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BALCH, R T ; BROEG, C B ; LAURITZEN, J I

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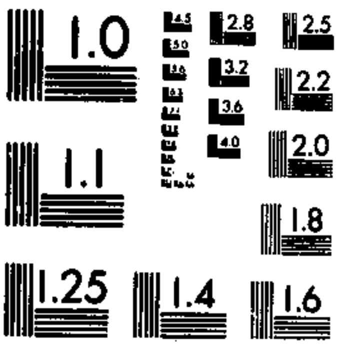

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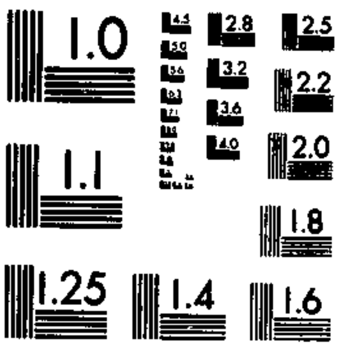

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Effect of Burning on the Deterioration of Sugarcane Under Louisiana Conditions[1]

By R. T. Balch, *senior chemist*, and C. B. Broeg,[2] *associate chemist, Agricultural Chemical Research Division, Bureau of Agricultural and Industrial Chemistry*, and J. I. Lauritzen,[3] *formerly senior plant physiologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

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INTRODUCTION

Mechanization and shortage of labor have revolutionized sugarcane-harvesting operations in Louisiana during the past decade. To mention but one of these changes, the removal of trash by hand has been largely replaced by a burning operation after the cane is cut by machine at top and bottom and placed across adjacent ridges with two or more rows forming heap-rows. It has been realized that this burning causes a certain amount of damage which has not been fully evaluated.

Cut cane normally decreases in value in two respects whenever there is an appreciable delay in its milling: It loses weight through evaporation of moisture from the stalks and it loses sucrose and quality through enzymic deterioration. Burning apparently causes cane to change its usual deterioration characteristics and it may also cause, indirectly, other and more serious changes in sugarcane that is not promptly milled.

Unfortunately, a considerable delay often occurs under Louisiana conditions and usually in field operations. Weather conditions, of course, greatly affect these losses in weight and sugars; but other important factors, such as the variety and age of the cane, also have considerable influence. The early part of the harvesting season is usually the more critical, barring freezing injury later, both because

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the generally warm and relatively dry weather prevailing then favors these losses and because sugarcane seems to show a minimum of resistance toward deterioration at that time.

If the seasonal average in weight loss should amount to 1 percent per day, the crop would shrink approximately 45,000 tons each day that cut cane was held in the field. Thus, if the average delay between cutting and milling should be 5 days, which is likely, cane growers may be losing 225,000 tons of cane, annually, worth about 1½ million dollars. The losses in sucrose and in quality penalize the processor, principally, for it means a lower yield of sugar and, often, increased operating difficulties.

In order to obtain more basic information on the effect of burning on mill cane, especially under Louisiana conditions, so as to evaluate better the losses which are brought about by delayed milling, a rather detailed study of the subject was undertaken by the authors. This paper deals with only one phase of the problem; namely, the relative effects of moisture and temperature on the deterioration characteristics of burned cane in comparison to those of unburned cane stored under the same conditions. Unfortunately, the data are not translatable into terms of field practices, but it is expected that further work will supply this information.

DIGEST OF LITERATURE

Data and conclusions resulting from the many previous attempts to evaluate the damage caused to harvested mill cane by burning trash are somewhat conflicting. This situation is not very surprising when one considers the differing experimental conditions and varieties and ages of cane that were used in these studies. The principal criteria used for assessing the damage were cane weight and sugar losses encountered while the cane was held for varying periods after being burned and cut down. It should be mentioned that outside of Louisiana it is customary to burn the cane while standing rather than afterwards. It is believed, however, that this difference in practices has no real significance in interpreting the results.

The effect of burning on weight loss in stored cane has not been too well established. The views would be less conflicting, perhaps, if the complete experimental conditions were known. Verett (*15*)[4] and Dymond (*9*) found, for instance, that burned cane stored in the field under low humidity conditions lost weight at a much more rapid rate than did unburned cane. Elliott (*10*) and de Froberville (*11*) obtained similar although much less striking results. On the other hand, Bechard (*4*) and Dodds and Fowlie (*6, 7, 8*) report an opposite finding but the differences between their burned and unburned cane samples were so small that they probably are not significant. In the latter group of tests the cane was bundled in lots of 500 to 1,000 pounds each, placed on the ground, and subjected to prevailing weather conditions. Lauritzen (*12*), in Louisiana, storing cane in a shady location, found, averaging 4 tests, no difference between burned and unburned cane with respect to the rate of weight loss. In another test conducted under field conditions, he found that burning had an adverse effect but

[4] Italic numbers in parentheses refer to Literature Cited, p. 21.

he stated that the cane weights were subject to error and may have been incorrectly determined and reported.

These various data are summarized in table 1. The important fact brought out in the table is the relatively large loss of weight shown for cut cane, whether burned or not, while being held for milling under field conditions. It is obvious that further testing should be done under actual field conditions, where drying is apt to be more severe, to determine whether or not there are any situations in Louisiana which would cause burned cane to behave differently from unburned cane, in respect to rate of weight loss.

TABLE 1.—*Published data on cane weight losses in burned and unburned cane*

Number of tests	Duration of tests	Daily rate of weight loss		Origin of data	
		Burned	Unburned	Country	Reference No.
	Days	*Percent*	*Percent*		
	8	2.89	1.94	Hawaii	15
5	8	3.49	2.83	do	10
7	5 to 13	1.60	1.47	S. Africa	11
2	9	2.49	1.23	do	9
1	3	.88	1.01	do	4
1	11	.96	1.05	do	6
1	15	.42	.54	do	17
1	15	1.08	1.18	do	18
4	5 to 14	.89	.89	Louisiana	12

The sucrose loss in sound, unburned cane in storage has been studied many times, but most critically by Lauritzen, Balch, and Fort (*13*). The principal result of deterioration in such cane is the hydrolysis of sucrose to form reducing sugars. The other changes are of little consequence, normally, and are detached only with difficulty. Resistance to deterioration, or lack of it, is a varietal characteristic; but many factors alter the behavior of any variety of cane placed in storage after being cut.

Moisture balance plays a dominant role in deterioration. The hydrolytic process is held in check by maintaining storage conditions which prevent the loss of moisture and, conversely, deterioration is favored by storing cane under drying conditions. Temperature is a minor factor. The maturity of the cane is also important, since cane becomes more resistant to deterioration with the advance of the harvesting season. It is possible that exposure of the growing cane to temperatures close to freezing is the important factor in this connection rather than the extra month or two of growth. It has not been possible to establish the true reason because these two factors have not been separable.

The effect of burning on the deterioration characteristics of harvested cane has also been variously reported. These studies yield some definite conclusions. It is necessary to assume that mill cane from which trash has been removed by burning is physically damaged by the heat of the fire with the result that some of its life processes are either destroyed or definitely impaired (*9*), and also that the damage to the various parts of the stalks is not uniform owing to the varying intensity of the fire from spot to spot. This loss of life or injury to the cells of the stalks makes them subject to invasion by micro-organisms which produce nonsugars at the expense of sugars. Thus, in burned cane one can expect to encounter two types of deterioration: one the result of the natural, though impaired, processes that cause inversion of sucrose and the other the result of the action of micro-organisms. Factors which affect either one or both of these processes bear upon the type and rate of deterioration which burned cane undergoes when held in storage.

In many of the investigations dealing with the behavior of burned cane in storage no recognition was given to the influence of moisture in bringing about deterioration. Many of the tests were made under drying conditions and it was found in these cases that burned cane usually kept better than unburned cane. This lends proof to the assumption that burning partially destroys the enzymic system of the stalk which is responsible for sucrose hydrolysis and that dry storage conditions retard the growth of micro-organisms. When the storage period is sufficiently long (only a few days is generally required), however, the degree of deterioration of burned cane usually equals or exceeds that of the unburned cane. This result unquestionably reflects the increasing activity of micro-organisms.

The effect of high moisture conditions on deterioration in quality of burned cane has been variously reported. Williams, Hugh, and Singh (*16*) and others (*1, 5*) decided that sprinkling burned cane or keeping it covered with trash, after it was cut, was beneficial or had no ill effect. Others concluded, however, that high moisture conditions promoted deterioration. In Cuba processors were allowed, by contract, to refuse burned cane at any time during rainy weather but they would accept burned cane in dry weather for periods up to 5 days after burning (*14, p. 16*). The inference is that moisture is conducive to deterioration of burned cane. Recently, factual evidence has been presented to support this conclusion.

Wold (*17*), making a number of tests on burned cane stored in various ways, showed that it kept better under dry conditions than under wet conditions. These results gave only a partial picture as he made no comparisons with similar cane which had not been burned. Such a comparison was made by Lauritzen (*13*) and his data show that burned cane usually has deterioration characteristics opposite to those of unburned cane. It appears that the patterns of deterioration in mill cane following the removal of trash by fire are quite similar to those following a freezing injury. It may be assumed on this basis that any type of injury which allows the cane stalks to be invaded by micro-organisms will produce rather similar effects and that under any set of storage conditions the rate of deterioration will vary largely with the degree of injury and activity of the micro-organisms. These points, however, are difficult to demonstrate.

The principal criteria for measuring sucrose losses through deterioration in the studies reviewed were changes in apparent sucrose (either as sucrose in juice or in cane or calculated available sugar) and changes in apparent purity. Glucose determinations were made in a few instances as a check on sucrose hydrolysis. These determinations are quite satisfactory in studying deterioration of sound, unburned cane, but do not yield a clear picture of the chemical changes which result from the action of micro-organisms. Changes in pH and acidity are quite useful criteria in this connection and only Dodds and Fowlie (*6*) report such values. They found that the acid content increased more in burned than in unburned cane stored under similar conditions, as might be expected.

Sucrose losses vary so greatly with environmental conditions that an average of the available data would not have much meaning. It is sufficient to say that the sucrose loss in either burned or unburned cane has been shown in the literature to be enormous within a few days with some varieties under certain conditions.

EXPERIMENTAL CONDITIONS

Sampling.—The method of sampling cane was essentially the same in all of the experiments to be reported. Two adjacent heap-rows cut by machine and consisting of three rows of cane each, furnished material for the samples. One heap-row was burned when conditions were most appropriate and in accordance with usual field practice: the other heap-row was left unburned. The number of samples of each type selected varied with the experiment and was determined by multiplying the number of planned storage conditions by the number of storage periods after which the cane was to be analyzed, all replicated 5 times, plus 5 samples for the check, or initial, analyses. For the open-air storage test, 35 samples were selected for use under 2 conditions and for 3 storage periods. For the tests conducted under controlled conditions, 6 variations were used with either 2 or 3 storage periods. Thus either 65 or 95 samples of burned and of unburned cane were selected for these experiments.

The samples were obtained by taking the cane from the selected part of the heap-row and placing 1 stalk at a time in sequence in as many piles as the required number of samples until the desired number of stalks, usually 20, were accumulated in each pile. The cane in each pile was then stripped of trash or of any unburned matter, bound and taken to the storage house. All bundles of cane were weighed. After removing the check samples an equal number of bundles representing each type of cane was placed at random under the selected storage conditions. The check samples were milled as promptly as possible after being brought from the field. At convenient intervals (from 2 to 4 days), 5 replicated bundles of cane representing each storage condition were removed from storage, reweighed, and milled.

Storage.—In the open-air storage test burned and unburned cane were placed in racks. Half of each type of cane was sprinkled three times daily and the remainder was left "dry." Some rain fell during the course of the experiment which somewhat affected the results obtained on the dry cane, as will be discussed later.

For the tests under controlled conditions, the cane was placed in insulated, constant-temperature rooms, 10 feet by 12 feet by 9.5 feet high, in suitable racks off the floor, to allow a relatively free movement of air around the bundles of cane. The air was circulated by the electric fan of the refrigerating unit. Humidity of the rooms was manually controlled, with water humidifiers supplemented by sprinkling used for high humidity conditions and calcium chloride driers of suitable capacity used for drying conditions. Temperatures and humidities (to be reported later) varied between experiments.

Cane varieties.—The open-air storage test was made on C. P. 29/120, second stubble cane. The tests under controlled conditions involved the following C. P. varieties: 29/120, plant cane; 34/92, first stubble; 34/120, first stubble; and 36/105, second stubble. The inversion ratings found for these varieties are, respectively, 2.3, 3.6, 1.7 and 3.6.[5] Co. 281 with a rating of 1.0 was used as a comparative standard in determining the rating of the other varieties.

Juice extraction.—The individual bundles of cane representing both the check samples and the samples after selected intervals of storage were passed one time through a 3-roll, motor-driven cane mill adjusted to give about 60 percent juice extraction. Unfortunately, the extraction of duplicate sets of bundles on different days was not as uniform as was desirable, and the variations doubtless affected the composition of the juices to some degree. The error, however, is not believed sufficient to alter the conclusions. The juice from each bundle of cane was screened through 16-mesh wire cloth and an aliquot taken for routine analysis. The data so obtained were appropriately averaged. For the detailed analysis, a composite juice sample was prepared from each group of replicated bundles of cane, thoroughly mixed, and given an additional screening through 200-mesh wire cloth.

Methods of analyses.—Routine testing of the juice samples consisted of determining the Brix solids by hydrometer, apparent sucrose by polarization (Pol), and apparent purity by calculation, using the customary methods (*2*). Many of the juice samples from burned cane stored under wet conditions for periods of 6 or more days could not be cleared for polarization by the customary use of basic lead acetate. In these cases it was necessary to resort to the use of alcohol plus basic lead acetate on 2 normal weights of juice subsequently made up to 100 ml.; and even then the clarity of the resultant solution was often not too good.

The detailed analyses consisted of the following determinations: pH, electrometrically, using glass electrode; acidity, by titrating 10 ml. of the screened juice with N/10 alkali using phenolphthalein as the indicator; sucrose, by a standard chemical method (*3, p. 569*) involving the determination of reducing sugars before and after inversion with invertase employing the Lane-Eynon method (*3, p. 570*) with 10 ml. Fehling's solution; total sugars, by summation of the initial reducing sugar content and sucrose; dry substance, by drying weighed samples of juice on sand under reduced pressure at 70° C. (*3, p. 557*); and nonsugars, by subtracting total sugars from the dry substance value.

EXPERIMENTAL RESULTS

Since each of the five tests made in this series involved some change in conditions, it was felt that the data could not be consolidated or

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[5] Unpublished data of Division of Sugar Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering.

averaged satisfactorily. The results of each experiment are therefore presented and discussed separately.

Experiment 1.—This test was made on C. P. 29/120 cane early in the harvesting season. The cane was stored under prevailing open-air conditions which are summarized in table 2. Rain falling on 4 out of 6 days largely prevented the cane stored under "dry" conditions from losing weight after the third day. The weight loss would have been much greater had the original dry weather continued for the duration of the experiment.

TABLE 2.—*Conditions during period of open-air storage of burned and unburned (sprinkled and not sprinkled) cane (C. P. 29/120)*

Date	Rainfall	Temperature		
		Maximum	Minimum	Mean
	Inches	*° F.*	*° F.*	*° F.*
October 1947:				
17	0	89	65	77
18	0	89	61	75
19	Trace	91	62	76.5
20	.30	82	62	72
21	1.75	83	63	73
22	0	85	64	74.5
23	.12	86	66	76
Total and averages	1.17	86.4	63.3	74.9

Routine analyses of the juice samples from both the burned and unburned cane were made after 3, 4, and 6 days. These data are plotted in figure 1. The detailed analyses were made after 3 and 6 days' storage and are reported in table 3. The data appear as changes in composition, that is, as deviations from the values obtained on the juice from the check samples of cane.

The lot of cane used in this experiment exhibited a low degree of resistance to deterioration. This low resistance was reflected in the high rate of sucrose loss and the drop in purity even in juice from cane stored under the most favorable conditions. This characteristic is usually shown by early harvested cane. Typically, the most rapid drop in purity occurred in unburned cane stored under dry conditions—there was a drop in purity of over 19 points in 6 days. Burned cane stored under wet conditions, the best conditions under which to keep unburned cane, deteriorated almost as rapidly as the unburned cane left unsprinkled. There seemed to be no significant difference in the rate of deterioration of burned cane under dry conditions and unburned cane kept moist. In this experiment the burned cane thus showed a deterioration pattern that was opposite to that of the unburned cane.

Judging from the rapid invasion of the burned cane under moist conditions by micro-organisms, the cane must have been severely damaged by the heat of the trash fire. After 6 days of storage, this cane yielded juices that could not be clarified without the aid of alcohol to precipitate the gums formed by bacterial action. Examination of

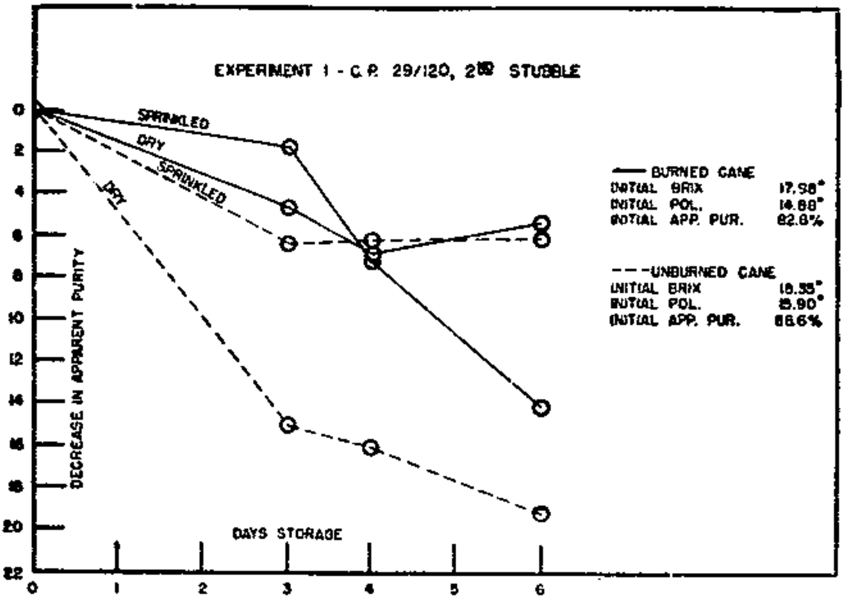

FIGURE 1

FIGURE 1.—Data from routine analyses of juice samples from burned and unburned cane (C. P. 29/120, second stubble) after storage.

the juices showed a large inoculum of yeast which must also have contributed to the deterioration.

The detailed analyses of the juices from burned cane that was sprinkled showed a progressive and pronounced drop in pH, increase in acidity, a large loss of sucrose without an accompanying formation of reducing sugars, and a substantial increase in nonsugars during storage. Under dry conditions, the action of micro-organisms must have been held in check as the changes in the composition of the juices from the cane thus stored were found to be similar to those occurring in unburned cane, as shown also by the routine analyses.

These results indicate that the principal effect of burning on cane is physiological. The stalks apparently lost their ability to ward off invasion by micro-organisms when conditions were favorable for their growth and the enzyme system of the cane stalks responsible for inversion of sucrose seemed to have been greatly impaired: otherwise, burned cane stored under dry conditions would not have kept so well.

The relatively high air temperatures that prevailed during this experiment undoubtedly contributed toward the rapid rate of deterioration, especially where the growth and activity of micro-organisms were involved.

The physical conditions for burning the trash, in this test, were most favorable. The warm, dry weather following the cutting of the cane quickly dried the leaves. The burning was judged excellent. To obtain information on the degree of heating to which the cane stalks were subjected in burning off the trash, a thermocouple was inserted underneath the rind and parallel to the surface of a stalk of cane

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TABLE 3.—*Experiment 1 (detailed analyses), C. P. 29/120, second stubble, stored in open-air October 17–23, 1947*

Field treatment of cane	Initial composition		Storage conditions		Changes in juice composition [1]						Changes in cane weights
	Item	Value	Treatment	Period	pH	Acid	Sucrose	Reducing sugars	Nonsugars	Solids	
				Days		*Ml.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Burned	pH	5.25	Sprinkled	3	−0.25	0.32	−5.92	5.36	0.55	−0.01	−0.8
	Acid	2.18 ml		[2] 6	−.85	1.59	−11.22	4.96	6.26	−.75	1.3
	Sucrose	85.62 percent									
	Reducing sugars	8.25 percent	Not sprinkled	3	0	.12	−3.52	3.47	.05	.83	−4.1
	Nonsugars	6.13 percent		6	−.10	.25	−5.44	4.10	1.34	.68	−5.0
	Solids	17.94 percent									
Not burned	pH	5.25	Sprinkled	3	0	.01	−5.03	4.51	.52	.57	−1.5
	Acid	1.93 ml		6	0	0	−6.32	4.69	.63	.10	−.5
	Sucrose	87.96 percent									
	Reducing sugars	6.80 percent									
	Nonsugars	5.24 percent	Not sprinkled	3	.05	.09	−11.57	11.19	.28	.86	−5.6
	Solids	18.53 percent		6	.10	.35	−15.20	14.19	1.01	1.00	−5.6

[1] Unmarked values, increase; negative values, decrease; sucrose, reducing sugars, and nonsugars based on solids.
[2] Appreciable acetic acid and gum formation was found by end of this period; samples also contained large inoculum of yeast.

situated near the top of the heap-row before being fired. The lead wires were protected by an asbestos covering. The maximum temperature observed was 56° C. which occurred very shortly after passage of the flame-front. Rather surprisingly, this temperature remained practically constant for about 20 minutes. The stalks were too hot to hold comfortably in the hand during this period. The stalk surfaces were, of course, more strongly heated since their wax coating, which melts at about 78°, had melted in many places.

Experiments 2 and 3.—These and the following experiments were conducted under controlled temperature and humidity, in order to determine more precisely than possible in open-air testing the relative effects of these two factors on the behavior of burned and unburned cane stored after cutting.

The storage conditions were the same for Experiments 2 and 3. The storage rooms were adjusted, in pairs, to temperatures of 18° C. (65° F.), 24° (75° F.) and 29° (85° F.). One room of each pair was adjusted to a saturation deficit of approximately 0.03 inch mercury (wet condition) and the remaining rooms to a deficit of approximately 0.36 inch mercury (dry condition). Saturation deficits express the water-holding capacity of the air independent of temperature; and it is possible, by this system of control, to obtain about equal rates of evaporation of moisture from the cane at different temperatures. The relative humidities and the actual saturation deficits used are given in table 4 (experiment 2) and table 5 (experiment 3).

The variety C. P. 34/120 was used in Experiment 2 and C. P. 36/105 in Experiment 3. Analyses were made after the cane had been stored

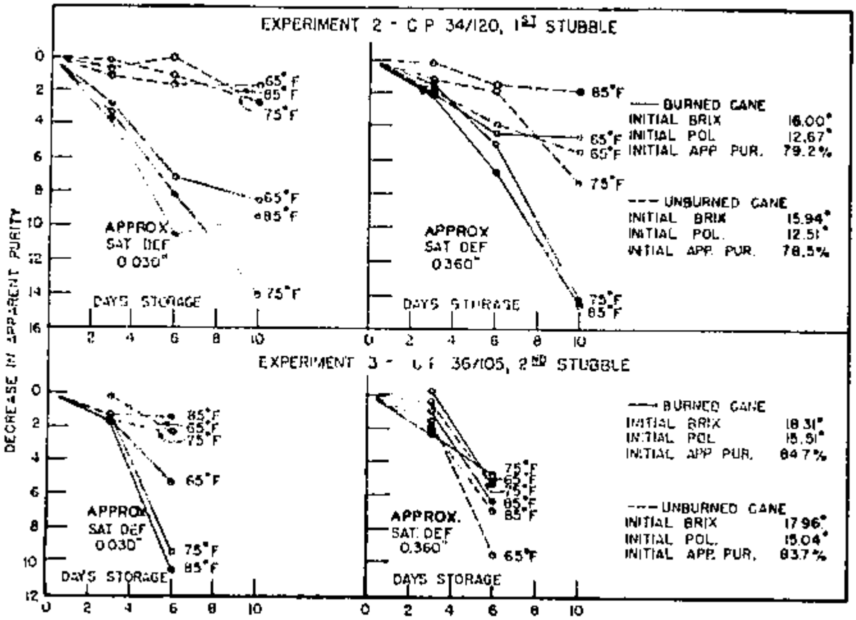

FIGURE 2.—Data from routine analyses of juice samples from burned and unburned cane (C. P. 34/120, first stubble and C. P. 36/105, second stubble), after storage.

3, 6, and 10 days, and 2 and 6 days, respectively, in the two experiments. The analytical data are reported in figure 2 and in tables 4 and 5.

These data bring out a point not evident from Experiment 1, namely, that burned cane stored under dry conditions may deteriorate as much as the same cane under wet conditions, if storage is continued long enough. However, the type of deterioration in the two cases appears to be quite different. In burned cane kept dry, deterioration showed little effect of action by micro-organisms—there was a gain in reducing sugars in the juices about equivalent to the loss of sucrose and only small changes in acidity and pH values were observed.

The behavior of the unburned cane under both wet and dry conditions was typical. The rate of deterioration seemed to increase, significantly, although not greatly, with the temperature. At least, in the C. P. 34/120 samples sucrose loss in unburned cane at 65° F. appeared to be definitely smaller than that occuring at the higher temperatures; but this effect was not so noticeable with the C. P. 36/105 cane. The naturally lower resistance of the latter variety could account for this result and also explain the fact that the burned C. P. 36/105 cane, stored under dry conditions and at the same temperatures, did not deteriorate as rapidly as the unburned cane, while both C. P. 29/120 and 34/120 canes showed an opposite trend.

While these variable results could have been caused by a differing degree of heat injury, this is not probable, since the cane was considered to be well burned in all cases. An attempt was made to obtain a temperature reading of the cane while burning, but the thermocouple apparently became exposed to the passing flames. A very high temperature was observed momentarily which dropped to 54° C. shortly after the flame-front passed. This probably represented more nearly the correct temperature of the cane. This temperature is close to that observed in the burning of the cane used in Experiment 1.

Experiment 4.—This experiment was set up similarly to the two immediately preceding except that a different set of temperatures and saturation deficits was used. The temperatures used were 13° C. (55° F.), 24° (65° F.) and 29° (75° F.); and the approximate saturation deficits of 0.030 inch and 0.225 inch mercury were maintained at each of these temperatures. Drying conditions were less severe than in experiments 2 and 3; yet the rate of weight loss was about the same in all three experiments (see table 8).

The cane for this experiment, C. P. 34/92, was burned under rather unfavorable conditions. Rain fell during the night previous to burning and the green leaves did not have time to dry thoroughly before firing. The trash burned slowly and not very well. A temperature measurement of the burning cane showed only 48.5° C. in contrast to apparent temperatures of 56° and 54° observed previously. The analytical results indicate that heat injury was just as severe as in the other experiments (fig. 3 and table 6).

There was only a little evidence of gummy fermentation in the juices from burned cane stored under moist conditions in this experiment. The action of micro-organisms was more evident, as might be expected, at temperatures of 65° and 75° F. than at 55° F. The pattern of deterioration exhibited by these samples is about the same as shown by the preceding ones, stored under similar conditions.

TABLE 4.—*Experiment 2 (detailed analyses), C. P. 34/120, first stubble, stored under controlled conditions, October 24–November 3, 1947*

Field treatment of cane	Initial composition		Storage conditions			Changes in juice composition [1]						Changes in cane weights
	Item	Value	T [2]	H [3]	Period	pH	Acid	Sucrose	Reducing sugars	Nonsugars	Solids	
			° F.	Percent	Days		Ml.	Percent	Percent	Percent	Percent	Percent
			65	-------	3	−0. 05	0. 13	−0. 43	0. 05	0. 38	0. 28	−0. 6
				96.	6	−. 25	. 52	−2. 53	1. 88	. 64	−. 03	. 2
				. 025	10	−. 45	. 73	−8. 21	4. 23	3. 98	−. 49	. 3
				-------	3	−. 05	. 05	−. 35	. 20	. 15	. 97	−4. 9
				48.	6	−. 05	. 38	−1. 68	1. 31	. 37	1. 35	−11. 2
				. 320	10	−. 05	. 23	−1. 57	1. 22	. 35	2. 72	−13. 6
Burned	*p*H	5.25	75	-------	3	−. 10	. 23	−. 33	. 35	−. 02	. 31	−. 7
	Acid	2.96 ml		97.	6	−. 20	. 42	−4. 01	3. 09	. 92	−. 11	−. 3
	Sucrose	82.00 percent		. 026	10	−. 60	1. 00	−11. 53	5. 89	5. 84	−1. 14	−1. 8
	Reducing sugars	8.01 percent		-------	3	−. 05	. 13	. 01	. 39	−. 40	. 83	−4. 7
	Nonsugars	9.99 percent		60.	6	0	. 34	−1. 66	2. 02	−. 36	1. 34	−8. 9
	Solids	15.60 percent		. 346	10	−. 10	. 61	−8. 31	7. 15	1. 16	2. 21	−14. 5
			85	-------	3	−. 15	. 30	−1. 23	. 74	. 49	. 06	−1. 3
				97.	6	−. 45	. 84	−5. 87	3. 65	2. 22	−. 07	−1. 0
				. 036	10	−. 75	1. 48	−12. 56	5. 61	6. 95	−. 84	−0. 9
				-------	3	−. 05	. 27	. 17	. 25	−. 42	. 87	−5. 2
				70.	6	−. 10	. 40	−3. 13	3. 01	. 12	1. 28	−9. 4
				. 360	10	−. 15	. 59	−9. 19	8. 16	1. 03	1. 65	−15. 7

Not burned	pH	5.25	65	96. .025	3	0	.11	—.41	.35	.06	.19	—.8
	Acid	2.98 ml			6	0	—.02	—1.11	.89	.22	—.48	.1
	Sucrose	82.84 percent			10	0	.09	—.91	.45	.46	—.14	—.7
	Reducing sugars	7.49 percent		48. .320	3	0	.19	—2.05	1.68	.37	.28	—5.8
	Nonsugars	9.67 percent			6	0	.34	—3.31	3.31	0	1.20	—10.0
	Solids	15.75 percent			10	0	.30	—3.66	3.85	—.19	1.97	—14.0
			75	97. .026	3	0	0	.17	—.14	—.04	.17	—.4
					6	0	.01	—.82	.44	.38	—.48	.4
					10	—.05	—.08	—1.21	.67	.54	—.42	.2
				60. .346	3	0	.11	—1.30	1.36	—.06	.75	—5.9
					6	0	.11	—1.64	1.94	—.30	1.22	—8.7
					10	—.05	.40	—3.76	3.91	—.15	2.06	—13.9
			85	97. .036	3	0	.03	—.54	.34	.20	—.04	—.6
					6	—.05	.30	1.11	—.10	.09	—.45	—.2
					10	—.10	.07	—2.37	.94	1.43	—.92	—.6
				70. .360	3	0	.11	--------	Sample lost.	--------	--------	—5.3
					6	—.05	.30	—2.02	1.92	.10	.83	—11.1
					10	—.15	.40	—2.50	2.99	—.51	1.80	—12.4

[1] Unmarked values, increase; negative values, decrease; sucrose, reducing sugars and nonsugars based on solids.
[2] T=Temperature. [3] H=relative humidity and saturation deficit in inches mercury, respectively.

TABLE 5.—*Experiment 3 (detailed analyses), C. P. 36/105, second stubble, stored under controlled conditions, November 4–10, 1947*

Field Treatment of Cane	Initial composition: Item	Initial composition: Value	Storage conditions: T [2]	Storage conditions: H [3]	Storage conditions: Period	Changes in juice composition [1]: pH	Changes in juice composition [1]: Acid	Changes in juice composition [1]: Sucrose	Changes in juice composition [1]: Reducing sugars	Changes in juice composition [1]: Nonsugars	Changes in juice composition [1]: Solids	Changes in cane weights
			° F.	*Percent*	*Days*		*Ml.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
				96.	2	−0.05	0.08	−0.38	0.58	−0.20	−0.57	0.7
			65	.025	6	−.40	.49	−5.01	2.38	2.63	−.99	2.1
				48.	2	0	−.01	.23	.34	−.57	.52	−3.1
	pH	5.35		.320	6	−.15	.20	−3.14	3.48	−.34	1.14	−9.0
	Acid	2.70 ml		98.	2	−.05	−.02	−.51	.48	−.27	−.48	−.2
	Sucrose	86.95 percent	75	.017	6	−.55	.80	−7.16	3.17	3.99	−.94	2.8
Burned	Reducing sugars	5.46 percent		60.	2	−.05	.10	−.32	.58	−.26	.11	−3.3
	Nonsugars	7.59 percent		.346	6	0	.29	−3.35	2.70	1.65	.80	−8.2
	Solids	18.44 percent		98.	2	−.10	.10	−.15	.54	−.39	−.26	.2
			85	.024	6	−.65	.16	−7.13	3.63	3.50	−1.61	2.6
				70.	2	−.10	.05	−.55	.97	−.42	.23	−3.9
				.360	6	0	.18	−4.36	3.93	.47	1.15	−9.3
				96.	2	−.05	−.06	−.82	.61	.21	−.45	.4
			65	.025	6	−.05	0	−2.14	.83	1.31	−1.01	2.3
				48.	2	0	.15	−.82	1.66	−.84	.25	−3.2
	pH	5.35		.320	6	−.10	.27	−7.60	7.77	−.17	1.47	−10.8
	Acid	2.63 ml		98.	2	−.05	.04	−.88	1.03	−.15	−.52	.5
	Sucrose	86.59 percent	75	.017	6	−.10	−.02	−.55	.44	.11	−.90	2.1
Not burned	Reducing sugars	6.08 percent		60.	2	.05	.07	−.50	1.18	−.68	.36	−3.1
	Nonsugars	7.33 percent		.346	6	−.05	.29	−3.78	3.67	.11	.88	−6.4
	Solids	18.09 percent		98.	2	−.10	0	−1.02	.72	.30	−.45	.7
			85	.024	6	−.30	.40	−.32	.16	.16	−.79	1.6
				70.	2	−.05	−.08	−1.08	2.01	−.93	.20	−3.4
				.360	6	−.10	.15	−5.35	5.63	−.28	1.21	−8.8

[1] Unmarked values, increase; negative values, decrease; sucrose, reducing sugars and nonsugars based on solids.
[2] T=Temperature. [3] H=relative humidity and saturation deficit in inches mercury, respectively.

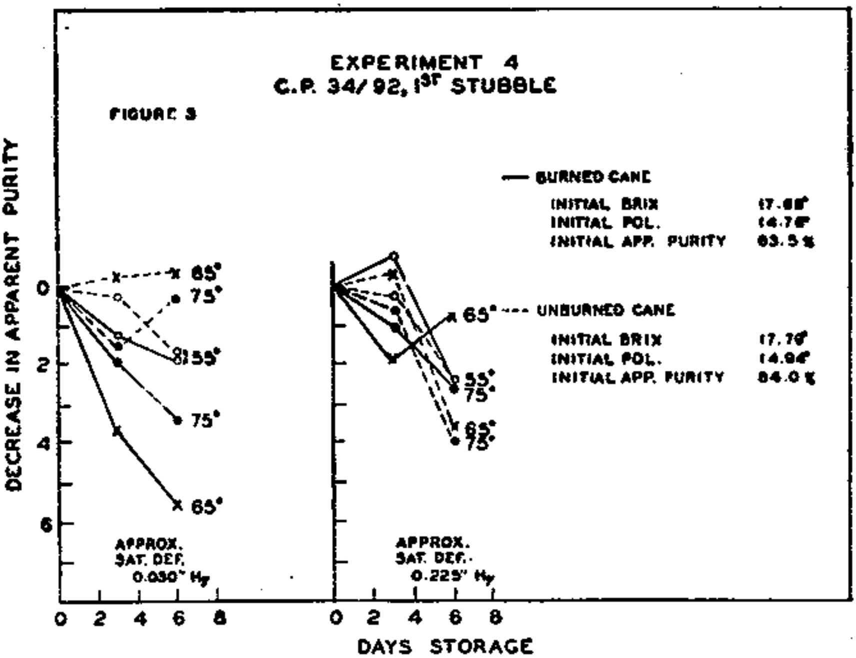

FIGURE 3.—Data from routine analyses of juice samples of burned and unburned cane (C. P. 34/92, first stubble), after storage.

In spite of its higher inversion rating, C. P. 34/92 did not deteriorate, under similar conditions, so badly as C. P. 29/120 and 34/120. It is believed that this result is due to the increased resistance of this lot of cane to deterioration with the advance of the season. The factors responsible for change in inversion rating of a sugarcane might be associated with exposure of the standing cane to cold weather. In this experiment official minimum temperatures of 34° and 35° F. occurred on the mornings of November 8 and 9, respectively, and the cane from which these samples were selected was cut on November 12. The previous low temperature was 49° occurring on November 3.

Experiment 5.—The variety C. P. 29/120 was used again to determine how it might behave under controlled conditions in contrast to those prevailing during the early season test. The cane was from a different location, however, and from a plant instead of a stubble crop. This lot of cane samples was stored at temperatures of 13° C. (55° F.) and 24° (65° F.) and at saturation deficits of approximately 0.030 inch, 0.062 inch, and 0.225 inch mercury, at each temperature. It was hoped that an intermediate condition in respect to drying would reveal some useful information.

The analytical data obtained are given in figure 4 and table 7. The contrast between these results and those obtained on this variety in Experiment 1 is very striking. Here the cane showed unusual resistance to deterioration under all the conditions of storage used. The somewhat lower storage temperatures were partially responsible for this result; but it is believed that the natural increase in resistance was a much more important factor. This lot of cane was subjected to

TABLE 6.—*Experiment 4 (detailed analyses) C. P. 34/92, first stubble; stored under controlled conditions; November 14–20 1947*

Field treatment of cane	Initial composition: Item	Initial composition: Value	Storage conditions: T[2]	Storage conditions: H[3]	Storage conditions: Period	Changes in juice composition[1]: pH	Changes in juice composition[1]: Acid	Changes in juice composition[1]: Sucrose	Changes in juice composition[1]: Reducing sugars	Changes in juice composition[1]: Nonsugars	Changes in juice composition[1]: Solids	Changes in cane weights
			° F.	*Percent*	*Days*		*Ml.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
				97.	3	−0. 10	−0. 04	−1. 41	0. 38	1. 03	−0. 30	1. 5
				. 013	6	−. 10	. 06	−1. 41	. 72	. 69	−. 30	. 6
			55	49.	3	−. 10	0	−. 67	−. 07	. 74	1. 03	−5. 2
	pH	5.30		. 220	6	−. 10	. 16	−2. 01	1. 70	. 31	1. 17	−9. 3
	Acid	3.00 ml		96.	3	−. 10	. 09	−3. 40	1. 37	2. 03	−. 63	1. 3
Burned	Sucrose	86.91 percent	65	. 019	6	−. 10	. 38	−4. 56	2. 15	2. 41	−. 67	. 7
	Reducing sugars	5.17 percent		65.	3	−. 10	. 02	−1. 33	. 47	. 82	. 49	−4. 5
	Nonsugars	7.92 percent		. 216	6	−. 10	. 12	−2. 20	1. 43	. 77	1. 49	−7. 9
	Solids	17.61 percent		98.	3	−. 15	. 03	−2. 07	. 66	1. 41	. 07	. 3
				. 017	6	−. 35	. 69	-5. 38	1. 85	3. 53	−. 18	−1. 0
			75	74.	3	−. 10	. 05	−. 83	. 78	. 01	. 54	−4. 3
				. 225	6	−. 05	. 10	−2. 08	1. 54	. 54	1. 31	−9. 2
				97.	3	−. 05	0	−1. 17	−. 02	1. 19	. 09	. 3
				. 013	6	−. 05	. 16	−1. 12	. 28	. 85	−. 18	. 3
			55	49.	3	−. 10	. 21	−. 67	02	. 65	. 91	−5. 8
	pH	5.30		. 220	6	−. 10	. 35	−3. 15	2. 38	. 75	1. 44	−8. 4
	Acid	2.90 ml		96.	3	−. 05	−. 06	−. 55	−. 35	. 90	. 26	. 5
Not burned	Sucrose	87.48 percent	65	. 019	6	−. 05	. 19	−1. 15	. 08	1. 07	−. 07	. 8
	Reducing sugars	5.12 percent		65.	3	−. 10	. 12	−1. 45	. 33	1. 12	. 95	−4. 6
	Nonsugars	7.40 percent		. 216	6	−. 05	. 18	−3. 43	2. 93	. 50	1. 48	−7. 4
	Solids	17.77 percent		98.	3	−. 10	. 13	−1. 46	. 39	1. 07	−. 54	−. 2
				. 017	6	−. 05	. 20	−1. 70	. 30	1. 40	−. 25	−. 7
			75	74.	3	−. 10	. 13	−. 75	. 51	. 24	. 88	−5. 0
				. 225	6	−. 05	. 29	−4. 09	3. 21	. 88	1. 56	−7. 9

[1] Unmarked values, increase; negative values, decrease; sucrose, reducing sugars and nonsugars based on solids.
[2] T=Temperature. [3] H=relative humidity and saturation deficit in inches mercury, respectively.

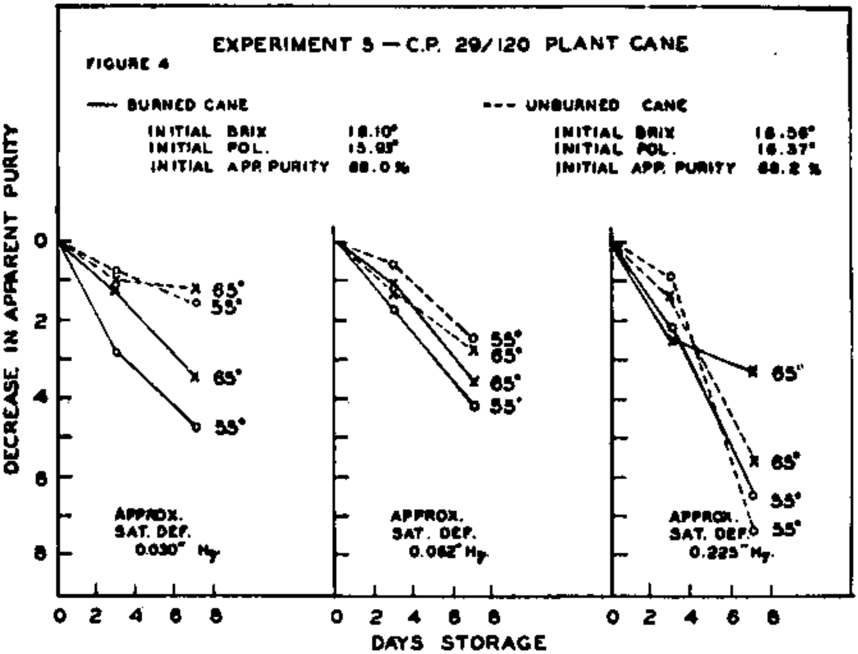

FIGURE 4.—Data from routine analyses of juice samples from burned and unburned cane (C. P. 29/120, plant cane), after storage.

temperatures possibly slightly below freezing on two successive mornings immediately before cutting, in addition to the near-freezing temperatures earlier in the month (Novemer 8 and 9).

None of the juices from burned cane showed any pronounced fermentation during the 7 days of observation, and the deterioration that occurred—a simple inversion of sucrose to reducing sugars—seemed to be normal. There were no significant changes in either the acidity or pH of the juices.

The field conditions were not very favorable for burning the cane used in this experiment, especially in comparison with conditions obtaining in Experiment 1. The trash burned quite satisfactorily, although slowly. Temperatures of the burning cane were observed to be 56° and 61° C. at two locations. The different behavior of this cane cannot, therefore, be attributed to a lack of injury by fire.

DISCUSSION AND CONCLUSIONS

Numerous inconsistencies noted in the data may be explained by the fact that, in spite of all the precautions normally taken to obtain representative and uniform samples of cane and cane juices and to analyze these juices accurately, abrupt deviations from a definite trend frequently occur. The greatest source of error may be in sampling the cane although there is only indirect evidence in favor of this opinion.

TABLE 7.—*Experiment 5 (detailed analyses), C. P. 29/120, plant cane; stored under controlled conditions,* **December 1–8, 1948**

Field treatment of cane	Initial composition: Item	Initial composition: Value	Storage conditions: T [2]	Storage conditions: H [3]	Storage conditions: Period	Changes in juice composition [1]: pH	Acid	Sucrose	Reducing sugars	Nonsugars	Solids	Changes in cane weights
			°F.	Percent	Days		Ml.	Percent	Percent	Percent	Percent	Percent
				97.	3	0	0.06	−0.66	0.97	−0.31	−0.60	−0.6
				.013	7	0	.20	−1.18	1.56	−.38	−.54	1.6
				86.	3	0	.04	.93	.22	−1.15	−.02	.1
	pH	5.40	55	.061	7	0	.12	−1.29	2.22	−.93	−.24	−1.5
	Acid	1.62 ml		54.	3	0	.02	−.26	.95	−.69	.07	−2.7
	Sucrose	88.08 percent		.198	7	0	.12	−2.43	3.48	−1.05	.20	−7.3
Burned	Reducing sugars	5.53 percent		97.	3	0	−.04	.61	.09	−.70	.04	1.0
	Nonsugars	6.39 percent		.019	7	0	.02	−.43	1.12	−.69	−.11	−1.1
	Solids	18.45 percent		87.	3	0	−.02	.14	.68	−.82	.24	−1.6
			65	.070	7	0.05	.04	−1.07	1.43	−.36	.22	−4.3
				63.	3	0	.02	−.54	1.15	−.61	.09	−3.4
				.228	7	0	.12	−.30	2.13	−1.83	.74	−5.9
						.05	−.08	.56	.23	−.79	−.06	1.2
				97.	3							
			55	.013	7	.05	−.02	.27	.64	−.91	−.19	0
				86.	3	0	−.04	−.01	.63	−.41	.03	.2
	pH	5.40		.061	7	0	.14	−1.10	1.23	−.13	−.01	−2.6
	Acid	1.58 ml		54.	3	0	.18	−.32	1.14	−.82	.44	−2.7
	Sucrose	89.04 percent		.198	7	−.05	.25	−5.04	5.60	−.56	1.45	−7.9
Not burned	Reducing sugars	4.92 percent		97.	3	.05	0	.60	.21	−.91	.02	.6
	Nonsugars	6.04 percent	65	.019	7	0	.04	.62	.47	−1.09	.02	−1.0
	Solids	18.71 percent		87.	3	0	−.04	.63	.40	−1.03	.46	−1.4
				.070	7	.05	.08	−.73	1.23	−.58	.32	−5.1
				63.	3	0	.06	−.57	.92	−.58	.46	−3.0
				.228	7	−.10	.14	−2.23	3.57	−1.34	1.20	−6.8

[1] Unmarked values, increase; negative values, decrease; sucrose, reducing sugars and nonsugars based on solids.
[2] T=Temperature. [3] H=relative humidity and saturation deficit in inches mercury, respectively.

An error of this type is particularly noticeable in Experiments 4 and 5. The check samples in both instances appeared to have a composition that was different from the cane samples placed in storage. This assumption is based on the deviations in the nonsugar content of the juices of the stored samples of cane as compared with the deviations found in the juice from the check samples. In Experiment 4, all juices from the stored cane showed an increase in nonsugar content; whereas, in Experiment 5, all juice samples decreased in nonsugar content. Although it has not been definitely proved, it is probable that there is a slight formation of nonsugars even in sound, unburned cane held in storage. A greater increase in damaged than in sound cane can be expected.

Faulty milling also introduces error in the data, for the composition of the juices will vary slightly with the degree of extraction. The degree of extraction was generally good for the set of samples ground consecutively on any one day while it was often several percents higher or lower on another day. Juice sampling and analysis introduce few errors, if carefully performed.

Despite the sampling difficulties and errors that may have entered into the results, the effect of burning the trash on the behavior of mill cane held in storage was quite clearly established. The compilation in table 8 of data obtained in the four controlled experiments indicates that burning has no effect on the rate at which cut cane loses weight through evaporation of moisture under drying conditions, at least in closed rooms and at temperatures ranging from 55° to 85° F. Adjusting the rooms to the same saturation deficit resulted in approximately the same loss of moisture at the different temperatures. The one exception was in cane stored at a saturation deficit of 0.061 inch to 0.070 inch mercury (Experiment 5), the reason for this conflicting result being unknown.

The pattern of sucrose loss through deterioration for unburned cane was the same as found previously (*13*). Moisture loss was the most critical factor affecting the rate and degree of sucrose hydrolysis in any variety of cane held in storage. For all practical purposes there was a gain in reducing sugars equal to the loss of sucrose. There was generally no significant change in *p*H or acidity values aside from those caused by loss of moisture by evaporation. Resistance toward deterioration increased with the advance of the season.

Burning injured the stalks to such an extent that they were readily invaded by micro-organisms under favorable moisture and temperature conditions. Typical acetic acid and gum-forming organisms apparently predominated although yeasts were also present. As a result of the action of these organisms, burned cane did not keep well under conditions favorable for unburned cane. At low humidities burned cane usually did not deteriorate as rapidly as unburned cane for the first few days, apparently because the growth of micro-organisms was held in check. Depending upon the activity of the micro-organisms, the pattern of deterioration of burned cane varied from one that appears normal—a simple hydrolysis of sucrose—to one in which there was a rapid formation of nonsugars at the expense of sugar. This applied to cane stored for periods up to about 1 week; thereafter the rate of deterioration in burned cane, especially under drying conditions, could be expected to increase rapidly.

TABLE 8.—*Average cane weight losses during storage under controlled drying conditions*

Experiment No.	Relative humidity	Temperature	Daily rate of weight loss	
			Burned	Unburned
	Percent	*° F.*	*Percent*	*Percent*
2	48	65	1.62	1.67
	60	75	1.47	1.60
	70	85	1.62	1.62
Average			1.57	1.63
3	48	65	1.52	1.70
	60	75	1.51	1.31
	70	85	1.75	1.58
Average			1.63	1.56
4	49	55	1.64	1.77
	65	65	1.41	1.38
	74	75	1.48	1.49
Average			1.51	1.55
5	54	55	.97	1.01
	63	65	.99	.99
Average			.98	1.01
5	86	55	.09	.15
	87	65	.57	.60
Average			.33	.38
Average all tests			1.28	1.30

There was some evidence that resistance toward deterioration in burned cane may also increase with the advance of the season, but further tests are needed to determine whether this is so, such tests should be made since this factor is of practical significance to Louisiana sugarcane growers.

This study was not sufficiently extensive to warrant a true comparison between the individual varieties. The data reported here indicate that the variety C. P. 34/120 with an inversion rating of 1.7 is very little better than the variety C. P. 36/105 with a rating of 3.6. The variety C. P. 29/120 in two tests under different conditions showed the least and the greatest resistance toward deterioration, respectively. This is an excellent example of the change which sugarcane frequently undergoes with the advance of the Louisiana season. It also shows how difficult it is to measure the resistance of sugarcane accurately or to make a true comparison between varieties. If a varietal comparison is to be made, it is very important that the cane be subjected

to the same cultural and weather conditions and be harvested at the same time.

The data given in this report furnish ample evidence that a considerable degree of the difference between actual factory recovery of sugar and theoretical recovery, based upon the analysis of fresh, clean cane could be accounted for by delay in milling the harvested cane. It is obvious that every effort should be made to insure the delivery of freshly cut cane to the factory if losses are to be reduced or avoided.

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