. The sugar yield of treatment 12 (9,56 TERC/ha) was 48,46% lower than treatment 1 (18,55 TERC/ha). The efficiency of all treatments in using water to produce sugar was almost constant at a mean value of 1,06 ± 0,07 TERC/ha/100mm of water (see Table 2).

4/c)Regression

c) Regression of yield on total precipitation: (See Fig.1 (a) - (c)): Cane yield (t/ha, ERC % cane, and TERC/ha were found to be linearly related to total precipitation(mm). The equations which best approximate the linear regressions are:

i) Cane yield (t/ha) = -2,48 + 0,0782(total precipitation); r = 0,93***

ii) ERC % cane = 12,21 + 0,0012(total precipitation); r=0,93***

iii)TERC/ha = -2,02 + 0,0121(total precipitation); r=0,95***

Despite the close correlation obtained, yield was also affected by frequency of irrigations and amount applied per irrigation. Treatment 6 (17,14 TERC/ha) outyielded treatment 5 (15,97 TERC/ha), even though both treatments received 1 522mm, total precipitation. The same applies to treatments 11 and 9 which both received 1 267mm total precipitation, but yielded 14,98 and 12,34 TERC/ha respectively (see Table 2).

d) Stalk characteristics: Table 4 shows that the main stalk characteristic which affected yield was stalk length. There was a decline in stalk length from 2,55m in treatment 1 to 1,34m in treatment 12. Stalk length was affected more by differences in internode length than by differences in internode number. Differences in mid-point diameter between treatments were negligeable, and stalk numbers varied slightly from 168,4 to 184,9 ($x 10^{-3}$) stalks per hectare. This variation appeared to have been randomly distributed, with no relation to treatments.

Severe lodging occurred in treatment 1 (93%), with 15% of the stalks producing flowers. There was a tendency for cane taller than 1,8m to lodge and to flower, whereas shorter cane did not.

DISCUSSION

Results may be more simply evaluated and explained by a consideration of ERC yields (t/ha) in relation to control yield, viz.

Treatment	ERC yield t/ha	% of control	Yield loss %
I1	18,55	100,0	-
I2	18,46	99,5	0,5
I3	16,29	87,8	12,2
I4	17,04	91,9	8,1
I5	15,97	86,1	13,9
I6	17,14	92,4	7,6
I7	17,26	93,0	7,0
I8	14,74	79,5	20,5
I9	12,34	66,5	33,5
I10	11,81	63,7	36,3
I11	14,98	80,8	19,2
I12	9,56	51,5	48,5

5/(a) Effect of.......

(a) Effect of irrigating at 100mm pan deficit.

Results showed that irrigating at a pan deficit of 100mm caused no appreciable yield loss when compared with irrigation at a deficit of 50mm, provided the estimated deficit was replenished, i.e. provided 100mm of irrigation water was applied. This is shown by the following comparisons:

I1 (50mm deficit) vs. I2 (100mm deficit): Yield loss 0,5%

I6 (" ") vs. I7 (" "): Yield loss 7,6-7,0=0,6%

It was apparent therefore that the total available moisture for thes soils was considerably greater than the 102mm measured in the top 90cm.

When the estimated deficit of 100mm was not fully replenished, as in the case of treatments 3 and 8 which were irrigated with 50mm at alternate pan deficits of 50mm and 100mm, then a significant drop in yield resulted, viz.

I2 vs. I3 : Yield loss 12,2 - 0,5 = 11,7%.
I7 vs. I8 : Yield loss 20,5 - 7,0 = 13,5%.

(b) Effect of irrigating at deficits greater than 100mm.

A comparison of treatments 7, 11, 10 and 12, which were irrigated with 102mm at cumulative pan deficits of 100mm, 150mm, 200mm, and 250mm respectively, is shown in Figure 2, where it can be seen that yield loss was directly related to cumulative pan deficit at the time of irrigation.

(c) Effect of stress 0-3 months after harvest.

Treatments 2 to 5 were without irrigation for 31 days from 8th October to 8th November, during which time an open pan deficit of 150mm was accumulated. There was no means of evaluating the effects of this early stress, but a comparison of treatment 2 with treatment 1 (which was not stressed) indicated that it had no marked effect on yield.

Treatments 6 to 12 were not irrigated from 8th October until late December, with cumulative deficits ranging from 116mm to 200mm at the time of irrigation. The effects of this prolonged stress period are shown by comparisons of treatments which were similar in all other respects viz:

I1 (No early stress) vs. I6 (early stress) Yield loss 7,6%
I2 (" " ") vs. I7 (" ") Yield loss 7,0-0,5=6,5%
I3 (" " ") vs. I8 (" ") Yield loss 20,5-12,2=8,3%

(d) Effect of stress at early full canopy

Assuming that the decline in yield due to the stress period from 8th October to 8th November was negligible (see para(c) above), then the yield reductions in treatments 4 and 5 may be attributed to stress that developed in December/January when only 51mm was applied at cumulative pan deficits of 100mm.

Two such stress periods (I4) reduced yield by 8,1% whereas three stress periods (I5) increased the yield loss to 13,9%.

6/(e) Effect of......

(e) Effect of stress at 6-8 months of age.

Treatment 9 was subjected to two major stress periods, the first during the pre-canopy period when it was not irrigated from 8th October to 28th December, and the second during March/April/May when three consecutive irrigations of 51mm were applied at cumulative pan deficits of 150mm. It was shown (para (c) above) that the effect of the early stress was an average yield loss of 7,5% (mean of 7,6, 6,5, and 8,3), and thus the effect of the stress at 6-8 months of age was a yield loss of 33,5 less 7,5 = 26,0%.

Treatment 11 was also irrigated at deficits of 150mm during this period, but irrigations of 100mm were applied as compared to the 51mm irrigations given to treatment 9. As a result of this the overall yield loss was much less severe at 19,2%, compared to the 33,5% loss recorded for treatment 9, in spite of these two treatments receiving the same total amount of irrigation water. Thus the timing of irrigations, and the amount applied per irrigation, had a greater effect on yield than the total amount applied over the growing season.

CONCLUSIONS

Post-canopy stress was more detrimental to yield than was pre-canopy stress, and stress at 6-8 months of age caused a greater loss in yield than stress in the early full canopy stage.

From field capacity and wilting point determinations carried out on the trial site, it was established that the total available moisture in the top 90cm of soil was 102mm. However, results showed that cane irrigated at a cumulative pan deficit of 100mm (equivalent to approximately 100% depletion of available moisture) sufferred no yield loss provided it was irrigated with an equivalent amount of water when the deficit was reached. Reserves of moisture below 90cm would account for this to some extent, but the matter requires further study before it can be fully explained.

DEL/Dec'83
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4200/11 MOISTURE STRESS TRIAL

TABLE 1a) DATE OF IRRIGATION AND ACCUMULATED OPEN PAN DEFICIT ON THAT DATE

DATE OF IRRIGATION	DAYS AFTER HARVEST	TREATMENTS (Grouped according to similarity of Irrigation						
		1	6	4	5	3	8	9
Sept 27	12	-	-	-		-	-	-
Oct 8	23	82	82	82		82	82	82
27	42	88						
Nov 8	54	70		158*		158*		
24	70	62		62		62		
Dec 3	79	56		56				
18	94		116*			100*	116*	
19	95	47						
23	104	66	75	113*		75		191**
Jan 7	114	73						73
12	119	40		113*		113*		40
20	127	61		61		61		61
26	133				104*			
28	135	58		58				58
Feb 2	140	44		44	60	102*		44
11	149					49		49
24	162	54						
Mar 2	168	46				100*		
18	184	47				47		147*
25	191	53						
30	196					84*		
Apr 4	201	61						
7	204					48		
14	211							144*
19	216	62						
28	225					96*		
May 3	230	66						
11	238					48		
17	244	47						
19	246							150*
27	254	45						
June 6	264					102*		70
13	271	52					21	
30	288	48						
July 19	307	43						

Legend: Tables 1a) and 1b)

* - accumulated pan deficit at the end of a stress period where 51mm was applied.

** - Accumulated pan deficit at the end of a stress period where 102mm was applied.

NB. Where accumulated pan figures for 2 or more treatments are grouped together in one column, it means that over that time period the treatments were irrigated identically.

4200/11 MOISTURE STRESS TRIAL

TABLE 1b) DATE OF IRRIGATION AND ACCUMULATED OPEN PAN DEFICIT ON THAT DATE

DATE OF IRRIGATION	DAYS AFTER HARVEST	TREATMENTS (Grouped according to severity of stress)						
		1	6	2	7	11	10	12
Sept 27	12							
Oct 8	23	82	82	82	82	82	82	82
27	42	88						
Nov 8	54	70		150**				
24	70	62						
Dec 3	79	56		118**				
18	94		116*		116**			
19	95	47						
28	104	66	75	113**		191**		
30	106						208**	
Jan 7	114	73			140**			
8	115							270**
12	119	40		113**				
20	127	61			101**	175**		
26	133			104**			207**	
28	135	58						
Feb 2	140	44			102**			
11	149	49		94**				
21	159					145**		241**
24	162	54						
28	166				115**			
Mar 2	168	46		100**				
8	174						200**	
18	184	47						
23	189				98**	155**		
25	191	53		100**				
30	196							
April 4	201	61						
7	204				93**			240*
14	211			92**			184**	
19	216	62						
22	219					148**		
28	225				96**			
May 3	230	66						
5	232			96**				
11	238							
17	244	47						
24	251				109**			
27	254	45		92**				
30	257					155**	198**	225**
June 13	271		52		63		43	
30	288				48			
July 19	307				43			

4200/11 MOISTURE STRESS TRIAL

TABLE 2: IRRIGATION, RAINFALL AND WATER USE

	TREATMENTS											
	1	2	3	4	5	6	7	8	9	10	11	12
I 0-3 months												
No. of irrigations (total)	6	4	4	5	5	2	2	2	2	2	2	2
No. of treatment irrigations	4	2	2	3	3	-	-	-	-	-	-	-
Irrigation (mm)	292	292	190	241	241	88	88	88	88	88	88	88
Rainfall (mm)	172	172	712	172	172	172	172	172	172	172	172	172
II 3-10 months												
No. of irrigations (total)	20	12	16	18	17	20	12	16	14	8	9	7
No. of treatment irrigations	17	9	13	15	14	17	9	13	11	5	6	4
Irrigation (mm)	1 020	1 057	816	918	867	1 020	1 071	816	765	663	765	561
Rainfall (mm)	242	242	242	242	242	242	242	242	242	242	242	242
Total irrigation (mm)	1 312	1 349	1 006	1 159	1 108	1 108	1 159	904	853	751	853	649
Total rainfall (mm)	414	414	414	414	414	414	414	414	414	414	414	414
Total precipitation (mm)	1 726	1 763	1 420	1 573	1 522	1 522	1 573	1 318	1 267	1 165	1 267	1 063
Yields												
TC/ha	129,55	129,46	114,76	120,28	112,44	123,49	122,01	105,79	89,39	86,83	109,40	71,07
TERC/ha	18,55	18,46	16,29	17,04	15,97	17,14	17,26	14,74	12,34	11,81	14,98	9,56
Water use efficiency												
TC/ha/100mm	7,51	7,34	8,08	7,65	7,39	8,11	7,76	8,03	7,06	7,45	8,63	6,69
TERC/ha/100mm	1,07	1,05	1,05	1,08	1,05	1,13	1,10	1,12	0,97	1,01	1,18	0,90

4200/11 MOISTURE STRESS TRIAL

TABLE 3: YIELD DATA

TREATMENTS	Cane Yield t/ha	ERC % Cane	TERC/ ha
1 - 5 : Irrigated to schedule pre-canopy			
1. Net 51mm @ 50mm deficit throughout (Control)	129,55	14,33	18,55
2 Net 102mm @ 100mm deficit throughout.	129,46	14,24	18,46
3 Net 51mm @ alternate 100/50mm deficit throughout	114,76	14,21	16,29
4 2 x 100mm deficit) early full canopy	120,28	14,19	17,04
5 3 x 100mm deficit) net 51mm @ 50mm thereafter	112,44	14,20	15,97
6 - 12 Irrigated to schedule from full canopy			
6 Net 51mm @ 50mm deficit	123,49	13,89	17,14
7 Net 102mm @ 100mm deficit	122,01	14,14	17,26
8 Net 51mm @ alternate 100/50mm deficit	105,79	13,93	14,74
9 Net 102mm @ 150mm deficit early full canopy 3 x 51mm @ 150mm deficit late summer.	89,39	13,78	12,34
10 Net 102mm @ 200mm deficit	86,83	13,56	11,81
11 Net 102mm @ 150mm deficit	109,40	13,68	14,98
12 Net 102mm @ 250mm deficit	71,07	13,45	9,56
Significance	P=0,001	P=0,01	P=0,001
L.S.D. P=0,05	12,69	0,49	1,84
P=0,01	16,89	0,65	2,46
S.E. single plot	10,97	0,42	1,59
S.E. treatment mean	4,48	0,17	0,65
C.V.%	10,01	3,01	10,38
Trial Mean	109,54	13,97	15,34

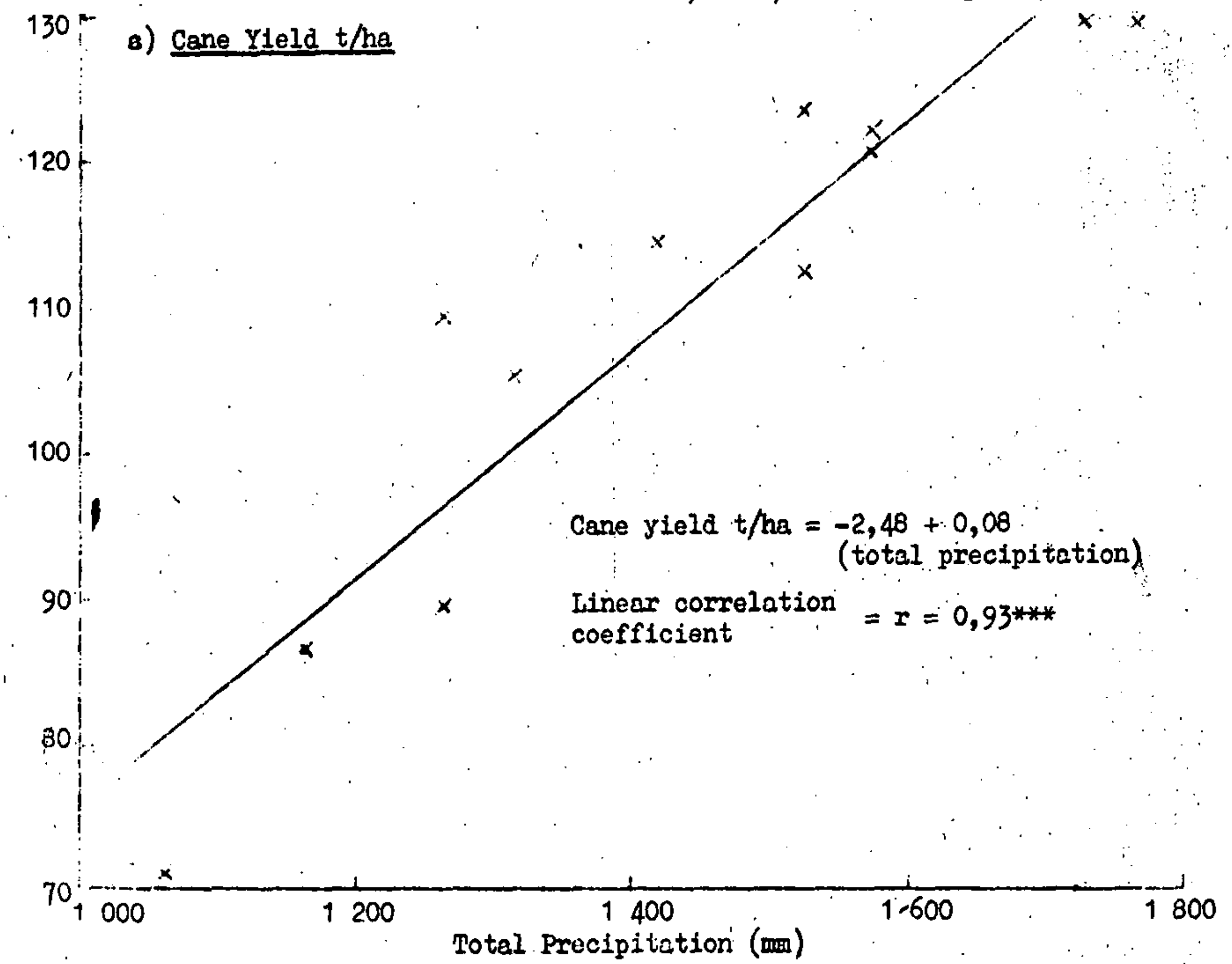
4200/11 MOISTURE STRESS TRIAL

TABLE 4 STALK DATA

TREATMENTS	Stalk counts/ ha x 10^{-3}	Stalk ength m	Inter- node no.	Mean internode length cm	Stalk diameter cm	Lodging %	Flowering %
1 - 5 Irrigated to schedule pre-canopy							
1 Net 51mm @ 50mm deficit throughout (control)	170,1	2,55	20,1	12,7	1,8	93	15
2 Net 102mm @ 100mm deficit throughout	177,9	2,28	20,1	11,3	1,8	48	3
3 Net 51mm @ alternate 100/50mm deficit throughout	169,1	1,92	20,2	9,5	1,9	18	1
4 2 x 100mm deficit } early full canopy; net 51mm @ 50mm	169,9	2,15	20,3	10,6	1,8	37	3
5 3 x 100mm deficit }	174,8	2,02	19,9	10,2	1,8	30	1
6 - 12 Irrigated to schedule from full canopy							
6 Net 51mm @ 50mm deficit	182,4	2,14	19,7	10,9	1,7	33	0
7 Net 102mm @ 100mm deficit	181,9	2,12	19,9	10,7	1,8	43	3
8 Net 51mm @ alternate 100/50mm deficit	177,7	1,70	18,9	9,0	1,7	9	0
9 Net 102mm @ 150mm deficit early full canopy; 3 x 51mm @ 50mm deficit late summer	176,2	1,52	17,6	8,6	1,8	0	0
10 Net 102mm @ 200mm deficit	168,4	1,46	18,4	7,9	1,9	2	0
11 Net 102mm @ 150mm deficit	184,9	1,73	19,3	9,0	1,8	3	0
12 Net 102mm @ 250mm deficit	169,2	1,34	17,7	7,6	1,7	2	0
Significance		***					
L.S.D. P=0,05		0,24					
P=0,01		0,32					
S.E. single plot ±		0,21					
S.E. treatment mean ±		0,08					
C.V.%		10,75					
Trial mean	175,2	1,91	19,3	9,9	1,8	27	2

Figure 1

a) Cane Yield (t/ha)
b) ERC % cane
c) TERC/ha on total precipitation (mm)



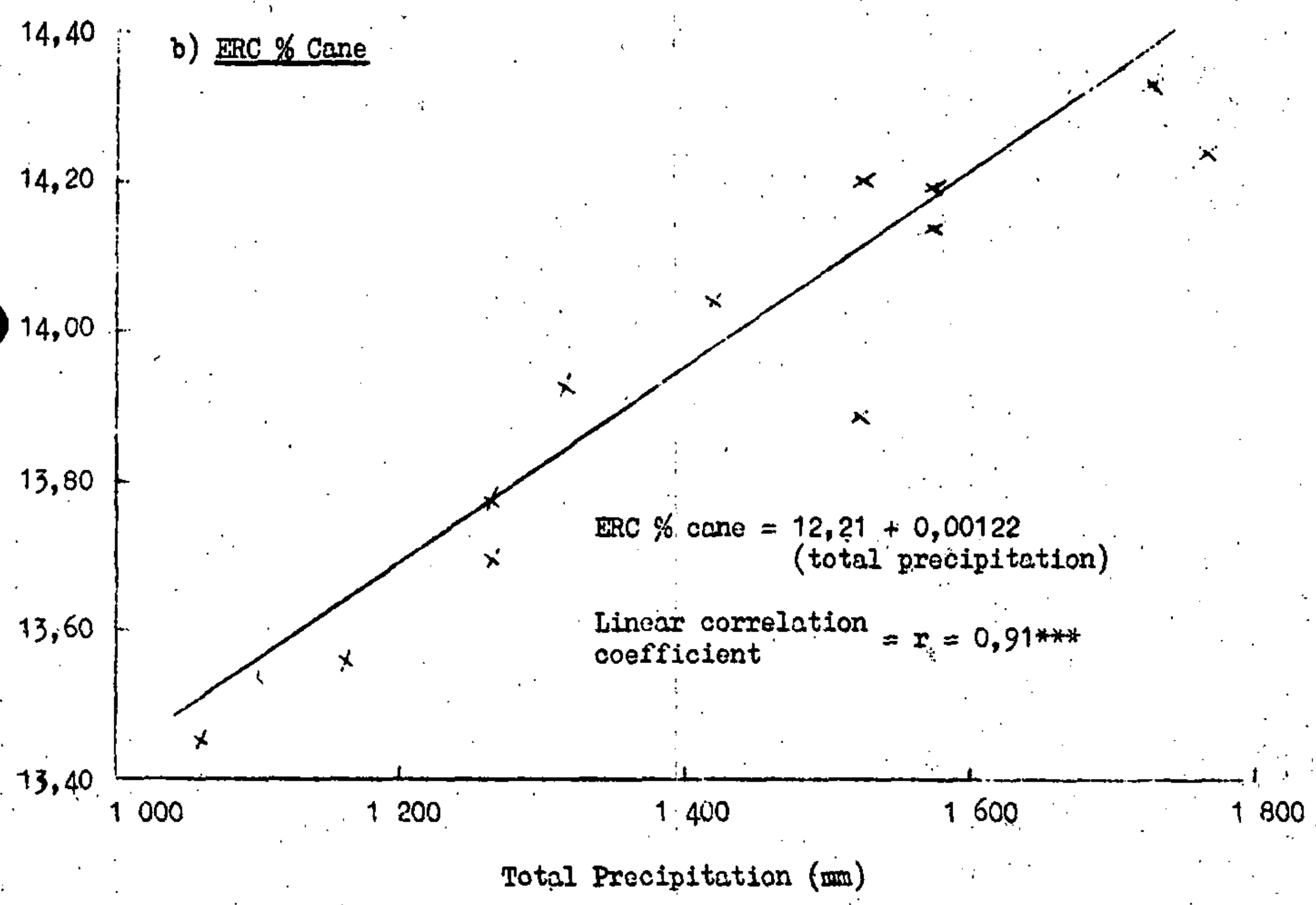


Figure 1 (c)

c) TERC/ha

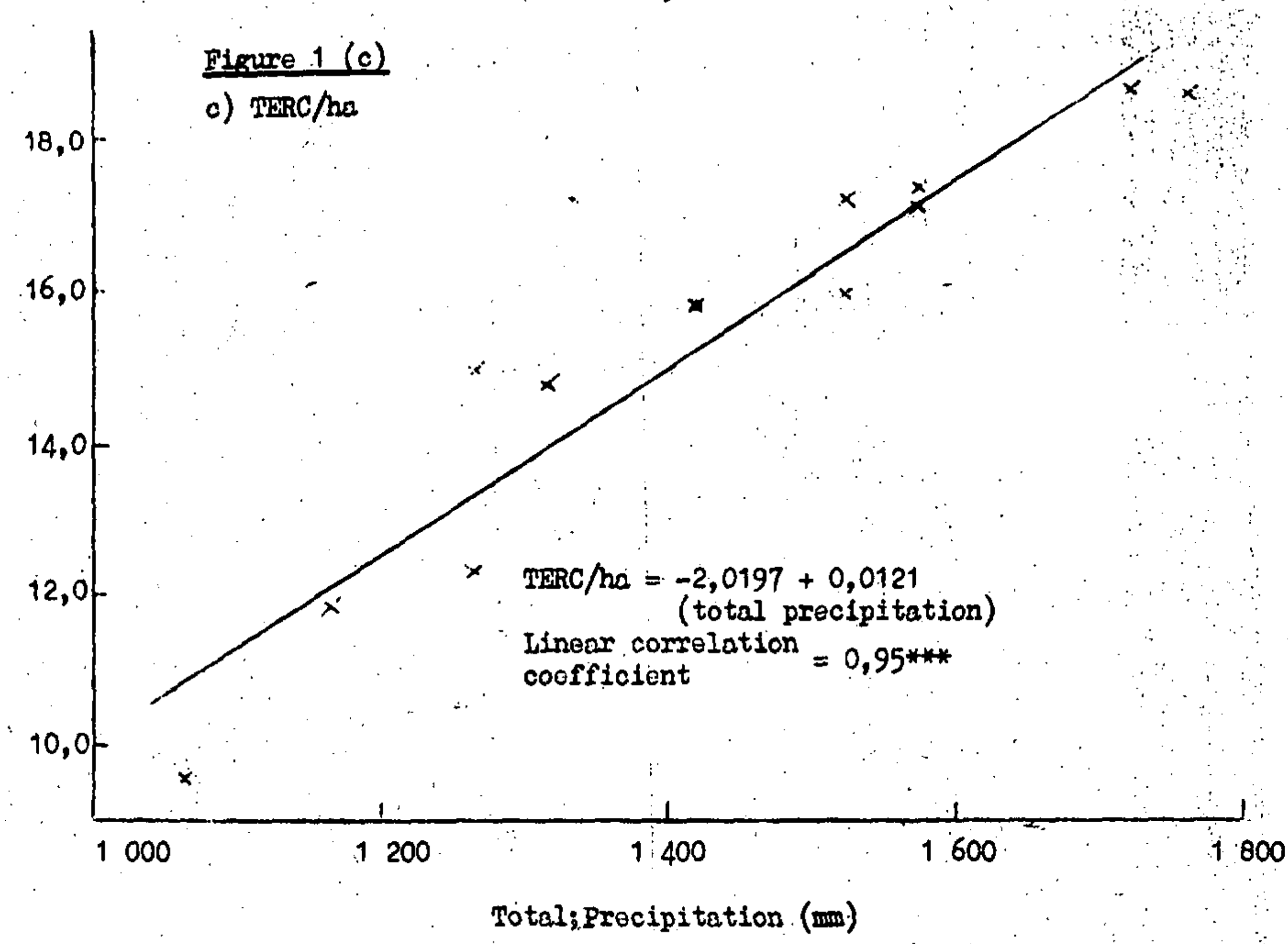


Figure 2. Effects of Irrigating at Different Deficits on Yield