Narrative Annual Report- PART C – Technical Report

I. Project Summary

1.Title: Demonstrating Increased Resource Use Efficiency
In the Sugar Industry of Southern Africa
Through Environmentally Sustainable Energy Production

2. Number: ISO/13

3. PEA: Scientific and Industrial Research and Development Centre (SIRDC), Harare, Zimbabwe

4. Location: Zimbabwe

5. Starting Date: 1st August 1997
6. Completion Date: August 2001
7. Financing: Total Project Cost: USD 734, 997.

II Period covered by this Report:

Report No. 7
From 1st August 1999 to 31st July 2000

Periods covered by Previous Reports:

Report No.	From:	To:
1	1st August 1997	31st January 1998
2	1st February 1998	31st July 1998
3.	1st August 1998	31st January 1999
4.	1st August 1998	1st June 1999
4a.	1st August 1998	31st July 1999
5	1st August 1997	31st June 1999
6	1st August 1999	31st January 2000

Note:
Report No 4 is the Pre-mid term review progress report
Report No 5 is the Post mid term review progress report

Areas cropped

Crushing: A total of 167.7ha was planted with sweet sorghum for the sole purpose of carrying out a 24hr run at Triangle in order to evaluate ethanol / sugar and electricity production.

Growth Analysis: A total of 1ha was planted for detailed experimental monitoring, 0.5ha each at Chiredzi and Harare.

Seed Bulking: 2.5 ha planted at Chiredzi for the purposes of bulking seed of new varieties being evaluated.

Table 4. Total water supplied to the crop (CRS)

Month	Irrigation (mm)	Rainfall mm	Total received mm
December 1999	24	32	56
January 2000	0	165	165
February 2000	0	290	290
March 2000	0	101	101
April 2000	0	26	26
May 2000	0	4	4
Total	24	618	642

4.1.1. Pest and Disease control

Diseases

All the five varieties planted at CRS were severely attached by leaf blight at about 6 weeks after emergence. The infection started from the bottom leaves spreading to the top leaves. A large percentage of leaves were attacked by the 9th week. The disease is soil borne and is very common in some fields at CRS. It was uneconomical to spray the crop. The recommended practice in dealing with soil borne fungal diseases are mainly cultural practices i.e., crop rotation with a non host crop, ploughing under of the infected crop and breeding for resistance. The recommended chemical control is dressing the seed with captan.

Pests

The major pest continues to be stem borer, *Chilo partellus* species however, it was successfully controlled by spraying Carbaryl 85% wetable powder (w.p). Aphids, which are a problematic pest under hot dry conditions were not a problem during this crop, under the cool and conditions.

4.1.2. Nutrient status (fertilisation)

Analysis was carried out by ZSA (See Table 7). The soil analysis results were used in combination with outlined guidelines in the Farm Management Handbook (1985) to arrive at rates to ensure adequate nutrient supply to the crop (see Table 7, 8 & 9).

4.1.3. Monitoring of Sugar Accumulation

Sugar analysis commenced at the booting stage in order to capture a complete profile of sugar accumulation and thus quantify the optimum PIU. (Period of Industrial use) for sampling protocol (Appendix Cii)

4.2. SIRDC

4.2.1. Monitoring/Partitioning Analysis

The sampling protocol used at SIRDC was the same as that used for CRS, however only fresh biomass was recorded for the SIRDC crop due to limited oven space.

4.2.2. Water Supply (Irrigation, rainfall, and TAM)

The Harare trial was strictly rain fed. Total rainfall received by the crop stands was over 700mm.

4.2.3.Pest and Disease control

No pests and disease of significant importance were observed and no control was warranted.

Weeds were controlled manually, i.e. hand hoeing and hand pulling. No herbicides were applied.

4.2.2. Nutrient status (fertilisation)

Compound D (7:14:8 N: P2O5: K2O) minimum 6.5% Sulphur, granular was applied at a rate of 300kg ha^{-1} as a basal fertiliser. Ammonium Nitrate (34.5% N, granular) was applied as two splits at four and six weeks after germination. at a rate of 220 kg ha^{-1} and this supplied a total nitrogen of 76kg N ha^{-1}. The total amount of nitrogen applied including that supplied by compound D was 100kg N ha-^{1}.

4.2.3. Monitoring of Sugar Accumulation

No monitoring of sugar accumulation was carried out at the SIRDC trial.

4.3. Triangle

4.3.1. Monitoring/Partitioning Analysis

Sugar monitoring for the purpose of assisting the project to determine harvesting commenced on 22nd February 2000, samples were collected at random considering the large area cropped.

4.3.2. Water Supply (Irrigation, rainfall, and TAM)

Irrigation scheduling was carried out using crop and root factors for cv Keller (see Table 15, Appendix C iii). Evaporation readings were recorded from standard open 'class A' pan situated at various weather stations at Triangle and used for irrigation scheduling on the entire crop under sprinkler irrigation. Crop water requirement was estimated using the method outlined in Appendix Ciii. Table 5 shows the total amount of water supplied to the crop from rainfall and irrigation.

Table 5. Total water supplied to the crop (Triangle)

Section	**Soil type**	**TAM (mm)**	**Irrigation (mm)**	**Rainfall (mm)**	**Total water supplied (mm)**
8	Sandy loam	77	72	777	849
61	Sandy clay loam	76	96	885	981
25	Sandy loam	57	88	878	966
62	Sandy clay loam	76	92	889	981
64	Sandy clay loam	76	96	749	845
63	Sandy clay loam	76	64	757	821
65	Sandy loam	76	72	753	825
24	Sandy loam	77	72	881	953
23	Sandy loam	77	96	884	980

The amount of rainfall received gives an indication of heavy leaching, which may have contributed to low yields achieved during this growing season. Most of the rainfall was received from January to mid March. In most cases the intensity was heavy resulting in severe run off and waterlogging conditions being experienced on most fields.

4.3.3. Pest and Disease control

Stalk borer was the problematic pest on Triangle fields. A Zimbabwe Sugar Association entomologist (Mr R Mazodze) positively identified *Chilo partellus* as the predominant pest attacking sweet sorghum crop on Triangle fields. Stem borer levels were effectively reduced to lower levels mainly through the use of carbaryl 85% w.p. Spraying commenced on 15th January 2000 but was seriously disturbed by rainfall from 17th to the 19th January. Spraying resumed on the 20th January2000 on most sections. Spraying was carried out using D2, 5 nozzles which are recommended for herbicide application but not insecticide application, However, the D2,5 nozzle was used due to unavailability of the ones recommended for pesticide application e.g. hollow cone nozzles which would direct the chemical into crop funnels. Despite this the pest was effectively controlled by lowering the lance i.e. bringing the nozzle as close to the crop funnels as is possible to reduce /narrow the angle and thus directing the chemical into crop funnels where stem borers were located. Scouting to assess the effectiveness of the spraying operation was done 4 days after chemical application, which confirmed that this method was effective in controlling the pest. A second application of carbaryl was carried out 8-10 days after the initial application. The second application was aimed at controlling larvae, which might have escaped the first application as the egg form. All sections received enough carbaryl for 3-4 sprays. However only one spray was possible at section 8, 24 and 61 as the crop had exceeded sprayable height. Spot application of Combat and Dipterex (granular form) was carried out on the above three sections.

Weed control

Weed problems were experienced in all sections particularly those sections where the herbicide atrazine was not applied at post sorghum emergence. Very high weed infestation levels were recorded at section 25 and 24. On section 24 although atrazine was applied on time many grasses were not effectively controlled and hand weeding was carried as a counteractive measure. Weed control was successfully carried out manually on sections 8, 61, 25 and 63. On some sections weed control was carried out using cultivators followed by manual labour. In sections where broad-leafed weeds emerged at the same time as sorghum, hand weeding was followed by application of atrazine to suppress a second resurgence of weeds.

At section 65, the major weed problem was ratoon cane. Heavy showers were received soon after round up was applied to the sugarcane after harvesting resulting in chemical wash off, thus rendering the herbicide ineffective. Hence the ratoon crop constituted the greatest proportion of the plants in section 25.

Other Agronomic practices

Thinning:

Thinning operations commenced on the 13th December1999 and were completed on 18th January 2000.

Gap filling

Gap filling was carried out in conjunction with thinning. Gap filling was carried out by means of transplanting thinned plants to areas where emergence was poor. Topping (a practice where top leaves are trimmed off) was done on transplanted plants to reduce transpiration. The overall effect was improved plant population in fields where there was poor emergence.

4.3.4. Nutrient status (fertilisation)

Fertilisation was based on the recommendations outlined in the Farm Management Handbook (1982).

4.3.5. Monitoring of Sugar Accumulation

Stems were send to ZSA for sugar analysis and some to the Triangle laboratory.

4.3.4. Harvesting and industrial processing

The sweet sorghum crop was manually harvested from 26 March to the 28th March 2000. First the leaves were stripped and the stems cut by machetes, the heads were removed after cutting the stalks. The stems were stacked into piles of (2m long and 1.5m high) for easier handling (see Table 6 for harvesting activities and timing). The stem bundles (approx. 3 to 4 tonnes each) were carried out of the fields using manual labour. Due to the prevailing wet soil conditions after cyclone Eline, it was virtually impossible to get tractors or other type of machinery into the fields to transport the cane out. This process is known as 'carrying out'. Besides being slow (thus contributing to the extended harvesting period), 'carrying out' is labour intensive and costly and it may well be a contributory factor to the high harvesting bill that was incurred after carrying out. The bundles were mechanically loaded onto trailers and transported to Triangle (Pvt) Ltd (approximate distances of between 20 to 40km) for industrial processing. Industrial processing was carried out using both the diffuser and the tandem mill, (Table 13).

Possible solutions to reducing the harvesting period would be to use defoliants (chemicals that remove the leaves and possibly seed). However, there is need for basic research on the effective rates of the chemical to be used successfully to remove sweet sorghum leaves and impact of such chemicals on sugar quality. There is also a need for appropriate harvesting machine for harvesting and separating the leaves from the stem.

Table 6. Harvesting activities and timing

Date	**Activity**
26-27 March 2000	Leaf stripping
28-29 March 2000	Cutting, stacking of stems
28-30March 2000	Carrying out and transportation of stems to the mill
29 March 2000-4 April 2000	Industrial processing using the diffuser line and the mill tandem

Sweet sorghum is also susceptible to lodging under strong windy conditions that often occur in Triangle around mid February. During this growing season cyclone Eline caused lodging on some fields at the Triangle site. According to Alexopoulou (1999) who observed the same phenomenon in southern European Union countries, this barrier to high sorghum productivity could be removed by appropriate cultural practices and genetic improvement.

RESULTS

Table 7. Soil nutrient analysis

Depth (cm)	Colour	Soil Texture	PH $CaCl_2$	Soil water conductivity (micro scm^{-1})	Mineral Nitrogen (pp ammonia + nitrate N)		Available P (raisin extract ppm P_2O_5)	Exchangeable Cations mg equivalents $100g^{-1}$				
					initial	incubation		K	Ca	Mg	Na	Total
CRS G-Blocks												
0-20	1B	SaCL	5.96	88	14	37	26	0.77	8.5	3.2	0.27	12.74
20-40	1B	SaCL	5.41	42	12	26	40	0.59	7.2	3.6	0.22	11.61
40-60	1B	SaCL	6.94	238	11	27	21	0.25	13.7	3.5	0.34	17.79
60-80	1B	SaCL	6.99	262	12	23	24	0.19	15	4.3	0.44	19.93
80-100	1B	SaCL	7.1	218	14	29	35	0.17	15.5	5.2	0.51	21.38
F Blocks												
0-20	1B	SaCL	5.56	49	12	27	28	0.35	8.0	3.2	0.29	11.84
20-40	1B	SaCL	5.46	59	13	52	25	0.40	8.1	3.6	0.22	12.32
40-60	1B	SaCL	5.07	33	15	31	13	0.15	7.3	3.3	0.30	11.05
60-80	1B	SaCL	5.13	56	12	30	13	0.12	7	3.7	0.4	11.22
80-100	1B	SaCL	5.12	49	14	27	9	0.10	6.6	3.7	0.49	10.89
SIRDC												
0-20	1B	SaCL	5.5	38	13	32	9	0.47	11.2	5.3	0.71	17.68
20-40	1B	SaCL	5.03	34	11	31	13	0.55	15.6	8.3	0.77	25.22

Colour Key
B= Brown/Brownish
l= Light

Texture Key
Sa= Sandy
CL= Clay

pH Values
Below 4.0= extremely acid
4.0-4.5= very strongly acid
4.5-5.0= strongly acid
5.0-5.5= medium acid
5.5-6.0= slightly acid
6.0-6.5= neutral
6.5-7.0= mildly alkaline
7.0-7.5= alkaline
Above 7.5 strongly alkaline

NB: For Triangle refer to note (2.3.1. and 4.3.4.)

Table 8. Criteria used to determine soil quality

Nitrogen (ppm) after incubation	Very low <20	Low 20-30	Medium 30-40	High >40	
P_2O_5 (ppm)	Acutely Deficient <7	Deficient 7-15	Marginal 15-30	Adequate 30-50	Rich >50
Exchangeable K Sand loam Reddish Brown clays	Deficient <0.10 <0.5	Marginal 0.10-0.20 0.10-0.30	Adequate 0.20-0.30 0.20-0.50	Rich >0.25 >0.50	
Status	**Poor**	**Medium**	**Good**	**Adequate**	**Very Rich**

Notes: As found at CRS and SIRDC

Table 9. Recommended fertilising

Fertiliser kg ha^{-1} to be applied	**Nutrient Status of the soil**		
	Good	**Medium**	**Poor**
N	Up to 30	30-50	50-80
P_2O_5	20-30	30-50	50-70
K_2O	20-30	30-50	50-70

Chiredzi

The Chiredzi soils are brown sandy clay loams of medium acidity.
Nitrogen status in the ploughing zone (0-30cm depth) was low, Phosphorous is available in adequate amounts, and the soils are rich in Potassium. (see Table 7, 8 & 9).

Harare

The soil are brown sandy clay loams and are slightly acidic (see Table 7, 8 & 9). Sorghum in general requires a soil pH range of between 5-6.5 for optimum growth (Farm Management Handbook, 1982) . Nitrogen availability status of the soil at planting was medium, but the soils showed a marked deficiency in Phosphorous but were rich in Potassium.

Table 10. Growth Analysis results (CRS).

CHIREDZI CFC PROJECT TRIAL (PLANTED DECEMBER 1999)

Row spacing (m)	0.75
Plant spacing (m)	0.1
m2/plant	0.075
Plants per ha	133,333

Keller (23 Dec)

Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass: Fresh Weight FW g/m2	STDS	Dry Weight DW g/m2	STDS	Moisture Cont. % (w/w)	LAI Estimated m2/m2	STEM DW g/m2 Main St.	STEM Till.	LEAVES DW g/m2 Main St.	LEAVES Till.	Seeds & Panicles DW g/m2 Main St.	Sugars ERC % Sorg
23-Dec-99	0													
27-Dec-99	4	Emerg.	0	0	0	0	0	0.00	0.0	0.0	0.0	0.0	0.0	
25-Jan-00	33	Veg.	390	92	51	12	87	0.22	19.28	0.0	31.2	0.0	0.0	0.0
08-Feb-00	47	Veg.	1481	383	181	47	88	0.76	85.3	0.0	95.3	0.0	0.0	0.0
22-Feb-00	61	Boot	5004	781	670	105	87	3.31	447.0	0.0	203.0	0.0	20.5	1.9
07-Mar-00	75	Flower	4564	247	788	43	83	3.05	516.3	0.0	186.2	0.0	77.8	4.2
21-Mar-00	89	milk	5715	649	1039	118	82	2.77	741.3	0.0	165.3	0.0	112.2	7.4
04-Apr-00	103	Dough	5828	543	1896	177	67	1.78	1267.3	0.0	161.5	0.0	342.3	6.3
18-Apr-00	117	Dough	5656	1061	1553	291	73	1.22	1032.4	0.0	91.1	0.0	258.4	7.2
02-May-00	131	maturity	5182	862	1684	280	68	0.13	1102.1	0.0	9.5	0.0	329.0	-

Wray (23 Dec)

Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass: Fresh Weight FW g/m2	STDS	Dry Weight DW g/m2	STDS	Moisture Cont. % (w/w)	LAI Estimated m2/m2	STEM DW g/m2 Main St.	STEM Till.	LEAVES DW g/m2 Main St.	LEAVES Till.	Seeds & Panicles DW g/m2 Main St.	Sugars ERC % Sorg
08-Feb-00	47	Veg.	1984	718	183	66	91	1.38	90.4	0.0	92.8	0.0	0.0	0.0
22-Feb-00	61	Boot	5140	832	875	142	83	4.22	624.7	0.0	250.3	0.0	0.0	1.9
07-Mar-00	75	Flower	5576	491	810	71	85	4.52	531.6	0.0	245.2	0.0	33.1	4.0
21-Mar-00	89	milk	5417	1171	1374	297	75	3.15	817.1	6.7	407.4	3.6	96.3	6.6
04-Apr-00	103	Dough	5700	720	1375	174	76	2.46	989.8	5.2	150.6	0.9	154.9	5.6
18-Apr-00	117	Dough	5563	496	1452	130	74	1.12	1035.1	0.0	78.0	0.0	157.9	6.6
02-May-00	131	maturity	5508	742	1559	210	72	0.00	1154.5	0.0	0.0	0.0	147.2	-

Cowley 23 Dec

Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass: Fresh Weight FW g/m2	STDS	Dry Weight DW g/m2	STDS	Moisture Cont. % (w/w)	LAI Estimated m2/m2	STEM DW g/m2 Main St.	STEM Till.	LEAVES DW g/m2 Main St.	LEAVES Till.	Seeds & Panicles DW g/m2 Main St.	Sugars ERC % Sorg
23-Dec-99	0													
27-Dec-99	4	Emerg.	0	0	0	0	0	0.00	0.0	0.0	0.0	0.0	0.0	
25-Jan-00	33	Veg.	398	121	71	22	82	0.28	18.07	4.2	40.31	8.3	0.0	0.0
08-Feb-00	47	Veg.	1280	660	192	99	85	1.27	69.3	8.2	97.5	17.0	0.0	0.0
22-Feb-00	61	Boot	4654	952	823	168	82	4.41	479.6	41.3	260.8	41.3	0.0	0.7
07-Mar-00	75	Flower	4929	453	1045	96	79	5.56	624.1	61.6	278.9	45.5	34.7	3.6
21-Mar-00	89	milk	5990	358	1219	73	80	11.57	737.9	42.4	261.9	22.7	130.6	6.7
04-Apr-00	103	Dough	5702	724	1609	204	72	2.88	1020.1	15.1	210.8	3.8	278.6	7.1
18-Apr-00	117	Dough	6632	868	2427	318	63	2.98	1306.3	127.0	194.7	27.6	526.1	7.1
02-May-00	131	maturity	5970	585	1772	174	70	1.68	1098.6	0.7	111.5	1.33	382.1	-

BJ281 (23 Dec)															
										STEM		LEAVES		Seeds & Panicles	Sugars
Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass				Moisture Cont.	LAI Estimated		DW g/m2		DW g/m2			
			Fresh Weight		Dry Weight									DW g/m2	ERC
			FW g/m2	STDS	DW g/m2	STDS	% (w/w)	m2/m2		Main St.	Till.	Main St.	Till.	Main St.	% Sorg
23-Dec-99	0														
27-Dec-99	4	Emerg.	0	0	0	0	0	0.00		0.0	0.0	0.0	0.0	0.0	
25-Jan-00	33	Veg.	259	71	38	10	85	0.19		14.30	0.0	24.0	0.0	0.0	0.0
08-Feb-00	47	Veg.	942	385	90	37	90	0.48		34.05	1.1	51.6	3.4	0.0	0.0
22-Feb-00	61	Boot	3924	824	702	147	82	4.05		465.0	9.6	218.7	9.0	0.0	0.2
07-Mar-00	75	Flower	4485	226	1012	51	77	3.15		677.9	0.0	218.2	0.0	83.3	5.4
21-Mar-00	89	milk	4205	641	1342	205	68	3.54		851.7	47.6	205.7	19.4	163.4	6.1
04-Apr-00	103	Dough	6628	963	1628	236	75	1.96		946.0	52.4	142.3	15.9	343.8	6.0
18-Apr-00	117	Dough	4924	609	1743	216	65	1.00		998.4	46.6	78.2	6.3	369.3	7.7
02-May-00	131	maturity	4709	1001	1422	302	70	0.00		899.2	0.0	0.0	0.0	295.0	-

BJ190 (23 Dec)															
										STEM		LEAVES		Seeds & Panicles	Sugars
Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass				Moisture Cont.	LAI Estimated		DW g/m2		DW g/m2			
			Fresh Weight		Dry Weight									DW g/m2	ERC
			FW g/m2	STDS	DW g/m2	STDS	% (w/w)	m2/m2		Main St.	Till.	Main St.	Till.	Main St.	% Sorg
23-Dec-99	0														
27-Dec-99	4	Emerg.	0	0	0	0	0	0.00		0.0	0.0	0.0	0.0	0.0	
25-Jan-00	33	Veg.	185	91	37	18	80	0.15		13.60	0.0	23.3	0.0	0.0	0.0
08-Feb-00	47	Veg.	1364	429	144	45	89	1.47		59.55	0.0	84.9	0.0	0.0	0.0
22-Feb-00	61	Boot	4809	814	544	92	89	4.34		342.3	3.3	195.1	3.7	0.0	0.3
07-Mar-00	75	Flower	5548	234	901	38	84	4.67		613.0	6.6	279.0	2.8	0.0	1.4
21-Mar-00	89	milk	6499	406	1262	79	81	3.97		870.2	0.0	220.4	0.0	123.1	2.9
04-Apr-00	103	S-Dough	6653	1047	1513	238	77	2.58		985.1	25.0	156.4	4.3	240.0	2.7
18-Apr-00	117	H.Dough	6719	716	1757	187	74	1.60		970.1	0.0	112.6	0.0	499.0	3.1
02-May-00	131	maturity	5713	955	1765	295	69	0.84		925.6	0.0	52.2	0.0	417.6	-

Table 11. Growth Analysis results (SIRDC)

HARARE CFC PROJECT TRIAL (PLANTED DECEMBER 2000)

Row spacing (m)	0.75
Plant spacing (m)	0.1
m2/plant	0.075
Plants per ha	133,333

Keller (23 Dec)

Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass Fresh Weight	
			FW g/m2	STDS
23-Dec-99	0			
27-Dec-99	4	Emerg.	0	0
25-Jan-00	33	Veg.	364	82
15-Feb-00	54	Veg.	1265	90
10-Mar-00	78	Boot	4418	380
15-Apr-00	114	Flower	4627	239
21-Mar-00	89	milk	4924	170
04-Apr-00	103	Dough	4485	200
18-Apr-00	117	Dough	-	-
02-May-00	131	maturity	4423	193

Wray (23 Dec)

Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass Fresh Weight	
			FW g/m2	STDS
25-Jan-00	33	Veg.	660	746
15-Feb-00	54	Veg.	1581	268
10-Mar-00	78	Boot	3765	186
15-Apr-00	114	Flower	4492	153
21-Mar-00	89	milk	4117	112
04-Apr-00	103	Dough	4297	123
18-Apr-00	117	Dough	-	-
02-May-00	131	maturity	4136	111

cowley (23 Dec)

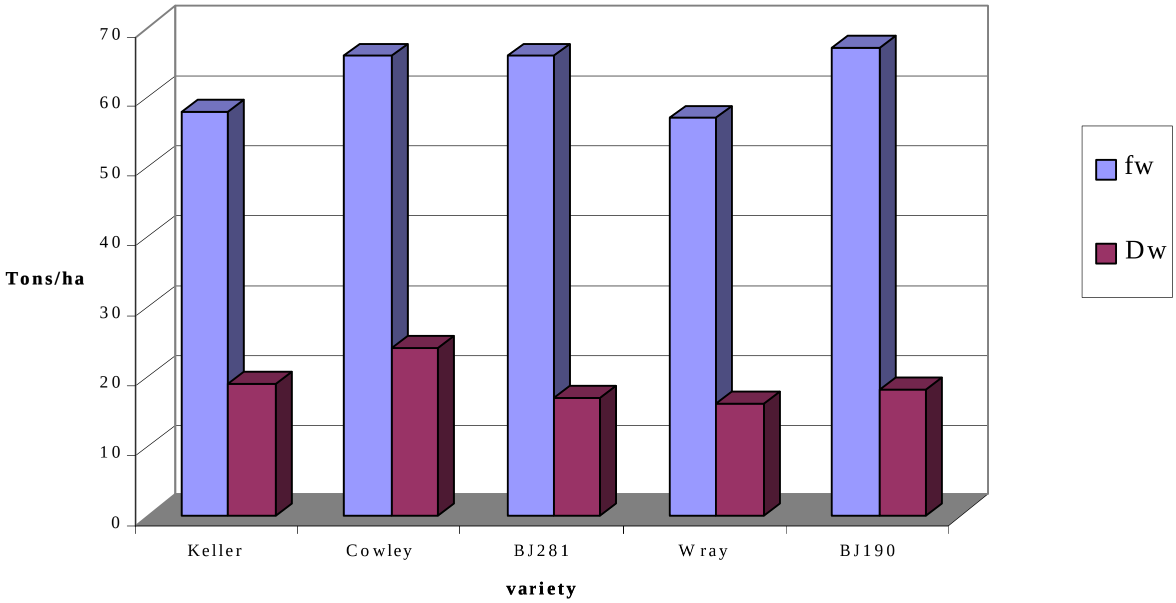
Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass Fresh Weight	
			FW g/m2	STDS
23-Dec-99	0			
27-Dec-99	4	Emerg.	0	0
25-Jan-00	33	Veg.	222	44
08-Feb-00	47	Veg.	532	156
10-Mar-00	78	Boot	2812	331
15-Apr-00	114	Maturity	4903	514
21-Mar-00	89	Milk	5370	235
04-Apr-00	103	Dough	5645	294
18-Apr-00	117	Dough	-	-
02-May-00	131	Maturity	5666	170

Table 11. Contd

BJ281 (23 Dec)				
Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass Fresh Weight	
			FW g/m2	STDS
23-Dec-99	0			
27-Dec-99	4	Emerg.	0	0
25-Jan-00	33	Veg.	224	54
15-Feb-00	54	Veg.	2663	205
10-Mar-00	78	Boot	3379	83
15-Apr-00	114	Flower	4580	283
21-Mar-00	89	Milk	4752	156
04-Apr-00	103	Dough	5138	262
18-Apr-00	117	Dough	-	-
02-May-00	131	Maturity	4616	113

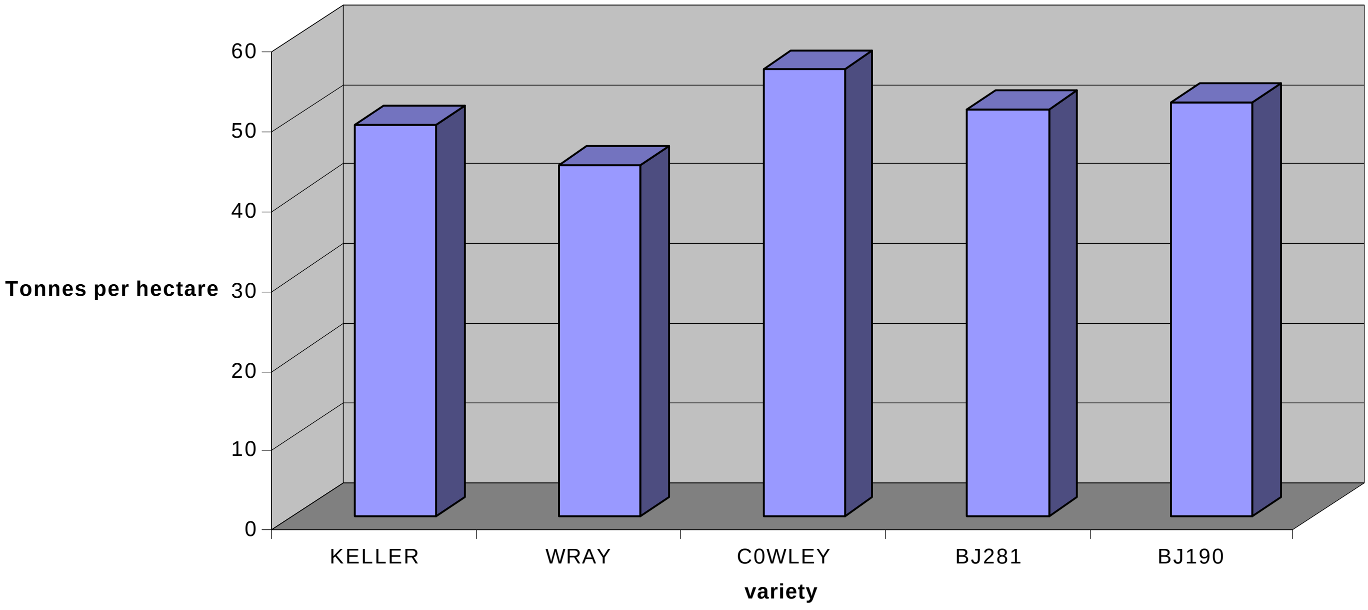
BJ190 (23 Dec)				
Date of Sampling	Days After Planting	Growth Stage	Mean Standing Biomass Fresh Weight	
			FW g/m2	STDS
23-Dec-99	0			
27-Dec-99	4	Emerg.	0	0
25-Jan-00	33	Veg.	179	37
15-Feb-00	54	Veg.	1447	145
15-Apr-00	114	Boot	2746	44
07-Mar-00	75	Flower	3931	264
21-Mar-00	89	Milk	5205	212
04-Apr-00	103	Dough	5190	151
18-Apr-00	117	Dough	-	-
02-May-00	131	Maturity	4972	153

Notes: - (No sampling was carried out)



Graph 1. Comparison of biomass yield among the five varieties

In terms of biomass at the CRS site BJ190 recorded the highest yield followed by in descending order, Cowley and BJ 281 , then Keller and Wray (see Table 10 & Graph 1).



Graph 2. Comparison of biomass yield among the five varieties (SIRDC)

In terms of biomass at the SIRDC site, Cowley recorded the highest yield fresh biomass yield followed by in descending order, BJ 190, BJ 281 , Keller and Wray (see Table 11 & Graph 2).

Table 12. Sugar analysis results (CRS)

Sugar analysis data								
		Purity	Fibre	Brix	Pol	RS	TFAS	ERC
variety	Stage			%Sorghum stems				
Keller	Booting	51.1	10.7	7.6	3.9	2.5	6.3	1.9
Bj281	Booting	35.7	10.9	7.2	2.6	3.3	5.7	0.2
Bj190	Booting	31.2	11.2	6.2	1.9	2.9	4.7	0.3
Wray	Booting	50.6	7.5	7.7	3.9	2.1	5.9	1.9
Cawley	Booting	52.3	10.9	8.1	2	3.4	5.2	0.7
Chifu	Booting	27.5	10.3	7.2	2	3.4	5.2	0.7
Ln1	Booting	28.3	6.9	5.4	1.5	3.4	4.7	0.4
Ln2	Booting	25.1	7.4	6.3	1.6	3	4.4	0.7
Mutumbuka	Vegetative		0	0	0	0	0	0
Keller	Flowering	64.5	12.8	9.6	6.2	2	8.1	4.2
Bj281	Flowering	60.6	11.9	13.7	8.3	3.1	11.3	5.4
Bj190	Flowering	47.7	12.3	7.5	3.6	2.6	6.1	1.4
Wray	Flowering	62.4	10.5	9.7	6.1	1.9	7.8	4
Cawley	Flowering	61	12.9	9.3	5.7	1.9	7.4	3.6
Chifu	Flowering	33.1	9.9	8.2	2.7	3.4	5.9	0.1
Ln1	Flowering	29	8.6	7.4	2.1	3.3	5.3	0.5
Ln2	Flowering	0	0	0	0	0	0	0
Mutumbuka	Vegetative	0	0	0	0	0	0	0
Keller	milking	77.2	8.7	11.8	5	1	10	7.4
Bj281	milking	67.2	12.6	12.7	8.6	2.3	10.7	6.1
Bj190	Flowering	57.8	11.2	8.6	5	2	6.9	2.9
Wray	Flowering	74.4	10	11.2	8.3	1.1	9.4	6.6
Cawley	Flowering	74.6	13.1	11.5	8.6	1	9.5	6.7
Chifu	Flowering	55.7	9.6	9.8	5.5	2.9	8.2	3.2
Ln1	Flowering	44.7	7.1	8.7	3.9	3	6.7	1.5
Ln2	Booting	40.3	8.9	6.7	2.7	2.8	5.3	0.6
Mutumbuka	Vegetative	0	0	0	0	0	0	0

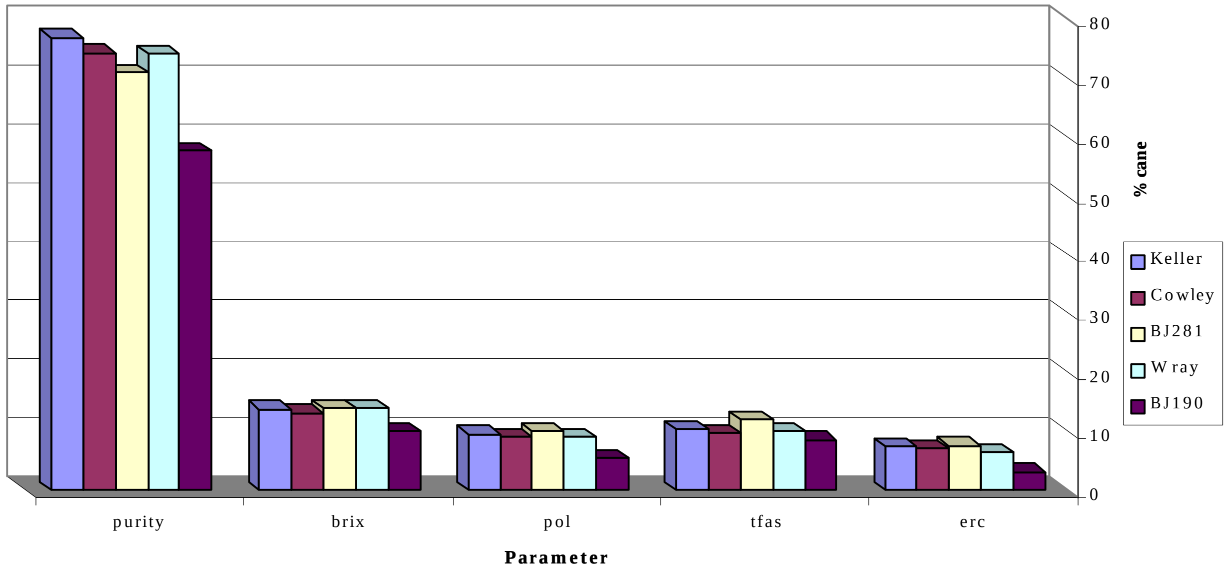
Table 12. Contd

Sugar analysis data								
		Purity	Fibre	Brix	Pol	RS	TFAS	ERC
Variety	Stage			%Sorghum stems				
Keller	Hard dough	72.0	12.9	11.4	8.2	0.6	8.7	6.3
Bj281	Hard dough	64.5	13.5	13.3	8.6	1.3	9.9	6
Bj190	Hard dough	55.1	13.5	8.8	4.9	1.2	6.1	2.7
Wray	Hard dough	69.5	12.4	10.9	7.6	0.6	8.1	5.6
Cawley	Soft dough	73	15.6	12.6	9.2	0.5	9.7	7.1
Chifu	Soft dough	62.9	12.1	11.5	7.2	1.3	8.4	4.9
Ln1	Soft dough	34.3	9.3	8.1	2.8	1.6	4.3	0.1
Ln2	Soft dough	44.4	8.4	8	3.5	1.4	4.9	1.3
Mutumbuka	Flowering	29	10.4	6.8	2	1.6	3.5	-0.5
Keller	Hard dough	69.6	12.7	13.8	9.6	0.9	10.4	7.2
Bj281	Hard dough	71.3	13.3	14.1	10.1	2.2	12.1	7.7
Bj190	Hard dough	55.2	13.8	10	5.5	3.2	8.6	3.1
Wray	Hard dough	65.9	12.1	13.9	9.2	1	10.1	6.6
Cawley	Hard dough	68.7	15.6	13.2	9.1	0.5	9.6	7.1
Chifu	Hard dough	47.5	12.1	10.1	7.2	3.9	8.5	4.9
Ln1	Hard dough	19.1	9.7	6.8	1.3	2	3.2	-1.4
Ln2	Hard dough	32.4	10.9	7.9	2.6	4	6.3	-0.2
Mutumbuka	Soft dough	31.8	10.6	8	2.6	4.1	6.5	-0.2

Key

Notes:

Brix:	total dissolved solids
Pol	Polarity measurement of juice to give estimate of sucrose content
Purity:	Ratio of Pol (sugar Component) to brix i.e (Pol% extract *100)/brix% extract
Fibre:	Total weight _(moisture + brix)
RS:	Reducing sugars (measured using Felinghs A+B) including glucose &fructose
TAFS:	Total Fermentable as sucrose: TFAS% sorg =Pol%sorg + (0.95RS% sorg)
ERC:	Estimated recovery Crystal(0.98*%sorg-0.417 Non Pol %sorg-0.035 Fibre % sorg, ZSA Lab Report)
	These factors represent losses in filter cake, molasses, and bagasse respectively and are based on Triangle
Non- Pol	Brix –Pol



Graph 3. Comparison of sugar yield among the five varieties

Comparison of sugar yield among the 5 varieties show that BJ281 achieved the highest sugar yield, followed in descending order by Keller, Cowley, Wray and BJ190. All the 5 varieties achieved peak sugar level between the soft and hard dough stages. The graph below shows the comparison in terms of sugar yield among the varieties.

Table 13. Sugar quality and yield of the Triangle crop

Section	Area (ha)	Total tonnes sorghum	Tonnes ha^{-1} sorghum	ERC %	Pol %	Brix %	Fibre %	Tonnes Molasses	Purity %	Tonnes Pol	Tonness Brix	Tonnes Fibre	Tonnes ERC
8	14.2	462.22	32.6	5.6	8.49	13.71	15.95	15.72	61.94	39.25	63.37	73.72	25.89
23	29.5	680.1	23.1	5.01	7.83	12.86	17.1	23.12	60.89	53.25	87.45	116.28	34.06
24	26.2	644.74	24.6	5.6	8.37	13.3	16.54	21.92	62.97	54.00	85.75	106.65	36.10
25	16.6	408.28	24.6	5.9	8.44	12.8	16.71	13.88	65.92	34.46	52.27	68.22	24.11
61	10.8	273.16	25.3	5.82	8.42	12.93	16.80	9.29	65.12	23.00	35.32	45.89	15.90
63	14.8	357.06	24.1	6.24	8.87	13.45	16.33	12.14	65.97	31.67	48.01	58.29	22.29
62	29.4	590.16	20.1	4.93	7.97	13.53	16.8	20.07	58.92	47.05	79.86	98.37	29.09
64	15.1	279.6	18.5	5.58	8.17	12.65	16.94	9.51	64.54	22.84	35.38	47.36	15.6
65	12.8	331.20	25.9	5.08	7.82	12.74	15.72	11.26	61.37	25.9	42.2	52.06	16.83
3*		6.64		4.73	7.67	13	16.55	0.23	58.98	0.51	0.86	1.10	0.31
14*		213.18		7.79	9.79	13.01	14.34	7.25	75.76	20.88	27.74	30.57	16.60
Total		**4246.34**								**352.81**	**558.21**	**698.51**	**236.78**
Cane		**219.82**								**54.51**	**86.61**	**107.75**	**36.41**
Sorg	**168**	**4026.52**	**23.96**	**5.57**	**8.3**	**13.12**	**16.43**	**122.24**	**63.25**	**298.30**	**471.60**	**590.76**	**36.41**

*cane

Quality

The total amount of alcohol produced was 43 685 litres from 80 tonnes TRS (Total Reducing Sugars), translating to yields of between 55 and 58 litres of alcohol per 100kgs of TRS in molasses. High purity of 77.2% and ERC 7.4 % was recorded from samples send to ZSA and Triangle labs prior to harvesting. However low purities averaging 62.6% and ERC averaging 5.5% were recorded during crushing. This reduction in quality was due to:

i) extended harvesting period (leaf stripping began 3 to 4 days before harvesting crushing)

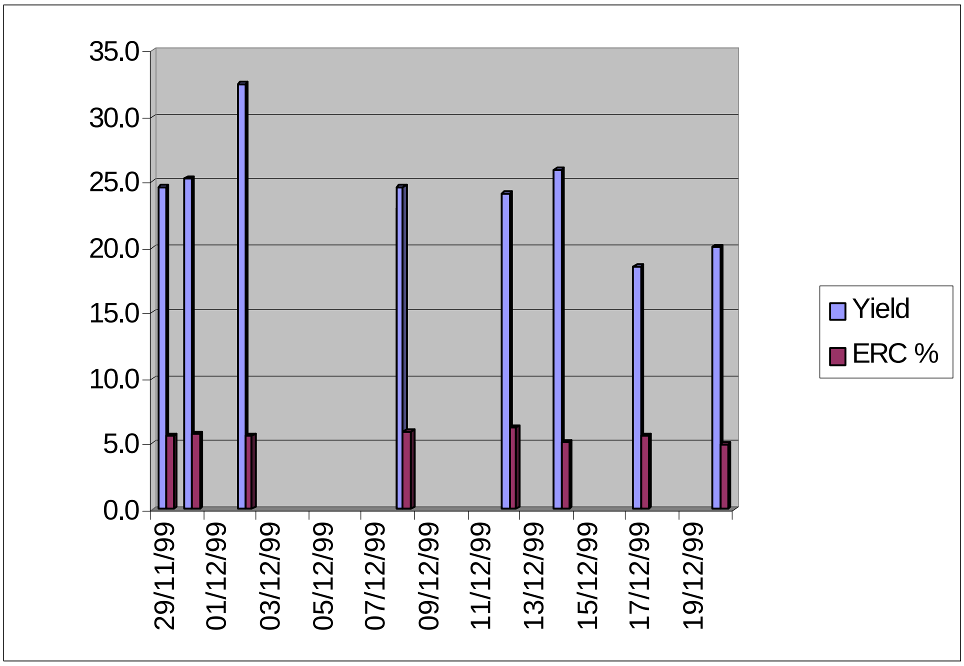
ii) extended crushing period (crushing of the 4026.52 t sweet sorghums stems was carried out over a week due to constant breakdown of the mill machinery, and also the prevailing high climatic temperatures accelerated deterioration of sweet sorghum stems awaiting crushing on the mill site)

Delaying processing after harvest leads to quality decrease (see Graph 4 & 5). This aspect of quality deterioration was assessed during the first year trials (1997/98), and results show that delays in processing stripped and cut stems leads post harvest losses. The prolonged crushing period is probably the single greatest factor in the deterioration of the biomass quality. The deterioration resulted from the prolonged periods (potentially up to 7 days; 120 hours) between initial leaf stripping and actual processing. The thinner cuticle of sweet sorghum when compared to sugarcane makes the sorghum stems more prone to damage during harvesting, transport and loading. Undoubtedly, sorghum's greater sensitivity to handling makes the duration between harvesting and processing more critical than sugarcane and a clear deterioration in quality can be seen in Graph 5 after 20 to 25 hours mill run time. Thus closing the gap between harvesting and industrial processing of sweet sorghum stems is an aspect, which has to be critically managed in the oncoming trials to minimise post harvest losses.

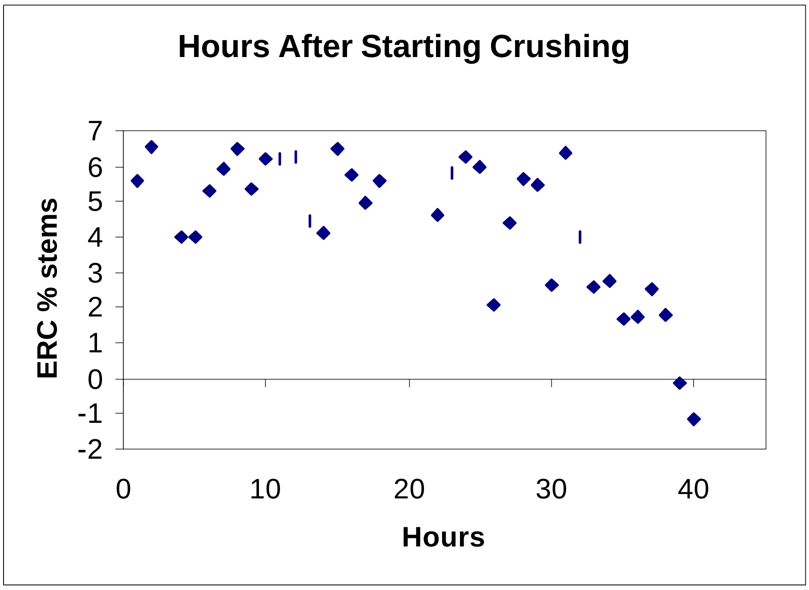
Yield

A total yield of 4 027 t was achieved on Triangle fields, giving an average yield of 24t $_{stems}$ ha^{-1}. The estimated yield of 30t $_{stems}$ ha^{-1} based on the sweet sorghum yields of 30 to 50t $_{stems}$ ha^{-1} achieved during phase I of the trial. Although yields achieved this season fell below the expected yields, the total tonnage harvested still enabled a comprehensive crushing trial. The low yields can be attributed to the following reasons (see Present status against planned status)

Generally delaying planting contributed to low yields (see Graph 4). The much earlier planted crop i.e. 2-3 weeks after the ideal planting date of 15 November 1999 achieved better yields compared to the much later planted crop i.e. 5 weeks after the ideal date.



Graph 4. Yield and sugar quality against planting date



Graph 5. Sugar quality decrease over time

Table 14. Seed quantities

Variety	**Seed quantities (kg)**
Keller	101
Cowley	312
Wray	10
BJ190	55
BJ281	64

Table 14 shows the amount of seed collected from the trial CRS plot. Currently the project is making efforts to secure Keller seed for planting in the oncoming season, from Transworld Seed Corporation as well as from Prof. Li Dajue of the Chinese Academy of Sciences.

C APPENDIX

Sampling Protocols

i) Growth analysis

The 1st (outer) row was omitted on every plot. On the 2nd row one (outer) metre was also omitted. The 2nd metre on the 2nd row was taken as the 1st metre. All the plants from this metre were counted and their fresh weights determined. These plants were discarded. The plants from the second metre were counted and their fresh weight determined, and the total number of tillers per plant recorded. (i.e the 3rd metre of the row immediately following the 1st sampling metre). The first 3 plants of the 2nd metre were partitioned, (however if a plant was missing it was not substituted as this would result in an overestimation of the unit area yield), and fresh weights and dry weights were recorded. For dry weight measurements, the partitioned plant parts were cut into small pieces and put in viking papers and oven dried at 100^{o}C. The number of tillers per plant was also recorded, partitioned and dry weights recorded.

For partitioning, the fully expanded leaves were separated from expanding. Both expanding and fully expanding leaves had their areas determined using a leaf area metre. Stems of partitioned plants were chopped and oven dried . All the above measurements are also carried on the tillers taken from the main stems for partitioning. Dead leaves from both the 1st and 2nd samples metres were also oven dried and the dry weights recorded.

For the Harare trial only fresh weight measurements were recorded. No dry weights were recorded due to lack of a drying oven space. Fresh weight was recorded as follows: the outer row was omitted on every plot. The 2nd row outer metre was also omitted. The 2nd metre on the 2nd row was then regarded as the 1st sampling metre. All the plants from this metre were counted and their fresh weight determined.

ii) Sugar analysis

Sugar analysis was carried out by the Zimbabwe Sugar Association and Triangle laboratory. Sweet sorghum quality measurement was based on the methodology used for sugarcane. Sampling for sugar analysis commenced at the booting stage for each variety on the trial field. The crop intended for crushing (Triangle fields) was also sampled for sugar analysis closer to the targeted crushing date. Sampling was carried at bi- weekly intervals up to maturity. However due to constant break down of the Land rover it was not possible to strictly adhere to the bi-weekly sampling and sending of sweet stems to ZSA. The stage at which the Purity %, POL %, ERC (**Estimated recoverable crystal**) and ERF (**Estimated recoverable fermentables)** peaked was obtained and recommendations made as regards the best period to harvest. Sweet sorghum stems (total number of stems = 20 to 25) were hand harvested randomly in order to obtain a representative sample. Harvesting was carried out by cutting the stalks at between 2 to 5cm above ground level, removing the tops and stripping the leaves off. The stems were then delivered to the Zimbabwe Sugar Association laboratories were the stems were pushed through simple crushing mills and the resulting bagasse and juice collected in separate containers. For fibre percentage measurements, the bagasse was oven dried for 24hrs at 110^{o}C using a Labotec oven. (Mr Chamuka ZSA, pers commn) For Brix and Pol values the juice was blended using a T50 Blender. The resulting filtrate was used for Brix and Pol measurements were the Brix extract % values were recorded using an RFM 500

Refractometer (Bellingham and Stanley Ltd.) and for Pol % extract values a Polatronic Universal meter (Schmidt and Haensch) was used. Actual Brix and Pol % values were read off the Schmidt table.

Parameters for sugar analysis

Pol: the apparent sucrose content in cane or juice expressed as a percentage by mass

Brix: the total dissolved solids content in cane or juice expressed as a percentage by mass.

Non-pol: Brix minus Pol

Fibre: the dry water minus insoluble matter in cane

Reducing sugars (RS): the reducing substances calculated as invert sugars. Major reducing sugars are glucose and fructose

Purity: the percentage of sucrose in total dissolved solids in cane or juice

$$= \frac{\text{Pol \% x 100}}{\text{Brix \%}}$$

ERC: This is calculated on the basis of pol and then adjusted for factory losses based on non-pol and fibre, using the following equation:.

= **(a x Pol) – (b x Non-pol) – (c x Fibre)***

ERF: There are no non-pol losses, consequently the ERC formula has been modified to provide estimates of recoverable fermentables.

ERF: = **(a x Pol) – (c x Fibre)***

Note: * All variables are expressed as % cane, and where all constants a,b and c are derived from mill performance data to represent Pol losses in filter cake, molasses and bagasse respectively.

Clowes et al (1998)., Zimbabwe Sugarcane Manual

iii) Irrigation Procedures (Triangle and CRS)

Evaporation readings from class A pan were collected and used for irrigation scheduling on the entire crop under sprinkler irrigation. Crop water requirement was estimated using evaporation readings from the standard class A evaporation pan and the root and crop factors data for Keller (Table 15).

The depth of water application (mm/m) at a given stage was obtained as follows:

Dnet = (TAM .% Depletion)

Where

TAM = Total available moisture obtained as follows:

TAM = (Available moisture capacity of soil x Root depth of the crop)

% Depletion = the maximum amount of water allowed to be depleted in the soil before Replenishing. (50%)

Crop water requirement was estimated using the following equation (awc.Rz.%depletion)

Thus net depth of application is given as follows:

Dnet = **(awc.Rz.0.5)**

Where :

Awc = available moisture capacity (20% for the Chiredzi sandy clay soils)

Rz = root depth

0.5 = % depletion (50%)

The irrigation efficiency used for the sprinkler section was 80%. So the gross application depth was Dnet /Ea

Dgross = Dnet/0.8

The Dgross is the actual depth of water (mm) applied per irrigation session.

Ref. (Crop water requirements, Irrigation and drainage paper, FAO, page 15)

Table 15. Root and crop factors for Keller used for crop water requirement establishment

Weeks after emergence	Root Depth (mm)	Crop factor (Kc)
1	185	0.35
2	261	0.86
3	338	0.86
4	446	1.19
5	614	1.19
6	654	1.19
7	787	1.19
8	914	1.19
9	914	1.19
10	914	1.19
11	914	1.19
12	914	1.19
13	914	1.19
14	914	1.19
15	914	1.19
16	914	0.92
17	914	0.92
18	914	0.92

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