

DETERIORATION LOSSES IN WHOLE STALK SUGARCANE

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Abstract

A series of trials was carried out to determine the losses in cane weight, the reductions in recoverable sugar content, and the changes in juice quality and chemical composition, following the harvesting of whole stalk cane which was either unburnt, burnt and cut immediately, or burnt and allowed to remain standing for a number of days before harvest.

It was concluded that all cane starts to deteriorate immediately it is harvested or burnt, and that the rate varies according to weather conditions. Unburnt cane deteriorates more rapidly than burnt cane during the week immediately following harvest, but thereafter burnt cane tends to deteriorate more rapidly.

The recommendations are that all cane should be milled as soon as possible after harvest, and only enough cane should be burnt to meet the requirements of one day's harvesting.

Introduction

It has long been realised that both grower and miller would benefit considerably if it were possible to process cane immediately after it is harvested, though in practice this never happens. Delays of three or four days, and often much longer, between harvesting and milling are common within the industry. Such delays result in losses of recoverable sugar due to deterioration of cane quality, and they are of considerable economic importance to the industry as a whole.

A number of Australian workers (Barrie², Egan³, Young⁷ and Waddell^{5 6}) have reported on weight and sugar losses following the harvesting of whole stalk cane. Changes in juice quality and its chemical composition, the effects of burning, weather and varieties have also received attention.

The imminent introduction into the South African industry of a cane payment system based on recoverable sugar rather than sucrose content of cane has served to emphasize the need for information on whole stalk deterioration under different seasonal and harvesting conditions. In this paper the results are reported of a series of deterioration trials, conducted jointly by the Sugar Industry Central Board, the Sugar Milling Research Institute and the SASA Experiment Station, between November 1970 and February 1972.

Materials and Methods

A series of five trials was carried out at the Experiment Station, covering early, middle and

late periods of the harvesting season (April - February). Plant and ratoon cane of the variety NCo 376 was used. The age of the cane varied from 17 to 21 months.

Three of the five trials comprised the following treatments;

- A. Unburnt cane all harvested into 9-stick bundles on day 0. (Unburnt cut)
- B. Cane burnt and harvested immediately into 9-stick bundles on day 0. (Burnt cut)
- C. Cane burnt and left standing in the field, and only harvested into 9-stick bundles on the days on which sucrose testing was carried out. (Burnt standing).

In the two remaining trials (1/71 and 3/71) treatment C was omitted. All cane was topped at the base of the fifth leaf sheath.

In addition sufficient composite 12-stick bundles of cane from all treatments were collected so that reducing sugars and "dextran" (gums) could be determined in first expressed juice, during each trial. In the final trial (1/72) pH and starch content of the juice were also determined.

Sampling in the field was randomised within replicates. Treatments A, B and C (contained within one cane row) were replicated six times in all but one trial (3/71), when only five replicates were present. The analyses were carried out on days 0, 1, 2, 3, 4, 7, 11, 15 and 21 after harvesting the cane.

On day 0 all unburnt cane bundles required for the duration of the trial were first removed from the area. The cane was then burnt and all samples to be cut immediately were similarly harvested. The burnt cane then remaining was harvested when required.

All bundles of cane for treatments A and B were weighed on day 0, and excepting for the day 0 samples they were returned and stacked in the field. Selected bundles were subsequently reweighed on the day of analysis for sugar content, in order to determine the weight loss during the intervening time.

On each day of analysis after harvest, six of the 9-stick bundles from each treatment were sent to the Central Board laboratory, Mount Edgecombe, for direct pol/purity/fibre determinations (Anon¹) on the clean whole sticks. The comparable 12-stick bundles were dispatched to the Sugar Milling Research Institute for various analyses as described above.

Treatments and harvesting details are summarised in Table I.

TABLE I
Summary of sampling periods, cane age and treatments harvested

Trial number	Period covered	Cane age (months)	Treatments* harvested
2/70	Nov.-Dec. 1970	18 (P)	A, B, C
1/71	Mar.-Apr. 1971	18 (P)	A, B,
2/71	Jul.-Aug. 1971	21 (P)	A, B, C
3/71	November 1971	17 (1R)	A, B,
1/72	Jan.-Feb. 1972	18 (2R)	A, B, C

* A = unburnt cut B = burnt out C = burnt left standing

Results and Discussion

The data in Table II show the changes which occurred in purity, sucrose, estimated recoverable sugar (E.R.S.)* and units of recoverable sugar at intervals over a period of 21 days after harvesting each trial. The means from all trials for the three harvesting treatments are also given. The data have been adjusted for changes in weight which occurred as the trials progressed. In burnt standing cane where no "day 0" weights were available, adjustment was made on the basis of the average initial weight of burnt cut cane, and in consequence the estimates of weight change are less reliable.

Waddell^{5, 6} and Young⁷ reported that stalk weights increased by 2.5% to 5.0% in standing cane during the first few days after burning, and weight gains noted in trial 1/72 support their observations. This is probably due to uptake of water from the soil by the undamaged root system of the cane plant when leaf transpiration is halted or much reduced. Evaporation losses, however, must still have occurred through the ruptured stalk.

Purity sucrose, E.R.S.* and weight change

A decline in purity, sucrose and recoverable sugar was observed from the time cane was cut or burnt in all instances except one (trial 2/71). Rates of deterioration varied according to weather conditions, being relatively slow in the cool, dry winter period (July-August) and most rapid in the hot humid summer months (December-March) towards the end of the season.

The average data indicate that rates of deterioration differed considerably between the three harvesting treatments. During the first 7 days after harvest, decline in juice purity (see fig. 1A) was more rapid in the unburnt cut than in burnt cut cane, this being reflected in the amount of recoverable sugar (see fig. 1B). Subsequently the position was reversed, a rapid decline in juice purity occurring in the burnt out cane in the latter part of each trial.

In the burnt cane left standing a higher juice purity was maintained for a longer period than in either of the other treatments (see fig. 1A).

*ERS % cane = $S - 0,485 \left(N + \frac{F}{8,5} \right)$, where

S = sucrose content, N = non-sucrose content and F = fibre content of the cane.

Despite this, the decline in recoverable sugar was rapid (see fig. 1B) and remained well below that in cane cut immediately after burning, during the first part of each trial.

The results show that burnt cut cane consistently lost weight at a faster rate than did unburnt cane (see fig. 1C). Weight losses from cane subjected to these two treatments during the various trials as shown in Table II, clearly reflect the effects of temperature and rainfall.

Reducing (invert) sugars

Figure 2A (based on average data) shows that almost from the time of harvest the increase in the amounts of reducing sugars was greater in the unburnt cane than in any of the burnt cane. This can be related directly to the more rapid decline in purity already noted in the unburnt cane, which was mainly due to inversion. This confirms the findings of Waddell⁶. He proposed that a pre-harvest burn effectively sterilizes part of the stalk, covering it with a protective coating of charred material or concentrated juice which delays infection by micro-organisms causing deterioration. However, the unburnt cane stalk remains unsterilized and unprotected so that micro-organisms are able to enter the stalk near the eyes and in cracks to cause inversion of the sucrose.

Alternatively enzymatic activity may be reduced in burnt cane as a result of the high temperatures during burning, whereas cutting unburnt cane might stimulate bud development, so causing an increase in the production of reducing sugars.

Only towards the latter part of each trial was there a marked increase in reducing sugar content of the burnt cane, and purity then declined sharply. (see fig. 2A).

Starch content

Figure 2B shows that during trial 1/72, the starch content of the first expressed juice from the unburnt cut cane fell rapidly from 1100 to 400 ppm in the first four days following harvest. The decline in starch content was much more gradual in juice from the burnt cut cane, some 600 ppm remaining after 21 days, while only a small reduction was noted in the burnt cane left standing. It is interesting to note that the unburnt cane which showed the most rapid increase in reducing sugars also showed greatest reduction in starch content. This also suggests differences in rate of enzymatic activity between burnt and unburnt cane.

"Dextran" (gums)

Changes in "dextran" content of the first expressed juice of cane from the various treatments during a winter and a summer period are shown in figs. 3A and 3B. In the unburnt cut cane there was virtually no variation in dextran content either in the winter or summer months. However, the burnt cut cane showed a considerable increase in "dextran" in the latter part of each trial, the amount present being higher in the summer months when rate of deterioration was faster. "Dextran" was detected only a few days after burning in the cane left standing during the

TABLE II
Summary of the results from the deterioration trials (means of six replicates)

Trial 2/70 Nov. - Dec. 1970 (Mean temp. 22,7°C - Rainfall 86,4mm)															
Day	A. Unburnt cut					B. Burnt cut immediately					C. Burnt left standing				
	Purity %	Sucrose %	E.R.S. %	Units recov. sugar	Wt. loss or gain %	Purity %	Sucrose %	E.R.S. %	Units recov. sugar	Wt. loss or gain %	Purity %	Sucrose %	E.R.S. %	Units recov. sugar	Wt. loss or gain %
0	91,7	13,70	12,50	100	—	91,5	13,70	12,40	100	—	91,5	13,60	12,30	100	—
2	89,0	13,15	11,69	94	-2,6	89,7	13,08	11,66	94	- 5,2	88,7	11,80	10,42	85	- 1,7
4	87,3	12,69	11,07	89	- 4,6	88,0	13,24	11,64	94	- 5,4	85,7	10,35	8,81	72	- 4,2
7	88,0	12,84	11,24	90	- 6,3	81,7	12,01	10,09	81	- 8,3	83,8	9,72	8,10	66	+1,3
11	85,2	12,36	10,64	85	- 9,1	66,5	9,18	6,29	51	-12,6	71,3	8,43	6,07	49	+2,8
21	68,0	9,24	6,44	52	-15,2	47,5	5,74	1,99	16	-26,4	44,7	4,63	1,18	10	-9,3
Trial 1/71 Mar. - Apr. 1971 (Mean temp. 22,8°C - Rainfall 178,4mm)															
0	87,8	13,28	11,65	100	—	86,6	13,01	11,30	100	—	—	—	—	—	—
2	84,5	12,74	10,88	93	- 2,1	84,5	12,55	10,69	95	- 2,6	—	—	—	—	—
4	80,4	11,89	9,76	84	- 4,7	83,7	12,63	10,70	95	- 4,9	—	—	—	—	—
7	77,6	11,46	9,12	78	- 5,3	82,3	11,95	9,96	88	- 7,3	—	—	—	—	—
11	74,2	10,64	8,12	70	- 7,5	74,4	10,33	7,87	70	-10,8	—	—	—	—	—
21	67,9	9,58	6,66	57	- 8,0	66,8	8,17	5,50	49	-15,4	—	—	—	—	—
Trial 2/71 Jul. - Aug. 1971 (Mean temp. 16,°C - Rainfall 28,8mm)															
0	91,5	15,25	13,88	100	—	90,1	15,28	13,77	100	—	91,5	15,25	13,86	100	—
2	90,7	15,33	13,89	100	- 1,9	90,5	15,43	13,95	101	- 2,4	90,6	15,17	13,68	99	+1,0
4	87,3	14,81	13,08	94	- 3,5	90,2	15,20	13,70	99	- 4,0	90,6	14,11	12,71	92	-2,9
7	81,9	13,55	11,37	82	- 4,4	89,1	14,98	13,36	97	- 4,4	89,8	13,36	11,89	86	-5,2
11	80,5	13,09	10,82	78	- 7,0	82,9	14,13	12,32	89	- 7,3	90,3	15,06	13,42	97	+7,2
21	76,0	12,27	9,72	70	- 8,7	75,8	11,65	9,17	67	-10,7	84,9	12,70	10,88	78	-1,3
*Trial 3/71 November 1971 (Mean temp. 20,2°C - Rainfall 55,6mm)															
0	91,5	16,67	15,26	100	—	90,9	16,44	14,97	100	—	—	—	—	—	—
2	89,6	16,00	14,45	95	- 0,0	90,4	15,70	14,20	95	+ 1,0	—	—	—	—	—
4	90,7	15,61	14,13	93	- 0,6	91,1	15,90	14,35	96	- 0,1	—	—	—	—	—
7	86,9	15,27	13,41	88	- 2,5	87,3	15,33	13,51	90	- 2,6	—	—	—	—	—
11	82,7	14,33	12,17	80	- 6,1	82,5	14,15	11,97	80	- 7,2	—	—	—	—	—
21	75,1	13,20	10,39	68	- 9,8	74,4	11,68	9,01	60	-13,4	—	—	—	—	—
Trial 1/72 Jan. - Feb. 1972 (Mean temp. 24,3°C - Rainfall 4,9mm)															
0	91,8	16,17	14,79	100	—	91,3	16,08	14,66	100	—	91,3	16,08	14,66	100	—
2	89,0	15,60	13,93	94	- 3,5	89,5	15,77	14,16	97	- 3,7	88,6	15,91	13,89	95	+8,8
4	83,7	14,69	12,59	85	- 5,6	88,3	15,51	13,79	94	- 6,2	87,2	15,00	13,01	89	+4,2
7	80,1	13,61	11,29	76	- 8,4	85,2	14,48	12,53	85	- 9,7	85,0	14,56	12,36	84	+5,1
11	76,7	13,28	10,64	72	-11,2	76,8	12,65	10,08	69	-14,6	80,1	13,42	10,68	73	+4,7
21	70,9	11,85	8,84	60	-18,2	63,4	9,50	6,14	42	-25,7	63,4	9,44	5,70	39	-2,1
Mean	Five trials					Five trials					Three trials				
0	90,9	15,01	13,62	100	—	90,1	14,90	13,42	100	—	91,3	14,98	13,61	100	—
2	88,6	14,56	12,97	95	- 2,0	88,9	14,51	12,93	96	- 2,6	89,3	15,02	12,66	93	+2,7
4	85,9	13,94	12,13	89	- 3,8	88,3	14,50	12,84	96	- 4,1	88,3	13,15	11,51	85	-1,0
7	82,9	13,35	11,29	83	- 5,4	85,1	13,75	11,89	89	- 6,5	86,8	12,55	10,78	79	+0,4
11	79,9	12,74	10,48	77	- 8,2	76,6	12,09	9,71	72	-10,5	82,0	12,30	10,06	74	+4,9
21	71,6	11,23	8,41	62	-12,0	65,6	9,35	6,36	47	-18,3	69,1	8,92	5,92	43	-4,3

* Means of five replicates only.

summer period, the amount increasing rapidly, but finally not equalling that in the burnt cut cane.

According to Egan (1968) gums in this context may be defined as "alcohol-precipitable, water soluble polysaccharides of high molecular weight, and include many of the normal gum constituents of sugarcane as well as such deterioration products as dextran". The method used by S.M.R.I. for the determination of "dextran" was that developed by Nicholson and Horsley (1959).

pH of juice

Figure 3c shows that the pH value of juice from unburnt cane dropped only slightly during trial 1/72, while in juice from the burnt cut cane it fell from 5,2 to 4,8. A rapid decline in pH was recorded however in the juice from burnt standing cane, the value falling from 5,3 to 4,3 between days 4 and 15. This indicates the presence of considerable numbers of acid forming bacteria, and the possible formation of acetic and lactic acid. Waddell⁶ has suggested that a fairly rapid dilution of juice and circulation of soil water in the burnt standing treatment may tend to encourage and spread the action of micro-organisms.

Conclusions

1. Cane starts to deteriorate from the time it is harvested whether it is unburnt, burnt and cut immediately, or burnt and left standing.
2. Rates of deterioration vary considerably depending on weather conditions, being most rapid in the hot humid summer months. Except in winter losses of recoverable sugar during the week following harvest average 2-3 percent per day.
3. Unburnt cut cane dries out more slowly than does burnt cut cane. However, purity of juice from unburnt cane generally declines more rapidly than that of juice from burnt cut cane, at least during the week immediately following harvest. This is reflected in the much larger amount of reducing sugars present in unburnt cane at the end of this period.

4. Recoverable sugar from burnt standing cane seldom equals that from cane cut immediately after burning. In addition the dilution effect caused by the uptake of water after burning may reduce the sucrose and E.R.S. contents. The practice of burning more cane than can be harvested in one day is therefore not recommended.
5. Deterioration products such as dextrans form relatively more quickly in burnt cut cane than in unburnt cane, although only small amounts are generally found in all types of harvested cane until about 10 days or even longer after harvest.
6. Cane should be transported to the mill for processing as soon as possible after harvesting if substantial losses of sugar are to be avoided.

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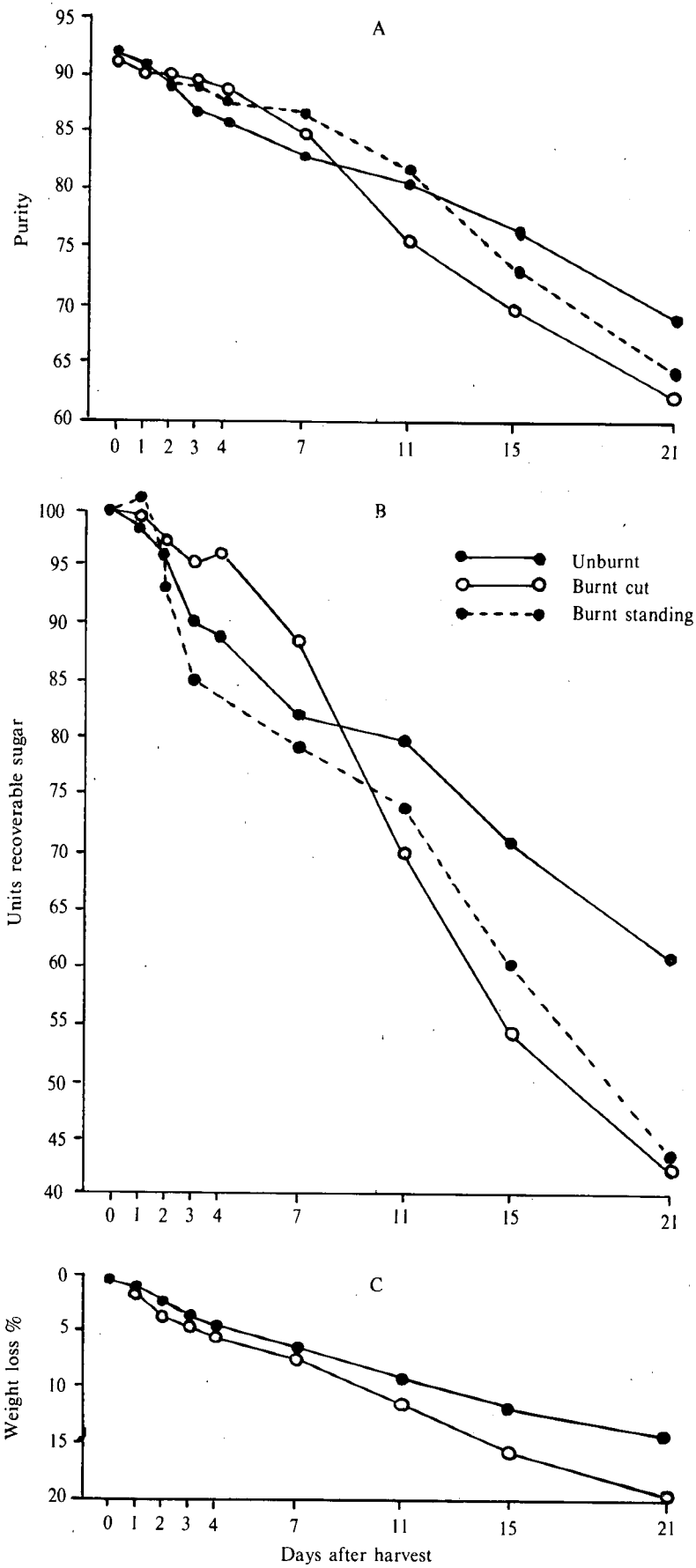


Figure 1. Decline in purity, recoverable sugar and weight with time of whole stalk cane (means of three trials).

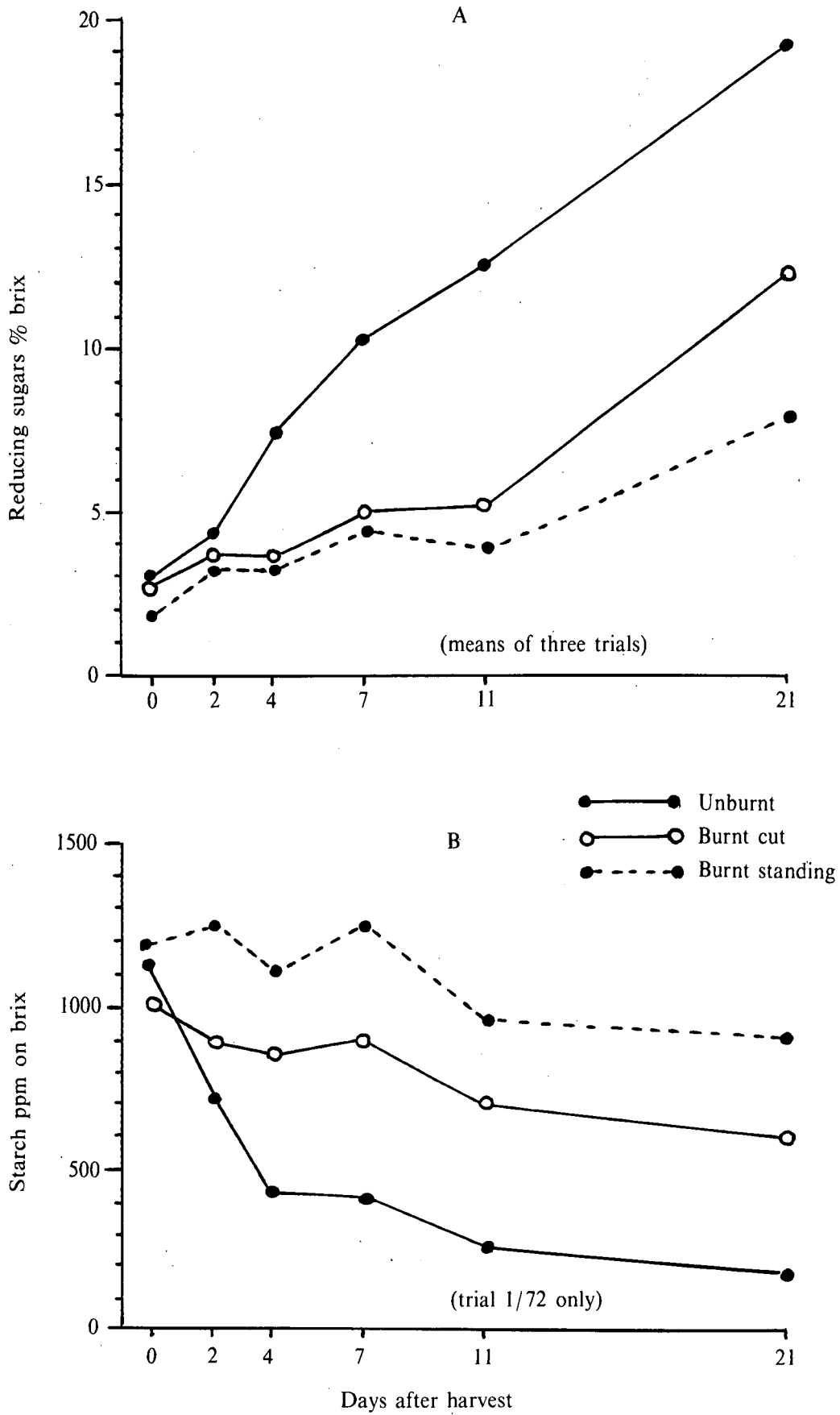


Figure 2. Changes in reducing sugars and starch content with time, after three cane harvesting treatments.

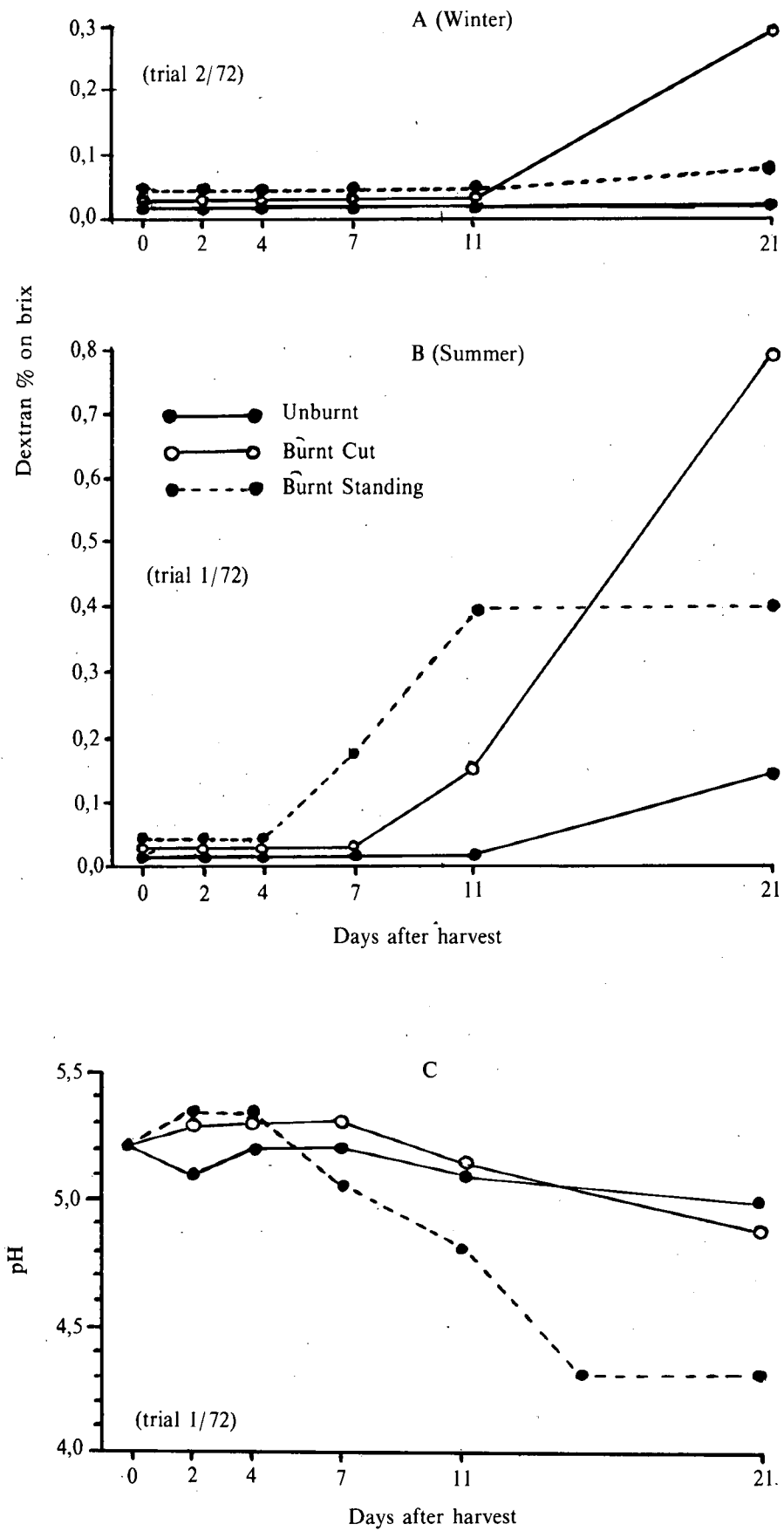


Figure 3. Changes in 'dextran' and juice pH with time after three cane harvesting treatments.