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CROP CYCLE LENGTH AND CANE AND SUGAR YIELDS

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SUMMARY

Two series of trials were initiated to compare different lengths of crop cycles for sugarcane harvested every 12 months under the local conditions over a six-year period. The first series involved harvesting cane every 24 months and in the second series cane was harvested after 16 or 20 months alternately. All trials included four cane varieties except one in the second series where only three varieties were planted. Cumulative results for both series of trials showed a difference in favour of the 12-month cane crop. In the first series after six years, cane and sugar yields were reduced by 19–48% and 22–60% respectively in the 24-month-old canes compared with 12-month-old crops. The level of reduction varied with cane variety. In the second series, the declines in cane and sugar yields were smaller, 5–44% and 7–49% respectively. Cane lodging, which increased with length of crop cycle, led to greater weed infestation, increased damage by rats and rendered manual harvest more difficult.

INTRODUCTION

In Mauritius, sugarcane is harvested 12 to 20 months after planting (plant cane) and then every 12 months for five or more ratoons. This practice has existed since the first cultivations in the seventeenth century although the planting seasons (including age of the plant cane at harvest) and number of ratoons are reported to have undergone some changes after 1850 (North-Coombes, 1993). A 12-month cane cycle is common practice in most of the sugarcane growing countries except where, for climatic conditions or economic reasons, different scenarios are used. In the Hawaiian sugar industry, a steady trend towards increased age at harvest since 1930 has been noted and the optimum age of most varieties in Hawaii in the 1980s exceeded 24 months (Tew, 1986). At Harwood in New South Wales Cox *et al.* (1994) have confirmed the major reliance on two-year crops on agronomic and economic grounds.

In 1984, a delegation of scientists from Hawaii carried out a study on cane production on the neighbouring island of Réunion and one of their recommendations was to increase sugar production by extending the traditional 12-month crop cycle (ABA International, Inc. & Bouvet and Associates, Inc., 1985). The adoption of a 24-month cycle in Réunion Island could increase the annual average sugar yield of 8.5 t ha^{-1} to 12 t ha^{-1} and reduce ratoon management costs by 50%. This led to the initiation in 1987 of a programme to evaluate and adapt the 24-month cycle under their conditions; the programme included breeding to select specific varieties for such conditions (CERF, 1987). The

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Mauritian sugar industry did not remain indifferent to such an initiative and a project to evaluate the advantages and drawbacks of such a cycle under Mauritian conditions was undertaken during the same year.

Cane planted during the long-season (February to April) and harvested in July or August of the following year, after 16 months or more, gave much higher yields than plant cane planted during the crop season and harvested after 12 or 13 months. Ratoon canes were harvested every twelve months thereafter. One possibility of having longer ratoons was to harvest cane alternately after 16 months in two consecutive years (in July in the first year and in November the following year) and then after 20 months by omitting one harvest (November to July of the year after). A project was initiated in 1990 to see if harvesting ratoons after more than 12 months could increase productivity by yielding more and reducing ratoon maintenance costs (weed control and trash management).

This paper examines the agronomic aspects, including cane and sugar yields, of longer cropping cycles compared with the traditional 12-month cycle.

MATERIALS AND METHODS

Two series of trials were initiated; the first series consisted of harvesting cane after every 12 or 24 months over a period of six years and in the second one cane was harvested after 16 or 20 months alternately compared with a 12-month interval.

Cycle of 12 or 24 months

Four trials, each a split-plot design with two cropping cycles as main plots and four varieties as subplots, were laid down in 1987 in different agroclimatic regions. The subplots consisted of 12 rows each of 20 m. Two local varieties and two varieties from Hawaii, where cropping at 24 months is commercial practice, were included as shown in Table 1.

The trials were planted in April following the standard local recommendations except for fertilizer rates which were increased in the longer cycle. The quantity of phosphorus, normally applied at planting (120 kg P_2O_5 ha^{-1}) was doubled in the 24-month plots. The same amounts of nitrogen and potassium applied at planting

Table 1. Sites and cane varieties for sugarcane cycles of 12 or 24 months.

Site	Soil type†	Mean annual rainfall (mm)	Varieties	
			Local	Hawaiian
Gibraltar	L4 – normal	2375	R570, M657/66	H57-5174, H59-3775
Etoile	H2 – normal	3100	R570, M657/66	H54-775, H59-3775
Union Park	B1 – gravelly	3625	R570, M657/66	H54-775, H59-3775
Palmyre	P1 – rocky	800	R570, M657/66	H57-5174, H59-3775

† Source: Parish and Feillafé (1965).

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(50 kg N and 75 kg K_2O ha^{-1}) and after harvests (60 kg N and 90 kg K_2O ha^{-1}) were repeated 6 months later in the longer-cycle plots.

The 12-month cane (H1 plots) was harvested as plant cane in October 1988 and successively every 12 months for five ratoons. The 24-month cane (H2 plots) was harvested for the first time in October 1989, followed by two other harvests in 1991 and 1993. The two sites found in the superhumid areas (Etoile and Union Park) were harvested green whereas burning was required at the two other sites. One day before each harvest, 30 stalks were chosen at random from each plot, crushed in a small mill, and sucrose content (industrially recoverable sucrose content – IRSC) was determined using standard procedures (STASM, 1970). In addition to the harvest results (cane and sugar yield) of each treatment, the weed control, attack by rats and response of labourers were also recorded.

Crop cycle of 16 or 20 months

Two trials were planted in April and August 1990 at Queen Victoria (mean annual rainfall 1825 mm) and New Grove (mean annual rainfall 3050 mm) respectively. The soil groups were L4-stony and B1-gravelly (Parish and Feillafé, 1965) respectively. In this series of trials, cane varieties were chosen from the locally recommended and commercially planted ones. At Queen Victoria, four varieties, namely, R570, M695/69, M3035/66 and M1557/70, were planted. Cane varieties R570, M3035/66 and M292/70 were the three varieties planted at New Grove.

The same rates of fertilizer were used at planting and after harvest for both cropping cycles. The statistical design used and plot sizes were similar to the first series except at New Grove where subplots consisted of only three varieties. At both sites, all plots of 12-month cane (CC1 plots) were harvested in September while plots of the longer crop cycle (CC2 plots) were harvested in July or November after either 16 or 20 months as shown in Table 2.

Harvest results together with observations on weed control, attack by rats and problems encountered during harvest were recorded.

Table 2. Harvesting pattern for the sugarcane cycle of 16 or 20 months.

Site	Cycle (months)	1991	1992	1993	1994	1995	1996
Queen Victoria	12	PC	1R	2R	3R	4R	—
	16–20	PC (Jul.)	1R (Nov.)	—	2R (Jul.)	3R (Nov.)	—
New Grove	12	PC	1R	2R	3R	4R	5R
	16–20	PC (Nov.)	—	1R (Jul.)	2R (Nov.)	—	3R (Jul.)

PC = plant cane; R = ratoon; harvest date in parentheses.

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RESULTS

Cycle of 12 or 24 months cane

Cane yields. The trials at Palmyre had to be stopped after two years of experimentation due to a severe infection of smut (*Ustilago scitaminea*) on three varieties. Cumulative results of the remaining three trials at Gibraltar, Etoile and Union Park, recorded over corresponding periods and over six years of experimentation revealed a net difference in favour of the 12-month cane crop (Table 3). The difference in cane yields between corresponding H1 and H2 plots was least during the first two years of comparison (plant cane + 1st ratoon for the 12-month cycle and plant cane for the 24-month cycle) when cane variety R570 at Gibraltar and Etoile and H54-775 at Etoile showed no significant difference. The superiority of the twelve-month cane and the difference in cane yields between the two cropping cycles increased with age of the ratoons.

Irrespective of sites, cane variety R570 with a decrease of about 25% was the least affected by the 24-month cropping system. The reduction was greatest in variety M657/66 and intermediate in the Hawaiian varieties.

Sugar yields. The sugar yield is the product of the cane yield and sucrose content (IRSC). The IRSC in H1 plots, in plant cane and ratoons, was also generally higher than in H2 plots (Table 4). The lower sucrose concentration in H2 plots

Table 3. Cane yields (t ha^{-1}) of sugarcane crops with cycle of 12 (H1) or 24 (H2) months at three sites over six years.

	Year and crop cycle						Cumulative yield over six years	
Variety	1988 + 89 (H1)	1989 (H2)	1990 + 91 (H1)	1991 (H2)	1992 + 93 (H1)	1993 (H2)	(H1)	(H2)
				Gibraltar				
R570	205.2	195.9	228.9	182.0	223.1	144.1	657.2	522.0
M657/66	183.5	104.6	202.6	111.7	205.4	102.8	591.5	319.1
H54-775	173.8	116.9	207.9	129.7	191.4	86.0	573.2	332.6
H59-3775	166.3	142.0	177.6	115.1	137.9	84.0	481.8	341.1
s.e.	5.76		7.16		6.29		8.73	
				Etoile				
R570	201.6	201.1	255.2	149.7	226.5	205.9	683.0	556.7
M657/66	185.1	114.2	246.3	83.2	223.8	142.4	655.2	339.8
H54-775	182.7	173.0	205.6	129.4	193.7	166.9	582.0	469.3
H59-3775	153.2	127.7	168.7	60.7	139.3	83.5	461.3	271.9
s.e.	6.14		14.06		5.14		21.9	
				Union Park				
R570	158.0	135.6	200.1	170.7	171.1	111.2	529.2	416.9
M657/66	152.1	74.1	176.4	113.4	156.2	48.8	484.7	236.9
H54-775	142.3	101.9	148.8	111.6	112.1	50.5	403.2	264.0
H59-3775	124.9	86.6	124.7	79.0	78.0	29.4	327.6	195.0
s.e.	4.63		4.58		5.42		7.81	

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Table 4. Sugar concentration (IRSC%) of sugarcane crops with cycles of 12 (H1) or 24 (H2) months at three sites over six years.

	H1		H2	H1		H2	H1		H2
Variety	1988	1989	1989	1990	1991	1991	1992	1993	1993
				Gibraltar					
R570	13.0	9.6	10.3	11.97	12.03	10.67	11.21	10.24	10.53
M657/66	13.1	11.4	11.6	12.49	13.02	11.10	12.71	11.84	11.43
H54-775	13.6	11.3	10.5	12.60	12.24	9.26	12.20	11.25	11.43
H59-3775	13.9	11.1	10.9	12.49	12.09	10.93	12.08	11.70	10.60
				Etoile					
R570	10.7	9.2	8.4	11.88	9.90	7.56	11.57	8.82	7.49
M657/66	11.8	10.7	10.4	12.51	12.51	8.19	12.62	10.55	8.62
H54-775	11.2	9.2	7.1	11.70	11.25	8.01	11.12	10.08	9.59
H59-3775	11.7	10.7	8.6	12.33	11.79	9.45	12.78	11.05	9.70
				Union Park					
R570	10.9	10.4	10.8	10.62	10.80	9.99	10.33	10.24	10.53
M657/66	11.0	11.6	10.7	12.42	12.06	12.06	11.48	11.84	11.43
H54-775	11.5	11.7	10.5	11.25	11.88	10.71	10.64	11.25	11.18
H59-3775	12.2	14.7	10.9	11.61	11.79	11.16	11.45	11.70	10.60

can be explained by the considerable amount of rotten and dry cane present at harvest after 24 months.

Both components of sugar yield thus contributed to the superior sugar yield of all varieties at all sites when cultivation was made by the traditional 12-month crop cycle (Table 5). Over a period of six years, the smallest difference in sugar yield between the two cropping cycles, a reduction of 27% with the 24-month cycle, was recorded at Gibraltar with variety R570. On a two-year basis, a reduction of 13.6% in sugar yield of variety R570 at Gibraltar was the best performance obtained with the 24-month cropping cycle. The worst performance was recorded by variety M657/66 at Etoile (during the second harvest of the H2 plots) where a yield decline of 78% was recorded.

Weed control. The control of weeds during the first half of the two-year cycle was achieved by using conventional herbicides and manual weeding as in the H1 plots. In the second half of the longer cycle, the lack of herbicide interventions resulted in moderate to severe weed infestation particularly in the Hawaiian varieties which had lodged. Vines (mainly *Mikania* spp.) and shrub type weeds covered the lodged cane in some plots, resulting in difficulties during harvest.

Attack by rats. Although rodenticides were applied regularly in all plots, rats caused serious damage in the 24-month plots. The attack was more pronounced in plots where cane had lodged and infestation by weeds was severe.

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Table 5. Sugar yields (t ha^{-1}) of sugarcane crops with cycles of 12 (H1) or 24 (H2) months at three sites over six years.

Variety	Year and crop cycle						Cumulative yield over six years	
	1988 + 89 (H1)	1989 (H2)	1990 + 91 (H1)	1991 (H2)	1992 + 93 (H1)	1993 (H2)	(H1)	(H2)
				Gibraltar				
R570	23.5	20.3	27.5	19.4	24.0	15.2	75.0	54.8
M657/66	22.4	12.1	25.9	12.4	25.3	11.8	73.6	36.3
H54-775	21.9	12.3	25.8	12.0	22.5	9.6	70.1	33.9
H59-3775	21.0	15.5	21.8	12.6	16.5	9.0	59.3	37.0
s.e.	0.62		0.39		0.65		1.02	
				Etoile				
R570	20.3	16.9	27.8	11.3	23.9	15.4	72.0	43.6
M657/66	20.9	11.9	30.8	6.8	26.1	12.3	77.8	31.0
H54-775	18.7	12.3	23.6	10.4	20.5	16.0	62.8	38.7
H59-3775	17.3	11.0	20.3	5.7	16.6	8.1	54.2	24.8
s.e.	0.47		1.59		0.23		2.07	
				Union Park				
R570	16.8	14.7	21.5	17.1	17.6	11.7	55.9	43.5
M657/66	17.1	8.0	21.5	13.7	18.2	5.6	56.9	27.3
H54-775	16.5	10.7	17.3	12.0	12.3	5.6	46.1	28.3
H59-3775	15.0	9.4	14.6	8.8	9.0	3.1	38.6	21.3
s.e.	0.45		0.37		0.66		0.44	

Harvesting. The cane-cutters preferred the twelve-month cane; the 24-month cane was reported to be harder to cut, had lodged and was infested with weeds. Harvest was more difficult at Etoile and Union Park where cane was harvested green. At Gibraltar, where cane was burnt prior to harvest and loaded mechanically in the field by a grab loader, harvesting was easier.

Crop cycle of 16 or 20 months

Cane yield. The CC2 plots at Queen Victoria were harvested in plant cane and three ratoons, the latter twice after 16 months and once after 20 months (1994). The normal cycle (CC1) was harvested in plant cane and in four ratoons. The cumulative results showed a net difference in favour of the shorter cycle, the difference varying with variety and ranging between 4.4 and 29.2% (Table 6). An interaction between variety and cropping system was observed at Queen Victoria; varieties M3035/66 and M1557/70 did not show a significant difference between the two cropping cycles. In February 1994, severe cyclonic conditions resulted in complete lodging of the 14- to 15-month-old cane.

At New Grove, where the ratoons were harvested twice after 20 months (in 1993 and 1996) and once after 16 months, cumulative cane yields of CC1 plots were also found superior to the longer-cycle plots. Variety R570 was the least affected, followed by M3035/66 and M292/70.

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Table 6. Cane yields (t ha^{-1}) of sugarcane crops with cycles of 12 or 16–20 months at two sites over six years.

Variety and cycle (months)	1991	1992	1993	1994	1995	1996	Cumulative yield over six years†
			Queen Victoria				
R570							
12	141.4	125.3	115.9	107.5	86.9	—	577.0
16–20	122.4	138.8	—	139.3	93.8	—	494.2
M695/69							
12	102.1	117.6	93.8	96.6	82.8	—	492.9
16–20	90.1	125.4	—	133.4	94.1	—	348.9
M3035/66							
12	102.4	115.4	90.7	96.6	80.0	—	485.0
16–20	103.5	134.7	—	131.0	94.2	—	463.5
M1557/70							
12	111.0	122.2	94.7	87.7	77.9	—	493.6
16–20	111.8	138.0	—	123.3	84.6	—	457.7
			New Grove				
R570							
12	94.1	74.4	76.5	66.6	76.6	55.3	443.5
16–20	110.3	—	113.4	52.4	—	95.9	371.9
M292/70							
12	77.5	76.8	67.6	55.1	64.1	44.8	385.9
16–20	60.4	—	62.1	42.9	—	51.0	216.4
M3035/66							
12	88.1	76.7	80.2	61.3	78.1	55.9	440.3
16–20	86.2	—	93.2	64.5	—	91.4	335.3

† S.e. of cumulative yields at Queen Victoria: 8.96; s.e. of cumulative yields at New Grove: 10.66.

Sugar yield. The IRSC values of the longer cycle cane (CC2) were influenced greatly by the time of harvesting; poor values were obtained with some varieties when the canes were harvested in July particularly after 20 months (Table 7). On the other hand, the IRSC of the CC2 plots was higher than for the normal cycle when harvested in November. In the plots harvested in July, early maturing varieties such as M292/70 at New Grove and M1557/70 and M695/69 had an appreciable sucrose content.

Irrespective of site and variety, the cumulative sugar yield obtained when cane was harvested after 16 or 20 months was lower than with the traditional practice (Table 8). The difference in sugar yields between the two crop cycles varied between 7% and 49%; the smallest difference was recorded at Gibraltar with variety M1557/70 and the largest difference at New Grove with M292/70.

Weed control. The control of weeds in the 16-month cane was similar to that required in the traditional cropping cycle. When the crop was left standing over one year, more weeds were present at harvest (after 20 months) particularly in varieties which lodged. The infestation was, however, less severe than that observed in the 24-month cane.

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Table 7. IRSC values (%) of sugarcane crops with cycles of 12 or 16–20 months at two sites over six years.

Variety and cycle (months)	1991	1992	1993	1994	1995	1996
			Queen Victoria			
R570						
12	11.63	11.68	10.31	11.41	11.08	—
16–20	9.02	13.19	—	9.56	11.10	—
M695/69						
12	11.81	12.06	11.95	11.54	12.66	—
16–20	10.91	13.41	—	10.82	12.49	—
M3035/66						
12	11.88	11.86	11.72	12.44	12.44	—
16–20	8.78	13.59	—	9.86	12.54	—
M1557/70						
12	12.11	11.75	11.41	11.05	12.39	—
16–20	10.31	13.43	—	10.26	13.21	—
			New Grove			
R570						
12	11.5	10.42	11.03	10.40	11.06	10.85
16–20	12.33	—	8.33	11.48	—	8.40
M292/70						
12	13.01	12.17	12.58	12.51	12.70	13.16
16–20	12.94	—	10.26	13.30	—	10.07
M3035/36						
12	11.61	12.17	12.17	11.14	12.05	12.35
16–20	13.43	—	9.14	12.58	—	9.38

Table 8. Cumulative sugar yields (t ha^{-1}) for sugarcane varieties with cycles of 12 or 16–20 months at two sites.

	Queen Victoria		New Grove	
Varieties	12 months	16–20 months	12 months	16–20 months
R570	64.8	53.10	48.3	39.3
M695/69	59.0	52.80	—	—
M3035/66	58.4	52.2	52.4	36.8
M1557/70	57.9	53.9	—	—
M292/70	—	—	48.8	25.1
s.e.	1.42		1.80	

Attack by rats. In spite of regular applications of rodenticides, attack by rats was observed in CC2 plots which were harvested after 20 months. The damage was severe in variety M292/70 at New Grove and moderate in the other varieties at both sites.

Harvest. Some difficulties were experienced at the harvest of the 16-month cane harvested green at both sites. As cane had to be carried manually to field borders for mechanical loading, the longer stalks had to be cut into three pieces to

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facilitate handling. The presence of weeds and damage by rats rendered harvest of the 20-month-old cane even more difficult.

DISCUSSIONS

Only one variety, R570, seemed to respond to the 24-month cycle; the three Hawaiian varieties tested showed adaptation problems whereas stalks of M657/66, which flowers profusely, dried after the first year. Variety R570 produced erect cane, did not flower and produced many new tillers and stalks during the second year. The latter is an important characteristic for two-year crops (Cox *et al*., 1994). The differences in cane and sugar yields could have been less if the varieties used were more specific for such a cropping pattern. In Hawaii, the 24-month canes are uprooted by bulldozer at harvest and no ratooning is practised (Rivalland, 1990); the differences in cane and sugar yields between 12- and 24-month crops were more pronounced in the older ratoons. The ratoon maintenance costs were not reduced by the longer cropping cycle because fertilizer rates and applications, and costs for weed control did not change significantly. The higher yields obtained by 24-month cane in Hawaii were also influenced by efficient irrigation techniques, regular or late application of fertilizers by fertigation, use of ripeners and favourable climatic conditions (Noel, 1990).

The results obtained with the 16- or 20-month cycle were intermediate between the 24-month cycle and the traditional one. The interaction between variety and cropping cycle observed at Queen Victoria showed some potential for this practice. Early maturing varieties showed a definite advantage (high IRSC) when the CC2 plots were harvested in July. In addition to very small savings on the ratoon maintenance costs, the adoption of such a practice would create problems for planning the harvest, harvest being restricted to only two months. The effect of a strong cyclone on 15-month-old cane as observed at Queen Victoria, should be a matter for concern if longer crop cycles are envisaged.

CONCLUSION

The traditional 12-month crop cycle was the best cropping pattern under the local conditions and it yielded significantly more than both the 24-month and the 16- to 20-month cycles. After six years, cane yields were reduced by 19% to 48% and sugar yields by 22% to 60% in the 24-month-old canes, the level of reduction varying with cane variety. Reductions in cane and sugar yields were smaller ranging between 5–44% and 7–49% respectively when cane was harvested after 16 or 20 months. More weeds at harvest, damage by rats, more difficult harvesting and risk of loss of crop by a cyclone or fire during the second year of growth are also important factors which together militate against the adoption of the longer crop cycles under Mauritian conditions.

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