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PRESIDENT'S MESSAGE - FLORIDA DIVISION

Pablo A. Carreno
Gulf and Western Food Products, Okeelanta, Florida

Another crop has passed and every year we philosophize by saying "One more that has gone by and one less to go."

This past crop was my 31st; however, I feel rejuvenated when I look around and see so many friends with many more crops on their shoulders than they care to hear about. But do not worry, I am not going mention names.

Although we in Florida had a call close to disaster, from a freeze that we experienced on the 26th of December 1983, we have no complaints about the outcome of this last crop. The damage was not as severe as had been anticipated.

Florida has ground a total of 12,056,044 short tons of cane to produce 1,201,919 tons of 96° Pol sugar for a yield of 9.97%. This crop has been Florida's second largest in history and the outlook for the coming one is promising, although it is too early for a reliable forecast.

Florida's industry, led by the Environmental Quality Committee, has worked hard to keep oppressive wetlands legislation from being enacted. Water is the issue of the 80's in South Florida and the industry has and will continue to work diligently to ensure that the Florida sugar industry will be able to use and drain water when necessary.

As we look to the 1985 Farm Bill, there is a generally optimistic feeling that there will be a Farm Bill and that the sugar program will be a part of it. Our current program will take us through the 1985-1986 crop.

It is proper to compliment the Reagan Administration and the United States Department of Agriculture for its excellent management of the sugar program. Unlike previous administrations, the current execution of the sugar program is working well for the benefit of farmers and consumers, and at no cost to the federal budget.

The topic of these remarks, however, is not to report statistics or talk about what we are presently doing, but to make some comments about the future of the sugar industry.

Looking back in history, the U. S. Sugar Industry has been functioning for many years under an umbrella of protectionism for the benefit of all concerned. The price of sugar and placement of this product was somehow controlled by government legislation and within this framework there have been good times and bad. These up and down cycles have been analyzed by experts. Lately, however, the upward cycles have been challenged by factors not seen before in this industry.

Public opinion has been persuaded to consume less sugar to the benefit of new sweeteners. Thus, sugar substitutes are here to stay. It is the opinion of some experts that demand for sugar substitutes will level off and within this market, new sweeteners will be competing against old ones. Therefore, sugar will always have room in the United States.

I am not a marketing analyst but I fear that the portion of the market that belongs to our sugar will develop a continuous shrinking process if we do not do something about it.

In the past few years we have witnessed the closing of several refineries and raw sugar operations. The reasons for these closings have been said to be lower per capita consumption, high labor cost, high energy cost, lack of government control and so on and on.

The truth, as I see it, is that the sugar industry has entered an era of great competition that demands from us a collective effort to cope with this situation. But first we have to recognize that there is a problem in order to be able to solve it.

Competition is the stimulant that seems to be required to shake us loose from our lethargy and furnish us with the energies required to win this contest; and to do so we are fortunate to have tools and human resources.

In Florida we have the Florida Sugar Cane League, the Florida Sugar Marketing and Terminal Association, the Florida Molasses Exchange and a very capable group of research organizations from private, government and college institutions.

All these have to be heartily congratulated for their accomplishments in their respective functions throughout the past years. But, to cope with the challenge ahead of us and to win the contest, not only must we keep up the good work, but some aggressive strategic planning is in order.

We have to climb into the ring and fight; we have to change from a defensive mood into an offensive one. And to start with, there are, in my opinion, two areas where we can do a lot more to accomplish our goal: Advertising and Industrial Research.

About four months ago I saw in Sugar y Azucar a beautiful cover picture showing a silver teaspoon pouring refined sugar into a small pile. I have seen many others, but only in magazines related to the sugar industry. But we, sweet sugar people, do not have to see them; we are all convinced that sugar is good, but unfortunately, are not the users but the producers.

You don't see this type of advertisement in other food related magazines or any other advertising media with a purpose of reaching the users, as competitors do. What about posters or logos like the one I saw a long time ago on the envelopes of a foreign sugar company saying "Sugar, Crystallized E ...and so on?

I am not an advertising expert but I do know that there are many efficient ways to reach the consumers and I do know that advertising begins to sell, that competitive advertising guides consumers' choices.

And don't tell me that this is a matter for the refineries to take care of, because we only produce raw sugar as a feedstock. That is another way to dodge the truth. Let us not do like the ostriches, that when under pressure hide the head under ground but have the rest of the body exposed.

If we want to survive in this competitive market, we better join forces. I can assure you that if both parties do not get together with an open minded approach to do something to surmount the obstacles ahead of us, then we will keep on losing the contest until doomsday.

It is encouraging to know that, according to a recent agreement reached by members of the Sugar Association, a special contribution fund is being raised to begin the promotion of sugar through advertising and public relations. However, the entire industry must support the program in order for it to be effective.

The other area where we could stress our efforts to accomplish our goals is in industrial research.

Our research program is rather more agricultural than industrially oriented. We do a lot of much needed research in cane variety development and cane related complex matters towards the optimization of the cane culture with its undisputable economical benefits.

However, concerning the factory, we in Florida stick to our traditional goal of improving the grinding rate, extraction, quality of sugar, energy savings, etc., with very little being done in research and development of new equipment or process. And most of it is done indpendently by each mill.

We should be ambitious enough to organize an industry production research program with the involvement of all mills. Ideas could be screened, the most promising ones could be selected and tested to further development into productive ones for the benefit of the industry.

Another area of the industrial research that nas to be emphasized is the development and utilization of products and by-products. I firmly believe that this is most needed to succeed in a competitive market

We cannot be content with what we already have; the traditional alcohol production from molasses, the utilization of bagasse for electrical co-generation, etc.

All of this has been proven to be not enough.

New applications have to be found for our sugar, molasses, bagasse and for our existing byproducts. New products ought to be developed from the existing gamma of chemicals in our products and waste. And this is what product research and development is all about.

We must be prepared to staunchly defend our industry in order to survive.

PRESIDENT'S MESSAGE - LOUISIANA DIVISION

Charley Richard
American Sugar Cane League, New Orleans, Louisiana

As co-hosts of the Fourteenth Annual Meeting of the American Society of Sugar Cane Technologists, the Louisiana Division would like to welcome all members, guests, friends and even our opponents here to Clearwater, Florida. I say welcome to the first group because you are part of an Association that should be proud of its accomplishments in our sugar industry. I say welcome to our adversaries because I would like to direct parts of this Presidential Message to you.

We have had these prophets of doom that have been predicting the downfall of our Louisiana industry for most of our 189 year history; but, in the last ten years or so these people have spoken a little louder and a little more frequently.

Our adversaries have said that we would continue to lose raw sugar factories and we have. In the last ten years we in Louisiana have lost 40 per cent of our mills and we now have only 21. Our adversaries have said that we would continue to lose growers and we have. We don't have a precise number but we have lost more than 30 per cent of our farms in the last ten years. Our adversaries have predicted that by now we would be out of the cane business. Well, obviously they were wrong and things may have even backfired on them. Our industry is as strong as it has ever been and is one of the strongest in the world. I'm sure our adversaries would question the validity of that statement especially knowing that we are predicting a poor crop for this year and so I'll just have to prove that they were wrong.

In the 1983 crop, our industry produced 606,000 short tons of sugar. Although this was less than either the 1982 or 1981 crops, these are the three highest consecutive production years we have ever had in the history of Louisiana sugar cane. These production figures were due both to good yields of cane tonnage as well as to high sugar recoveries.

Although we averaged only 23.8 net tons of cane per acre in 1983, (less than either the 1982 or 1981 crops) this yield was still above the average of the last ten years. It is true that production for 1984 will be down, but this can be attributed to the combination of some of the coldest temperatures and one of the wettest winters we have ever had. The Christmas, 1983, freeze followed by three months of unusually cold and wet weather caused much damage to overwintering buds and shoots. We have experienced these kinds of calamities in the past and we have survived, and there is no reason to see why we won't survive this one.

Sugar recoveries for five of the last six years have been above 10 per cent, while never before in the history of Louisiana production have we even reached 10 per cent. Capacity has increased so that mills have been able to handle our crop despite the loss in numbers of mills. Yields of sugar per acre for 1983 were the fifth highest on record and averaged 2.48 tons.

While achieving these hsee good production yields there have been other improvements made which really don't show up in the record books. For example, most growers have turned to mechanical planters and of course our harvesting process has been entirely mechanized since the 1950's. This has made our industry much more labor efficient and means that we have already crossed hurdles that other cane industries still have to cross when faced with dwindling supplies and rising costs of hand labor.

To what does our industry owe this success? Certainly, we need to thank God for providing us with the weather which has played a large role in the industry's yields.

The scientific segment of our Technologist Association has also had an essential role in these successes. All disciplines have contributed greatly, and the large investment in money and manpower in the varietal program has been instrumental in realizing these successes. The team approach to the Louisiana breeding and selection program through Louisiana State University, the United States Department of Agriculture, and the American Sugar Cane League has been most effective.

The grower segment of our Technologists Association has not been idle. A two-row soldier harvester able to harvest more than 100 tons of cane per hour, which was developed in part by growers, has proven to be successful. This harvester can also gather lodged cane more efficiently than one-row harvesters and can deliver cane of higher quality to the mill. Development of mechanical cane planters and furrow covering tools as well as elevator pilers for our cane loaders have contributed heavily to our good yields.

The processing segment of our industry has been hard at work both in the factories and at Audubon Sugar Institute. Improving the fuel efficiency of our boiling houses by switching from natural gas to bagasse, improvement of the cane sampling system with the core sampler and press analysis, automation of pans and other equipment in the factory, arcing of mill rolls, and biocide treatments have all contributed to improved sugar quality and cost efficiency.

The many companies and agencies who provide products and services to the cane industry have worked along-side the growers, processors and scientists to assist with research on new products, develop and promote these new and better products and provide the services that our industry requires.

While the scientists, growers and processors have been developing this information, the extension segment of our industry has disseminated this information to the industry where it can be put to practical use.

The commodity organizations, in addition to legislative activities, have sponsored and conducted research which has been a part of the yield increases our industry has seen.

All of these efforts have been essential to the success of our industry because of their practical nature. There is certainly a need for basic research, but our industry thrives on applied research and improvements that are quickly put to use on the farm and in the factory.

The future role of our technologists will be just as important. We now find ourselves in the computer era and entering the biotechnology era; thus, technologists will have an expanded role. Our dependence on practical research will not diminish but we also should not turn our backs on new technologies now emerging. Our industry will need and expect more from our researchers than in the past.

Research by itself will not keep us in business. The political arena, although not an area for this Association, is one we cannot ignore. We must work towards price legislation which will enable us to survive the coming lean year and will allow us to make a decent living. We can, as members of our respective industry organizations work for this legislation. The political action committees will certainly be of upmost importance in getting our message to Washington.

Political activity has also been important in protecting the kinds of research our industries need. We need to constantly prove to Federal and State administrators the need for applied research that helps the Louisiana farmer produce, rather than suffer redirected scientific goals towards basic research in human nutrition that sound more like welfare programs than agricultural research.

While achieving our scientific and political goals we also must go out and fight for our product. We have something to sell that is good, healthy and important. America should not be forced to give up its own production of sugar to satisfy those more interested in foreign programs than in domestic production.

As a final word to our adversaries, your pessimism has remained all these years because we have never really acknowledged you. Well, we now know that you will always be around, but we believe that there is a better way to overcome your pessimism. Our sugar industry will no longer allow you to misinform the public and our nation's Congressmen of the welfare of our industry nor of the healthfulness of our product in our diets without a unified response. Our industry will no longer allow you to disorient our scientific policy makers and disrupt the financial support for research without a unified response.

As technologists, as political lobbyists, and as promoters of sugar in the market place, we must continue to unify our commitments among the sugar industries of Louisiana. Florida, Texas, Hawaii, and Puerto Rico.

I believe that we can best describe our future position by saying that divided we shall certainly fall as growers, processors and service agencies, but united we shall stand and prosper as the United States Sugar Cane Industry.

SENSITIVITY OF SUGARCANE CULTIVARS TO MECHANICAL INJURY

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ABSTRACT

A laboratory test was devised to evaluate the sensitivity of sugarcane cultivars to bud injury. Germination results from a greenhouse test showed a wide range in cultivar sensitivity to mechanical injury caused by dropping a steel ball on the bud. Four sugarcane cultivars representing this wide range of sensitivity were selected for a field test. Seed cutting treatments in the field plots included hand-cut, whole-stalk cane chopped in the furrow after planting and seed cut with two types of mechanical chopper harvesters. Results showed that crop yields from mechanically cut seedpieces of two cultivars were similar to those from hand cut seed cane chopped in the furrow. The other two cultivars had lower yields when the seedpieces were cut using an abrasive chopper harvester as compared to hand cut seed cane chopped in the furrow. The application of a fungicide provided a yield increase in only one of the four cultivars. Yield results from the field test agreed with the germination results of the four cultivars from the laboratory test.

INTRODUCTION

Because of rising labor costs, mechanical harvesting of sugarcane for planting is increasing. For producers planting whole stalk cane, Louisiana type harvesters will work successfully in reasonably erect cultivars. For sugarcane producers planting billeted cane, chopper harvesters with modified chopping systems can be used in selected fields and cultivars. Sugarcane cultivars that have large protruding buds are easily injured by chopper harvesters, and poor stands often result. However, some cultivars without protruding buds have also produced poor stands of cane when the seed cane was harvested with a chopper harvester. If the sensitivity of a cultivar to chopper harvesting was known, additional seed could be planted to compensate for mechanical injury to the buds or hand cutting methods could be used.

The objectives of this research were: a) to determine the ability of a laboratory test to predict the sensitivity of sugarcane cultivars to mechanical injury caused by chopper harvesting, b) to compare yields of four sugarcane cultivars when seed cane was harvested with two chopper harvesters with that from hand-cut, whole-stalk cane chopped in the furrow, and c) to verify previous results (1) that captafol may increase tonnage yields when applied during planting to seedpieces lying in the furrow.

MATERIALS and METHODS

A laboratory test was devised to evaluate sugarcane cultivars for sensitivity to mechanical injury of the bud. On January 14, 1981, six commercial cultivars of sugarcane (CP 56-59, CP 62-374, CP 63-588, CP 68-1026, CP 70-1133, and CP 72-1210) were subjected to the laboratory test which consisted of dropping a 1-inch steel ball from 3, 6, 9, or 12 inches to impact on the bud of a single node seedpiece. The drop heights represented energy levels of 0.43-, 0.87-, 1.30-, and 1.74-inch pounds, respectively, of injury to the cane bud. A piece of plastic pipe with slots at the appropriate intervals was used for the drop tube. It was attached to an angle-iron holder used for aligning the seedpiece. Ten single-node seedpieces with undamaged buds were cut from a sugarcane stalk starting at the bottom of the stalk. If more than two seedpieces from each stalk had previous damage, the entire stalk was discarded. The 10 seedpieces from each stalk were subjected to an energy level treatment or served as a control, and were then planted in a greenhouse flat. The experimental design of the 6x5 factorial treatments was a split-plot, randomized complete block with four replications using varieties as main plots and energy levels as subplots. Each subplot comprised one-third of a greenhouse flat. The flats were placed in a greenhouse, and the seedpieces were allowed to germinate. The number of germinating shoots from each stalk was recorded on February 26, 1981. The percent survival, expressed as a percent of control, was determined for each cultivar and treatment combination. Interaction among the cultivars was determined using a chi-square test on the percent survival of the two lower energy levels (3). Interaction between cultivars was determined using a chi-square test on a 2x2 table.

Using these laboratory results, four cultivars of sugarcane (CP 63-588, CP 68-1026, CP 70-1133, and CP 72-1210) were selected for a field test comparing chopper harvested seedpieces with hand cut whole stalks chopped in the furrow. Seed cane was harvested on December 22, 1981 by hand and with two mechanical harvesters. Both harvesters cut seedpieces about 18 inches long. Harvester A is highly regarded for cutting seed cane in Australia. Harvester B had an "elephant foot" base cutter which elevated the cane into the feed rolls and was more abrasive to seed cane than the base cutter system on Harvester A.

Rotating components with features to improve gathering, feeding, and cleaning can injure or remove buds from the cane stalks. Neither chopper harvester is used commercially in Florida to cut seed cane. Seedpieces were placed in the furrow to form two continuous lines of cane. In one-half of the plots, the seedpieces were sprayed with captafol (fungicide) at a rate of 4 lb a.i./acre and subsequently covered. The experimental design of the 4x3x2 factorial treatment was a randomized complete block with four replications. Each plot was 26.25 feet long with a row width of 5 feet. Primary shoots were counted in the plots five times during February and early March, 1982, until tillering began. Plot yields were measured on December 22, 1982, using the plot harvesting method of the USDA Sugarcane Harvesting Lab (2). Treatment yields were tested for significance using analysis of variance, and Fisher's restricted LSD test was used to separate individual treatment means (3). A linear correlation analysis was done between plot yields and primary shoot counts on the different dates to determine if yields were related to shoot germination.

On January 12, 1982, stalks of four cultivars from the same seed sources used in the field test were subjected to the laboratory injury test as previously described. The percent survival, expressed as a percent of control, was determined for each cultivar and energy level of injury combination. A linear regression of the percent survival on the two lower energy levels and the control for each cultivar was done for significance, and slope coefficients were tested for significance between cultivars. Interaction among the cultivars was determined on the percent survival of the two lower injury levels as in the first experiment. Interaction between cultivars was determined as before.

RESULTS and DISCUSSION

Results of the laboratory injury test on six sugarcane cultivars are shown in Table 1. The germination of the control seedpieces varied considerably among the six cultivars. At the two higher energy levels of injury, the percent survival of the buds tended to approach a minimum level in several cultivars. The bud was usually obliterated at the highest energy level. This suggested that each cane bud was not struck squarely by the steel ball and, as a result, survived when it should have been destroyed. This provided an estimate of the operator's ability to line up the cane bud with the drop tube. Percent survival at the two lower energy levels of injury showed that CP 63-588 and CP 72-1210 were significantly more resistant to bud injury than the other cultivars. Cultivars CP 56-59, CP 68-1026, CP 62-374 and CP 70-1133 were more sensitive to bud injury than the other cultivars.

Table 1: Germinating buds and percent survival, confidence interval means of four energy levels of injury damage to cane buds of 6 sugarcane cultivars, Belle Glade, FL.

Cultivar	Germinating buds 1/ In control	Percent survival 2/ Energy level 1	2	3	4	Avg. 1-2	Cultivar interaction 3/
CP 56-59	31	52	26	10	23	39	CP 63-588, CP 72-1210
CP 62-374	25	32	40	36	16	36	CP 63-588, CP 72-1210
CP 63-588	24	88	75	63	33	81	CP 56-59, CP 62-374, CP 68-1026, CP 70-1133
CP 68-1026	30	50	27	13	13	38	CP 63-588, CP 72-1210
CP 70-1133	31	19	26	19	16	23	CP 63-588, CP 72-1210
CP 72-1210	30	60	73	43	30	67	CP 56-59, CP 62-374, CP 68-1206, CP 70-1133

1/ Based on a total of 40 buds.

2/ Percent survival is based on the control for each cultivar with survival in the control defined as 100 percent. Energy levels of 1, 2, 3, and 4 represent energy inputs of 0.43-, 0.87-, 1.30-, and 1.74-inch pounds, respectively.

3/ Cultivar interaction determined using chi-square test at 0.05 level on the total surviving buds of energy levels 1 and 2. Cultivars listed in the interaction column differ significantly with the row cultivar on bud survival.

Percent survival of the cultivars in the second experiment are shown in Table 2. A linear regression of the percent survival showed that a straight line relationship existed with respect to the two lower energy levels (0.43-, 0.87-inch pounds) of injury and the control. With the limited number of data points in this range, slope coefficients for the cultivars were not significantly different because of replication variation and the small number of degrees of freedom. (Thirty degrees of freedom are required for a good estimate of the error term, and only 20 were available.)

Analysis of the percent survival data (Table 2) of the two lower energy levels of injury showed that CP 63-588 had a percent survival significantly higher than CP 70-1133 and CP 72-1210. The cultivar

CP 70-1133 had a significantly lower chance of bud survival than CP 63-588 and CP 68-1026. These results suggested that CP 63-588 and CP 68-1026 would be more resistant to mechancial damage than CP 70-1133 and CP 72-1210.

Table 2. Germinating buds and percent survival of buds subjected to four energy levels of injury on 4 sugarcane cultivars, Belle Glade, Fl.

Cultivar	Germinating buds 1/ in control	Percent survival 2/ energy level 1	2	3	4	avg. 1-2	Cultivar interaction 3/
CP 63-588	38	71	42	21	13	57	CP 70-1133, CP 72-1210
CP 68-1026	36	69	42	17	28	56	CP 70-1133
CP 70-1133	22	46	5	9	5	25	CP 63-588, CP 68-1026
CP 72-1210	39	54	23	18	23	38	CP 63-588

1/ Based on a total of 40 buds.

2/ Percent survival is based on the control for each cultivar with survival in the control defined as 100 percent. Energy levels of 1, 2, 3, and 4 represent energy inputs of 0.43-, 0.87-, 1.30-, and 1.74-inch pounds, respectively.

3/ Cultivar interaction determined using chi-square test at 0.05 level on the total surviving buds of energy levels 1 and 2. Cultivars listed in the interaction column differ significantly with the row cultivar on bud survival.

Yield data from the field experiment is shown in Table 3. The analysis of variance showed significant differences between cultivars, seed cutting methods, cultivar x fungicide interaction and cultivar x seed cutting method interaction. Cultivar yield means across all treatments showed that CP 72-1210 had a significantly higher yield than the other cultivars while CP 68-1026 had a significantly lower yield than the other cultivars. The yields of CP 63-588 and CP 70-1133 were not significantly different. Seed cutting methods (Table 3) affected the resulting yields. Yields from seedpieces cut by hand were significantly higher than those from seedpieces cut with chopper harvesters. This difference showed that hand cut pieces were superior to those cut by the best chopper harvester. A significant yield difference occurred between seedpieces cut with the chopper harvesters. This yield difference showed that the aggressiveness of the harvester mechanisms can affect the subsequent yield of seed cane.

Table 3. Yields (tons/acre) of four cultivars of sugarcane harvested by three methods as seed cane, Belle Glade, Fl.

Cultivar	Hand cut	Harvester A	Harvester B	Cultivar avg.
CP 63-588	67.53	57.52	63.71	62.92
CP 68-1026	51.19	53.45	50.61	51.75
CP 70-1133	82.54	63.36	59.28	68.39
CP 72-1210	84.23	83.14	62.43	76.60
Harvesting method avg.	71.37	64.37	59.01	

$LSD_{.05}$ (Harvesting method) = 5.24 tons/acre

$LSD_{.05}$ (Cultivar) = 6.05 tons/acre

$LSD_{.05}$ (Harvesting method within cultivar) = 10.41 tons/acre

The use of captafol (fungicide) on the seedpieces did not significantly increase yields as a main effect (data not shown), but there was a significant cultivar x fungicide interaction. Captafol applied to seedpieces of CP 68-1026 resulted in a significant yield increase of 12.38 tons/acre over yields from seedpieces without the fungicide. Captafol applied to seedpieces of CP 63-588 and CP 70-1133 resulted in small but nonsignificant yield increases.

Analysis of the cultivar x seed cutting interaction showed that the seed cutting method did not affect the resulting yields (Table 3) of CP 63-588 and CP 68-1026. Hand cut seedpieces of CP 70-1133 produced significantly higher yields than the mechanically cut seedpieces, while yields from the seedpieces cut by the two harvesters were similar. Within CP 72-1210, yields from seedpieces cut by hand and by Harvester A were similar, while the yield from seedpieces cut by Harvester B was significantly lower than the yields from the hand cut and Harvester A seedpieces. The results showed that sugarcane cultivars can respond differently to seed cutting methods. Cultivar CP 70-1133 which had large bulging buds was the most sensitive cultivar in this test to injury from chopper harvesters. Obviously harvester components can easily remove or damage this type of bud.

Shoot counts, (data not shown) made in the field experiment during February and early March 1982 were significantly correlated (r=0.24 to 0.31, n=96) to the resulting yields. Reductions in yield at harvest can generally be attributed to reduced germination which caused reduced stalk populations with lower yields. The highest correlation of shoot counts to yields occurred with counts made on March 5, 1982, (r=0.31, n=96) after tillering had started.

Shoot counts, made on February 26, 1982, before tillering started, showed that plots with mechanically cut seedpieces contained 80 percent of the shoots found in plots with hand cut seedpieces. Specifically, plots of CP 63-588, CP 68-1026, CP 70-1133 and CP 72-1210 with mechanically cut seedpieces contained 92, 73, 54, and 103 percent, respectively, of the shoots found in plots with hand cut seedpieces. The field counts showed that reduced germination caused the yield reduction measured in CP 70-1133. The germination observed in CP 72-1210 did not follow yield results. Its shoot counts were considerably below those observed in the other cultivars but were acceptable for stand establishment (exceeded 1 shoot/ft of row).

Results from the laboratory injury test supported the field yield data. Mechanically cut seedpieces of CP 63-588 and CP 68-1026 did not have significant yield differences when compared to hand cut seedpieces. Significantly lower yields occurred when seedpieces of CP 70-1133 were mechanically cut as compared to those from hand cut seedpieces. This demonstrates the resistance of CP 63-588 and CP 68-1026 to mechanical injury and the sensitivity of CP 70-1133 to mechanical injury. The percent survival at the 0.43- and 0.87-inch pound level of injury suggests the degree of resistance of a cultivar to mechanical injury. Additional seed cane should be planted when sensitive cultivars are mechanically cut for seed to overcome the associated reduced germination.

Comparing field results with the percent survival in the first laboratory experiment, the results were not as conclusive because the relative sensitivity of the cultivars changed somewhat. Seed cane locations and different growing conditions for the crops probably contributed to this difference. Germination in the control treatments also differed between the two laboratory tests. The first laboratory test was conducted to determine the range of cultivar sensitivity to mechanical injury and to refine the laboratory test procedures. The second laboratory test was conducted on the cultivars used in the field experiment.

The two lower energy levels of injury should be used in the future laboratory tests and the number of replications should be increased. This would make the test more sensitive for data analysis. A resistant cultivar such as CP 63-588 should be included in the test cultivars for comparison purposes.

CONCLUSIONS

The laboratory injury test showed that sugarcane cultivars exhibit a wide range of sensitivity to bud injury. The appropriate injury levels for determining this sensitivity to bud injury were the 0.43- and 0.87-inch pounds of energy. A field test of seedpieces harvested using chopper harvesters showed that cultivars sensitive to mechanical injury showed reduced yields when compared to those from hand cut whole stalks chopped in the furrow. Additional seed cane should be planted when cultivars sensitive to bud injury are cut using chopper harvesters. Injury to seedpieces by chopper harvesters can be minimized by using a harvester which is not abrasive to the cane. The use of captafol increased the yield of only one cultivar (CP 68-1026) in the field test.

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CONSIDERATIONS FOR MECHANICALLY HARVESTING SWEET SORGHUM

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ABSTRACT

The general term "sweet sorghum" has a wide range of characteristics relative to production and mechanical harvesting. Sweet sorghum has been found to be more sensitive to production and harvesting techniques compared to sugarcane. Mechanical harvesting considerations are integrated with the agronomic and processing characteristics of sweet sorghum. Different mechanical harvesting systems were evaluated based on simplicity, overall performance, efficiency and cost. Forage harvesters were considered the most simple system of harvesting, however, depending upon the condition of the crop at harvest time a more elaborate mechanical system is needed. Whole stalk and combine type sugarcane harvesters have advantages and disadvantages depending upon field conditions and method of processing at the mill. An evolution of mechanical harvesting with a simple forage harvester through a more elaborate self propelled sugarcane combine harvester will be discussed.

INTRODUCTION

The conversion of sunlight into chemical energy through the process of photosynthesis in green plants is a primary source of unexhaustible energy.

Sweet sorghum is classified like sugarcane as a C_4 Malate former which has one of the highest photosynthetic rates among terrestrial plants. It has been grown in the southeastern United States for table syrup since its introduction by an English sugar planter in 1857. The starch content and rapid inversion of sucrose in the sorghum juice have discouraged its use in sugar production. But developments in processing technology have made sugar from sweet sorghum feasible. Sweet sorghum is a more suitable source of fermentable sugars for the production of ethanol than sugarcane.

The general term "sweet sorghum" has a wide range of characteristics relative to production and mechanical harvesting. Sweet sorghum is a sensitive crop in terms of environmental conditions compared to sugarcane. Yield and plant characteristics are affected by 1) variety; 2) plant population; 3) weather; and 4) field condition. These effects are interrelated.

Biomass yields of three selected varieties, shown in Table 1, ranged from 17.8 T/ha to 32.8 T/ha in 1980. There was also a wide range in the yields of stalk, leaves and tops among the varieties. One aspect that makes sweet sorghum a good potential energy crop is the availability of large quantities of bagasse or fiber to be used as fuel for distillation.

Table 1. Effect of varieties on the biomass yield of sweet sorghum.

Variety	Date of Planting	Yield (T/ha) Stalk	Leaves	Tops	Total
Wray	April 21	13.5	3.2	1.1	17.8
Theis	April 21	19.4	2.7	2.3	24.4
MN 1500	April 21	24.5	4.7	3.6	32.8

The ingredients for producing ethanol of course are the fermentable sugars. Results of variety and spacing studies during 1980 showed considerable differences in each form of fermentable sugar among the varieties but the differences in total fermentable sugars were more equal, Table 2. The variety with the highest biomass yield did not necessarily produce the most fermentable sugars. Calculated alcohol yields ranged from 4787 L/ha to 6609 L/ha among the three varieties tested.

Table 2. Effect of varieties on sugar and alcohol yields.

Variety	Date of Planting	Sugar yield (kg/ha) Sucrose	Glucose	Fructose	Total	Alcohol Yield L/ha
Wray	April 21	10,543	473	286	11,302	6,609
Theis	April 21	3,621	2,819	1,760	8,199	4,787
MN 1500	April 21	5,774	1,905	893	8,572	4,983

Harvesting Systems

In developing a mechanical harvester for sweet sorghum the engineer must consider the agronomic aspects of the crop and also the processing aspect. In what form does the processor want the material delivered to the mill: 1) juice only; 2) whole stalks only; 3) whole stalks w/leaves and tops; chopped w/leaves; 5) chopped without leaves; or 6) forage chopped (1/4 inch length)?

Mechanical harvesting systems for sweet sorghum were evaluated based primarily on simplicity, overall performance and cost. The condition of the sorghum at harvest dictated the type of harvester that would be most effective. The condition of the material to be delivered to the processing plant or method of processing also influence the type of mechanical harvester needed. The simplest and least expensive type of harvester evaluated was the single row pull type forage harvester, Figure 1. The performance of a forage harvester with a row crop header is affected by row size and spacing. The experimental results reported here were planted on rows 1.8 m from center to center but with 2 drills on each row spaced 60 cm apart.

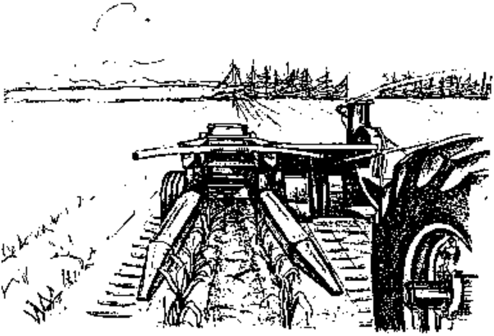

Figure 1. Simple forage type harvester.

The basic single row forage harvester with a 23 cm throat has a narrow cutting width and therefore is limited in the types of culture and crop conditions it can operate in efficiently.

A forage harvester with a 2-row header was more adapted to the planting pattern but again was ineffective due to the small throat and cutting area.

The effectiveness of a forage harvester would improve by increasing the cutting area similar to the broadcast headers available from forage harvester manufacturers. However, the size and ruggedness of the sweet sorghum stalk plus the cutting width, requires a more durable broadcast header. Replacing the cutter bar with rotating disk blades could provide an adequate cutting mechanism that is more durable and requires less maintenance.

Due to stalk length, a relative weak root system and heavy seed head, sweet sorghum tends to lodge easily and more severely than sugarcane. If the lodged stalks lay parallel to the row the forage harvester can perform at a reduced rate in the direction of lodging. If the stalks are lodged perpendicular to the row the head would extend and tangle with several adjacent rows; therefore, some type of active gathering and separating mechanisms such as spiral separators are needed, Figure 2. Otherwise the long stalks will hairpin around the stationary dividers of the forage harvester.

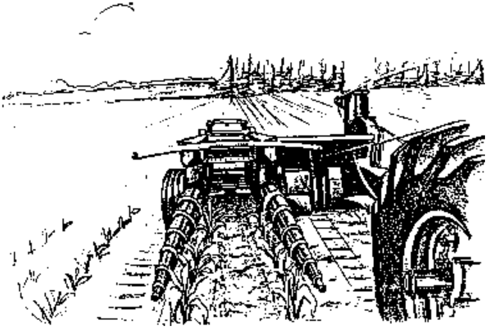

Figure 2. Simple forage harvester with cutting disk blades and spiral crop lifters.

Sweet sorghum normally produces a seedhead. In fact, some varieties yielded up to 2000 kg/ha of seed. The seed is valuable as a supplement to the fermentable sugars in making alcohol. Therefore, removing the tops and collecting them into separate containers could yield an additional 700 L/ha of alcohol. The 1981 forage harvesters did not have the capability of removing the seedhead. If the stalks are severely lodged separating the seedhead is more difficult. Varieties such as Wray, which produce shorter stalks do not lodge as frequently as the taller varieties i.e., MN 1500. Sorghum that maintains its erect position can be topped and the seedhead collected.

The system with the highest harvesting rate that leaves the harvested sorghum with the longest keeping quality (loss of fermentable sugars) can be obtained with wholestalk sugarcane harvesters. The harvesting operation includes cutting the stalk top and bottom, collecting the seedhead in a collection bin and piling the stalks into a heap row. If desired, the leaf trash can be removed by burning but this would accelerate the rate of inversion or deterioration of the fermentable sugars. The harvested stalks are loaded from the heap row into transport units with a grab type loader. This will allow some field storage or a more flexible total system compared to a cut load system. The whole stalk harvesting system is limited to stalk lengths, after topping, of 2.85 m. The height of the machine could possibly be modified but becomes less practical.

The problem of selecting a system adaptable to all conditions cannot be solved with the conventional forage or whole stalk harvesters. The capability to harvest tall stalks, crooked or straight stalks, recumbent stalks, topping or removing the seedhead and trash separation may all be needed under some conditions.

To incorporate the features discussed above, the forage harvester could take the following shape. To remove the seedhead, a topping mechanism would be attached capable of raising to a maximum height of 12 feet, Figure 3. The commercial blowing or throwing conveying system has a limited capacity, high energy consumption and is not effective for billets longer than 3.0 cm. The longer the billets, the better the keeping quality of the harvested sorghum and remember a given amount of energy is consumed each time the stalk is cut. Therefore, a harvester cutting the stalk into 5 mm lengths would require more energy than 300 mm lengths. To convey the longer billets at a high rate (30-60 tonnes/hr) a slat conveyor should be added, Figure 4.

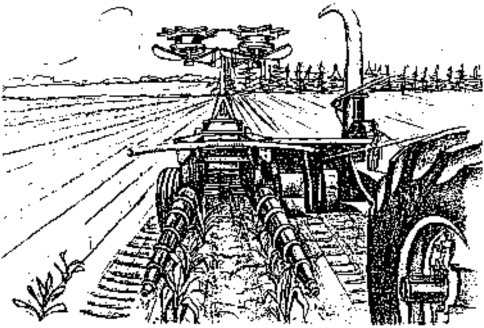

Figure 3. Simple forage harvester with cutting disk blades spiral crop lifters and a topping mechanism.

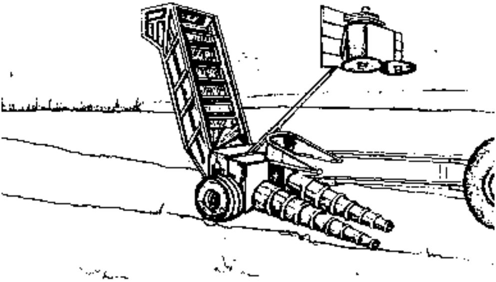

Figure A. Simple forage harvester with cutting disk blades, spiral crop lifters, topping mechanism and slat conveyor.

The additional weight of the spiral crop lifters, topper and slat elevator requires a modification of the forage harvester chassis. Plus the power requirements needed for the additional functions exceed the tractor PTO so an auxiliary engine and additional wheels are added, Figure 5.

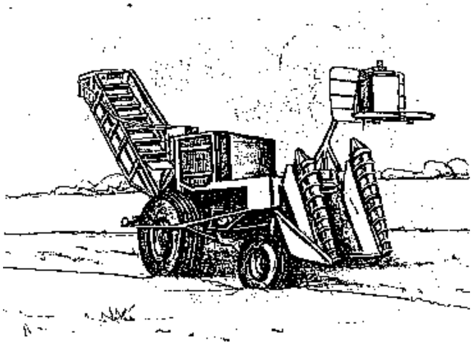

Figure 5. Simple forage harvester with cutting disk blades, spiral crop lifters, topping mechanism, slat conveyor, with 4-wheel chassis and an auxiliary engine.

Depending on the milling process and need for bagasse, the trash may or may not be harvested. If the leaf trash is removed, cleaning rolls or extractor fans would be added to the harvester, Figure 6.

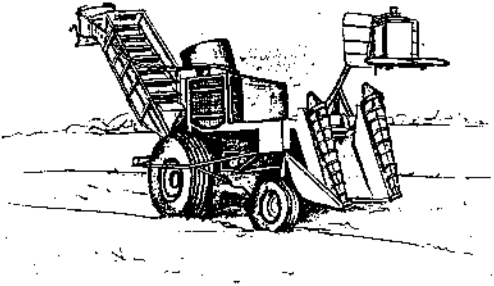

Figure 6. Simple forage harvester with bottom disk blades, spiral crop lifters, topping mechanism, slat conveyor, 4-wheel chassis, auxiliary engine and extractor fans.

The 4-wheel chassis has now become loaded with mechanisms and controls that are more than can be operated from the tractor pulling the unit so a self propelled machine can be easily justified. The machine would incorporate a drive train, steering, controls and an enclosed cab for a driver, Figure 7.

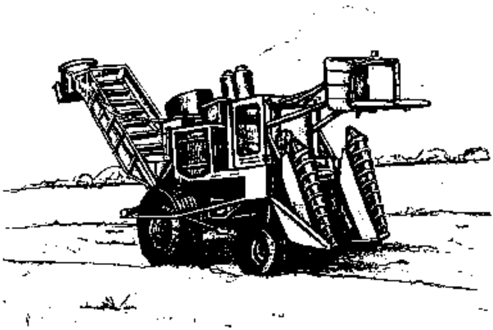

Figure 7. Simple forage harvester with bottom cutting disk blades, spiral crop lifters, topping mechanism, slat conveyor, 4-wheel chassis, auxiliary engine, extractor fans, operators cab and self propelled power train.

With these additions and modifications the simple forage harvester could now be called a combine harvester capable of harvesting sweet sorghum under adverse growing and field conditions as well as sugarcane. To obtain the features built into the combine harvester the cost has changed from approximately $5,000 for the forage harvester to approximately $125,000 for the combine harvester. The cost depends upon the features needed in the harvesting operation. All conditions would not require all the features of the combine harvester but field experience has shown the combine harvester is best suited for all conditions.

AN ECONOMIC ANALYSIS OF THE RELATIVE COSTS OF ALTERNATIVE SUGARCANE HAULING METHODS

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ABSTRACT

The transport of sugarcane from the farm represents a substantial cost in operating a raw sugar mill in Louisiana. The two major methods of transporting cane include tractor-drawn wagons, taken to the mill directly from the field, and truck-drawn trailers requiring a transloading operation. Comparison of the total cost for these procedures establishes a boundary, defined in miles, either side of which represents the economic feasibility of the respective methods.

This study provides a normative, long-run, transportation cost analysis, which establishes the economic parameters used to define the limits for alternatives. It also shows the impact of short-run distortions. These distortions reflect the economic impact of fixed assets.

INTRODUCTION

The economic feasibility of supplying the Louisiana sugarcane crop to the state's mills is largely a function of the price of raw sugar and the transport subsidies paid to growers by the mill. The price of raw sugar is generally determined by factors external to the sugar industry. Transport subsidies on the other hand are under direct control of the mill and therefore can be used to control the supply of

Typically, the transportion of sugarcane in Louisiana involves two methods - tractors with wagons and trucks with trailers. Results of a survey conducted by the Department of Agricultural Economics, LSU in 1981 and updated in 1983 indicated that the tractor and wagon method is employed by growers relatively close to the mill. The truck and trailer method was found to be employed by growers at all distances from the mill; however, this method was most popular at distances farther from the mill. This pattern of employment is expected to result from the relative cost advantages of the two methods at various hauling distances from the mill. This analysis identifies the relative costs, on a per-ton basis, of employing the different sugarcane transporting methods and the method with the relative cost advantage at various distances from the mill. The analysis includes both long-run cost considerations and the effect of short-run distortions on the long-run cost estimates. The resulting information can be applied to long-run and short-run decision situations.

METHOD

The survey conducted by the Department of Agricultural Economics, LSU, included a random sample representing 208 sugarcane growers, or approximately 25 percent of the sugarcane growers in the state. Results indicate that 60 percent of the growers transporting sugarcane by truck and trailer used trailers with a 24-ton payload. The typical payload of a wagon employed in the tractor and wagon method was found to be geographically separated. In the Bayou Teche region 55 percent of the growers transporting sugarcane by tractor and wagon used two 12-ton cane wagons in tandem. In the Mississippi River and Bayou Lafourche regions 72 percent of the wagons used had payloads of 10 tons or less and 88 percent of these were used in tandem. The average total payload suggested by the survey for two wagons in tandem in these regions is about 10 tons. Included in the analysis is a truck and trailer with a 24-ton payload, a tractor with two wagons in tandem for a combined payload of 24 tons, and a tractor with two wagons in tandem for a combined payload of 10 tons.

This economic cost analysis is a multiphase process. First, the relevant cost elements are used to compute per-unit cost for the various sugarcane hauling alternatives being considered. Second, these results are used in a comparative analysis to establish a least-cost method. Third, variables that modify per-unit costs are identified and their economic impact evaluated. Fourth, these data are then used in an analysis that addresses the economic impact of the time frame under which the alternatives are considered. In the long run all costs are relevant, hence, all cost elements, both variable and fixed are included in the analysis. In short-run situations, some cost elements, such as part or all of the ownership costs of in-place alternatives are sunk costs and should be excluded from management decisions.

Estimates of the total costs per hour for the various pieces of machinery and equipment that make up the different methods of hauling is presented in Table 1. Cost estimates for the diesel truck were obtained from various trucking agencies. The remaining estimates were extracted from the Department of

Agricultural Economics, LSU Research Report No. 626, entitled, Projected Costs and Returns, Sugarcane, Louisiana, 1984(1). Adjustments were made to reflect accelerated tractor tire wear due to highway use. Total costs per hour are divided into operating costs and ownership costs. Of the total fixed costs presented in each budget two items, interest and depreciation, combine to represent the costs of owning the individual piece of machinery or equipment. The remaining fixed costs together with the variable costs represent the costs of operating the machinery and equipment.

Table 1. Estimated operating and ownership costs per hour, sugarcane hauling and transloading machinery and equipment, Louisiana, 1985.

	Costs per hour					
Item	Class 8 diesel truck	24 Ton cane trailer	Transloader	5 ton cane wagon	106-130 hp tractor	12 ton cane wagon
	dollars					
Variable costs						
Operating costs						
			5.00	—		—
	.92	•••	6.57		3.88	
Lubricants	.61	•••	.74		.96	
Fuel	9.00		4.93		6.43	
Total operating variable cost	10.53	0.00	17.24	0.00	11.27	0.00
Total variable cost	10.53	0.00	17.24	0.00	11.27	0.00
Fixed costs						
Operating costs						
	5.00				5.00	
Overhaul		2.07		2.45		2.07
Insurance	.48	1.49	.95	.08	.34	.14
Highway taxes, license	.69					
Total operating fixed cost	6.17	3.56	.95	2.53	5.34	2.21
Ownership costs						
Depreciation	1.94	.98	9.47	1.00	3.21	1.69
Interest	2.27	.14	13.79	1.22	4.98	2.06
Total ownership fixed cost	4.21	1.12	23.26	2.22	8.19	3.75
Total fixed cost	10.38	4.68	24.21	4.75	13.53	5.96
Total cost	20.91	4.68	41.45	4.75	24.80	5.96

Total cost figures were used in the normative long-run analysis. Operating costs were used in analyzing extreme short-run distortions, reflecting zero ownership cost. While not included in the analysis, intermediate short-run distortions would depend on the amount of depreciation and interest remaining on each piece of machinery and/or equipment.

The analysis was structured to examine various decision situations by comparing the total cost of one method with the operating cost of another method. In this manner the costs of a method currently employed or for which the machinery and equipment are already owned, can be compared with the costs of a method for which the machinery and equipment would have to be obtained. In this manner only the relevant costs are considered in identifying the method with the greatest cost advantage in each decision situation.

The following assumptions were made for developing the operating and ownership cost of each hauling method for various distances from the mill from the per hour cost estimates presented in Table 1. The truck and trailer method of transporting sugarcane was assumed to include a Class 8 diesel truck and a single, double compartment, 24-ton capacity trailer. The cane is brought from the field to the transloading site using 5-ton cane wagons. The cane is unloaded to the ground, where it accumulates, until hoisted by a transloader into the trailer. The time to load the trailer is estimated to take fifteen minutes. The trailer is towed to the mill, where it is unloaded in the mill yard. The average speed of the truck and trailer is 30 miles per hour, with and without payload. The time spent at the mill to weigh, test, and unload the sugarcane, including delays, is estimated to be thirty minutes.

The tractor and wagon methods use a 106- to 130-horsepower tractor. The method characterized by a 24-ton payload includes two 12-ton cane wagons. The method characterized by a 10-ton payload includes two 5-ton cane wagons. Either method hauls direct to the mill from the field, eliminating a transloading step. Either method is estimated to travel at an average speed of 15 miles per hour, with and without payload.

The time required per trip for the truck and trailer includes the traveling time plus a fixed amount of time, reflecting loading time and of time spent at the mill. The time required per trip for the tractor and wagon includes the traveling time plus the time spent at the mill. These estimates per trip were used to convert the appropriate costs-per-hour estimates presented in the budgets (Table 1) into costs-per-trip estimates.

The total cost and operation cost of hauling a ton of cane to the mill by each method was calculated for 1-mile increments from 0 miles to 45 miles. The cost of transporting a ton of cane by truck and trailer includes costs associated with hauling the payload, costs associated with delivering a ton of cane from the field to the transloader, cost associated with transloading the cane into the trailer and time spent queuing and unloading at the mill. The cost of transporting a ton of cane by tractor and wagons includes costs associated with hauling the payload, and time spent queuing and unloading at the mill.

Using the costs estimates presented in the budgets, (Table 1), the total cost per 24-ton load for the truck and trailer include:

1. Costs related to the traveling time of the truck and trailer eiven as:

   (Total cost per hour, truck + total cost per hour, trailer)$\left(\frac{2X}{30 \text{ mph}}\right)$

   where X is the distance in miles from the transloader to the mill doubled to reflect a round trip and 30 mph is the speed of the truck and trailer.

2. Costs related to the time spent loading, queuing, and unloading, given as:

   (Fixed cost per hour, truck + fixed cost per hour, trailer)$\left(\frac{15}{60} + \frac{30}{60}\right)$

   where 15/60 hours represents 15 minutes loading time at the transloader, and 30/60 hours represents 30 minutes queuing and unloading time at the mill.

3. Cost related to the operation of the transloader per 24 tons of cane loaded, given as:

   (Total cost per hour, transloader)$\left(\frac{15}{60}\right)$

   where 15/60 hours represents the time to load 24 tons of cane.

4. Cost related to delivering the cane to the transloader, given as:

   (Total cost per hour, tractor + total cost per hour, 5 ton wagon)$\left(\frac{60}{60}\right)$

   where 60/60 hours represents 1 hour to deliver 24 tons of cane to the transloader.

The sum of the four components gives the total cost associated with hauling 24 tons of sugarcane using the truck and trailer method. Dividing the total cost by 24 tons gives the total cost per ton of cane hauled.

Calculation of the operating cost associated with transporting cane by truck and trailer is similar to the above algorithum, the exception being the removal of the ownership cost associated with each piece of machinery or equipment.

Using the costs estimates presented in the budgets, (Table 1), the total cost per load for either of the tractor and wagon methods, (24 tons total or 10 tons total), includes:

1. Cost associated with the tractor and wagons, given as:

   [Total cost per hour, tractor + 2(Total cost per hour, wagon)J $\left(\frac{2X}{15 \text{ mph}}\right)$

   the total cost per hour for the wagon is doubled to reflect two wagons in tandem; X is the distance in miles from the transloader to the mill, doubled to reflect a round trip, and 15 mph represents the speed of the tractor and wagons.

2. Costs related to the time spent loading, queuing, and unloading, given as:

   [Fixed cost per hour, tractor + 2(Fixed cost per hour, wagon)J $\left(\frac{30}{60}\right)$

   the fixed cost per hour of the wagons is doubled to reflect two wagons in tandem; 30/60 hours represents 30 minutes queuing and unloading time at the mill.

The sum of the two components gives the total cost associated with hauling 24 tons or 10 tons of sugarcane using the tractor and wagon method. Dividing the total cost by 24 tons or 10 tons, repectively, gives the total cost per ton.

Calculation of the operating cost associated with transporting cane by tractor and wagons is similar to the above algorithum, the exception being the removal of the ownership cost associated with each piece of machinery or equipment.

RESULTS

The estimates of total cost and operating cost per ton of cane hauled for the three hauling alternatives considered in the analysis for miles 0 to 20 are presented in Table 2. The relevant costs per ton of employing the different methods of hauling sugarcane at each distance from the mill were compared to identify the method with the least cost at each distance. The long-run situation, which considers total cost (ownership and operating) is presented, graphically, in Figure 1. Examination of these costs indicated that the tractor and wagon with a 24-ton payload had the greatest cost advantage up to 11.9 miles. Beyond this distance the truck and trailer method exhibited the greatest cost advantage. When the total cost related to the truck and trailer were compared directly with the total cost of the tractor and wagon with a 10-ton payload, the tractor and wagons exhibited a cost advantage up to approximately 2 1/2 miles. Beyond this distance the truck and trailer exhibited the cost advantage. Comparison of the two tractor and wagon methods indicates that the wagons with 24-ton payload have a cost advantage at all distances.

Table 2. Estimated total and operating cost per ton of sugarcane hauled for three alternative methods of transportation, Louisiana, 1984.

Miles	Tractor/wagon (12 ton x 2)		Tractor/wagon (5 ton x 2)		Truck/trailer (24 ton)	
	Total costs	Operating cost	Total cost	Operating cost	Total cost	Operating cost
Miles	dollars					
0	.53	.20	1.15	.52	2.11	1.27
1	.73	.32	1.61	.81	2.18	1.32
2	.94	.44	2.07	1.10	2.25	1.38
3	1.14	.55	2.52	1.39	2.32	1.44
4	1.35	.67	2.98	1.68	2.39	1.49
5	1.55	.79	3.44	1.96	2.47	1.55
6	1.75	.90	3.90	2.25	2.54	1.60
7	1.96	1.02	4.35	2.54	2.61	1.66
8	2.16	1.14	4.81	2.83	2.68	1.72
9	2.37	1.25	5.27	3.12	2.75	1.77
10	2.57	1.37	5.72	3.41	2.82	1.83
11	2.77	1.49	6.18	3.70	2.89	1.89
12	2.98	1.61	6.64	3.99	2.96	1.94
13	3.18	1.72	7.10	4.28	3.03	2.00
14	3.39	1.84	7.55	4.57	3.10	2.05
15	3.59	1.96	8.01	4.85	3.18	2.11
16	3.79	2.07	8.47	5.14	3.25	2.17
17	4.00	2.19	8.93	5.43	3.32	2.22
18	4.20	2.31	9.38	5.72	3.39	2.28
19	4.41	2.42	9.84	6.01	3.46	2.34
20	4.61	2.54	10.30	6.30	3.53	2.39

The first short-run situation examined in the analysis included comparing the total cost of the truck and trailer and the operating cost of the tractor and wagons with a 24-ton payload. These costs are presented in Figure 2. The figure also includes the long-run cost comparison of the two methods to illustrate the effects of removing the ownership costs of the tractor and the wagons from the comparison. Examination of these costs indicates that the tractor and wagons with ownership costs removed has a cost advantage over the truck and trailer method for distances up to 41.8 miles versus 11.9 miles in the long-run situation. This represents a significant distortion. The size of this difference is due largely to the dependency of the tractor and wagon costs on miles traveled. The difference between the tractor and wagon total costs and operating costs increases as the number of miles increases.

A second short-run situation, which compares the total costs of the tractor and wagons with a 24-ton payload and the operating costs of the truck and trailer is presented in Figure 2. Under this situation the tractor and wagon represents a cost advantage up to approximately 5 miles versus 11.9 miles in the long-run situation. This distortion is far less than the earlier deviation. The difference in distortions is made up in part by the differences in the cost of ownership removed in either case. However, the difference is largely due to the nature of the cost of employing the truck and trailer method, which includes some costs that remain fixed for each round trip, despite the number of miles traveled. As the number of miles increases, the costs of the tractor and wagons method increase more rapidly than the costs of the truck and trailer method.

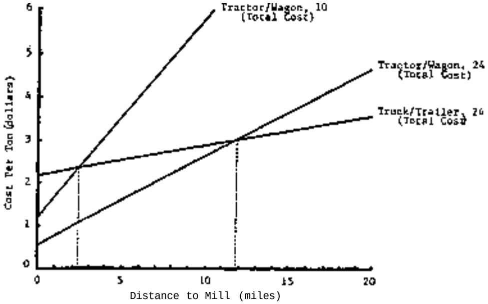

Figure 1. Estimated total costs per ton of sugarcane hauled, for various distances to the mill, tractor with two 5-ton cane wagons, tractor with two 12-ton cane wagons, and truck with 24-ton cane trailer, Louisiana, 1984.

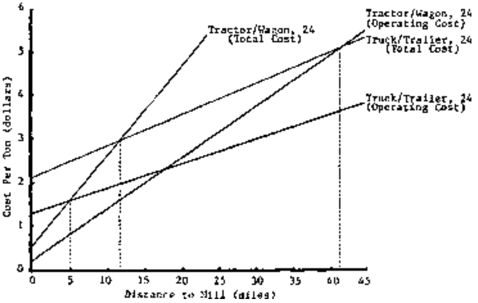

Figure 2. Estimated total and operating costs per ton of sugarcane hauled, for various distances to the mill, tractor with two 12-ton cane wagons and truck with 24-ton cane trailer, Louisiana 1984.

A comparison of the relevant costs of the truck and trailer method with those of the tractor and wagons with a 10-ton payload is presented in Figure 3. Examination of the operating cost of the tractor and wagon and the total cost of the truck and trailer indicates that the tractor and wagons have a cost advantage at distances up to approximately 7.3 miles versus approximately 2.5 miles for the long-run situation. Examination of the total cost of the tractor and wagons and the operating cost of the truck and trailer indicates that the cost advantage was with the tractor and wagons for less than 3/10 of a mile. The relative distances resulting from the analysis were in all cases less than the distances resulting from this analysis involving the truck and trailer and the tractor and the larger wagons. This is due in large part to the lower capacity of the smaller wagons, resulting in the relevant costs being spread over fewer tons.

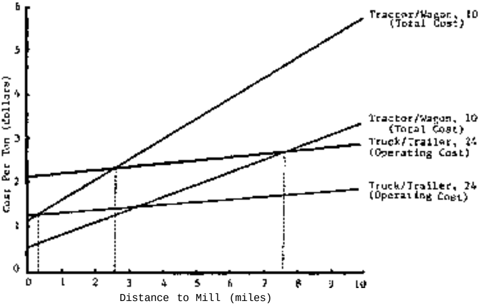

Figure 3. Estimated total and operating costs per ton of sugarcane hauled, for various distances to the mill, tractor with two 5-ton cane wagons and truck with 24-ton cane trailer, Louisiana, 1984.

CONCLUSION

The results of tne analysis indicate that the observed pattern of employing the selected methods of transporting sugarcane, the tractor and wagons being employed at distances closer to the mill and the truck and trailer at distances further from the mill, represent an economically rational use of resources. The tractor and wagon methods show a cost advantage over the truck and trailer method at shorter distances. Comparing the long-run costs of the tractor and wagons with a 10-ton payload and the truck and trailer, the former exhibited a cost advantage up to a distance of 2.5 miles from the mill after which the cost advantage was with the latter. The tractor and wagons with a 24-ton payload exhibited a cost advantage up to 11.9 miles from the mill over the truck and trailer.

This pattern of relative cost advantages occurs because the truck and trailer method has a relatively high cost per ton unrelated to the distance hauled and a relatively low cost per ton-mile when compared to the tractor and wagon methods. The higher cost of the truck and trailer method unrelated to distance is due to the transloading operation. The low cost per ton-mile is related to the greater hauling efficiency of the truck and trailer, spreading the costs per hour over a greater number of tons.

This analysis was then extended to show short-run distortions from the long-run situation described above. In some circumstances a rational decision determining the selection of a method of transportation in the short run may not be the long run least-cost method. The short-run distortions included in the analysis represented extreme situations where the ownership cost associated with one of the methods in a comparison was removed. This type of situation is faced when the equipment and machinery for that method of transportation is owned and fully depreciated. Intermediate short-run distortions would represent situations where the ownership costs were not fully removed.

This least-cost model simulates observed conditions in the Louisiana sugar industry and may be useful in explaining normative long-run cost situations, as well as short-run distortions from the normative

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SUGARCANE TOLERANCE TO DPX-5969 AND DPX-5967

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ABSTRACT

Sugarcane (interspecific hybrids of Saccharum sPP. CV. 'CP 65-357') tolerance to DPX-5969 and DPX-5967 was determined for spring and layby applications. Initial injury manifested as chlorosis and necrosis resulted from both application times. With the exception of DPX-5967 at 0.28 kg/ha, sugarcane recovered from initial injury by 60 days after treatment, and yields were not reduced. A spring application of DPX-5967 at 0.28 kg/ha caused a significant reduction cane yield and commercially recoverable sugar apparently due to minor decreases in sugar content and stalk density. Both compounds appear to be safe for use in cropland regions supporting both soybeans [Glycine max (L.) Merr.] and sugarcane when application rates are less than 0.28 kg/ha.

INTRODUCTION

Sugarcane (interspecific hybrids of Saccharum spp.) was the predominant crop in south Louisiana until the late 1970's. During that period, herbicide drift from phenoxy herbicides such as 2,4-D [(2,4-dichlorophenoxy)acetic acid] and silvex [2-(2,4,5-trichlorophenoxy)propionic acid] to susceptible crops was of little concern. As soybeans [Glycine max (L.) Merr.] increased in importance in south Louisiana (7), application of these herbicides became undesirable because of the injury risk.

In 1980, experiments were initiated to evaluate herbicides for control of annual morningglories (Ipomoea spp.) and other dicotyledonous weeds in sugarcane and soybeans. The herbicides DPX-5969 and DPX-5967 were reported to control a wide range of broadleaf weeds, seedling johnsongrass [Sorghum halepense (L.) Pers.], and other annual grasses when applied preemergence or postemergence in soybeans (4). Weeds controlled included smooth pigweed (Amaranthus hybridus L.) (5), cocklebur (Xanthium pensylvanicum Wallr.) (3,5,6), and sicklepod (Cassia obtusifolia L.) (1,4) when applied at 0.07 kg/ha. DPX-5969 applied postemergence at 0.03 kg/ha + surfactant controlled entireleaf morningglory (Ipomoea hederacea Jacq.), a common weed in sugarcane (3). Both herbicides provided 70% control of pitted morningglory (Ipomoea lacunosa L.) at the 5 or 8 leaf growth stage (3). In general, DPX-5969 was less injurious to soybeans than DPX-5967 (1,2,3,9); however, the injury to soybeans usually was temporary and did not cause a yield reduction.

The objective of this research was to evaluate tolerance of sugarcane to DPX-5969 and DPX-5967.

MATERIALS and METHODS

Studies were conducted in 1981 and 1982 at the St. Gabriel Research Station near St. Gabriel, Louisiana, on cultivar 'CP 65-357' plant cane. Soil on the study area was a Commerce silty loam (pH 7.0 1.2% organic matter, and 25% clay, 67% silt, and 8% sand).

The studies were randomized block designs with 1 row (1.9 m) by 5 m with 3 replicates in 1981 and 2 rows (1.9 m) by 7 m with 4 replicates in 1982. In 1981, spring treatments were applied broadcast (245 L/ha) at 0.04, 0.07, 0.14 and 0.28 kg/ha on April 3 using a standard gas pressurized backpack sprayer when the sugarcane was 20 cm tall and at the 5 collar growth stage.

In 1982, herbicides were applied overtop of the sugarcane using a CO_2 pressurized tractor sprayer on a 0.9 m band at 0.02, 0.04, 0.07, 0.14 kg/ha (190 L/ha) calibrated at 190 L/ha. Spring treatments were applied on March 19 when the sugarcane was 30 cm tall and at the 3 collar growth stage. Layby treatments were applied on June 4 after the last cultivation when the sugarcane was 1 m tall and at the 7 collar growth stage. Plots were maintained weed-free by hoeing, cultivation, and basally directed applications of 1.12 kg/ha ametryn [2-(ethylamino)-4-(isopropylamino)6-(methylthio)-5-triazine] plus 1% oil concentrate.

Sugarcane was evaluated periodically for injury symptoms, height, and stem density. Sugarcane injury was visually estimated on the basis of necrosis, chlorosis, or growth inhibition. Sugarcane height was measured from the ground surface to the uppermost dewlap. Sugarcane stem density in plots was determined by counting the number of stalks per 5 m of row in 1981 and 6 m of row in 1982.

Plots were harvested during November in both years by hand cutting stalks 2-5 cm above the ground surface, topping at the uppermost visible node, and stripping leaves. In 1981, a 10-stalk subsample was weighed and analyzed for sugar, while in 1982, a 20-stalk subsample was weighed and a 5-cane subsample was analyzed for sugar. Yield and sugar content of stalks were determined using standard analytical methods (8).

Data was analyzed using standard statistical techniques and means were separated by the Duncan's New Multiple Range Test.

RESULTS and DISCUSSION

Spring applications of DPX-5969 or DPX-5967 were more phytotoxic to sugarcane in 1982 than in 1981. In 1981, only DPX-5967 at 0.28 kg/ha caused injury 40 days after treatment (DAT) (Table 1). None of the other rates significantly damaged sugarcane. In 1982, all rates of both herbicides resulted in greater than 15% injury 30 DAT except for DPX-5967 at 0.02 kg/ha (Table 1). Minor injury was observed in the untreated plots due to a late frost. For the 1982 layby treatments, DPX-5967 injured sugarcane at all rates tested except 0.04 kg/ha, whereas DPX-5969 damaged sugarcane only at the 0.14 kg/ha rate. Layby applications of DPX-5969 tended to be less injurious to sugarcane than DPX-5967. Sugarcane visibly recovered from injury from spring applications by the 120 DAT evaluation. Injury symptoms were generally manifested as chlorosis or bleaching of new growth and patches of necrotic tissue along the margins of mature leaves.

Table 1. Sugarcane injury following an overtop spring or layby application of DPX-5969 and DPX-5967 near St. Gabriel, Louisiana, in 1981 and 1982.

Chemical	Rate	1981 Spring application 40 DAT 1/	1982 Spring application 30 DAT	1982 Spring application 120 DAT	1982 Layby appl. 70 DAT
	(kg/ha)	(%)	%	%	(%)
DPX-5969	0.02	-- 2/	28 3/ ab	0 a	0 b
DPX-5969	0.04	5 b	25 ab	0 a	10 b
DPX-5969	0.07	5 b	30 a	0 a	10 b
DPX-5969	0.14	28 ab	35 a	0 a	40 a
DPX-5969	0.28	35 ab	--	--	--
DPX-5967	0.02	--	15 be	10 a	40 a
DPX-5967	0.04	18 ab	25 ab	0 a	10 b
DPX-5967	0.07	12 b	30 a	0 a	30 a
DPX-5967	0.14	25 ab	35 a	0 a	40 a
DPX-5967	0.28	53 a	--	--	--
Metribuzin	2.70	5 b	10 c	0 a	0 b
Control	0.00	0 b	3 c	0 a	0 b

1/ Days after treatment.

2/ Rate not applied.

3/ Means within a column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test (*d* = 0.05).

With the exception of DPX-5967 at 0.28 kg/ha, sugarcane height was not reduced by either of the herbicides in 1981 (Table 2). In 1982, a spring application of DPX-5967 at 0.14 kg/ha resulted in sugarcane heights less than the standard metribuzin treatment, but equal to the untreated plots 30 DAT. However, by 120 DAT, the sugarcane recovered from this initial growth inhibition and no height reductions were observed. Plant heights measured 70 DAT were not affected by layby application of these herbicides.

Table 2. Sugarcane height as affected by a spring or layby application of DPX-5969 or DPX-5967 near St. Gabriel, Louisiana, in 1981 and 1982.

Chemical	Rate	1981 Spring application 40 DAT 1/	1982 Spring application 30 DAT	1982 Spring application 120 DAT	1982 Layby application 70 DAT
	(kg/ha)	cm			
DPX-5969	0.02	2/	24 abc 3/	223 a	229 a
DPX-5969	0.04	36 ab	25 abc	229 a	215 a
DPX-5969	0.07	32 ab	24 abc	222 a	209 a
DPX-5969	0.14	30 bc	23 bc	228 a	210 a
DPX-5969	0.28	31 abc			
DPX-5967	0.02	—	25 abc	213 a	205 a
DPX 5967	0.04	29 bc	25 abc	215 a	221 a
DPX-5967	0.07	32 ab	28 abc	219 a	213 a
DPX-5967	0.14	29 bc	22 c	222 a	191 a
DPX-5967	0.28	23 c		—	
Metribuzin	2.70	38 ab	27 ab	201 a	201 a
Control	0.00	36 ab	25 abc	229 a	229 a

1/ Days after treatment.

2/ Rate not applied.

3/ Means within the same column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test (α = 0.05).

Sugarcane stalk density was highly variable on the study area, making detection of stand different difficult. Spring applications did not significantly affect stalk density compared to untreated plots (Table 3). Layby application of DPX-5967 at 0.02 and 0.14 kg/ha decreased stalk density of sugarcane as compared to metribuzin at 2.70 kg/ha; however, this decrease was not different from the untreated

Table 3. Sugarcane stalk density as affected by a spring or layby application of DPX-5969 or DPX-5967 near St. Gabriel, Louisiana, in 1981 and 1982.

Chemical	Rate	1981 Spring application 120 DA 1/	1982 Spring application 30 DAT	1982 Spring application 120 DAT	1982 Layby application 70 DAT
	(kg/ha)	(105/stalks/ha)			
DPX-5969	0.02	2/	52 b 3/	104 a	104 ab
DPX-5969	0.04	55 a	54 b	90 a	101 ab
DPX-5969	0.07	58 a	76 a	99 a	95 ab
DPX-5969	0.14	52 a	56 b	103 a	97 ab
DPX-5969	0.28	40 a	—		—
DPX-5967	0.02	—	57 b	89 a	79 b
DPX-5967	0.04	56 a	63 ab	101 a	95 ab
DPX-5967	0.07	53 a	62 ab	99 a	95 ab
DPX-5967	0.14	55 a	57 b	104 a	82 b
DPX-5967	0.28	53 a	—		—
Metribuzin	2.70	48 a	55 b	Ill a	Ill a
Control	0.00	43 a	62 ab	104 a	104 ab

1/ Days after treatment.
2/ Rate not applied.

3/ Means within the same column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test («= 0.05).

Spring and layby applications of DPX-5969 and DPX-5967 did not affect sugarcane stalk weight and sugar content in 1981 and 1982 (Table 4). In 1981, DPX-5967 at 0.28 kg/ha was the only treatment that decreased cane yield and commercially recoverable sugar (Table 5). This yield reduction probably resulted from subtle decreases in sucrose and stalk density. Generally, spring applications of DPX-5969 or DPX-5967 at rates less than 0.28 kg/ha resulted in yields either equivalent to or slightly higher than plots treated with 2.70 kg/ha metribuzin. Layby application of DPX-5969 and DPX-5967 did not reduce sugarcane yield and resulted in yields comparable to the standard metribuzin application (Table 5).

Table 4. Sugar content and mean stalk weight of sugarcane following a spring or layby application of DPX-5969 or DPX-5967 near St. Gabriel, Louisiana, in 1981 and 1982.

		Sugar content			Mean stalk weight		
		1981	1982		1981	1982	
Chemicals	Rate	Spring	Spring	Layby	Spring	Spring	Layby
	(kg/ha)	(%)			(kg)		
DPX-5969	0.02	—	14.7 a-'	16.1 a	—	1.1 a	1.2 a
DPX-5969	0.04	17.0 a	16.0 a	15.2 a	1.3 a	1.2 a	1.1 a
DPX-5969	0.07	16.2 a	15.1 a	15.7 a	1.2 a	1.1 a	1.2 a
DPX-5969	0.14	17.7 a	15.0 a	15.1 a	1.3 a	1.1 a	1.0 a
DPX-5969	0.28	16.4 a			1.1 a		
DPX-5967	0.02		15.9 a	15.7 a		1.2 a	1.0 a
DPX-5967	0.04	18.2 a	16.0 a	15.0 a	1.2 a	1.1 a	1.0 a
DPX-5967	0.07	18.4 a	15.1 a	15.3 a	1.1 a	1.2 a	1.0 a
DPX-5967	0.14	17.1 a	15.1 a	15.9 a	1.1 a	1.1 a	1.1 a
DPX-5967	0.28	15.2 a			1.1 a		
Metribuzin	2.70	17.9 a	15.4 a	15.4 a	1.3 a	1.0 a	1.0 a
Control	0.00	17.8 a	16.1 a	16.1 a	1.3 a	1.1 a	1.1 a

1/Rate not applied.

2/Means within a column followed by the same number are not significantly different according to Duncan's New Multiple Range Test (a = 0.05).

Table 5. Cane yield and commercially recoverable sugar of sugarcane following a spring or layby application of DPX-5969 or DPX-5967 near St. Gabriel, Louisiana, in 1981 and 1982.

		Cane yield			Commercially Recoverable sugar		
		1981	1982		1981	1982	
Chemical	Rate	Spring	Spring	Layby	Spring	Spring	Layby
		Q 0 3 ks/ha)			(10^3 kg/ha)		
DPX-5969	0.02	—	82.0 a—'	90.3 a	—	6.6 a	8.1 a
DPX-5969	0.04	92.7 a	89.8 a	86.4 a	8.9 a	8.0 a	7.1 a
DPX-5969	0.07	83.1 a	80.0 a	89.8 a	7.6 ab	6.5 a	7.7 a
DPX-5969	0.14	91.7 a	80.8 a	75.6 a	9.1 a	6.7 a	6.3 a
DPX-5969	0.28	77.8 a			7.2 ab		
DPX-5967	0.02		88.5 a	76.0 a		8.0 a	6.6 a
DPX-5967	0.04	86.7 a	85.0 a	77.1 a	9.0 a	7.6 a	6.4 a
DPX-5967	0.07	87.5 a	89.0 a	76.5 a	9.0 a	7.3 a	6.4 a
DPX-5967	0.14	79.1 a	84.2 a	85.4 a	7.6 a	7.0 a	7.7 a
DPX-5967	0.28	57.3 b			4.7 b		
Metribuzin	2.70	76.7 a	73.0 a	73.0 a	7.8 ab	6.2 a	6.2 a
Control	0.00	81.5 a	84.2 a	84.2 a	8.2 ab	7.6 a	7.6 a

— Rate not applied.

2/

— Means within the same column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test (a = 0.05).

DPX-5969 and DPX-5967 show promise for use in sugarcane although registration is not likely. Analogs of these compounds may eventually provide a compound that controls broadleaf weeds in both sugarcane and soybeans. With increasing public pressure against the use of phenoxy compounds, the continued search for new, innovative methods of controlling broadleaf weeds in sugarcane is imperative.

CONCLUSIONS

DPX-5969 and DPX-5967 appear to be safe for use in sugarcane if applied at rates less than 0.28 kg/ha. Temporary chlorosis and necrosis can be expected for a duration of approximately 60 days. The sugarcane recovers from this injury and yields are not adversely affected. At application rates greater than or equal to 0.28 kg/ha, permanent injury and subsequent yield reduction may occur. Decreases in yield at high rates appear to be the result of a subtle decrease in stalk density weight and sugar content. However, these rates are well above that necessary for morningglory control (6).

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STALK HEIGHT ESTIMATION WITH ULTRASONICS 1/

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ABSTRACT

The use of ultrasonics was investigated for detecting sugarcane stubble height. A commercially available ultrasonic level controller was modified to allow its control by an external microcomputer and for recording of echo data. Tests were conducted in a laboratory setting to determine the accuracy of the system and the ability to distinguish between echoes from the ground surface and those from the stalks. Test indicate the use of ultrasonics for cutting height control for sugarcane harvesters is feasible and could provide sufficient accuracy.

INTRODUCTION

Precision height control of sugarcane harvester basecutting blades could significantly reduce field losses. Cochran (1974) revealed that cutting the cane too low introduces dirt in the harvester, causing excessive wear, reducing sugar recovery, and greatly increasing power requirements; conversely, cutting the cane too high increases sugarcane loss. Cochran reported that 25 mm of stalk remaining in the field is approximately equivalent to 2.24 metric tons of sugarcane per hectare.

Suggs and Abrams (1972) realized the shortcomings of using conventional ground-sensing fingers for rotary cutting equipment such as that on the sugarcane harvester. They proposed connecting the hydraulic lift cylinder to the basecutter motor's hydraulic circuit. Cutting too low would produce an increase in cutting resistance, thus increasing the hydraulic pressure. Increasing the hydraulic pressure would cause the lift cylinder to raise the cutting level. Equilibrium of the system would soon be established. However, field tests were not reported on this concept.

Ultrasonics have been used in various distance sensing applications. Paulson and Strelioff (1974) developed a height-measuring technique using ultrasonic sensors to determine the height of a cultivator frame above the soil surface. After filtering the returned signal with a low-pass filter, depth accuracy of +.63 mm at a ground speed of 2.68 meters/sec was obtained.

An automatic, ultrasonic control system maintained the end of a potato harvester loading boom within a specified height above a potato pile (Bailey et al, 1974). An ultrasonic sensor at the end of the boom was used to determine the distance to the potato pile surface. The boom was maintained at a constant height above the pile by the control system. By using ultrasonic sensing, significantly fewer potatoes were bruised, and the operator was freed from having to make boom adjustments while unloading.

The objective of this research was to determine the feasibility of using ultrasonics with the aid of a microprocessor as a means for regulating the cutting height of the basecutting blades on a sugarcane harvester. This was accomplished by 1) studying the ultrasonic reflective characteristics of irregular surfaces such as soil, field trash, and cut sugarcane, and 2) by developing software suitable for soil-stalk discrimination and signal averaging.

MATERIALS and METHODS

Ultrasonic Height Detection

The proximity of a reflecting target to an ultrasonic transducer is determined by the time elapsing between the transmission of an ultrasonic pulse and the reception of the echo. Since the time is related to the distance traveled, the distance to the target can be easily computed by using the equation

$$D = \frac{Vt}{2} \qquad (1)$$

where D is the distance to the target from the transceiver, V is the velocity of sound in air, and t is the time of travel between the transmission of the signal and the reception of the echo. Since D is a function of the velocity of sound through air, any variation in the velocity would cause inaccuracies in the distances calculated. Although temperature changes do affect the velocity of sound in air, if a relative distance is desired rather than an absolute value, the effects of varying air temperature can be ignored.

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Ultrasonic Detection System

System design. The system used for this research was composed of two units: 1) an ultrasonic power transceiver, and 2) a microprocessor-based controller. The power transceiver (Model DLM12, available commercially from Westmar, Inc., Seattle, Washington)2/contained all the components required for an ultrasonic sensing system, including a built-in, preprogrammed microcomputer. Because the DLM12 was developed for level sensing in a bin or tank, the program was not applicable to ground height detection. Therefore, the onboard computer was disabled and an external unit was developed to control the ultrasonic circuitry.

The external microprocessor unit was designed for software development and data acquisition. The heart of the system was a Motorola?./ M6802 microprocessor chip. In addition to the microprocessor, adequate memory and appropriate input/output ports for sending and receiving information from peripheral devices (CRT terminal, a chart recorder, and the control circuit of a servo-mechanism) were provided. By combining the DLM12 with the external microprocessor unit, an effective ultrasonic sensing system was developed.

Controlling software was developed for the external microcomputer so that it could initiate and detect ultrasonic pulses and record the resulting echo times. Specific algorithms were developed and tested to evaluate the suitability of the ultrasonic system for cutting height control. Discussion of specific software aspects follows.

Lost echo discrimination. Ultrasonic signals are sensitive to the target's angle of reflectance. The angle may be great enough to reflect the transmitted signal away from the receiver, resulting in a "lost echo" effect, as shown in Figure 1(A). Total or nearly total absorption of the signal by the target also results in a "lost echo" effect. Soil surfaces are very erratic in angular and absorptive characteristics, as shown in Figure 1(B). To recognize and thereby ignore lost echoes, discriminating software was developed. Each new echo time was compared with a predetermined limit; for example, twice the expected time required for an ultrasonic pulse to travel to the target and back. If the sample value exceeded this limit, it was assumed to be invalid. If the sample was less than the limit, it was considered valid.

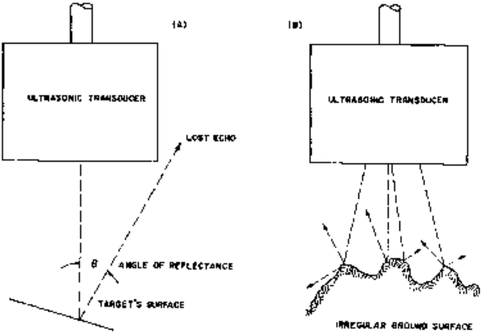

Figure 1. Effects of angle of reflectance on ultrasonic pulses.

The use of trade names is for information only and does not imply endorsement by Texas A&M University.

True soil surface detection. Because of the uncut cane stalks and the high trash conditions which exist in front of the basecutting blades of a sugarcane harvester, the transducer would ultimately have to be located behind the blades, as shown in Figure 2. The added protection the transducer would receive in this position, as well as the increase in soil exposure, are well worth the increase in the system's response time (about 0.5 seconds @ 6 km/hr). It is important to keep the cutting blades above the ground. When the blades cut below the ground surface, much of the soil is removed from the row, in effect, lowering the surface. The transducer, then measuring the relative height to the lowered surface, would produce false information with regard to actual ground height. This problem can be avoided if a small amount of cane is permitted to remain, thus guaranteeing that the cutters are above the ground.

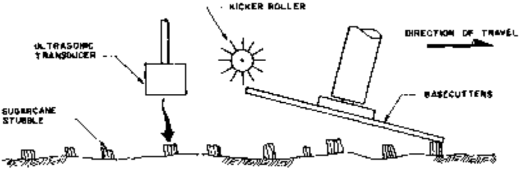

Figure 2. Proposed orientation of ultrasonic transducer with respect to basecutters.

Determination of Ultrasonic Resolution

For preliminary evaluation of the system's height measuring abilities, several tests were conducted over a prepared soil bin. The soil bin was a 6.7 m x 0.9 m x 0.6 m cart which traveled on a 15 m linear track. The ultrasonic transducer was fixed in the center of the track and 0.7 m above the cart. The motion of the cart under the transducer is equivalent to the motion of the transducer over the ground. The information from the transducer was processed by the microprocessor and fed to a strip-chart recorder, an oscilloscope, display terminal, or some combination of these instruments.

To determine the resolution of the distance measurements, dowel rods of 20, 100, and 150 mm were mounted to a board on the soil bin cart and passed beneath the ultrasonic transducer. The recorded echoes were compared to the actual values in order to determine the resolution of the system.

Ground Detection

In order to determine the ability of the ultrasonic system to accurately determine the distance from the transducer to the ground surface, the cart with soil only was passed under the transducer. Because of the many irregularities across the soil surface - cracks, clods, trash, etc., - some form of echo averaging was required. The method of averaging needed to be sensitive to general changes in ground height but not too sensitive to irregularities. An averaging program requiring a minimum of memory and computation time was needed. The weighted, running average met these requirements. It gives more weight to the most recent sample and requires storage of only the running average. The average is made such that:

$$A_n = \frac{S_n}{M} + \frac{M-1}{M} A_{n-1} \qquad (2)$$

or

$$A_n = A_{n-1} + \frac{S_n - A_{n-1}}{M} \qquad (3)$$

where A_n is the accumulated average after n samples have been taken, S_n is nth sample value, and M is the variable weighting factor. The weighting factor was varied between 2 and 128 for each test and the results compared to the actual ground profile. The profile was determined by running a linear variable displacement transformer (LVDT) over the soil surface and recording its output.

Soil-stalk detection and determination. The discrimination between echoes reflected from stalks and those from the soil surface is necessary for the determination of the cutting level. In order to test discrimination algorithms, a trimmed sugarcane stool was buried in the soil bin. By using the microprocessor to keep running averages of the ground echoes and the stalk echoes, an estimate of the stubble height could be made by computing the difference between these two averages. In an actual control system, cutting height would be maintained by minimizing the differences between the averages while still maintaining stalk detection. Methods for optimum detection and discrimination were tested.

Further tests were conducted to determine the accuracy of the discrimination algorithm in the case of multiple stalks. For each of two tests, a series of six wooden dowels was placed in the soil profile, The dowels used for one test were 15 mm high; those for the other were 10 mm high. The cart was passed beneath the transducer as before and the stalk heights calculated.

RESULTS

Resolution of Height Measurements

In order to determine the resolution of the system, objects of known heights were moved beneath the transducer and the response of the system was recorded on the strip-chart recorder. Figure 3 shows the wooden dowels and the resulting echoes. The apparent widening of the dowels and doming of their tops are caused by the changing angle of reflectance as the dowels pass through the transducer's 100 mm diameter sensing area. These effects are characteristic of targets with hard and very flat reflective surfaces. Due to the many irregular reflective angles of soil and cut sugarcane, these two effects are not expected to cause a problem in actual practice. The ultrasonic system demonstrated the ability to measure height to within +30 mm of the true height under ideal conditions.

WOODEN DOWELS OF 3 HEIGHTS:
20, 100, 150 mm

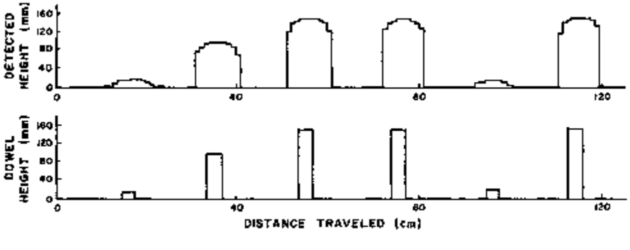

Figure 3. Ultrasonic response and accuracy test with 20, 100, and 150 mm wooden dowels

Performance in Ground Detection

Tests were conducted for a variety of soil profiles and evaluated using various weighting factors in the running average calculation. The results of one test are shown in Figure 4. The measured soil profiie is shown in Graph A, the raw echo data is plotted in Graph B, and the running averages with increasing weighting factors are shown in Graphs C-H. The output from the ultrasonic system corresponded reasonably well to the recorded surface profile. Increasing the weighted factor, M, in Equation 3 resulted in smoother profile curves. This effect was expected since the weighted average technique functions as a low pass filter and increasing M is equivalent to decreasing the cut-off frequency. These tests showed that the ground profile can be detected. The most appropriate weighting factor would best be determined empirically in the actual control system.

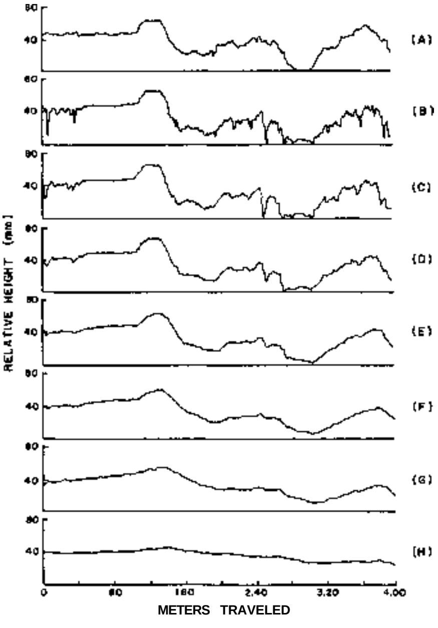

Figure 4. Ground surface profile. (A) Profile from LVDT. (B) Profile measured with ultrasonic device. (C) to (H) Profile using weighted averages of ultrasonic echoes with weights of: 2, 4, 8, 16, 32, 128.

Soil-Stalk Detection and Discrimination

The final stages of the laboratory testing involved detecting the ground and sugarcane stubble and differentiating between the two. There are reasons why cane must be distinguished from ground: 1) to keep the cane height from being included in the ground average, and thus making the ground surface seem higher than it actually is; and 2) to provide an accurate determination of remaining sugarcane stubble height so that appropriate cutting adjustments could be made. The difference between the ground average, A_G and the sugarcane stalk average, A_S , is the indicated stalk height.

The technique used for stubble detection used high and low relative thresholds to distinguish between stalk and ground samples. The use of two threshold levels reduced the effects of random noise in the ultrasonic signals. Figure 5 illustrates the operation of the dual threshold discrimination algorithm. Its operation was analogous to that of a Schmitt trigger in an electrical circuit. Sample heights below the low threshold were added to the ground average and those above the higher threshold were added to the stalk average.

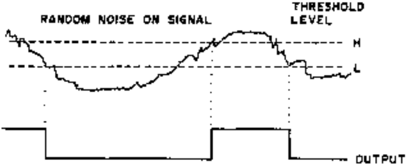

Figure 5. Effect of high (H) and low (L) thresholds on determination of stalk or ground echo.

A test using the bi-level detection scheme was run on a profile which included sugarcane stubble (Figure 6). Graph A is the output before averaging and discriminating. Graphs B and C show the stalk average Ag, after discrimination; C has some averaging; B does not. Graphs D through H show the ground average, AQ, for increasing weighting factors. The data shown indicates the ability of the soil-stalk discrimination algorithm to separate the echoes. Graph B is flat before and after the stubble, indicating that none of the echoes in those areas were seen as stalk echoes. The weighted averaging in Graph C shows how the addition of stalk echo values raises the running average. The estimated stubble height would be calculated by subtracting the ground average *AQ* from the stalk average A_g. The appropriate ground average responsiveness, Graphs D through H, would be chosen as needed for a given field situation.

Additional tests were conducted with dowel rods of 10 and 15 mm height placed in the soil to determine the accuracy of the discrimination technique. For both heights the upper and lower thresholds were set at 11 and 8 mm above A_G. The detected stalk height, A_S-A_G, was measured as approximately 10 mm for the 15 mm heights. The test with 10 mm dowels produced an estimated stalk height of approximately 5 mm. Although the 10 mm height was very close to the limit of resolution of the system, the calculated height was always positive. A third test run on the soil surface with no dowels produced a stalk height average that oscillated around 0 mm with a range of +5 mm. Although the algorithm tended to underestimate the actual dowel height, the resulting average could be used as an input parameter to a cutting control system.

CONCLUSIONS

Ultrasonics have been shown to be useful for measuring relative ground height as well as stubble height. Laboratory tests have confirmed that ultrasonic waves reflected off irregular soil and stalk surfaces are perceptible and informative. With the aid of a microprocessor, soil and stubble reflection samples can be distinguished and respective averages computed. The difference in the two averages could be an estimate of the cutting height in the field. Cutting height regulation using detection appears to be feasible. Research is continuing to develop this method for use on sugarcane harvesters.

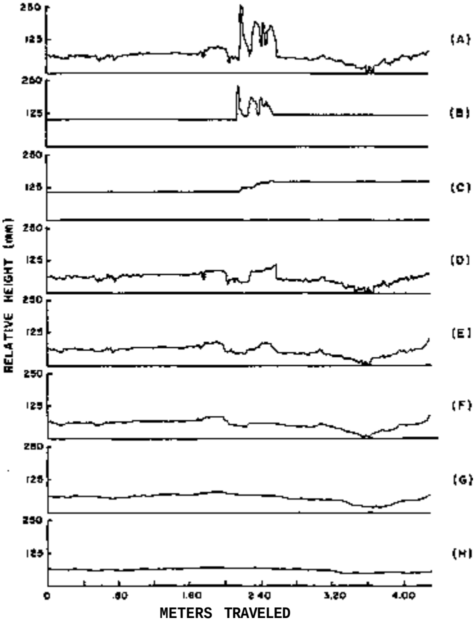

Figure 6. Ground and sugarcane discrimination. (A) Actual profile of ultrasonic echoes. (B) and (C) Sugarcane stubble weighted averages with weights of 1 and 128, respectively. (D) to (H) Ground weighted averages with weights of 1, 2, 4, 16, and 128, respectively.

ACKNOWLEDGEMENTS

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CLONAL SELECTION OF SUGAR CANE FOR TEXAS AND LOUISIANA
FROM A COMMON GERMPLASM POOL

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ABSTRACT

The sugar cane (a complex hybrid of Saccharum spp.) cultivar improvement program for the irrigated Lower Rio Grande Valley of Texas, initiated in 1961, has expanded greatly over the past 20 years. Initially, only 8 to 12 cultivars, selected from those previously released from commercial production in Louisiana or Florida, were screened annually for their production potential in the Lower Rio Grande Valley. The current introduction and screening program is more comprehensive utilizing 1) all clones advanced from the first to the second line trials at the U. S. Sugarcane Laboratory at Houma, Louisiana; 2) the advanced "CP" assignments from the U. S. Sugarcane Field Station, Canal Point, Florida; and 3) the "L" assignments from the Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana. During the period 1981-83, 191 clones were assigned Texas ("TCP") selection numbers. These clones were derived from crosses made at Canal Point but were selected in Texas from the early line trials. Only 10% of the lines selected in Texas were advanced to "CP" assignment status in Louisiana, the other 90% having been discarded. The difference in selections from a common germplasm pool was influenced by the response of clones to two contrasting environments and by the difference in selection criteria of the two programs.

INTRODUCTION

Sugar has been a major commodity of the Lower Rio Grande Valley for well over 150 years. From the establishment of the first mill in 1858 (Cowley and Smith, 1969), the early industry, although successful, was plagued with logistical problems, i.e. lack of transportation and distance to markets, as well as chronic crop production problems with insects, diseases, and salinity. By 1922, the sugar industry of the Lower Rio Grande Valley ceased to function.

During the 1960's, a need arose for new crop enterprises to bolster farm incomes and to provide employment. The Texas Agricultural Experiment Station at Weslaco and the Crops Research Branch of the U. S. Department of Agriculture (USDA) initiated studies to reassess the potential for sugar cane production in this irrigated region. During the first decade of sugar cane cultivar evaluation, approximately 8-12 cultivars were introduced annually to Texas from the U. S. Sugarcane Field Station at Canal Point, Florida, the U. S. Sugarcane Field Laboratory at Houma, Louisiana, and the Louisiana Agricultural Experiment Station at Baton Rouge, Louisiana. When the W. R. Cowley Sugar House began milling operations in late 1973, seven cultivars recommended for commercial production in the Lower Rio Grande Valley were CP 44-101, CP 52-68, CP 55-30, CP 61-37, L 60-25, L 62-96, and NCo 310. All cultivars were or had been grown commercially in Louisiana.

During the mid 1970's, the number of introductions was increased to approximately 30 annually to more rapidly identify promising candidates for commercial production. A review of the selection program in 1979 noted that 16 cultivars had been released for commercial production in Texas; but that, only two cultivars, CP 66-315 and CP 68-350, had been released independently from Florida and Louisiana (Table 1). These results suggested that the diversity of the germplasm introduced to Texas was limited due to previous selection of the material for environments somewhat dissimilar from that of the Rio Grande Valley of Texas. A second disadvantage cited was that only early-maturing cultivars were being tested and that potentially a late-maturing cultivar might be needed to replace NCo 310 if sugar cane smut (caused by Ustilago scitaminea Syd.) became a major problem.

Based on these concerns, research was initiated to evaluate germplasm for Texas from all the selections from the first clonal trials at the U. S. Sugarcane Laboratory at Houma. By obtaining clones at this stage in the breeding program late-maturity germplasm could likely be selected. The objective of this research was to compare simultaneous selections in both Texas and Louisiana of a common pool of sugar cane germplasm to identify promising parental breeding lines for Texas.

Table 1. Sugar cane cultlvars grown in Texas 1973-1984.

CP 44-101-/	CP 63-588^/	L 60-25^
CP 50- 28^/	CP 65-357-'	L 62-96^
CP 52- 68^	CP 66-315^	
CP 55- 30^	CP 67-412^/	NCo 310^
CP 56- 59^	CP 58-350^	
CP 57-614-'	CP 70-321-'	
CP 61- 37-'		

— Released In Texas only.
2/
— Released in Texas and Louisiana.
— Released in Texas and Florida.

MATERIALS and METHODS

Selections at Houma from the first line trials of the Houma 1976-1978 breeding series were introduced from 1979-1981 and planted at the Texas Agricultural Experiment Station quarantine farm at Rio Grande City, Texas. The clones were grown under production practices common to Texas and selections were made based on Brix, number of stalks, and vigor. These same lines were evaluated simultaneously in second line trials in Louisiana following traditional selection criteria, i.e. Brix, erectness, number of stalks, vigor, stalk density, and stalk diameter. Following selection and evaluation during a three-year period, cultivar assignments from Texas and Louisiana were compared. In addition, promising parental breeding lines were identified by reviewing the crossing combinations of the Texas assignments.

RESULTS and DISCUSSION

From the 1976-1978 Houma breeding series, 2188 clones of sugar cane were evaluated in Texas and Louisiana. The total of "CP" assignments from the USDA program at Houma and "TCP" assignments from the Texas Agricultural Experiment Station at Weslaco are presented in Table 2. More assignments were made in Texas than in Louisiana, possibly because of the less rigorous selection criteria and because with the use of combine harvesters fewer clones were eliminated from the program due to their tendency to lodge. About 10% of the lines received a "TCP" assignment which interestingly agrees with the selection rate established in 1957 (Breaux et al., 1963) when the U. S. Sugarcane Field Laboratory revised its selection program. The number of common assignments between Texas and Louisiana during the three years of the study totals 21 or approximately 10% of the "TCP" assignments, but from 1976 to 1978 the number of common assignments decreased between the two programs (Table 2). The cause of this trend and the potential for its continuation cannot be assessed at this time. However, the critical issue of the study is that because of differences in criteria and environment, germplasm for Texas needs to be introduced from the earlier stages of the Louisiana selection program.

Table 2. Number of "CP" or "TCP" assignments made from clones in the 1976-1978 Houma breeding series by the Texas and Louisiana selection programs.

Houma breeding series	Total clones	Total assignments		Common assignments	
		Texas	Louisiana		
	(Number)	(TCP)	(CP)	(Number)	(% of Texas Total)
1976	757	77	43	11	14
1977	656	99	60	8	8
1978	775	36	71	2	6
Total	2188	212	174	21	10

Common assignments of the 1976-1978 Houma breeding series between Texas and Louisiana are presented in Table 3. In these cases, the "CP" designation received priority over the "TCP" designation. A review of the parentage of the common assignments between Texas and Louisiana shows that lines CP 66-346, CP 72-355, CP 73-343, and L 65-69 are useful parents in both programs.

Table 3. Common "CP" assignments in Louisiana and Texas.

Line	Parentage
1976 series	
CP 81-302	CP 52- 68 x CP 70-300
CP 81-309	CP 65-357 x CP 67-411
CP 81-310	CP 70-321 x L 62-96
CP 81-320	CP 65-357 x CP 66-346
CP 81-324	CP 70-300 x CP 66-346
CP 81-326	CP 71-334 x L 65-69
CP 81-331	CP 65-357 x CP 66-346
CP 81-334	CP 73-345 x CP 66-346
CP 81-336	CP 72-355 x L 65-69
CP 81-338	CP 66-346 x L 65-69
CP 81-340	CP 71-318 x CP 66-346
1977 series	
CP 82-513	CP 74-383 x CP 72-355
CP 82-517	CP 74-383 x CP 72-355
CP 82-522	CP 72-555 x CP 73-343
CP 82-523	CP 72-355 x CP 73-343
CP 82-529	CP 77-403 x CP 66-346
CP 82-531	CP 72-356 x CP 73-343
CP 82-538	CP 70-330 x CP 73-343
CP 82-539	CP 70-330 x CP 73-351
1978 series	
CP 83-631	CP 65-357 x CP 77-413
CP 83-640	CP 76-330 x CP 77-413

From a review of the parentage of all "TCP" assignments made on the 1976-1978 Houma breeding series, the most popular lines for utilization as parents in a Texas breeding program are given in Table 4.

Table 4. Most frequently observed parents of the Texas "TCP" assignments.

Parent	Total crosses	Texas assignments
	(Number)	(%)
CP 66-346	59	28
L 65-69	37	17
CP 72-355	26	12
CP 65-357	25	12

CP 66-346 was by far the most common parent, being represented in 28% of the progeny that received a "TCP" assignment. CP 66-346 is known as a good male parent that tends to confer a large, attractive barrel in its progeny. Larger barrel size is preferred in the Texas program than in the Louisiana program and the clones which received "TCP" assignments tended to be of slightly larger barrel size than most Louisiana "CP" selections. L 65-69, CP 72-355, and CP 65-357 are excellent parents for early maturity and good juice quality. L 65-69 confers good resistance to sugar cane mosaic virus, CP 72-355 confers good stalk population, and CP 65-357 is a good general combining line with good erectness and population. Because L 65-69 and CP 65-357 are susceptible to sugar cane smut (caused by *Ustilago scitaminea* Syd.), progeny should be screened for susceptibility to the disease in later stages of the program.

The results of the study suggest that, as long as numbers are manageable, the Texas selection program has been improved by introducing germplasm from the earlier stages of the Louisiana selection program. More time will be needed to assess the ultimate success, i.e. the release of commercial cultivars, of this increased effort.

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POST-FREEZE DETERIORATION OF THREE YIELD CHARACTERISTICS OF SUGARCANE

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ABSTRACT

Sugarcane (Saccharum spp.) declines in yield measured as t ha^{-1} of sugar (THS) with time, following a killing freeze. Of the two components of THS, kg of sugar t^{-1} of cane (KST) and t ha^{-1} of cane (THC), most post-freeze deterioration studies have focused on KST and other factors related to the juice such as brix, % sucrose, % purity, and titratable acidity. The purpose of this study was to measure THC, KST, and THS for a number of clones over time following a killing freeze. Each characteristic was analyzed by linear regression and characteristics were compared by correlation. Twelve clones showed significant rates of decline in THS. Eight of the above could be attributed directly to significant KST declines, two to KST and THC declines, one to THC decline, and one could not be explained. Eight clones did not have significant rates of THS decline; three of the eight were attributed to non-significant KST and THC declines, three to non-significant THC declines only, and two to significant negative correlations between THC and KST. The data suggest that although THC decline following a freeze may not be as important to THS decline as KST decline, it varies sufficiently among clones to justify its measurement in post-freeze deterioration studies of sugarcane clones.

INTRODUCTION

Sugarcane (Saccharum spp.) yield losses occur with time after a killing freeze (1,2,4,6). Average sugar losses of up to 9.2% per week have been reported (2). These sugar losses can be particularly pronounced in Florida where sugarcane is harvested into April and freezes may occur as early as December. In 1976, 1982, and some earlier years, some commercial fields were not harvested due to extreme post-freeze deterioration.

Many characteristics of mature sugarcane are affected by freezing temperatures. The time exposed and the severity of the freezing temperatures determine the amount of damage to different characteristics. Changes in Brix, sucrose, purity, and titratable acidity have been measured previously (3). Another approach has been to combine Brix, sucrose, and purity and to calculate the theoretical yield, kg of sugar t^{-1} of cane (KST) (2). It has also been shown that the rate of decline of stalk weight after a killing freeze differs according to clone (2).

In this study, effects of a natural freeze on some CP sugarcane clones were analyzed. Since sugar yield measured as t ha^{-1} of sugar (THS) has as components KST and cane yield measured as t ha^{-1} of cane (THC), attention was focused on how KST and THC affected THS over time after a killing freeze.

MATERIALS and METHODS

Beginning on 19 January 1981, following a severe freeze from 12-14 January 1981, in which temperatures fell to -7.0° C, four replications of five stalks each were sampled from each of 14 experimental and one commercial sugarcane clone which were planted on muck soils in randomized complete-block designs with four replications each at Saunders Farm, about 24 km south of Clewlston, Florida. The stalks were cut at ground level and topped at the uppermost hard joint. This procedure was carried out at weekly intervals for 5 weeks. The same procedure was carried out for three commercial clones, but these five-stalk samples were taken from commercial fields at Saunders Farm at weekly intervals for only 4 weeks. Experimental clones varied in 3 crop cycles, plant crop: CP 75-1322, CP 75-1411, CP 76-1050, CP 76-1053, CP 76-1306, and CP 76-1519; first-ratoon crop: CP 75-1082, CP 75-1091, CP 75-1257, CP 75-1553, CP 75-1632, and CP 75-1935; and second-ratoon crop: CP 74-2005 and CP 74-2013. 'CP 63-588,' a commercial clone was included in each test and was sampled from all experiments. The clones sampled from commercial fields were: 'CP 70-1133' as plant crop, 'CP 65-357' as first-ratoon crop, and 'CP 56-59' as third-ratoon crop.

Determination of KST was done as described by Gascho and Miller (2), except that the sample size for the final harvest date was 15 stalks rather than five. The experimental plots were hand cut and weighed with a tractor-mounted weighing device to determine THC. After the final harvest, a factor was calculated for each cultivar to convert its weekly five-stalk weight to THC. Sugar yield in t ha^{-1} of sugar (THS) was calculated by multiplying THC by KST. Final estimates of cane yields were taken from mill calculations for the clones sampled from the commercial fields.

Each dependent variable was regressed linearly on time, with weeks as the unit of measurement. The average of the four replications for each week by clone treatment was used in the regression calculations. To determine if linear regression slopes (b) differed significantly from 0, the following t-test was used: t = (calculated b)/Sb, where Sb = pooled standard error of b. All t-tests were made at the 5% level of significance. Simple linear correlation coefficients also were calculated for all possible pairs of characteristics.

RESULTS and DISCUSSION

THC decreased linearly with time in all but three clones after the January freeze, but the decline was significant in only three clones, CP 63-588-SR, (CP 63-588 plant crop, CP 63-588 first-ratoon crop, and CP 63-588 second-ratoon crop will be considered as separate clones, denoted by CP 63-588-PC, CP 63-588-FR, and CP 63-588-SR, respectively) CP 70-1133, and CP 76-1306 (Tables 1-3). The increases in THC for CP 75-1082, CP 75-1091, and CP 75-1935 were not significant and probably represented variation in stalk weight, because there was no green leaf tissue after the freeze. Changes in THC ranged from 2.0 to -10.8 t ha^{-1} $week^{-1}$.

Five clones, CP 63-588-PC, CP 63-588-FR, CP 70-1133, CP 74-2013, and CP 76-1519 did not show significant linear declines over time in KST (Tables 1-3). The rate of KST loss ranged from 3.2 to 9.8 kg t^{--1} $week^{-1}$ for the 10 clones with significant declines.

Table 1. Regression coefficients (b) and coefficients of simple determination (r^2) for three yield characteristics of eight sugarcane clones, as plant-cane, regressed on time (weeks) after a freeze.

Clone	b			r^2		
	THC	KST	THS	THC	KST	THS
	t ha^{-1}	kg t^{-1}	ha^{-1}			
CP 63-588	-1.3	0.0	-0.2	0.02	0.00	0.02
CP 70-1133	-10.8[1/]	-2.0	-1.3[1/]	0.27	0.14	0.33
CP 75-1322	-1.4	-3.6[1/]	-0.4	0.07	0.24	0.25
CP 75-1411	1.2	-7.9[1/]	-0.5[1/]	0.19	0.42	0.62
CP 76-1050	-1.8	-9.8[1/]	-1[1/]	0.08	0.61	0.54
CP 76-1053	-0.7	-8.5 [1/]	-0.7[1/]	0.01	0.34	0.22
CP 76-1306	-4.4[1/]	-5.1[1/]	-1.1[1/]	0.27	0.21	0.52
CP 76-1519	-3.1	-1.7	-0.5[1/]	0.11	0.28	0.23

1/ t test significant at the 5% probability level.

Table 2. Regression coefficients (b) and coefficients of simple determination (r^2) for three yield characteristics of eight sugarcane clones, as first-ratoon cane, regressed on time (weeks) after a freeze.

	b			r^2		
	THC	KST	THS	THC	KST	THS
	t ha^{-1}	kg t^{-1}	t ha^{-1}			
CP 63-588	-2.1	-2.7	-0.4	0.06	0.15	0.15
CP 65-357	-1.2	-4.4[1/]	-0.6	0.03	0.25	0.22
CP 75-1082	1.0	-3.2[1/]	-0.2	0.01	0.26	0.02
CP 75-1091	2.0	-4.7[1//]	-0.3	0.03	0.57	0.06
CP 75-1257	-1.2	-8.4-[1/]	-0.7[1/]	0.04	0.53	0.41
CP 75-1553	-3.1	-8.5[1/]	-1.2[1/]	0.18	0.60	0.63
CP 75-1632	-1.5	-5.0[1/]	-0.5[1/]	0.06	0.51	0.37
CP 75-1935	0.03	-6.5[1/]	-0.4	0.00	0.56	0.26

1/ t test significant at the 5% probability level.

Table 3. Regression coefficeints (b) and coefficients of simple determination (r^2) for three yield characteristics of eight sugarcane clones, as second-and-third-ratoon cane, regressed on time (weeks) after a freeze.

Clone	Crop[1/]	b			r^2		
		THC	KST	THS	THC	KST	THS
		t ha^{-1}	kg t^{-1}	t ha^{-1}			
CP 56-59	TR	-1.8	-6.7[2/]	-0.5[2/]	0.06	0.48	0.27
CP 63-588	SR	- 5.2[2/]	-3.9[2/]	-0.8[2/]	0.32	0.38	0.51
CP 74-2005	SR	-1.8	-3.4[2/]	- 0.5[2/]	0.05	0.33	0.20
CP 74-2013	SR	-0.9	-2.3	-0.3	0.02	0.15	0.10

1/ Crops are second ratoon (SR) and third ratoon (TR).

2/ t test significant at the 5% probability level.

Eight clones, CP 63-588-PC, CP 63-588-FR, CP 65-357, CP 74-2013, CP 75-1082, CP 75-1091, CP 75-1322, and CP 75-1935 did not show significant linear declines in THS (Tables 1-3). Five of the above eight clones, CP 65-357, CP 75-1082, CP 75-1091, CP 75-1322, and CP 75-1935 showed significant declines in KST but not in THC. The other three clones with non-significant THS declines, CP 63-588-PC, CP 63-588-FR, and CP 74-2013 showed non-significant THC and KST declines. CP 76-1519 was the only clone which showed non-significant THC and KST declines, but a significant THS decline.

Table 4. Correlation coefficients (r) among three sugarcane yield characteristics of 20 clones.

Clone	Crop[1/]	KST vs. THS	THC vs. THS	KST vs. THC
CP 56-59	TR	0.55[2/]	0.89[3/]	0.12
CP 63-588	PC	0.36	D.95[3/]	0.05
CP 63-588	FR	0.59[3/]	G.91[3/]	0.22
CP 63-588	SR	0.50[2//]	0.93[3/]	0.16
CP 65-357	FR	0.67[3/]	0.76[3/]	0.03
CP 70-1133	PC	0.39	0.96[3/]	0.12
CP 74-2005	SR	0.65[3/]	0.88[3/]	0.23
CP 74-2013	SR	0.64[3//]	0.85[3/]	0.15
CP 75-1082	FR	-0.27		0.92[3/] -0.62
CP 75-1091	FR	0.06	0.86[3/]	-0.45[3/]
CP 75-1257	FR	0.76[3/]	0.72[3/]	0.10[2/]
CP 75-1322	PC	0.79[3/]	0.76[3/]	0.20
CP 75-1411	PC	0.89[3/]	0.43	-0.01
CP 75-1553	FR	0.83[3/]	0.71[3/]	0.19
CP 75-1632	FR	0.58[3/]	0.81[3/]	0.01
CP 75-1935	FR	0.73[3/]	0.62[3/]	-0.07
CP 76-1050	PC	0.79[3/]	0.70[3/]	0.11
CP 76-1053	PC	0.91[3/]	0.78[3/]	0.45[2/]
CP 76-1306	PC	0.74[3/]	0.60[3/]	-0.09
CP 76-1519	PC	0.22	0.96[3/]	-0.05

1 Crops are plant cane (PC), first ratoon (FR), second ratoon (SR), and third ratoon (TR).

2/ Significance at the 5% level.

3/ Significance at the 1% level.

The data suggest that the rate of decline of THS after a freeze, for some clones is dependent on the rate of THC decline alone or in combination with the rate of KST decline. The data show that KST is an important factor; of 20 clones, eight, CP 56-59, CP 74-2005, CP 75-1257, CP 75-1411, CP 75-1553, CP 75-1632, CP 76-1050, and CP 76-1053 showed significant THS declines due primarily to significant KST declines (Tables 1-3). While changes in THC were not as important overall as changes in KST, there were three clones in which THC changes dominated in determining whether or not THS would decline significantly. CP 70-1133 showed a significant rate of THS decline due more to its THC than to its KST decline (Table 1). CP 75-1082 and CP 75-1091 did not show significant THS declines. These non-significant declines were best explained by the significant negative correlations between THC and KST shown by these two clones (Table 4). Thus, in evaluating sugarcane clones for tolerance to freezing temperatures, both THC and KST should be measured over time.

It was evident that the relative effects from the freeze on KST and THC differed by clone. The most promising clones were CP 63-588-PC, CP 63-588-FR, and CP 74-2013 because their THS and both components of THS, THC and KST, did not decline at significant rates. The better-than-average tolerance to freezing measured for CP 63-588 was in agreement with previous reports (5,6).

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POST-FREEZE DETERIORATION OF SUGARCANE VARIETIES IN FLORIDA

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ABSTRACT

Ten "CP" (Canal Point) varieties and four "CL" (Clewiston, United States Sugar Corporation) varieties were sampled after two freezes to evaluate the effects on juice quality. Three 5-stalk samples per variety were collected from a variety nursery at 10, 17, 24, and 38 days after the second freeze (the first freeze of -3°C (26°F) in January 1982). Crusher juice was analyzed for Brix, pol, pH, and titratable acidity. Sucrose, purity and kg sugar per metric ton of cane (S/T) were calculated according to the modified Winter-Carp-Geerligs formula. Average changes in juice quality of the freeze-damaged cane were 10% for Brix, 59% for sucrose, 54% for purity, 80% for S/T, 0.60 for pH, and 63% for titratable acidity during the 28 days of sampling period. Among the 14 varieties studied, three varieties (CL 61-620, CL 59-1052, and CP 63-588) showed the slowest rate of change in sucrose, purity, and S/T, whereas two varieties (CP 57-603 and CL 54-378) had the fastest rate of change in these three characters. Cane delivered to the factory during the same period showed similar trends of deterioration in juice quality.

INTRODUCTION

A freeze of -3 to -2°C (26 to 28°F) on January 12, 1982 in most of the sugar-producing areas in Florida caused extensive damage to the sugarcane crop (1). Warm weather after the freeze speeded the deterioration of the cane which reduced sucrose yield during processing. Some cane remained unharvested because sucrose and purity were so low the cane was uneconomical to harvest and process.

The degree of freeze injury directly affects the rate of deterioration (3,4,6). Relatively light freezes of -2 to 0°C (28 to 32°F) have no significant depressing effect on Brix and sucrose (8). Freezes of greater severity -5 to -4°C (22 to 25°F) cause measurable deterioration in a few days (6,10). Irvine (6) reported that the resistance of mill cane to freeze damage is determined by the resistance of the stalk tissue to freezing and resistance of the juice to deterioration following a freeze. Cane with completely frozen stalk may last only one to two weeks. Cane with completely frozen leaves but little stalk damage may be of acceptable quality three months after freezing(3,8). Changes in juice quality have been used for comparing the keeping qualities of varieties following a freeze (3,4,5,9,11,12,14).

The objectives of this study were to determine effects of freezing on the juice quality of mill cane of several CP and CL varieties and to study the trends in juice deterioration rate of mill cane delivered to the factory during the test period.

MATERIALS and METHODS

Fourteen clones of sugarcane from a non-replicated variety nursey grown near 20-Mile Bend were sampled at 10, 17, 24, and 38 days after the severe freeze on January 12, 1982. Three 5-stalk samples were taken from each variety at each sampling date. The stalks were hand cut at ground level and topped at the last firmed hard internode. The samples were ground immediately after harvest in a 3-roll sample mill. Juice samples were taken for analyses which included the measurement of Brix, pol, pH, and tritratable acidity. The titratable acidity was measured by titrating two 10-ml juice samples with 0.1N NaOH until pH reached 8.4 (6). Sugarcane per metric ton of cane (S/T) was calculated in accordance with the modified Winters formula (2).

Correlation coefficients between various characters except pH of juice quality at each sampling date were calculated.

Date of juice quality of six commercial varieties (CP 56-59, CP 63-588, CP 65-357, CP 70-1133, CL 54-378 and CL 59-1052) also were collected daily from January 22 through February 28, 1982 from Osceola Sugar Mill for investigating the deterioration of juice quality following the severe freeze. These varieties were grown at 20-Mile Bend, Zone I (about 16 to 23 kilometers east from Lake Okeechobee on the north side of Highway 98), Zone II (about 13 to 26 kilometers east from Lake Okeechobee on the south side of Highway 98), Pahokee and other areas.

RESULTS and DISCUSSION

Changes in Brix, sucrose, purity, S/T, pH, and titratable acidity, following the severe freeze on January 12, 1982, are summarized in Table 1.

Table 1. Juice quality changes in 14 sugarcane varieties following second freeze in the field.

Variety	Day after 2nd freeze	Brix °	Sucrose %	Purity %	S/T kg	pH	Titratable[1/] acidity
CP 56-59	10	14.8	13.2	88.7	92.7	4.43	2.96
	17	14.4	8.7	60.1	46.9	4.31	3.50
	24	14.2	8.7	58.5	45.5	4.00	5.00
	38	13.9	5.7	41.2	17.5	3.99	8.07
CP 57-603	10	14.8	8.6	58.5	46.0	4.19	3.04
	17	14.1	6.9	48.8	29.0	3.85	5.94
	24	13.8	6.1	44.6	22.3	3.98	6.10
	38	13.1	2.5	19.1	—	3.64	8.43
CP 63-588	10	14.7	11.0	75.0	70.6	4.42	2.66
	17	14.6	8.0	54.7	39.2	4.00	4.54
	24	14.3	8.5	56.4	42.8	3.89	6.97
	38	13.1	5.9	45.0	21.8	3.84	8.61
CP 65-357	10	13.7	11.2	81.9	76.1	4.45	2.75
	17	14.0	5.8	41.3	18.0	4.06	6.28
	24	13.1	5.2	38.8	13.5	3.96	7.28
	38	11.8	4.5	37.3	13.0	4.06	6.06
CP 68-1026	10	15.3	12.0	78.7	79.0	4.14	3.70
	17	15.0	7.2	48.1	29.9	3.85	6.79
	24	14.8	8.6	55.8	43.0	4.16	7.12
	38	14.5	---	---	---	3.83	13.88
CP 69-1052	10	14.9	11.2	75.2	71.6	4.40	3.50
	17	14.4	6.0	42.0	19.0	4.07	5.66
	24	14.1	6.1	39.5	15.1	3.87	8.62
CP 70-1133	10	14.8	11.0	74.8	70.7	4.53	3.62
	17	13.7	6.6	48.2	27.2	4.16	5.74
	24	13.8	6.2	44.1	21.8	4.02	8.87
	38	13.2	3.8	28.8	2.2	3.94	7.93
CP 72-1210	10	16.0	11.4	70.8	70.2	4.29	4.06
	17	15.8	7.6	47.8	31.0	3.93	6.89
	24	15.2	6.9	46.2	26.8	4.00	8.42
	38	14.0	3.6	26.1	3.6	3.76	10.13
CP 72-2086	10	15.1	12.4	81.7	83.4	4.27	4.34
	17	14.7	6.4	43.9	22.6	3.87	8.29
	24	13.5	4.3	29.3	11.9	3.95	9.11
	38	13.0	3.1	19.9	11.5	3.74	12.83
CP 73-1547	10	13.5	8.0	66.3	52.6	4.20	3.96
	17	14.0	6.6	46.8	26.6	3.95	6.98
	24	13.2	5.5	39.8	15.3	3.86	8.36
	38	13.5	5.0	35.3	18.8	3.89	8.47
CL 54-378	10	14.8	12.0	80.7	80.4	4.53	3.78
	17	13.7	6.7	49.1	28.5	4.28	5.27
	24	13.6	4.6	33.1	6.4	3.84	8.26
	38	13.5	3.1	20.6	0.7	3.70	10.40
CL 59-1052	10	15.6	13.5	86.6	94.2	4.85	2.65
	17	16.1	12.6	78.7	83.3	4.41	4.13
	24	15.7	11.9	75.8	77.1	4.38	4.97
	38	11.9	6.3	53.0	29.7	4.02	6.15
CL 61-620	10	16.4	14.6	88.8	102.9	5.07	2.41
	17	16.1	12.6	78.5	83.2	4.23	3.93
	24	15.3	12.0	79.3	80.1	4.38	3.72
	38	14.1	10.0	71.3	62.1	3.90	7.99
CL 68-575	10	16.8	14.2	84.5	97.4	4.43	2.90
	17	15.7	8.3	74.5	74.6	4.06	5.04
	24	15.8	11.1	70.2	67.2	4.10	5.25
	38	15.9	5.0	31.4	3.7	3.69	12.60

[1/] ml 0.1 N NaOH per ml crusher juice.

Ten days after the freeze, five varieties exceeded 12% sucrose, seven varieties exceeded 80% purity, and four varieties exceeded 89.8 kgs in S/T among 14 varieties, only four varieties (CP 56-59, CL 59-1052, CL 61-620 and CL 68-575) exceeded the levels of all these three characters of juice quality. The lower quality than the normal performance (13) might indicate that most of the CP varieties suffered some damage during the freezes on December 12, 1981. Also, a rapid deterioration of the juice quality of those CP varieties might have occurred soon after the severe freeze. CP 57-603, which is a late-maturing variety, had the lowest juice quality among 14 varieties at the first sampling date.

Based on the change in juice quality during the test period, CP 65-357 deteriorated as rapidly as CP 63-588. CL 59-1052, CL 61-620 and CL 68-575 had the lowest rate of deterioration. At the first sampling period, CP 56-59 had as much S/T as did these three CL varieties but it lost its S/T nearly five times faster than did those CL varieties. Four CP varieties (CP 63-588, CP 69-1052, CP 70-1133 and CP 72-1210) had nearly equal levels of sucrose (11%), purity (75%) and S/T 69.8 kgs at the first sampling date, but CP 63-588 deteriorated at a slower rate than did the other three varieties. These results also indicated that the deterioration rate of juice quality slowed down during the third sampling date. The slowed deterioration rate was probably caused by the cool weather that occurred preceding that date.

Average changes in juice quality in this test were 10% for Brix, 59% for sucrose, 54% for purity, 80% for S/T, and 63% for titratable acidity during the 28 days of test period. Among the 14 varieites studied, three varieties (CL 61-620, CL 59-1052 and CP 63-588) showed the slowest rate of change in sucrose, purity and S/T, whereas two varieties (CP 57-603 and CL 54-378) had the fastest rate of change in those three characters. The average pH value dropped from 4.45 at the first sampling date to 3.85 at the last sampling date.

A complete evaluation of deterioration rates is not available because pre-freeze samples were not taken. However, the measurements on the rates of deterioration estimated by the changes in juice quality suggested that there were differences in cold tolerance among varieties. Irvine (6) also reported that varietal differences In keeping quality may be detected following a severe freeze. The rate of post-freeze deterioration was affected by diseases, such as red rot and others. It was frequently observed that the deterioration spread in the cane stalks from freeze-injured lateral buds and insect wounds.

Simple correlation coefficients, titratable acidity and other characters of juice quality at each of the four sampling dates were summarized (Table 2). The titratable acidity was negatively correlated with Brix, sucrose, purity and S/T.

Table 2. Correlation coefficients (r) between titratable acidity and other characters of post-freeze juice samples at four sampling dates.

Correlation between		Days after freeze 10	17	24	38
Brix and	TA[1/]	-.210	-.259	-.597[2//]	-.658[2/]
Sucrose and	TA[1/]	-.375	-.663[3/]	-.803[3/]	-.404
Purity and	TA[1/]	-.372	-.709[2/]	-.812[2/]	-.561[2/]
S/T[4/] and	TA[1/]	-.391	-.677[2/]	-.786[3/]	-.425

1/ Total titratable acidity.

2/ Significant at the 5% level of probability.

3/ Significant at the 1% level of probability.

4/ Sucrose per metric ton of cane.

Cane delivered to the factory during the test period showed similar trends of deterioration rate in juice quality. Correlation coefficients between days after the severe freeze and the measurements of three characters of juice quality from commercial field samples are summarized in Table 3. The analyses indicated both sucrose and S/T of most varieties were negatively correlated with the length of time following the severe freeze on January 12, 1982. Among three varieties (CP 56-59, CP 65-357 and CP 70-1133) examined at 20-Mile Bend, the correlation coefficients were greater than those at either Zone I or Zone II. The results suggested differential rates of deterioration in juice quality in samples occurred among these locations. The results also suggested that cane at the 20-Mile Bend location suffered more extensive damage than did at other locations.

Table 3. Correlation coefficients between three characters of juice quality and days after a severe freeze (on January 12, 1982) from commercial mill samples delivered to the Osceola Sugar Mill.

		Correlations		
Variety	Location[1/]	Brix vs days after freeze[2/]	% Sucrose vs days after freeze	S/T vs days after freeze
CP 56-59	20-Mile Bend	-.373[3/]	-.728[4/]	-.841[4/]
	Zone I & II	-.339[3/]	-.460[4/]	-.498[4/]
	All locations	-.227	-.383[4/]	-.452[4/]
CP 63-588	All locations	-.060	-.306[3/]	-.184
CP 70-1133	20-Mile Bend	-.375[4/]	-.676[4/]	-.819^
	Zone I	-.281	-.469[4/]	-.619^-'
	Pahokee	.019	-.122	-.209
	All locations	-.169	-.124	-.357[3/]
CP 65-357	20-Mile Bend	-.074	-.50l[4/]	-.702[4/]
	Zone I	-.436[4/]	-.462[4/]	-.392[3//]
	All locations	-.276	-.446[4/]	-.451[4/]
CL 54-378	Zone II	-.489[4/]	-.779[4/]	-.758[4/]
CL 59-1052	Zone II	-.025	-.412[3/]	-.654[4/]

1/ 20-Mile Bend = about 32 km southeast of Lake Okeechobee; Zone I = about 16-22 km southeast of Lake Okeechobee on the north side of Highway 98; Zone II = about 13-26 km southeast of Lake Okeechobee on the south side of Highway 98; Pahokee = about 2-8 km from the lake.

2/ Samples collected daily from January 22 through February 19, 1982.

3/ Significant at the 5% level of probability.

4/ Significant at the *1%* level of probability.

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USE OF GROUND LOSS ESTIMATES AND VISUAL LODGING RATINGS TO DETERMINE SUITABILITY OF SUGARCANE VARIETIES TO MECHANICAL HARVESTING

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ABSTRACT

Sugarcane in Louisiana is mechanically harvested by whole-stalk harvesters which function best in erect cane. In the past, visual numerical ratings were used to measure lodging tendency of varieties. Since lodging ratings do not identify brittleness or breakage during harvest, ratings of lodging have not been satisfactory in quantifying harvest losses. Recent tests have shown that estimates of ground loss together with visual ratings of lodging constitute a more complete measure of how well an unreleased variety will be adapted to mechanical harvesting. In 16 tests, varieties were visually rated for erectness prior to harvest in 1983, using a scale of 1 to 9 where ratings of 1 indicated totally erect cane and 9 indicated severe lodging. Ground loss in tons per hectare was estimated by multiplying mean stalk weight by the number of whole stalks and stalk pieces (recorded as equivalent to whole stalks) left by the harvester after cutting. In a combined analysis of two tests, the unreleased varieties L 75-2, L 78-63, CP 78-303 and CP 78-304 had significantly more ground loss than the best harvesting commercial variety, CP 65-357, although these varieties did not differ significantly from CP 65-357 in visual ratings for lodging. Consequently, the four unreleased varieties were identified as poorly suited to mechanical harvesting, based on ground loss estimates. A system of estimating ground loss at the infield and outfield stages of testing could complement erectness ratings and help eliminate varieties which harvest poorly.

INTRODUCTION

It is essential that sugarcane varieties be well suited to mechanical harvest since nearly all sugarcane used for planting and milling in Louisiana is cut by whole-stalk mechanical harvesters. Since 1950, when mechanical harvesting replaced hand-harvesting, only varieties well suited to mechanical harvesting have been planted extensively. These varieties include CP 36-105, CP 44-101, CP 52-68, NCo 310 and CP 65-357 (3,7).

Two major factors contribute to whether a variety is adapted to mechanical harvesting: brittleness and erectness (5).

Sugarcane grown in Louisiana may be exposed to hurricane force winds. High winds can cause stalk breakage and lodging resulting in losses in cane tonnage and sugar quality at harvest time (8). Data from a calibrated stalk-breaking device indicate that as a group the CP varieties, which presently occupy 98% of the sugarcane acreage in Louisiana, tend to be more brittle than the introduced varieties such as Louisiana Purple, POJ 234, NCo 310 and POJ 213 (2).

Early selection for erectness in unreplicated clonal plots is difficult since lodging may vary by location and year. Significant negative associations have been shown between erectness and stalk height, stalk weight and tons of cane per hectare (1). Although varieties which have poor harvesting traits are discarded some are not eliminated until the final stage of testing (the outfield level) of the Louisiana sugarcane variety development program (6).

Observation without measurement has identified the best harvesting varieties such as CP 65-357 by noting the ground loss from standing cane to heap row when variety yield experiments were cut mechanically at the infield (intermediate) and outfield (final) stages of testing (4). The present study was begun to determine if significant differences in ground loss between varieties could be detected by counting the number of stalks and pieces of stalks left by the harvester, and if ground loss in tons of cane per hectare could be estimated at the infield and outfield stages of testing.

MATERIALS and METHODS

Outfield Tests

Sugarcane variety outfield tests in Louisiana are planted in a complete randomized block design with 3 to 4 replications (4). Plots in these multi-location tests are on three rows 1.8 m apart x 9.6 m in length (.0052 ha). All plots are separated end to end by 1.5 m breaks. Nine varieties were evaluated in two second ratoon outfield tests during October, 1983. The varieties were generally erect in both tests. Sixteen varieties were evaluated in two plant cane tests during early December. The plant cane tests were harvested later in the season than the ratoon test, and much more lodging was present than in ratoon tests. The four outfield tests were analyzed separately as randomized complete block designs. A combined analysis was conducted by crops. A correlation coefficient was calculated for the four tests comparing visual ratings and ground loss determinations.

Infield Tests

Infield testing is an intermediate stage in the breeding program. Infield tests are replicated 2 or 3 times and planted at 2 separate locations, Ardoyne Farm near Houma and St. Gabriel near Baton Rouge, LA. Infield plots are planted on three rows 1.8 m apart x 4.9 m long with 1.2 m breaks (.0026 ha). Erectness ratings and mature stalk counts were made in the Ardoyne infield tests prior to harvest in 1983. Ground loss determinations were conducted as in the infield tests in four plant-cane, four first-ratoon and four second-ratoon tests. The correlation between erectness ratings and ground loss was calculated in all infield tests harvested at Ardoyne during 1983.

Varieties were visually rated for erectness on a scale of 1 to 9 before they were mechanically harvested. A rating of 1 indicates a variety that was perfectly erect and 9 was one that was completely lodged. A commercial standard such as CP 65-357 rated a "5" using this system. Ground loss estimates were made after the 3-row plots were cut with a conventional whole stalk harvester and stalks placed across two rows, the heap row. The number of stalks and pieces of stalks left behind in each plot by the harvester were counted and multiplied by the mean stalk weight of the respective variety from the appropriate test (plant or ratoon) to estimate loss per plot in weight per unit area. Ground loss was estimated for four outfield and twelve infield variety tests during 1983.

RESULTS and DISCUSSION

Outfield Tests

Significant differences in amount of ground loss were found among varieties evaluated in the two second-ratoon tests. Significantly more ground loss occurred in plots of L 75-2 than the other varieties (Table 1) while erectness ratings of L 75-2 were not significantly different from CP 76-331 or CP 76-301. Erectness alone would not have eliminated L 75-2 from the variety testing program.

Table 1. Combined analysis of estimated ground loss and erectness ratings of nine sugarcane varieties in two second-ratoon outfield experiments during October, 1983.

Variety	Ground loss tons of cane per ha	Erectness ratings
CP 70-321	0.72 a[1/]	4.88 a
CP 72-370	0.74 a	5.00 a
CP 70-330	1.03 a	5.15 ab
CP 65-357	1.17 a	5.00 a
CP 76-331	1.41 a	5.75 bc
CP 72-356	1.41 a	4.88 a
Cp 74-383	1.79 a	4.77 a
CP 76-301	1.93 a	5.63 bc
L 75-2	3.50 b	6.00 c

1/ Means in columns followed by the same letter are not significantly different at the 5% level of probability according to Duncan's Multiple Range test.

The combined analysis of the two outfield plant cane experiments indicated no significant differences in ground loss between the commercial varieties presently being grown in Louisiana (Table 2). Among unreleased varieties with the most ground loss, CP 78-304, L 75-2 and CP 78-303 were not significantly different from each other and had ground losses ranging from 4.7 to 8.4 tons per hectare. The erectness ratings and the values for ground loss for the various varieties were not in complete agreement, suggesting that some varieties harvested well when lodged and some harvested poorly when erect. The most erect commercial varieties in the two plant cane experiments were CP 74-383 and CP 72-356. Both varieties had erectness ratings of 5 and were also in the group with the least amount of ground loss. The varieties which were the least erect were CP 78-303 and CP 78-304 with ratings of 7.27 and 6.65, respectively. The variety L 75-2 which was in the worst group for ground loss had an erectness rating of 5.50 which was significantly lower than CP 78-303 and CP 78-304. The variety CP 65-357 was not significantly different from L 75-2 in erectness rating, yet it had the least amount of ground loss with 0.7 tons per hectare in the two plant cane experiments. Thus, erectness ratings alone could give a false impression as to the suitability of varieties to mechanical harvesting.

The results from correlations between ground loss and erectness ratings are found in Table 3. Although results from the four outfield experiments all showed a significant or highly significant positive association between degree of lodging and ground loss, the r values were not generally high. This may indicate that, as in the case of L 75-2, ground loss may be a better estimation than erectness ratings for evaluating varieties for adaptability to mechanical harvesting.

Table 2. Combined analysis of estimated ground loss and erectness ratings of sixteen sugarcane varieties in two plant-cane outfield experiments during 1983.

Variety	Ground loss tons of cane per ha	Erectness ratings
CP 65-357	0.67 a[1/]	5.65 abcd
CP 72-370	1.09 ab	5.25 ab
CP 78-310	1.66 ab	5.60 abcd
CP 74-383	1.57 ab	5.00 a
CP 73-351	2.00 ab	5.25 ab
L 78-35	2.17 ab	5.75 bcd
CP 70-321	2.74 abc	6.25 de
CP 76-301	3.03 abc	5.50 abc
CP 78-317	3.14 abc	5.65 abcd
CP 72-356	3.39 abc	5.00 a
CP 77-310	3.48 abc	5.25 ab
CP 76-331	3.70 abc	6.15 cde
L 78-63	4.48 bc	6.10 cde
CP 78-304	4.69 bcd	6.65 ef
L 75-2	5.83 cd	5.50 abc
CP 78-303	8.45 d	7.27 f

1/ Means in columns followed by the same letter are not significantly different at the 5% level of probability according to Duncan's Multiple Range test.

Table 3. Correlation coefficients (r) for ground loss (measured in tons per ha) with erectness ratings in four outfield experiments during 1983.

Location	Plant cane	Location	Second ratoon
R. Hebert	0.31[1/]	St. John	0.41[1/]
McLeod	0.63[2/]	Georgia	0.37[1/]

1/ Significant at 5% level of probability.

2/ Significant at 1% level of probability.

Infield Tests

The correlation coefficients comparing ground loss and erectness in 12 infield tests are found in Table 4. A significant or highly significant positive association was found between ground loss and degree of lodging in all first-ratoon tests. Significant associations were found in one plant cane test and one second-ratoon test. Correlations in the remainder of the experiments were non-significant. One possible explanation for the poor association in plant cane is that erectness ratings were made early in the season long before harvest. More lodging occurred later in the year after the ratings had been made but prior to the time experiments were harvested. This probably indicates that varieties should be rated for erectness at the time experiments are cut.

Table 4. Correlation coefficients (r) for ground loss (measured in tons per ha) with erectness ratings in 12 infield experiments during 1983.

Test	Plant cane	Test	First stubble	Test	Second ratoon
79 series	-0.24 NS	78 series	0.47[2/]	78 series	0.34 NS
80 series	0.06 NS	79 series	0.70[1/]	79 series	-0.37 NS
80 series	-0.52[1/]	79 series	0.49[2/]	79 series	-0.15 NS
81 series	-0.11 NS	80 series	0.51[2/]	80 series	-0.41[1/]
All tests	-0.02 NS		0.49[2/]		0.32[2/]

1/ Significant at 5% level of probability.

2/ Significant at 1% level of probability.

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THE POTENTIAL OF A MODIFIED SUGARCANE SPINDLE BIOASSAY

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ABSTRACT

A modified sugarcane spindle bioassay is presented. Examination of the assay's response to GA_3 indicated that the maximal GA-induced leaf growth occurred 3 cm to 5 cm from the stalk apex. The first leaf with a prominent midrib usually was most responsive to GA_3, and greatest growth occurred during the second 24 hr of incubation in the presence of GA_3. However, leaf growth decreased after the first 24 hr period in the absence of added GA_3. Also, there was genotypic response of sugarcane to GA,. CP 70-321 exhibited the greatest GA-induced growth compared to controls, whereas NCo 310, the least. Aside from its potential use in detecting cultivar growth responses, this tissue was well suited to study the control of cell expansion in sugarcane. This bioassay responded well to GA_3, but not to another potential endogenous growth regulator, IAA. Evidence is presented to indicate that GA-induced leaf growth may be related to peroxidase activity.

INTRODUCTION

There are numerous reports of plant hormones and other synthetic plant growth regulators affecting the growth of sugarcane (Nickell, 1979). Much of the research with sugarcane has been done under field conditions. Field plot research is the ultimate requirement of any work done with potential growth regulators; however, this work is time consuming and requires considerable effort to delineate the effects of environmental and genetic variances. Most (1968) developed a sugarcane spindle bioassay which was used to monitor the response of sugarcane to various gibberellins. This bioassay could potentially be used to screen for effective growth regulators, shorten the testing period, reduce the variability encountered with field observations, and serve as a system to study the physiological responses of sugarcane to growth regulators.

Presented herein is a modification of the spindle bioassay which incorporates more of the gibberellic acid (GA) responding tissue than used by Most (1976). The locational response of sugarcane spindle leaves to GA_3, the responses of several sugarcane varieties to GA_3, and the effects of IAA, ethylene and glyphosate are also examined. In addition, the use of this system to correlate GA-induced growth with changes in peroxidase activity is examined.

MATERIALS and METHODS

Six commercial cultivars of <u>Saccharum</u> were grown in the field at St. Gabriel, Louisiana. All work was done between August 15 and November 15, during 1981, 1982 and 1983. The spindle tissue was obtained by first cutting the stalk 40 cm below the top most visible dewlap (TVD). The stalk and leaves were then cut a second time at the TVD. The stalks were immediately placed in water and brought to the laboratory. The outer leaves of the spindle were removed exposing an internode between 1-2 cm in length. The stalk was cut 0.5 cm below the top of this internode and then 10 cm above the original cut. When viewing the cross section of the spindle, there were two or three leaves surrounding the first leaf with a prominent midrib. The apex was located in the basal portion of the spindle approximately 8 cm from the upper cut.

In order to determine which regions of the spindle leaves responded to GA_3, 1 cm sections were cut sequentially from the stalk apex to 10 cm above the apex and placed on Whatman #1 filter paper with enough solution to form a thin film on the paper. The solution usually consisted of 1% sucrose, 1 mM potassium phosphate (pH 6.0) and 1.01% tetracycline with or without 10^{-5} M GA_3, indole-3-acetic acid (IAA), or glyphosate. For ethylene treatments, the beakers of spindles were placed in a 4-liter vacuum jar into which the proper amount of ethylene was injected under vacuum. The vacuum was released immediately after injection. Growth was measured as the increase in length of the longest leaf of the spindle. For the experiments where serial 1 cm sections were cut, 12 cm spindles were used. In all other cases, 10 cm spindles were placed in covered 500 ml beakers containing enough solution to cover the bottom 1 cm of the spindle.

To determine the effect of GA_3 on leaf peroxidase, six sets of 24 spindles were placed in growth medium without GA_3 for 24 hr, and then one-half of the sections were treated with GA_3 for an additional 24 hr, while the controls remained in fresh growth medium for the additional 24 hr. The outer two or three leaves then were removed, leaving the first leaf with a midrib and all internal leaves. From each spindle two 1 cm sections were cut between 3-5 cm from the tip of the stalk apex. The 1 cm sections were packed into syringe tubes described by Terry and Bonner (1980), and then rinsed for 1 hr with the treatment solution without tetracycline. After rinsing, the sections were vacuum infiltrated with distilled water at 4° C and centrifuged 8 min at 1000 g. This step was repeated twice, and then the extracellular solutions released during three spins were combined. Following the water infiltrations and centrifugations, the spindle sections were infiltrated with 50 mM $CaCl_2$ and centrifuged three times. The peroxidase activity of the extracellular solution was assayed with 4-aminoantipyrine according to the Worthington Manual (1978).

RESULTS

Cutting spindle leaves into 1 cm serial sections and placing them in solution with or without GA_3 allows one to determine which leaves are most responsive to GA_3, and where, along each leaf, this response occurs. Results summarized in Figure 1 show that the outer leaf of the spindle rarely grew, even in the presence of GA_3. The next inner leaf exhibited growth at the basal end. The third leaf usually had a prominent midrib, grew well and responded maximally to GA_3; although, in some cases more internally-located leaves grew faster. The leaves found rolled within leaf number six, counting from the outside to the inside of the spindle, usually grew at a rate similar to leaf number six. Maximal growth occurred between 3 cm and 5 cm from the apex and continued to approximately 8 cm from the apex.

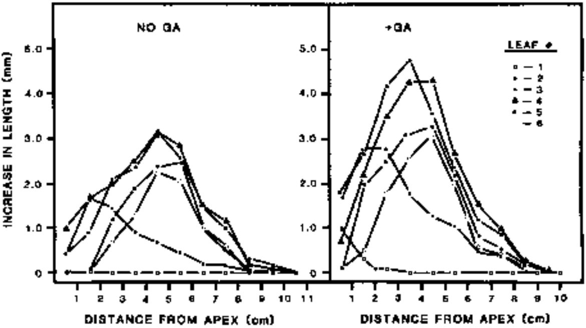

Figure 1. The effect of GA_3 on the growth of each leaf of serial 1 cm spindle segments of NCo 310. Leaf number one was the outer leaf. Growth was measured for 72 hr.

Table 1 reveals that the spindles of several cultivars grown in Louisiana showed varying responses to GA_3. When growth responses to GA_3 were compared as a ratio of GA-treated to untreated leaves, the commercial variety CP 70-321 exhibited the greatest GA-induced growth compared to controls, whereas NCo 310 responded the least (Table 1). CP 65-357 also responded less to GA_3 than the other cultivars, but its total increases in length were the greatest + GA_3. It should be noted that CP 70-330 responded well to GA_3, but its growth with and without GA_3 were lower than any other variety tested. When the GA_3 effect is measured simply as a difference in length, then CP 61-27 (7.6 cm) and CP 70-321 (7.5 cm) responded best to GA_3. The time course for the response of CP 70-321 to GA, is given in Table 2. Maximal growth usually occurred between 24 hr and 48 hr after adding GA_3. In addition, spindle leaves responded well to GA_3 during the second 24 hr period when it followed a 24 hr period without GA_3 (Table 4). Selection of spindles with similar growth rates usually decreased the standard errors, thus decreasing the time needed to detect GA-induced growth (Tables 2 and 4, and unpublished results).

Table 1. The effect of GA on spindle enlongation of several commercial sugarcane cultlvars. The increased length was measured after 44 hr.

Treatment	CP 65-357	CP 70-330	NCo 310	CP 61-27	L 62-69	CP 70-321
	Variety					
			Increase in length (mm)			
+ GA	22.7 (1.3)[1/]	9.6 (0.5)	12.8 (0.9)	22.0 (1.4)	17.7 (1.4)	19.3 (1.3)
- GA	16.0 (0.8)	6.3 (0.2)	10.4 (1.0)	14.4 (0.8)	11.0 (0.8)	11.8 (0.8)
EFFECT + GA/-GA	1.42	1.52	1.23	1.55	1.53	1.64

[1/] Standard errors in parenthesis.

Table 2. Time course for the effect of GA_3 on the growth of 60, 10 cm spindles from CP 70-321.

Time (hr)	GA	Total increase in length (mm)	Increase in length during last 24 hr (mm)
24	+	9.3 (0.44)[1/]	9.3
	-	8.1 (0.22)	8.1
	+GA/-GA	1.2	1.2
48	+	24.6 (1.85)	15.3
	-	11.8 (0.61)	3.7
	+GA/-GA	2.1	4.1
72	+	29.2 (1.38)	4.6
	-	14.3 (0.64)	2.5
	+GA/-GA	2.0	1.9

[1/] Standard errors in parenthesis.

In addition to testing the effect of GA_3 on spindle leaf growth, the effects of two other plant hormones, IAA and ethylene, and a herbicide, glyphosate, were tested. IAA and ethylene did not affect the growth with this bioassay, and glyphosate affected growth only at very high concentrations (Table 3).

Table 3. The effect of IAA, ethylene and glyphosate on spindle growth for 48 hr.

Treatment	Concentration	Increase in length (mm) during last 24 hr
IAA	10^{-5} M	12.3
	0	12.2
Ethylene	100 ppm	8.4
	0	8.0
Glyphosate	10^{-1} M	1.5
	10^{-2} M	4.3
	10^{-3} M	5.7
	0	5.8

Table 4 shows the change in cell wall peroxidase which occurred when spindles were treated with GA_3. GA_3 promoted growth and decreased peroxidase activity. The greatest effect of GA_3 was on the peroxidase fraction centrifuged from the walls after vacuum infiltration with 50 mM calcium chloride.

Table 4. The effect of GA_3 on 50 mM calcium-soluble cell wall peroxidase. Spindles were treated for 24 hr with GA after a previous 24 hr without GA. Spindles were selected for uniformity after 24 hr. Only those with an increase in length between 7 cm and 10 cm were used.

Treatment	Total increase in length (mm)	Increase in length during 24 hr +GA (mm)	Peroxidase $A_{510} \cdot min^{-1} \cdot g^{-1}$
+GA	19.1 (0.65)[1,2/]	11.6	22.5[2/]
-GA	11.3 (0.35)	3.8	9.3
EFFECT + GA/-GA	1.7	3.1	2.4

[1/] Standard errors in parenthesis.

[2/] Average of 3 experiments with 24 spindles per treatment per experiment.

DISCUSSION

Most (1967) initially developed a bioassay for gibberellins using sugarcane spindles which included approximately 3 cm of leaves. These data indicate that the next 2 to 3 cm of leaf tissue away from the apex also responded well to GA . Including this tissue in the present assay reduces errors in sampling caused by the previous method of cutting spindles within the GA-responding region. The greatest growth in response to GA, occurred 3 to 5 cm from the apex and between 24 and 48 hr after exposure to GA . Compared to controls, GA-induced growth was also increased when the spindles were preincubated for 24 hr without GA. Besides enhancing the effect of GA , preincubation allowed the selection of more uniformly growing spindles, which might lead to an increase in the detectability of rapid growth responses

Since the most responsive leaves were three to five centimeters from their origin at the apex, it would seem most likely that GA affected cell expansion. A similar situation has been found with oat internodes (Adams et al., 1975) and lettuce hypocotyls (Stuart et al., 1977). Likewise, in these two cases and the work by Most (1967), sugarcane leaves did not respond to 48 hr IAA. Longer treatment periods and more stable auxins were not tested. Also, the spindle bioassay was not responsive to 48 hr of ethylene, and only high concentrations of glyphosate inhibited growth.

Since GA, causes a pronounced and rapid effect on sugarcane spindle leaf cell expansion, this assay may be of value for physiological studies pertaining to the mechanisms controlling cell expansion and leaf growth in sugarcane. Accordingly, it is important that this tissue does not respond to IAA, because one would then have to worry about GA-induced changes in IAA levels in the leaves being responsible for changes in growth rate. This is especially true since many growth regulators affect the activity of peroxidase which often possesses IAA-oxidase activity (Gasper et al., 1982). IAA-oxidase converts IAA to an inactive form, thus decreasing growth in some plants. With the spindle bioassay this is probably not a factor in GA-induced growth; therefore, one can concentrate on another function of peroxidase, to promote the cross-linking of polymers in the wall which contain phenolic-like constituents (Fry, 1979). There is some evidence to indicate that GA decreases the secretion of peroxidase into the cell wall (Fry, 1980). This decrease in peroxidase would lead to less cross-linking of cell wall polymers such as lignin, thus weakening the wall and allowing greater growth. Although Most (1968) did not measure peroxidase or lignin, he suggested that slow growing sugarcane internodes become more rapidly lignified than rapidly growing internodes, and Thom and Maretzki (1970) found peroxidase isozymes in sugarcane. The data presented here indicate that GA causes a decrease in extracellular peroxidase which may be related to GA-induced growth.

Besides its use as a physiological model, this bioassay may be of value in quantifying the responses of sugarcane cultivars to plant growth regulators. This hypothesis is supported by the differential response of several cultivars to GA,. These results are not specific to this assay because there have been other reports of differing sugarcane cultivar responses to GA (Bull, 1964; Moore and Buren, 1978).

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EFFECT OF RESIDUE FROM UNBURNED SUGARCANE HARVEST 1/

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ABSTRACT

Sugarcane was grown with crop residues from harvested unburned sugarcane applied to the soil at 0, 1 and 2 times the amount produced, and N applied at 0 and 168 kg N/ha. Net cane yields in the following ratoon crops were unaffected by crop residue levels, but were increased by N application in the 3rd and 4th ratoons. Sugar contents were reduced by N application in the 3rd ratoon, and were reduced by increasing residue level in the 4th ratoon. Plant growth in the 3rd ratoon was increased with N application, but was affected little by residue levels. Residue application tended to increase slightly the soil sodium adsorption ratio at the soil surface and to decrease water infiltration rates, but the effects were not detrimental to the crop. A subsequent sweet sorghum crop showed beneficial effects due to increased sugarcane residue and N application on the previous sugarcane crop.

INTRODUCTION

Traditional sugarcane culture worldwide involves burning sugarcane fields prior to harvest in order to eliminate the excess trash (3). Concern over potentially harmful effects of this practice on air quality has led to consideration of harvesting unburned sugarcane. Harvest and milling efficiency dictate that a system be developed that would leave unburned residue in the field rather than incur the expense of transporting it to the mill to be dealt with in the extractive process. Thus large quantities of plant material would be deposited back on the soil. Little is known about how to manage such large depositions of crop residue and what impact this will have on the soil and oh subsequent

This study was conducted to evaluate the effects of various levels of residue from an unburned sugarcane harvest on sugarcane production, soil properties, and a subsequent sorghum crop.

MATERIALS and METHODS

Two sugarcane cultivars, NCo 310 and L 62-96, were planted in the fall of 1973 on a Raymondville clay loam soil (Vertic Calciustoll) in the Lower Rio Grande Valley of Texas. Treatments consisted of 3 crop residue rates (0, 1 and 2 x) and 2 rates of N application (0 and 168 kg N/ha). The different residue rates were achieved by removing all residue after harvest from the no residue plots and applying it to the 2 x plots. The treatments were replicated 4 times in plots consisting of four rows spaced 152 cm apart by 12.2 m long. Treatments were imposed following harvest of the plant cane crop.

Harvests were made annually for the 1st through 4th ratoon crops by hand cutting the middle two rows in each plot and weighing the sample. On the 3rd and 4th ratoons a 15-stalk subsample was removed, stripped, and then milled to extract the juice. Total dissolved solids (Brix) and sucrose content (pol) were determined on the juice samples and the yields of sugar per ton of cane were calculated (2).

Other measurements of sugarcane growth and soil properties were taken at various times during the study. Measurements of cane height were made for each plot at periodic intervals during the 3rd ratoon in 1977. Soil samples were taken at 0-15, 15-30, 30-61 and 61-91 cm depths in April 1977 during the 3rd ratoon for each residue treatment. Electrical conductivity and sodium adsorption ratio of a saturated paste (4) were determined on these samples. In March 1978 during the 4th ratoon, infiltration rates were determined for each residue treatment on top of the bed and in the furrow by driving a cylinder 30 cm long and 30 cm in diameter into the soil to a depth of 15 cm. Water penetration was measured for one hour. Also at this time, soil samples were taken to a depth of 15 cm from each residue treatment on the top of the bed and in the furrow for determination of gravimetric moisture content and bulk density, and soil samples were taken to the same depth from each residue and N level treatment for inorganic N determination. Ammonium- and nitrate- N were determined using a Kjeldahl digestion and distillation procedure (1).

In 1979 after harvest of the 4th ratoon sugarcane crop, the study area was cultivated by disking and chiseling then rebedded and planted to sweet sorghum. In late July the sweet sorghum in each plot was evaluated by giving a numerical rating of 0 to 5 from poorest to best based on a visual estimate of size, color and vigor of the sweet sorghum growth.

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RESULTS and DISCUSSION

Residue application rates on a dry weight basis averaged about 15.7 and 31.9 metric tons/ha/yr at the 1 and 2 x rates, respectively, during the 4 years of this study. Residue rates had no significant effect on sugarcane yield of either cultivar throughout the study (Table 1). Nitrogen application increased yields only on the 3rd and 4th ratoons. Annual variation in sugarcane yields reflects both variation in climatic conditions from year to year as well as the tendency of sugarcane yields in the Lower Rio Grande Valley to decrease in later ratoons.

Table 1. Influence of unburned sugarcane residue and N application on net cane yields for 4 ratoon crops of two sugarcane cultivars.

Treatment main effects[1/]	NCo 310				L 62-96			
	1st rtn	2nd rtn	3rd rtn	4th rtn	1st rtn	2nd rtn	3rd rtn	4th rtn
	metric tons/ha							
Residue rate								
0 x	101	109	90	111	73	85	68	76
1 x	106	102	86	102	72	91	72	79
2 x	109	111	86	106	79	74	70	84
Significance[2/]	NS	NS	NS	NS	NS	NS	NS	NS
N rate (kg/ha)								
0	111	107	84	93	78	81	65	74
168	100	107	90	113	72	85	75	86
Significance	*	NS	*	*	NS	NS	*	*

— Interactions were nonsignificant.

- Differences nonsignificant (NS) or significant at the 5% (*) level using analysis of variance and linear regression.

Juice quality and sugar content in the 3rd and 4th ratoons showed somewhat greater effects due to the treatments applied. In the 3rd ratoon for cultivar NCo 310, Brix, pol, purity and sugar content were all reduced by N application (Table 2). In the 4th ratoon pol, purity, and cane sugar content for both cultivars were decreased with increasing residue rate.

Table 2. Influence of unburned sugarcane residue and N application on Brix, pol, purity and sugar content for the 3rd and 4th ratoons of 2 sugarcane cultivars.

Crop cycle	Treatment main effects[1/]	NCo 310				L 62-96			
		Brix	Pol	Purity	Sugar content	Brix	Pol	Purity	Sugar content
		%							
3rd rtn	**Residue rate**								
	0 x	19.0	16.0	83.9	11.6	20.7	18.1	87.5	13.4
	1 x	18.8	16.0	84.7	11.6	19.5	16.9	86.4	12.4
	2 x	19.2	16.3	84.4	11.8	19.4	16.7	85.9	12.2
	Significance[2/]	NS	NS	NS	NS	NS	NS	NS	NS
	N rate (kg/ha)								
	0	19.9	17.1	85.8	12.5	20.3	17.7	87.6	13.1
	168	18.1	15.1	82.8	10.8	19.4	16.6	85.5	12.2
	Significance	*	*	*	*	*	*	*	*
4th rtn	**Residue rate**								
	0 x	18.5	15.5	84.0	11.2	20.3	17.3	85.1	12.5
	1 x	17.0	13.7	80.4	9.7	19.7	16.3	82.6	11.7
	2 x	16.9	13.1	78.1	9.1	19.4	15.8	81.3	11.3
	Significance	*	*	*	*	NS	*	*	*
	N rate (kg/ha)								
	0	17.6	14.4	81.6	10.3	20.1	16.8	83.6	12.1
	168	17.2	13.8	80.0	9.7	19.5	16.1	82.4	11.5
	Significance	NS	NS	NS	NS	NS	NS	NS	NS

[1/] Interactions were nonsignificant.

[2/] Differences nonsignificant (NS) or significant at the 5% (*) level using analysis of variance and linear regression.

Growth measurements taken during the 3rd ratoon in 1977 showed greater sugarcane growth with N application (Figure 1). Increasing residue rates, however, generally tended to decrease slightly the height attained by the sugarcane.

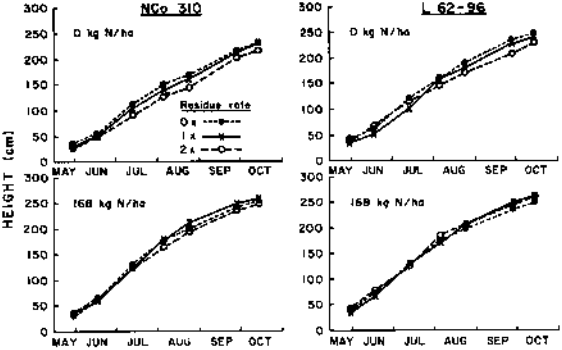

Figure 1. Effect of residue level and N application on sugarcane height increase with time for two cultivars during the 3rd ratoon.

Soil salinity and sodium measurements taken during the 4th ratoon showed only a slight relative increase in sodium levels near the surface at the 2 x residue rate compared to the other residue rates (Table 3). Sodium adsorption ratios, however, were well below levels which might be of danger to the crop. Electrical conductivity of the soil saturation extract was not affected by residue rate.

Table 3. Influence of unburned sugarcane residue on electrical conductivity (EC) and sodium adsorption ratio (SAR) of soil saturated paste in the 3rd ratoon crop.

Residue rate	Soil depth	EC	SAR
	cm	mmho/cm	
0 x	0-15	1.10	0.55
	15-30	1.15	1.67
	30-61	1.16	3.16
	61-91	1.77	4.86
1 x	0-15	1.30	0.56
	15-30	0.99	1.25
	30-61	0.91	1.25
	61-91	1.33	3.37
2 x	0-15	1.02	1.27
	15-30	0.82	1.62
	30-61	1.27	3.80
	61-91	1.66	5.76

Soil physical properties were more strongly influenced by the residue rates after the 4th ratoon. Water infiltration rates on the bed and in the furrow, though variable due to swelling and shrinking of this heavy soil, decreased with increasing residue level (Table 4). This decreased infiltration may have been caused by physical constraint of incorporated but partially decomposed residues, or by reduced effectiveness of tillage operations. Infiltration was greater on top of the bed than in the furrow probably due to compaction caused by equipment and also since residue would tend to accumulate in the furrow. Soil bulk density increased with increasing residue rate which is consistent with the observed decrease in infiltration rates and further indicates that residue may inhibit the effectiveness of tillage operations. Moisture content also decreased as the residue rate and bulk density increased.

Table 4. Influence of unburned sugarcane residue on soil water infiltration, bulk density and moisture content on top of the bed and in the furrow in the 4th ratoon crop.

Location	Residue rate	Water infiltration	Bulk density	Moisture content
		cm/hr	gms/cm³	%
top of bed	0 x	5.42	1.13	51.4
	1 x	2.43	1.18	47.7
	2 x	0.12	1.22	43.1
	Significance[1/]	*	*	*
furrow	0 x	1.97	1.21	45.8
	1 x	3.67	1.26	42.1
	2 x	0.10	1.36	35.4
	Significance	*	*	*

[1/] Differences nonsignificant (NS) or significant at the 5% (*) level using linear regression.

Inorganic soil N levels in the spring during the 4th ratoon showed no significant effects due to residue rates or fertilizer applied in previous years (Table 5). All ammonium-N levels were high. Differences in soil N which may have been caused by the various treatments were apparently tied up in organic forms.

Table 5. Influence of unburned sugarcane residue and N application on inorganic soil N levels in the 3rd ratoon crop, and a visual rating of size, color and vigor of sweet sorghum planted following the 4th ratoon crop (0 - poorest, 5 = best).

Treatment main effects[1/]	NH_4^+-N	NO_3^--N	Sweet sorghum rating (0-5)
	---------- ppm ----------		
Residue rate			
0 x	27.8	4.5	2.4
1 x	25.1	4.5	2.2
2 x	26.8	4.1	2.9
Significance[2/]	NS	NS	NS
N rate (kg/ha)			
0	27.1	4.4	2.3
168	25.9	4.2	2.7
Significance	NS	NS	*

[1/] Interactions were nonsignificant.

[2/] Differences nonsignificant (NS) or significant at the 5% (*) level using analysis of variance and linear regression.

The subsequent sweet sorghum crop grown following harvest of the 4th ratoon sugarcane crop showed responses primarily to previous N application, but also to a lesser extent to residue rates (Table 5). Both N application and the 2 x rate of residue application improved the growth rating of the sweet

CONCLUSIONS

No serious detrimental effects occurred to the soil or to crop production due to the application of up to twice the level of residues which would normally have been burned prior to sugarcane harvest. Nitrogen deficiency apparently did not occur in this study until the 3rd and 4th ratoons as indicated by the lack of responses to applied N. Reductions in juice quality and sugar contents in the third ratoon due to N application may have resulted from excess N availability late in the year. The poorest growing conditions and lowest overall yields occurred that year. The quality reductions observed with increasing residue rate in the 4th ratoon also may have resulted from excess N availability late in the season.

Soil properties showed a slight but probably nondetrimental increase in sodium levels and no indication of salt accumulation due to the residue levels. Infiltration and bulk density were also negatively affected by increased residue levels, but again probably not to an extent harmful to crop production. Although inorganic soil N levels were high, inability to detect differences in inorganic soil N levels due to the treatments indicated that soil N reserves were also tied up in organic forms. The subsequent sweet sorghum crop was apparently able to take advantage of those reserves.

While agronomic considerations seem to indicate few barriers to harvesting unburned sugarcane, other factors must also be considered. Fire may play a substantial role in controlling pest populations. Also, mechanical systems have not yet been developed to efficiently handle separation of the residue from the cane during harvest. Finally, heavy tillage operations are required to incorporate this residue into the soil to facilitate rapid decomposition so that other field operations such as cultivation and irrigation can be performed. Such operations will adversely affect soil physical properties.

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EFFICIENCY OF CHEMICAL RIPENER ACTION IN SUGARCANE
VI. GROWTH-REGULATORY ACTION OF POLARIS AMONG CLONES
OF DIVERGENT SACCHARUM SPECIES

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ABSTRACT

Twenty Saccharum clones propagated in soil in the greenhouse were treated with the commercial growth regulator Polaris (Monsanto Agricultural Products Co.) at eight weeks of age. A majority of clones experienced significant growth repression within 35 days, while others revealed moderate to zero response. Growth repression was most severe in S. officinarum and inter-specific hybrids bearing predominantly S. officinarum germplasm. It was progressively less severe in S. spontaneum and S. sinense clones. Single clones of S. robustum and Erainthus maximus were also significantly affected. It is hypothesized that sugarcane sensitivity to Polaris is an inheritable trait that is transmitted in Saccharum largely by the S. officinarum or noble parent.

INTRODUCTION

Chemical ripener action in sugarcane appears to involve source and sink processes unrelated to growth regulation (3,2). However, the hallmark of candidate chemical ripeners has been their ability to modify some aspect of cane growth (1, pp. 443-464). Gibberellic acid acts as a powerful growth stimulant. Polaris (Monsanto Agricultural Products Co.)2/ and 6-azauracil (Nutritional Biochemicals Corp.) also increase growth when received in trace amounts. Confirmed ripeners such as Polaris and Ethrel (Amchem Products, Inc.) typically restrict internode expansion as their main visible effect. Newer materials such as CP 70139 (Monsanto) and Embark (3M Company) also act as growth repressants. Hence, although its role in cane quality improvement remains a matter of conjecture, the growth-regulatory attribute is a convenient indicator of ripening potential in candidate compounds.

It is generally recognized that the commercial sugarcanes of the future will be interspecific hybrids (6,7,5). In addition to S. officinarum, germplasm contributions will come from S. spontaneum, S. sinense, and S. robustum, and possibly also from certain of the "allied" genera such as Erianthus, Miscanthus, and Sorghum (1, pp. 25-37). The degree to which different sources of germplasm will contribute toward a hybrid's propensity to be ripened by chemical means remains totally obscure. One might well ask, for example, whether a proven cane ripener such as Polaris operates against growth processes common to all of the tropical grasses. Moreover, will all Saccharum species be equally responsive to a proven growth regulator, or, should differences exist, will these persist as reliable species characteristics? Such questions will become increasingly important to sugarcane breeders as superior ripeners are developed and find usage throughout the sugarcane world. In the present study the growth-regulatory action of Polaris was evaluated in 20 clones representing a range of distinct Saccharum species.

MATERIALS and METHODS

Saccharum clones were propagated in the greenhouse using a 2:1 soil-cachaza mixture as the growth medium. There were four interspecific hybrid clones (S. officinarum x spontaneum x S. sinense), seven S. officinarum clones, five S. spontaneum clones, and three clones of S. sinense. One S. robustum and one Erianthus maximus clone were also propagated.

Chemical ripener treatments consisting of control (water plus wetting agent) and Polaris (3000 p/m active material plus 0.10% Tween 20 in distilled water) were applied at 10 weeks when all plants were in the intermediate juvenile phase. Solutions were administered until all above-soil tissues were visibly wet. Application time was 0830 h on day 0.

Samples consisting of six whole plants/replicate were harvested at 0700 h on day 0, and at the same hour 35 days later. Green-weight values were recorded together with visual injury ratings at 35 days. There were three replications of each chemical treatment arranged in a completely randomized greenhouse design. Statistical analyses of growth data were performed between control and Polaris treatments within clones, utilizing conventional replications, and between species group means using the clones themselves as replications.

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RESULTS

Foliar injury symptoms had appeared in a majority of the Polaris-treated plants by 35 days (Table 1). These consisted of blade lamina yellowing, a general leaf desiccation (particularly among mature ranks), and a death of blade tips and margins. Numerical rating of the symptoms was rendered more difficult among *S. spontaneum* and "wild" clones owing to their greatly thickened midveins and constricted lamina

Table 1. Numerical rating values for foliar injury symptoms produced by Polaris in divergent Saccharum clones.

Species	Clone	Injury rating at 35 days[1/]	Species	Clone	Injury rating at 35 days
Interspecific hybrids	PR 980	4.3	*S. spontaneum*	Mandalay	2.3
	H37-1933	4.7		US 56-19-1	1.0
	Pindar	1.7		US 56-14-4	1.7
	POJ-28-78	4.0		US 56-68-4	3.3
				SES 327	4.0
S. officinarum	Badilla	1.0			
	Lahaina	4.3	*S. sinense*	Saretha	1.0
	Blanca	4.7		Chunnee	3.7
	Black Cheribon	5.0		Natal Uba	1.0
	Crystalina	5.0			
	Creole	1.0	*S. robustum*	NG 57-83	3.0
	Rayada	5.0	*E. maximus*	NG 232	5.0

1/ Numerical rating scale: 1 = No symptoms; 5 = severe symptoms. Data were compiled by visual inspection only and no statistical analyses were performed.

Growth repression by Polaris occurred in a majority of test clones, including the single *S. robustum* and E. *maximus* representatives (Table 2). As generalized group responses the Polaris effect was most severe in *S. officinarum*, moderately less so in interspecific hybrids, and progressively less severe in *S. spontaneum* and *S. sinense* (Table 3). Ratoon growth was unaffected by Polaris. At least one clone of each group was unresponsive to the ripener. Hence, the growth performances of clones Pindar (hybrid), US 56-19-1 (S. *spontaneum*), Chunnee (S. *sinense*), and Badilla and Creole (*S. officinarum*) differed markedly from other members of their groups in failing to respond to Polaris. The variability stemming from their inclusion as group replicates tended to restrict the number of Polaris means attaining statistical significance within *Saccharum* species (Table 3). One *S. sinense* clone (Natal Uba) significantly increased growth by 35 days as a result of chemical treatment (Table 2).

DISCUSSION

While growth repression is not necessarily a requisite feature of chemical ripening, it is a convenient "marker" or indicator of ripening potential among the best candidate compounds available today. Without exception, the superior ripening materials of the past have produced powerful growth-regulatory effects on sugarcane when adequately administered. The growth-regulatory feature has additional value when examining riper-sensitivity among primitive *Saccharum* forms. In such instances sugarcane's traditional quality parameters may be difficult or impossible to measure or to evaluate accurately against conventional quality standards.

Chemical ripeners are ordinarily tested upon the best commercial varieties currently being planted. The present results, to the contrary, offer some first tentative trends which the cane physiologist or breeder may encounter when seeking ripener sensitivity among more primitive sources of *Saccharum* germplasm. These include: a) large variations in clone and species response to Polaris, suggesting that ripener sensitivity is an inheritable feature rather than a basic biochemical response common to all forms within the genus *Saccharum*; b) pronounced growth repressions among *S. officinarum* clones, suggesting that hybrid sensitivity to Polaris may be largely a contribution of the *S. officinarum* or "noble" component of the individual genotype; and c) pronounced intraspecific variations ranging from zero to high chemical sensitivity. The latter implies that parents suitably sensitive to Polaris might be found among all *Saccharum* species for use in hybridization programs. It also implies that *Saccharum* taxonomy based on floral, anatomical, and morphological features may remain incomplete relative to growth and chemical-sensitivity potentials.

It is sometimes argued that response variations obtained from field trials are a consequence of the environmental and chemical-administration constraints that operate under field conditions (3). This was not the case at present where each plant received a more than adequate Polaris dosage to reveal chemical sensitivity if the potential to do so were there. Some level of Saccharum response variation might be explained in terms of anatomical and morphological variations (leaf waxiness, variable stomata numbers, varying lamina surface), but this does not account for the total lack of response sometimes obtained. This is more logically explained in terms of growth-regulator sensitivity existing as an inheritable trait; one which may be present with varying degree of expression, or not present at all.

Table 2. Growth performance of discrete Saccharum clones treated with Polaris [1/]

Species	Clone	Treatment	Green wt(g/plant) 0 & 35 days		
			0	35	% change
Interspecific hybrids	PR 980	Control	100	196	96.0
		Polaris	97	82* [2/]	-16.0*
	B37-1933	Control	100	202	102.0
		Polaris	102	66**	-35.3*
	Pindar	Control	108	152	40.7
		Polaris	105	142	35.2
	POJ-2878	Control	59	167	183.1
		Polaris	61	106**	73.8*
S. officinarum	Badilla	Control	57	93	63.2
		Polaris	60	116	93.3
	Lahaina	Control	87	160	83.9
		Polaris	88	86**	-2.3**
	Blanca	Control	69	178	158.0
		Polaris	69	67**	-2.9*
	Black Cheribon	Control	89	135	51.7
		Polaris	90	56*	-37.8*
	Crystalina	Control	248	295	19.0
		Polaris	244	179*	-26.6*
	Creole	Control	65	79	21.5
		Polaris	61	80	31.1
	Rayada	Control	113	173	53.1
		Polaris	113	83*	-26.5
S. spontaneum	Mandalay	Control	45	77	71.1
		Polaris	43	59*	37.2
	US 56-19-1	Control	59	68	15.3
		Polaris	59	70	18.6
	US 56-14-4	Control	59	66	11.9
		Polaris	59	63	6.8
	US 57-68-4	Control	34	63	85.3
		Polaris	32	48	50.0
	SES 327	Control	48	89	85.4
		Polaris	50	48**	-4.0*
S. sinense	Saretha	Control	59	66	11.9
		Polaris	57	67	17.5
	Chunnee	Control	79	87	10.1
		Polaris	77	65	-15.6
	Natal Uba	Control	63	139	122.2
		Polaris	62	158*	154.8
S. robustum	NG 57-83	Control	36	57	58.3
		Polaris	37	43**	16.2*
Erianthus maximus	NG 132	Control	139	150	7.9
		Polaris	151	100*	-33.8*

— Polaris was administered as an aqueous foliar spray containing 3000 p/m active ingredient. Application time was 0830 h on day 0.

- *Indicates a significant deviation of the Polaris value from the corresponding control value within the same column (P<.05). **Indicates (P<.01).

Table 3. Saccharum growth responses to Polaris as species averages.

Saccharum species	No. of clones examined	Treatment	Ave. green wt (g/plant) at day 0	35	% change	Ratoon wt (g/plant) at day 70
Interspecific hybrids	4	Control	92	164	78.3	48
		Polaris	91	93	2.2	51
S. officinarum	7	Control	104	159	52.9	24
		Polaris	104	96*[1/]	-7.7*	30
S. spontaneum	5	Control	49	73	49.0	23
		Polaris	49	60	22.4	23
S. sinense	3	Control	67	97	44.8	24
		Polaris	65	97	49.2	28

[1/] Asterisks indicate a significant deviation of the Polaris value from the corresponding control value (P<.05).

The high sensitivity of S. officinarum (noble) clones to Polaris can be taken as a favorable omen for cane breeders seeking to intensify this feature in new interspecific hybrids. An abundance of noble germplasm is presently available in USDA collections (4). Employed traditionally as the female parent, the ripener-response trait would presumably aggregate more rapidly from noble sources owing to a maternal transmission of the somatic (2N) chromosome number, rather than the gametic (N) number as transmitted by the male parent (1, pp. 45-49). On the other hand, the selection of male parents for such conventional traits as disease resistance and superior harvest characteristics might also be accomplished with a view toward intensifying rather than diminishing ripener sensitivity in the ensuing progeny. From within the species S. sinense, for example, with other qualities being equal, the clone Chunnee would appear to enhance the propensity to ripen while Saretha and Natal Uba would contribute none of this feature to the interspecific hybrid.

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COMPARATIVE EFFECTIVENESS OF FULL-FIELD AND FIELD-EDGE BAIT APPLICATIONS IN DELIVERING BAIT TO ROOF RATS IN FLORIDA SUGARCANE FIELDS

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ABSTRACT

Current rodent control measures in Florida sugarcane emphasize the placement of toxic baits at field perimeters, either by aerial application, in bait stations, or both. In a 2-phase study involving 16 fields, we determined that perimeter bait applications, although providing greater bait density, were less effective than whole-field applications in delivering bait to roof rats living in field centers. Removal of rats (by trapping) from the edges of perimeter-treated fields to simulate bait-induced mortality did not result in a major shift in rat movements toward field perimeters. Further work is needed on registration of effective rodenticides for application in sugarcane and on optimal bait distribution patterns to provide cost-effective rodent control.

INTRODUCTION

Rodent damage to sugarcane has been estimated to amount to $10 million in one year for one large grower-processor in Florida (6). Current rodent control measures in Florida sugarcane emphasize the placement of toxic baits in field edges by aerial application or in bait stations. These methods have evolved for several reasons: the difficulty of penetrating maturing sugarcane, the belief that rats are killed or leave fields at harvest and reinvade fields from surrounding areas, the expense of whole-field bait application, and the fact that until recently, no bait was registered for in-field use in Florida sugarcane. The need for in-field treatment to reduce rodent populations in Hawaiian sugarcane fields has long been recognized (3,12). Data are lacking on the comparative effectiveness of whole-field versus field-edge applications in delivering baits to rats inhabiting Florida sugarcane fields. The primary targets of aerially-applied rodent baits in Florida sugarcane are the cotton rat (<u>Sigmodon hispidus</u>) and the roof rat (<u>Rattus rattus</u>). Movement data obtained in earlier studies (4) indicated that only a small percentage of cotton rats occupying a field would encounter baits placed at the field edge. Very little information is available on roof rat movements in Florida sugarcane, however rats have been trapped throughout fields.

In Hawaii, roof rats (= black rats) are seldom captured in sugarcane fields, and primarily occupy the large non-crop areas surrounding fields, e.g. gulches or wastelands (11,13). Lindsey et al (9) concluded that in Hawaiian sugarcane, perimeter bait stations may be effective for roof rats because 78-93% of roof rats captured along field edges had consumed bait station oat groats treated with a marker. Hawaiian sugarcane field rodent populations (primarily the Polynesian rat, <u>Rattus exulans</u>) are drastically reduced by harvest operations, and rats that survive leave the fields (10). In Florida, many rats survive harvest and continue to live in the fields. Following a 1983 field test (7), the fate of 49 radio-collared roof rats in four fields was determined immediately after the fields were burned, and 27 radio-collared roof rats in three fields were tracked through loading of cut cane (all fields were hand-harvested). Only six rats (12%) died as a direct result of the burn, and eight (30%) were apparently crushed or suffocated in their shallow nests, usually located under cane stools, by mechanical loaders. Thus roof rat mortality directly related to harvest was less than 50% of field populations. Two radio-collared rats that were not recovered immediately after harvest were still living in the field one month later. In May 1982, 20 roof rats were radio-tracked over a 2-week period in two harvested sugarcane fields (8). Only one rat left the field where it was tagged and moved to an adjacent ditch-bank, despite the fact that the resprouting cane in this field was approximately 60 cm in height and provided relatively little cover. During a 2-year livetrapping study (5) roof rats were captured in the field in almost every month, including those following harvest.

Apparently, roof rats in Florida sugarcane fields behave quite differently than those in Hawaiian sugarcane, which is perhaps not surprising considering the great differences in physical features and cultural practices of these two regions. Nevertheless, field-edge baiting could provide crop protection in Florida sugarcane if roof rats living in field interiors frequently visited field edges, or if bait-induced mortality at perimeters caused a rapid (while bait was still available) shift in rat movements toward field edges.

We compared the effectiveness of full-field and field-edge baiting in delivering baits to roof rats throughout fields and determined whether or not rats move to the field edge and consume bait in response to a population reduction at the edge.

METHODS

Phase I - No population reduction along edge - Eight sugarcane half-fields (7.3 ha in size), in which at least six roof rats had been captured in 24 trap-nights, were selected in September 1982. Traps were Haguruma (Japanese) wire-mesh live traps (Honolulu Sales, Ltd., Honolulu, HI) baited with apple.

Study half-fields were stratified into edge and center (Figure 1). The middle ditch, a 1.3 x 1.3 m irrigation ditch, was considered as field-edge because current baiting procedures include applying bait along it. Four of the selected fields were randomly assigned to edge-treatment and four to full-field treatment. The proportion of trapped rats that consumed bait was determined for each stratum within fields.

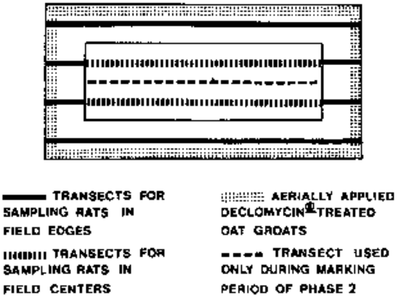

Figure 1. Field-edge treated field, showing location of trapping transects. The layout of whole-field treated fields was identical, however the same quantity of demeclocycline hydrochloride-treated bait was distributed over the whole field. All fields were approximately 7.3 ha.

Slightly-crimped oat groats were treated with 1% demeclocycline hydrochloride (DMCH) by weight in an acetone slurry. (Demeclocycline hydrochloride was formerly named demethylchlortetracycline, abbreviated DMCT). After evaporation of the acetone, the treated oat groats were overcoated with 6% by weight 1:9 Rhoplex AC-33 and water. DMCH induces a golden-yellow fluorescence in bones and teeth under long-wave ultraviolet light (3,600-3,700 S) (2). It has been used as an effective rodent marker for bait consumption studies (9,11).

Treated oat groats (4.5 kg) were applied to each test field by aerial application. In full-field applications, bait was evenly distributed over the entire field (5.6 kg/ha, or 5 lb/A). In field-edge applications, bait was applied in a swath just inside the field edge (Figure 1), in the same manner as is currently practiced by some Florida sugarcane growers. Consequently the bait density in the treated swaths of field-edge treated fields was several times that of whole-field applications; this insured that the same total quantity of bait was available to rats in both types of treatments. The test was conducted in two stages, three days apart, each stage including two full-field and two field edge treatments. Rats were allowed to consume treated oat groats and become marked for six days following application. Four trapping transects (370 m long) were established by cutting paths through each half-field. Rat snap traps baited with apple chunks were placed at intervals along each transect for two consecutive nights (Figure 1). The trap interval was 5.5 m in the field-center stratum and 9 m in the field-edge stratum, so that trapping effort was similar in each stratum per field. A buffer zone of 30 m with no traps was established between edge and center strata.

Mandibles from all trapped rats were examined independently under long-wave UV light by two evaluators for presence or absence of fluorescence. Several mandibles from roof rats not exposed to DMCH were available as references. Mandibles which were scored positive for fluorescence by one evaluator and negative by the second were examined by a third evaluator. The score given by the two evaluators in agreement was considered correct. The sample evaluated by the third evaluator always included additional mandibles to those in question.

Variation in proportions of rats marked per stratum was tested using a 2-factor split-plot design, in which plots are fields with bait treatments representing whole plot effects and strata representing subplot effects. Untransformed and arcsine transformed proportions of rats marked were analyzed using the ANOVA Procedure of the Statistical Analysis System (SAS) software package at the Northeast Regional Data Center, University of Florida. An a priori contrast was used to compare the mean proportion of rats marked in the centers of edge-treated fields with the means of the other three treatment x stratum combinations using a constructed error term and adjusted t-statistic (1). The accepted significance level was $P \leq 0.05$.

Phase 2 - Population reduction along edge - Eight additional study fields were selected in October 1982 and randomly assigned to edge or full-field treatment as in Phase 1. Strata and transects were established as in Phase 1, with an additional transect in the center stratum (Figure 1). Japanese live traps baited with apple chunks were set at 15-m intervals along the three center stratum transects for three consecutive nights. All rats trapped were marked with numbered Monel® ear tags.

Oat groats treated with DMCH were then applied to the study fields as in Phase 1. Six days following bait application, rats were trapped for six consecutive days with live traps placed at 15-m intervals along edge transects (Figure 1). In perimeter-treated fields, rats were killed, removed and frozen. All rats were examined for presence of an ear tag. In full-field treatment fields, rats were ear-tagged and returned to the fields. Live traps were removed and snap traps were placed (the same day) at 7.6-m intervals on all portions of all transects except the center transect (Figure 1) for three consecutive nights. The 6-day period during which rats could have dispersed to field edges was considerably longer than the period (two days) over which oat groats have been observed to persist on the ground before being consumed.

Rat mandibles were examined for DMCH fluorescence as in Phase 1. Variation in proportions of rats marked was analyzed as in Phase 1.

RESULTS

Phase 1 - No population reduction along edge - Roof rats [442] were captured from the eight test fields post-treatment($\bar{x}$ = 56.0 from full-field and 54.5 from field-edge treated fields). Since the ANOVA results for untransformed and transformed proportions of rats marked per strata were essentially the same, and the distribution of residuals of untransformed data was close to normal, only the results of the untransformed data analysis are given. ANOVA results indicated a highly significant treatment x stratum interaction (P = 0.002), thus the effect of field-edge versus whole-field treatment depends upon which stratum is considered, edge or center (Table 1). A linear contrast on the mean proportion of rats marked in the centers of edge-treated fields with the means of the other three treatment x stratum combinations yielded a highly significant difference (P<0.001).

Table 1. Number of roof rats marked by consumption of demeclocycline hydrochloride-treated bait/number trapped in whole-field or field-edge baited sugarcane fields, Clewiston, Florida, October 1981.

	Treatment							
	Whole-field baited				Field-edge baited			
Field	1	2	3	4	5	6	7	8
Stratum trapped								
Edge	46/50	24/28	13/14	29/30	39/40	35/36	13/17	34/35
	$\bar{x}$ = 92% marked				$\bar{x}$ = 92% marked			
Center	26/32	17/22	21/21	23/24	10/27	2/25	2/17	4/21
	$\bar{x}$ = 85% marked				$\bar{x}$ = 19% marked			

Phase 2 - Population reduction along edge - Roof rats [360] were captured from the eight test fields post-treatment ($\bar{x}$ = 20.2 from full-field and 69.5 from field-edge treated fields). A mean of 43.0 roof rats were removed from field-edge treated fields during removal trapping, and 26.5 roof rats were captured from these fields in the final snaptrapping.

ANOVA results again indicated a significant treatment x stratum interaction (P = 0.01). A linear contrast on the mean proportion of rats marked in the centers of field-edge treated fields with the means of the other three treatment x stratum combinations (Table 2) yielded a highly significant difference (P<0.001).

Table 2. Number of roof rats marked by consumption of demeclocycline hydrochloride-treated bait/ number trapped in whole-field or field-edge baited sugarcane fields, Clewiston, Florida, October 1982. Rats were trapped and removed from the edge strata of field-edge treated fields for six days before the final snaptrapping results were obtained.

	Treatment							
	Whole-field baited				Field-edge baited			
Field	9	10	11	12	13	14	15	16
Stratum trapped								
Edge	13/13	19/21	3/4	14/16	13/20	29/35	7/8	5/9
		$\bar{x}$ = 88% marked				$\bar{x}$ = 73% marked		
Center	7/8	9/10	5/5	3/4	1/11	1/13	1/7	1/3
		$\bar{x}$ = 88% marked				$\bar{x}$ = 16% marked		

Of 122 roof rats eartagged in field centers pretreatment, only two were recaptured in the final snaptrapping. One of these, in a field-edge treated field, moved from the center to the edge stratum.

A total of 72 roof rats were eartagged and released in the edge stratum of whole-field treated fields, during the removal period in edge-treated fields. Of these, seven were recaptured in the final snap-trapping, all in the edge stratum.

DISCUSSION

Field-edge bait applications were less effective than whole-field applications in delivering bait to roof rats living in field centers. The majority of rats inhabiting field centers in edge-treated fields did not move to field edges and consume the marked bait. Even when rats were removed from the edges of edge-treated fields, to simulate bait-induced mortality, there did not appear to be a major shift in rat movements toward field edges during the period that bait was available. However, the mean percentage of rats (18%) from both phases of the study that consumed DMCH-treated bait and were later trapped in field centers was notable. This suggests that some roof rats move far enough in maturing sugarcane fields to encounter bait applied in swaths, particularly if bait were to be applied farther into fields than is currently practiced. When economic constraints are considered as well as optimal population control, a compromise between whole-field and field-edge treatments, such as in-field swath baiting, probably will be the most practical approach. Bait density may have to be higher in swaths than in whole-field applications in order to provide a sufficient quantity of bait for all rats.

The difference between the number of roof rats captured in field centers [61] vs field edges [126] during the final snaptrapping in Phase 2 may simply reflect the unequal trapping effort in these strata (1,536 trap nights in field centers vs 2,688 in field edges). There was less difference between field center [192] and field edge [250] captures in Phase 1, when trapping effort was more equal between strata (1,312 vs 1,504 trap nights).

Eartagging did not provide information on whether or not rats from field centers moved to field edges in response to population reduction at the edges. Recapture success for roof rats was extremely low, as we have found it to be in previous studies (14). Overall there did not appear to be a major shift in roof rat movements toward field edges in response to removal of rats in edge-treated fields. The ratios of roof rat captures between center and edge strata in whole-field treated fields .(27:54) and field-edge treated fields (34:72) were similar. If many rats had moved from field centers to edges in field-edge treated fields, a smaller ratio of center to edge captures would be expected. Most of the roof rats captured in the edges of the field-edge treated fields were DMCH-marked (73%), although not quite as many as in whole-field treated fields (88%). If a large number of rats had moved into the edge strata of field-edge treated fields from field centers or surrounding fields, a smaller percentage of marked rats would have been expected. An important consideration in Phase 2 was our ability to remove a significant portion of the populations in the field-edge treated fields. A total of 173 roof rats were removed from the edges of the four field-edge treated fields, more than twice as many as were subsequently captured in edge strata during snaptrapping with approximately the same level of trapping effort (twice as many traps were used in snaptrapping for half as many nights as in removal trapping). While it can be argued that our reduction was not as great as a highly effective rodenticide treatment might have been, we believe that a substantial reduction was achieved in the field-edge treated fields.

Implications for Current Baiting Practices

Further work is needed on registration of effective rodenticides which can be applied in-field in Florida sugarcane. Zinc phosphide is the only toxicant which is currently approved for in-field use in Florida sugarcane because it is the only one for which a tolerance level has been established and residue data obtained in this crop. The only rodenticide currently registered for in-field treatment of Florida sugarcane (ZP® Rodent Bait AG, Bell Laboratories, Inc.) was ineffective in reducing roof rats in a field test (7), and its efficacy on cotton rats is unknown. Anticoagulant baits, which are used by many growers, may be legally applied only to noncrop areas outside of fields. Such applications would be even less likely than a field-edge application to effectively reduce in-field rat populations. No regulations specifically prohibit the use of rodenticide bait stations in field edges, however these require maintenance and are labor intensive if used properly. It is possible that rat mortality over a longer period than was simulated in this study, such as might occur with properly maintained bait stations or repeated aerial applications, might result in greater rat dispersal from field centers than we observed. An effective in-field application would undoubtedly be more cost-effective.

Until they can be legally applied in-field, we do not recommend that Florida growers broadcast anticoagulants, except perhaps in situations where noncrop areas are extensive and support large rodent populations. As effective rodenticides registered for in-field application become available, research on swath intervals and bait density may lead to a bait distributional pattern that greatly improves bait delivery to rats, and is at the same time economically feasible.

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THE LOUISIANA SUGAR INDUSTRY: PERSPECTIVE GAINED APTER A YEAR IN THE INDUSTRY

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ABSTRACT

Present aspects in quality control, research and development, and future trends in sugar cane harvesting, processing, and product sale and shipment are reviewed. Each area is reviewed from impressions and experience developed during the first year of a young professional's perspective upon entering a different industry—sugar.

INTRODUCTION

Recent upheaval in world trade for industrial products has produced Shockwaves affecting all segments of the many "smokestack industries" of America. Modern, computerized, and efficient industrial complexes are being constructed in many of the developing nations resulting in reduced labor costs and excellent product quality while much of industrial America is battling with antiquated, inefficient and labor intensive production facilities and management philosophies.

A recent article in The Wall Street Journal " entitled "Smokestack America may not be over the hill" stated, "In recent years there has been a rush to bury the auto companies the steel mills and the rest of U. S. heavy industry as hopelessly out-of-date. The only hope for America was to expand in high-technology industries and, at the same time, reconcile itself to being largely a service economy" (3). Unfortunately, many U. S. raw sugar production facilities can be included in the ever-increasing list of industrial complexes falling prey to this concept. In 1972, forty-three mills produced raw sugar in Louisiana. Within a ten-year period, only 21 mills remain operative and several of these function with serious threat of failure. Although production of raw sugar remains stable, how much longer can the industry withstand erosion from factory failures.

It is difficult to envision that a country leading in technological advances contains within its boundaries entire industries on the verge of collapse. However, such is a prevalent status among much of America's industry. During the context of this discussion of brief review of probable causes for this state in American industry is addressed. Additionally, special attention is given to the Louisiana raw sugar industry with proposed avenues for future means of development and stabilization. In no way does this discussion propose to contain all the answers to problems facing the raw sugar industry. But through perspective gained during a year in the sugar industry, comments on quality control, research and development, and the future of the raw sugar industry are expressed in the hope of contributing some recognition of possible alternatives for tomorrow.

DISCUSSION

To gain some perspective into the factors which led to present U. S. industrial plight, a review into American history and economics is warranted. Prior to U. S. involvement in World War II, the U. S. economy was embroiled in a depression. Factories were closed resulting in countless numbers of unemployed workers. Upon entering the war, U. S. factories began producing at maximum levels to replenish depleted reserves and future demands of the largest mobilized military confrontation in U. S. history. At the end of World War II, much of the industrialized world laid in ruins. Demand for U. S. products reached all-time highs. Productivity never surpassed demand. Furthermore, "after World War II, we were stuck with all of this marvelously undamaged industry, some of which was new when Abraham Lincoln was president" (3).

Not until the mid- and late-1960's were problems revealed demonstrating the tangent U. S. industry had taken, greatly weakening its ability to compete in a world market situation. The following summarizes many of the events which characterize earlier direction: 1) industry could charge whatever price desired because demand exceeded supply, 2) in doing so, industry ignored much of the new and exciting technology being marketed and developed, 3) product demand was so great that frivolous concessions were often made to appease union membership, 4) U. S. foreign policy provided for financing and development to rebuild war damaged industry with new state-of-the art industrial complexes, and 5) companies continued allowing wages to escalate passing the burden onto consumers and contributing greatly to the inflationary spiral. These factors combined with a rapidly growing American population (known as the Baby Boom Generation) laid roots for U. S. industrial attitude.

Although simplistic in nature and not completely applicable to raw sugar marketing over the past forty years, much of the management and development philosophies of other industries can be paralleled to the Louisiana raw sugar industry. Indeed our facilities are antiquated and inefficient while labor costs are often excessive and product quality inconsistent. Remaining under the greatly needed umbrella of the former sugar act and now the 1981 farm bill, minimal assistance produced by this legislation remains insufficient and forces the industry to maintain a complacent attitude in moving towards technological advancement rather than utilizing price support as means to reduce labor cost, increase product quality, and increase factory efficiency. Tight cash flow, poor crops, and lack of capital are reasons for lack of change. In doing so, the industry realized a great disservice.

So what specifically can be done about the many problems plaguing the industry, especially in light of the insecurity of being excluded from the 1985 farm bill. By no means can the industry survive on a world market without the protection of price supportive legislation. Staffing and management, factory automation, process efficiency, quality control, process control, chemical control, sugar cane agricultural operations, and research and development all deserve attention; yet, appropriate treatment of these areas will not result until legislation is passed showing support for the raw sugar industry.

The following sections illustrate conditions observed in the Louisiana raw sugar industry which should change and stand in need of capital influx. Observations include direction that should be taken in light of renewed capital expenditures into the industry.

Management and Talent - In the April 2, 1984, edition of The Wall Street Journal, Jack Falvey wrote, "Managers must understand that a major part of their jobs should be spent constantly looking for good talent. It is an unending task. Few accept this challenge. They seldom realize that the best time to interview is when no vacancy exists" (4). Our industry is in dire need of young innovative individuals who can prosper from the wisdom of experienced managers and sugar experts while being allowed to develop and share knowledge of new and exciting technology. Together these individuals must join forces and move the industry forward towards computerization, modernization, and efficiency.

However, poor salaries, minimal benefits, overbearing and outdated management styles, and poor working conditions and facilities will not attract the quality or quantity of young professionals needed to address the many problems plaguing our industry. Recent incentives such as those proposed by U. S. Sugar Corporation are outstanding and should be emulated by the entire industry (5). Excuses of short seasonal operations should not be used as reasoning for not hiring much needed talent. Innovative thinking in salary justification by developing outside utilization of talent might be an alternative.

Additionally, labor forces should be regrouped, and retrained, and reimplemented with incentives compensating for excellence and versatility in job function. Honeywell, Inc. and TRW, Inc. are two examples of large companies which now pay workers according to the number of skills they master (5). Other companies (e.g. Comerica, Inc., General Motors, Pitney Bowes Business Systems, Ford Motors, Schering-Plough, and Eastman Kodak) give cash awards for employee ideas which result in cost-savings; for instance, Eastman Kodak reported saving $16 million in 1983 from such suggestions (6, 7).

Management by objective and management by incentive for all employees should become an everyday practice in our industry. People are a great natural resource, and only through excellent personnel can the sugar industry begin to move forward. Working as an aggressive team with well-defined objectives as exemplified by Japanese industry (9) and others (1), management and labor can establish the industry as a viable competitor both domestically and abroad (10).

Furthermore, financial management and direction must involve individuals who understand both market trends and sugar technology. To entrust an industry so greatly needing technological advancement to financial managers lacking in technical skills is a dangerous practice. Most Fortune 500 institutions now direct their companies with managers possessing superior financial skills as well as technical skills. Good management and talent combined with well-defined objectives and capital resources will be necessary if the sugar industry is to secure a future.

Factory Automation - Several million years ago, dinosaurs, the largest reptile on earth, perished because of their inability to adapt to a changing environment. Such is the fate of many U. S. domestic raw sugar facilities unless they adapt and conform to the present trend of automation through computer-

Several hundred small companies offer small black boxes which possess the ability to control a given area or piece of machinery. However, only through total automation with central computer control can factories realize the benefits of increased production efficiency and lower labor costs. In doing so, a high quantity and quality sugar can result per ton cane, processed at a lower cost.

Many companies now operate entire production facilities with one-fourth the personnel per shift as compared to most Louisiana factories. These types of facilities are becoming more commonplace worldwide and will further strengthen foreign superiority of raw sugar production unless a similar course is plotted for the U. S. industry.

Quality Control/Process and Chemical Control - Raw sugar operations around the world recover the equivalent of 280 pounds of raw sugar per ton of cane. These factories utilize controlled cane delivery schedules ensuring fresh cane, thorough process scrutiny through good chemical control, and excellent storage facilities for stable sugar keeping.

From the time cane is harvested until the resulting raw sugar is delivered to the refiner, chemical control should be utilized to ensure product quality and process efficiency. In Louisiana, the lack of uniform and adequate chemical control is staggering. Mill reports are published daily containing figures and data which simply are not supportive of factories when visited or results when carefully scrutinized. The necessity for well-trained, well-staffed, and adequately equipped laboratories for the implementation of standardized analyses procedures is ever-present. Seasonal employment (particularly for the chief chemist) does little for the continuity of laboratory control as well as the domestic economy.

Particularly of due need are degreed chemists trained in a wide range of areas such as analytical procedures, laboratory augmentation, management, applied research and development, and process control in subjects such as chemistry, biology, mathematics, polymer science, basic engineering, computer science, and physics.

Accurate chemical control must be established in Louisiana raw sugar factories to adequately assess the true production efficiency of existing facilities. Only upon doing so can necessary adjustments begin so as to ensure maximum recovery of sugar and process efficiency at cost savings.

Agriculture Operations - Louisiana State University and the U.S.0.A. have provided for an outstanding group of talented and motivated professionals supplying valuable information to growers on the agronomy of sugar cane. However, beyond breeding studies, cultivation practices, and harvesting techniques there is a large host of areas remaining to be implemented in Louisiana.

Fresh, clean, unburnt, and virtually bacteria free cane is being utilized by many operations as a means of increasing sugar yield. There is an apparent gross misconception by some in the Louisiana industry believing that yield of cane or tons cane ground by a factory is an excellent measure of that factory. Unfortunately, raw sugar refiners disagree with this notion as payments are based on quantity and quality of sugar delivered to their factory site. Although a good yielding crop provides for excellent opportunity for sugar production, a lower yielding crop producing larger quantities of recoverable sugar could be more suitable to both the sugar cane grower and raw sugar factory. In essence, both grower and factory must become raw sugar producers, not cane producers, striving for high sugar recovery and quality. Burning cane, rolling it in mud, crushing it with present mechanical harvesters must be replaced with efficient mechanical systems providing the highest quality starting product possible—i.e., sugar cane.

A consideration of the value of burning versus non-burning of cane on soil conditions, sugar cane yield and quality, air pollution; mechanical harvester design; and cultivation practices must not only continue but must be intensified both in principle and in application. New technology in the agriculture section must be continually developed and applied so as to secure the quantity and quality product necessary to maintain industry stability.

Research and Development - Finally, corporations such as Dow, DuPont, Shell, Exxon, Bell Telephone, and many others allocate large budgets for both theoretical and applied research (11). They do so in the quest of securing marketable products or technology for future sales and expansion. With a broad base from which to work, these companies continually recruit bright and innovative individuals into their

Although no raw sugar facility can support such endeavors alone, the raw sugar industry must unite and develop resources from both the private sector and government agencies so as to support creative and productive research on sugar utilization as well as by-product utilization. The prevailing attitude that little more can be done for sugar is the very attitude that will contribute to the demise of this industry. Unless taken as a serious objective, the industry will be eventually overrun by competitive sweeteners, poor public image, and price support withdrawal. Thoroughly researched innovation must result in marketing raw sugar and associated by-products.

It is discomforting to learn that the National Science Foundation reported requests for funding dropped 50 percent after an administrative announcement of proposed budget cuts in 1982. Although funds remained intact, proposals continued declining and have yet to increase. Deliberate and exhaustive measures must be initiated to secure funding for both basic and applied research and development. Only through broader based operations with greater market exposure can the U. S. raw sugar industry be expected to move towards survival with reduced price support.

Price Support - A recent item appearing in The Wall Street Journal, "Reaganites prepare plans to remove much support for farming," exemplifies a serious threat facing agrarian America (12). The virtues of a free-market, supply-side, balance-of-payment economic attitude is one to be relished. However, to abruptly abolish farm aid is to destroy many weak farming industries—specifically raw sugar.

The impact of the upcoming 1985 farm bill upon sugar remains unclear. However, if excluded, the following cannot be prevented: 1) collapse of not only the Louisiana raw sugar industry, but the majority of the domestic raw sugar industry, 2) upon collapse a dependence on foreign produced sugars to meet U. S. consumer demands paralleling a course once taken by the U. S. oil industry, 3) a "domino effect" on all industries presently serving the domestic raw sugar industry, 4) a reduced ability to secure balance-of-payments as more sugar will be imported into the country, and 5) a weakening of the U. S. economy as tax revenues decrease from no domestic production and unemployment figures escalate. Being excluded from the 1985 farm bill will in essence destroy an entire industry as well as a social way of life for large numbers of people. However, minimal price stabilization does little besides preserve the industry from disaster.

The Louisiana raw sugar industry needs a "capital surge" as do many other domestic industries. Unfortunately, the opportunity has never been extended to any of this industry to implement much of the state-of-the-art technology available. This has perpetuated a form of industrial operation lacking often in talent, process efficiency, quality control, and research and development. But, how can the private sector be expected to support the industry and provide for capital resources for improvements when accounting statistics show it to be an undesirable investment under the economic umbrella of high interest rates and low price support.

Incentives are necessary from the U. S. government to secure viable benefits such as to stimulate private investment into the raw sugar industry. It is not the intent of this article to challenge the wisdom of congressional leadership; however, it is criminal to destroy domestic industry for the sake of what initially appears to be short-sighted savings to tax payers. If the industry should collapse, the taxpayer will ultimately lose.

Innovation in providing legislation which will secure not only subsidy but investment incentives are necessary if the domestic raw sugar industry is to prosper and grow. In doing so, better and more talent can be incorporated into the industry resulting in the stimulation of factory automation, process control, and research and development.

The raw sugar industry can become a viable entity if provided with proper supportive legislation. However, only we can make this happen through hard, aggressive, innovative tactics. Good public relations showing the world as Mr. Laszo Toth's recent article that sucrose is indeed "nature's own" must be stressed (2). Our American Sugar Cane League and ASSCT must play a vital role for both grower and raw sugar factory.

"Things may come to those who wait. But only the things left by those who hustle" (13). Through intense, well-planned, and well-implemented strategy, the Louisiana raw sugar industry with the entire U. S. domestic industry can regain recognition for providing a necessary product to U. S. consumers while contributing to the stabilization of the U. S. economy.

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THE EFFECT OF WHEEL DAMAGE AND DELAY IN MILLING ON DETERIORATION OF SUGARCANE JUICE

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ABSTRACT

On November 23, 1982, a single row, approximately 110 m long, of the sugarcane variety CP 65-357 in the first ratoon crop was cut and topped by a conventional, whole-stalk harvester at Houma, Louisiana. One half of the "heap row" was then mashed by a single pass of one front and one rear wheel of a rubber-tired farm tractor weighing about 3700 kg to simulate the damage incurred by the harvester when rolling over the heap row while cutting the second row. The remainder of the heap row was not mashed and used as control. Two 10-stalk samples or the equivalent from both damaged and control cane were milled once through a 3-roller mill at 0, 3, 7, 10, 14, and 17 days after harvest. Parameters measured in crusher juice included sucrose content, apparent purity, the yield of theoretical recoverable sugar per ton of cane (sugar yield) and dextran content. Little or no change occurred in either damaged or control cane over the period of sampling for sucrose content, purity and sugar yield. However, dextran increased at a significantly higher rate in damaged cane than control cane. These data suggest that for mature cane, whether damaged or not, cut late in the season when the ambient temperatures are cooler, the rate and extent of deterioration as measured by changes in sucrose content, purity or sugar yield are difficult to detect. However, there is an increase in dextran which can cause an abnormal increase in polarization and unless dextran is measured, serious deterioration could go undetected.

INTRODUCTION

A number of parameters have been investigated and used as indicators of deterioration of cane juice, notably pH and titratable acidity. Obvious drops in sucrose content, apparent purity and the yield of theoretical recoverable sugar per ton (sugar yield) have also been used as indicators of juice deterioration. However, none of these parameters are completely satisfactory (6, 7, 9). Several workers in Australia (11, 12) and the United States (4, 7) have demonstrated that soluble polysaccharides, particularly dextran, are better indicators of cane juice deterioration.

Sugarcane (*Saccharum* spp.) deterioration occurs in sound, burned or frozen cane, but the process can be accelerated by the bruising, tearing, slicing or mashing engendered by all aspects of mechanical harvesting, and the delay between harvesting and milling. Sound, whole-stalk sugarcane may not show significant signs of deterioration for up to 6 days after cutting; cut-chopped sugarcane shows increases in gums and dextran after only 1 day and a decrease in juice purity 2 days after cutting (10). Cut-chopped sugarcane deteriorates more rapidly than whole-stalk cane due to the greater ratio of cut surfaces to cane volume in the presence of the bacterium, *Leuconostoc mesenteroides* (Clsenkowsky) van Tieghem (6, 9). The bacteria infect the cane pieces at cutting, and dextran is produced at the expense of sucrose. Dextran affects the analytical tests for sucrose and purity, the shape of the sucrose crystal, the exhaustibility of massecuites and final molasses, and more importantly, the factory yield of sucrose.

In Louisiana, the single-row, whole-stalk harvester harvests most of the cane by cutting the cane stalk at the ground level and removing the immature tops and piling the stalks on the heap row. Normally, there is a miminum of damage to the stalks by this type of harvester; however, when beginning in a new field or block of cane, or when making a 6-row heap row, the rear wheel of the harvester passes over the first row harvested. The damage done by the harvester would presumably allow the bacteria easy entrance, and the dextran level would rise, especially if milling is delayed after cutting.

The objective of this study was to examine the effect of wheel damage and delay in milling after harvest on the deterioration of cane, including the effect on the concentration of dextran in the juice.

MATERIALS and METHODS

On November 23, 1982, a single row, approximately 110 m long, of the sugarcane variety CP 65-357 in the first ratoon crop was cut and topped by a conventional whole-stalk harvester at Houma, Louisiana. One-half of the heap-row was then mashed by a single pass of one front and one rear wheel of a rubber-tired farm tractor weighing about 3700 kg to simulate the damage incurred by the harvester. The remainder of the heap-row was not mashed and used as control. Duplicate samples of 10 stalks or equivalent from both mashed (damaged) and unmashed (control) cane were crushed once through a 3-roller mill at 0, 3, 7, 10, 14 and 17 days after cutting. In the damaged cane many of the stalks were broken, and a sample equivalent to 10 stalks was taken. The juice analyses were made in the usual manner: Brix by refTactometer apparent sucrose by polarization and apparent purity as the ratio of apparent sucrose to Brix (14). The yield of theoretical recoverable sugar per ton of cane (sugar yield) was calculated from these data according to the formula outlined by Legendre and Henderson (13), and dextran was estimated by the method described by Roberts (15) from subsamples delivered to Sugar Processing Research, Inc., New Orleans, Louisiana.

All tests of significance were determined by t-test (5). Regression equations were calculated for sucrose content, purity, sugar yield and dextran content in both damaged and control cane. The significance of the difference between any two regression coefficients was also determined by simple t-test.

RESULTS and DISCUSSION

The results for sucrose content, apparent purity and the yield of theoretical recoverable sugar per ton of cane (sugar yield) showed no difference between mashed (damaged) and unmashed (control) cane as an average of all sampling dates (Table 1). A comparison of regression equations indicated that the differences for these parameters between the damaged and control cane from 0 to 17 days between harvest and milling were small (Table 2). Intercept, slope and correlation coefficients were similar in both damaged and control cane for each parameter; the negative correlation coefficients indicates that, with delay in milling after cutting, there is a decrease in sucrose content, apparent purity and sugar yield, regardless of the condition of the cane. Undoubtedly, the cool mean daily temperature of 18°C and the excessive rainfall (23.95 cm) during the sampling period (November 23 to December 10, 1982) reduced the rate of deterioration. These data support the earlier findings that sucrose content, apparent purity and sugar yield are inadequate measures of cane deterioration (7, 9).

In this study, the only parameter that showed significant differences between damaged and control cane was dextran content (Table 1). According to Clarke, et al (2), dextran production increases with wetness and warmth, the optimal temperature for Leuconostoc growth being 18 to 32°C. Though the mean daily low temperature was 15°C, the mean high temperature was 22°C. A significant difference between regression coefficients suggests that dextran increased at a significantly higher rate in damaged cane than in control cane (Table 2). Figure 1 shows that by day 17, the dextran concentration of juice from damaged cane was three times the concentration found in control cane. Dextran is dextro-rotary (1), having a specific rotation of at least three times that of sucrose. The results suggest that sucrose content, apparent purity and sugar yield were not adversely affected by the wheel damage; however, cane juice containing dextran is subject to "false pol" (8). The increase in dextran found in damaged cane, undoubtedly contributed to an increase in polarization, thus causing all values to be exaggerated.

Table 1. Crusher juice analyses of unmashed (control) and mashed (damaged) sugarcane taken at 6 dates after cutting.

Treatment	Interval between harvest and milling (days)	Crusher juice analyses: Sucrose content (%)	Apparent purity (%)	Sugar yield per ton (kg)	Dextran (ppm)
Control	0	18.04	89.84	134.1	-
Damaged		17.55	88.50	129.5	-
Control	3	19.01	89.12	140.7	337
Damaged		19.22	90.11	143.1	811
Control	7	18.70	87.69	137.4	556
Damaged		18.28	89.28	135.5	838[1]
Control	10	18.67	92.98	140.9	474
Damaged		17.82[1]	92.43	134.2	1641
Control	14	18.19	86.71	112.8	796
Damaged		18.03	89.57[1]	133.9	2214
Control	17	17.00	83.46	121.7	863
Damaged		17.30	87.24[1]	126.7[1]	2478
Control	Average of all days	18.26	88.30	134.6	660
Damaged		18.09	89.52	133.8	1596[1]

- Indicates significant difference from the control, P = 0.05, using t-test.

Table 2. Regression coefficients for sucrose content, apparent purity, sugar yield and dextran content vs. time after cutting in unmashed (control) and mashed (damaged) sugarcane.

Treatment	Intercept a	Slope b	Coefficient correlation r
		Sucrose content (%) vs. time (days)	
Control	19.88	- 0.07	- 0.61[1/]
Damaged	18.47	- 0.05	- 0.47
		Apparent purity (%) vs. time (days)	
Control	90.90	- 0.30	- 0.58[1/]
Damaged	89.97	- 0.05	- 0.18
		Sugar yield (kg/mt) vs. time (days)	
Control	141.06	- 0.75	- 0.65[1/]
Damaged	137.43	- 0.42	- 0.46
		Dextran content (ppm on juice) vs. time (days)	
Control	282.82	36.97	0.96[2/]
Damaged	232.90	133.68	0.97[2/]

1/ Significant at P 0.05.

2/ Significant at P 0.01.

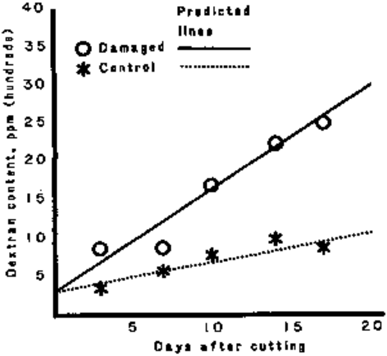

Figure 1. Changes in dextran content in damaged and control sugarcane. Dextran ppm on juice.

Tilbury (16) reported that a marked Increase in C-axis crystal elongation occurred in massecuites containing dextran at from 4000 to 27000 ppm on Brix. Further, Coll et al (3), showed that dextran content increased progressively from dilute juice to final molasses. From the results of the present study, it is reasonable to assume that problems would have occurred in processing shortly after harvest for damaged cane and by the 14th day for control cane.

In conclusion, these data suggest that for mature cane, whether damaged or not, cut late in the season when the ambient temperatures are cooler, the rate and extent of deterioration as measured by changes in sucrose content, apparent purity and/or sugar yield can be deceiving. Deterioration may be masked by the presence of dextran which can cause an abnormal increase in polarization. Unless dextran is measured under these circumstances, serious deterioration could go undetected.

ACKNOWLEDGEMENTS

Appreciation is extended to Dr. W. S. C. Tsang and Dr. Margaret A. Clarke, Managing Director, Sugar Processing Research, Inc., for analyses of cane juice samples for dextran and for their helpful

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EXPERIMENTAL VERIFICATION OF A DYNAMIC MODEL OF A VACUUM PAN

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ABSTRACT

A dynamic model of sugar crystallization in a vacuum pan has been developed. The model is simulated on a digital computer to predict the conditions at any time in the pan from a set of initial conditions. The results of the model are compared with experimental data taken during a test run on an Audubon Sugar Insititute vacuum pan.

INTRODUCTION

As is well known, the crystallization step is the most important and complex in the sugar production process and has a strong influence on the quality of the final product. Much effort has been devoted to the development of automatic control systems for the vacuum pan by various investigators throughout the world. However, because the relationships involved in the process are complex, the control and operating techniques currently used are the end result of a considerable body of experience in pan design and operation rather than the direct application of knowledge of the process dynamic behavior. These techniques are not necessarily the best which could be used. For the purpose of finding the best controls it is necessary to develop a dynamic model for a given pan.

In this paper, the dynamic model of a vacuum pan is developed and verified by experiments on the pan. This verified model provides the basis for simulating a vacuum pan and studying various control schemes.

Crystallization stage - The aim of vacuum pan operation is essentially to produce sugar crystals of a given size in a reasonable time, minimizing the formation of fine grain through nucleation.

The crystallization of sugar is carried out by boiling a sugar liquor in a vacuum pan in a discontinuous manner (batch process) Figure 1. A certain amount of sugar liquor is introduced in the pai and its concentration is increased by evaporation of water. The sucrose crystallizes from the supersaturated solution. Steam condensing inside a calandria provides the energy of evaporation and the vapor from the pan is condensed by direct contact with cooling water in a barometric condenser, which also provides the vacuum. The vacuum pan at LSU's Audubon Sugar Institute (ASI) is provided with a motor-driven circulator to improve mixing and achieve greater uniformity of the crystallizing mass.

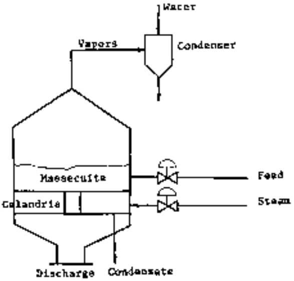

Figure 1. Sketch of vacuum pan.

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The contents of the pan consist of water, dissolved impurity, dissolved sucrose, and crystals, which is called the massecuite. The mother liquid composition can be characterized by the Brix B and purity P .

$$B = \frac{\text{mass of total dissolved solids}}{\text{mass of solution}} = \frac{S+I}{S+I+W} \quad (1)$$

$$P_u = \frac{\text{mass of dissolved sucrose}}{\text{mass of total dissolved solids}} = \frac{S}{S+I} \quad (2)$$

Dynamic model equations - To establish the dynamic model it is necessary to know the main mathematical relations which govern the process. They are derived from some basic relations or laws describing the physical phenomena in the pan. The models include the conservation laws - material and energy balances - and the crystal growth rate as a function of supersaturation.

All the models are derived under the following assumptions: a) a well mixed vacuum pan; b) negligible heat losses; c) no false grain and conglomeration produced.

1. Material balances.

Total mass balance:

$$M = I + W + S + C \quad (3)$$

Dissolved sucrose balance in mother liquor:

$$\frac{dS}{dt} = FB_f P_f - \frac{dC}{dt} \quad (4)$$

Dissolved impurity balance in mother liquor:

$$\frac{dI}{dt} = FB_f(1-P_f) \quad (5)$$

Water balance in mother liquor:

$$\frac{dW}{dt} = F\,(1-B_f) - E \quad (6)$$

Thieme (5) found from measurements of hundreds of crystals that the relationship of crystal volume to side dimension was 0.66 L , 0.67 L , 0.78 L-* for the three most frequently occurring types of cane sugar crystals (Figure 2). The average of these may be used for approximating calculations of crystal volume in the form of:

$$V = 0.7\,L^3 \quad (7)$$

The mass of crystal:

$$C = \rho \cdot N_c \cdot V \quad (8)$$

The rate of transfer of sucrose from syrup to crystal

$$\frac{dC}{dt} = \rho \cdot N_c \cdot \frac{dV}{dt} = \rho \cdot N_c \cdot \frac{d}{dt}\,(0.7 \cdot L^3)$$

$$= 2.1 \cdot \rho \cdot N_c \cdot L^2\,\frac{dL}{dt} \quad (9)$$

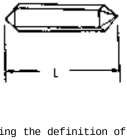


Figure 2. Sketch of sucrose crystal showing the definition of crystal size.

2. Energy balances:

$$\frac{d}{dt} E_M = FC_{pf}T_f + Q - E\Delta H_w \tag{10}$$

$$E_M = (WC_{pw} + SC_{ps} + IC_{pI} + CC_{pc})\,T \tag{11}$$

3. Enthalpy balances on calandria:

$$C_M \cdot \frac{dT_{cs}}{dt} = F_s\,(H_{ss} - H_c) - Q \tag{12}$$

$$Q = UA\,(T_{cs} - T)/60 \tag{13}$$

$$H_c = (T_{cs} - 32) \cdot 1.0 \tag{14}$$

4. Equilibrium phase relationships:

The pure sucrose solubility (2) is:

$$SAT = 63.819 - 5.108 \times 10^{-3}\,T + 7.836 \times 10^{-4}\,T^2 - 1.5492 \times 10^{-6}\,T^3 \tag{15}$$

Solubility coefficient of the solution (3) is:

$$SC = 1 - \left(b_o + \frac{(T-b_1)}{b_2}\right)\frac{I}{W} \tag{16}$$

$b_1 = 140$ F $\qquad b_2 = 360.0$ F $\qquad b_o = 0.10$ (for cane sugar)

The calculation of the supersaturation in impure solution is based on the ICUMSA definition of supersaturation for solutions crystallizing at constant impurity-to-water (I/W) ratio.

$$SS = \frac{(100-SAT)}{SAT} \cdot \frac{S}{W} \cdot \frac{1}{SC} \tag{17}$$

$$OS = SS - 1.0 \tag{18}$$

5. Crystal growth rate expressions.

The growth rate expression chosen by Wright and White (7) is a simplification of the growth expression derived by Sillin (4):

$$\frac{dL}{dt} = p_1\,(OS - p_2)\,\exp\left[\frac{-E_{act}}{R}\left(\frac{1.8}{T+459.69} - \frac{1}{333.16}\right)\right]\exp\left(p_3\,\frac{I}{W}\right) \tag{19}$$

In the above expression, the activation energy selected derives from laboratory tests on cane sugar massecuites (4). This value controls the variation of growth rate with temperature.

$$E_{act} = 11.0 - 0.02\,\frac{(T-140)}{1.8} + 8.0\,\frac{I}{W} \text{ kcal/gmol.} \tag{20}$$

where p_1-p_3 are parameters that must be determined experimentally for the ASI pan.

6. Model parameters and physical properties:

Density of the massecuite:

$$D_M = M/\left(\frac{C}{D_c} + \frac{S}{D_s} + \frac{I}{D_i} + \frac{W}{D_w}\right) \tag{21}$$

Boiling point rise:

The proportional relationship of elevation of boiling point to the solids/water ratio is somewhat dependent on the amount and type of impurity. A typical relation derived by Wright and White (6) is from data on cane sugar production (3).

$$BPR = [b_3 (\frac{S+I}{W}) + b_4 (\frac{I}{S+I})] \ 1.8 \tag{22}$$

where $b_3 = 2.20$ $\quad b_4 = 1.10$

Pressure in pan:

$$P = P' + 1/2 \ h \cdot D_m \tag{23}$$

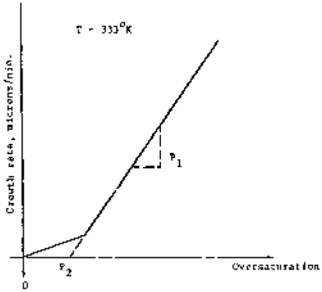
Where P is **the** absolute pressure in the middle of the boiling massecuite and P' is the absolute pressure above the boiling massecuite.

Temperature in massecuite:

$$T = SATURT(P) + BPR \tag{24}$$

Model parameters determination and model validating - Parameters Pi-P-3 in the growth rate equation are undetermined. These are: a) the proportionality constant in the linear growth expression p1 at 60° C (140 °F); b) the null oversaturation value above which the linear growth rate-oversaturation relationship appears (P2); c) the parameter determining the retardation effect of impurities on the growth rate (p3).

They have to be determined to meet the pan and material to be used. (A diagram illustrating the definition of parameters p1, and p2 is given in Figure 3.



$$\frac{dL}{dt} = P_1 \ (OS - P_2) \ e^{-\frac{E}{R} (\frac{1}{T} - \frac{1}{333})} \ e^{\frac{P_3 I}{W}}$$

Figure 3. Relationship between growth rate and oversaturation at 333°K (140°F).

The ASI experimental pan was available for model-parameter determination and model validation. To do this, a set of data was measured and recorded periodically to describe the conditions in the pan during the strike. The initial conditions were also recorded at the beginning of the experiment. A series of simulation runs was made from the initial conditions using the mathematical model in which the model parameters were systematically varied. The calculated conditions were then compared with the data recorded from the real process. In this manner we determined a set of parameter values which resulted in the smallest difference between the calculated and measured values.

The ASI pan is equipped with several instruments for the on-line measurement of temperature, absolute pressure, level in the pan, and level in the syrup tank. The Brix of the mother liquor, apparent purity (A.P.) of mother liquor and crystal size were measured off line. Supersaturation was determined from the temperature, absolute pressure, and A.P. of the mother liquor. The mass of the massecuite was determined from the level in the pan, and the cummulative mass of syrup fed was determined from the level in the syrup tank.

The experiments are for A strike using magma. The syrup used was 61 Brix and 85 A.P. The batch begins when the footing, which is a mixture of sucrose, impurities, water and crystals to be grown is sucked into the pan and covers the calandria. Steam is admitted to the calandria and water is allowed to boil off until the supersaturation is high enough to provide the driving force for crystal growth and is below the value at which false grain appears. Syrup is added during the strike; when the pan becomes full, the feeding is stopped and a cut is taken by removing most of the massecuite. The remaining massecuite in the pan becomes the new footing. Boiling and feeding is restarted and continued until the pan is full again, at which point the feeding is stopped. Growth continues, and the crystal content increases. After a final tightening period, the pan contents are removed.

Because the calandria of the ASI pan is special, it was found that the circulation in the pan is so good that the temperature difference between the top of the massecuite and the bottom of the massecuite is small. Because of this, equations 23 and 24 were modified as follows:

$$P = P' + (1/2\ h \cdot D_m) \times 0.1$$

$$T = SATURT(P) + BPR + 3.$$

These equations would only apply to the ASI pan.

Comparison of model prediction and experimental results - The parameters which minimize the error between the calculated conditions and the experimental data are as follow:

$$p_1 = 100. \qquad \text{microns/(min. - }^oSS)$$

$$p_2 = 0.005. \qquad ^oSS$$

$$p_3 = -2.45$$

The results of the selected parameter values are shown in Figure 4 in which the pertinent process variables are plotted against time. These graphs show how the model prediction using these parameter values fitted the data recorded from the real process.

DISCUSSION

In the computer simulation of the pan, the process variables are more constant than on the real pan because the supersaturation and crystal content can be precisely controlled at their set points. Such precise control is not possible on the real pan.

The effect of supersaturation and purity on the growth rate is shown in Figure 4. The curve for the crystal size (L) is almost a straight line while the supersaturation (SS) is almost constant. The discontinuity in all the curves marks the point at which the cut was taken.

As the grain grows in size, the surface area upon which the crystal can grow gets larger. This should increase the crystal growth rate and allow higher boiling and feed rates. However, as shown in Figure 4, the drop in purity causes the crystal growth rate to slow down so that the feed rate after the cut is lower than before the cut.

Of the parameters of the crystal growth rate model, the value of parameter p_2 is too small to have an effect at the conditions of our experiments. The value of 100 microns/(min - °SS) for parameter p_1 is not too far from the value of 123 reported by Wright and White (6). The value of -2.45 for parameter p_3 is also close to the value of -1.75 reported by Wright and White; however, since all of our experiments were conducted with high-purity A-strike syrup, it is difficult to establish confidence on the value of p_3, which is the parameter that controls the retardation effect of impurities on the crystal growth rate.

CONCLUSION

It is evident that the model results using the parameter values given above match those observed in the actual pan reasonably well. Thus the validated model may be used for the evaluation of various pan control systems through computer simulation.

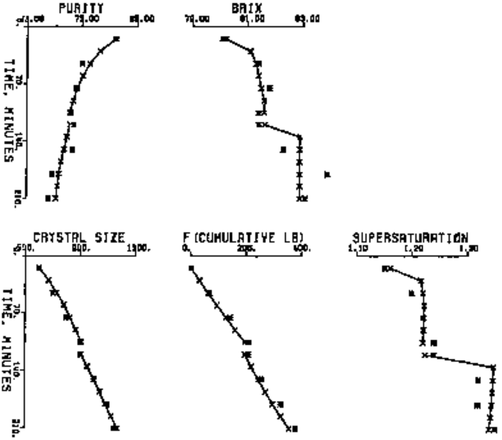


Figure 4. Model prediction and data points from test

X Data points from test

X Model prediction

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NOMENCLATURE

A	heat transfer area of the calandria, ft
B_f	mass fraction solids of feed syrup
BPR	boiling point rise, °F
C	mass of sucrose crystals in the pan, Lb
C_m	heat capacity of the calandria, Btu/°F
C_{pf}, C_{pw}, C_{ps}, C_{pi}, C_{pc}	heat capacity of feed, water, sucrose, impurity, and crystals, Btu/Lb. °F

D_m, D_{cr}, D_s, D_{I}, D_w	density of massecuite, crystal, sucrose, impurity, and water, Lb/cu. in.
E	evaporation rate of water from the pan, Lb/min
E_{act}	energy of activation of the crystallization reaction, kcal/gmol
$\hat{E}_M$	thermal energy of massecuite, Btu
F	feed rate of syrup to the pan, Lb/min
F_s	steam flow, Lb/min
h	level of massecuite, in
H_c	enthalpy of the condensate leaving the calandria, Btu/Lb
H_{se}	enthalpy of steam, Btu/Lb
I	mass of impurity components in the pan, Lb
L	diameter of the crystal, micron
M	total mass in the pan, Lb
N_c	Number of crystals in the pan
OS	oversaturation coefficient of the solution
P'	the absolute pressure over the boiling massecuite, psi
P	the absolute pressure in the middle of the boiling massecuite,
P_f	purity of feed syrup (fraction)
R	gas constant, kcal/gmol K
S	mass of soluble sucrose in the pan, Lb
SAT	solubility of pure sucrose (percent by weight)
SATURT(P)	temperature of saturated vapor at pressure P, °F
SC	solubility coefficient of the solution
SS	supersaturation coefficient of the solution
T	temperature of massecuite, F
T_{cs}	temperature of saturated vapor in the calandria, °F
T_f	temperature of feed, °F
U	heat transfer coefficient, Btu/ft °F • hr
V	crystal volume, micron
W	mass of water in pan, Lb
ΔH_w	heat of vaporization of water in pan, Btu/Lb
ρ	density of sucrose crystals, Lb/micron

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IMPACT FRACTURE PROPERTIES OF CANE VARIETIES

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INTRODUCTION

The process of harvesting and milling cane requires that the cane stalks are fractured in specific ways, e.g. a clean cut is required for harvesting while complete fiber disruption is needed for milling.

The development of cane varieties during the last 25 years has produced types which although high in sucrose exhibit characteristics which are not acceptable, e.g. they have caused choking in the tandem.

This paper presents results obtained from a series of mechanical fracture tests carried out on five varieties of cane, some commercial, some research types.

The results obtained are reasonably consistent with milling characteristics for particular varieties and indicate that the techniques used do provide a reasonable method of assessing their milling capabilities.

<u>Stress-strain properties of materials</u> - Any material such as a cane stalk passing through a set of knives is subject to a set of internal forces and deformations known as stresses and strains. The properties of materials under the action of these stresses and strains are important engineering considerations since they determine the design and use of the materials and will also play an important role in the design of cutting systems.

The stress applied to any material is defined as the force per unit area applied to the specimen

$$S = P/_{Ao} \text{ lb. in}^{-2}$$

The strain produced is defined as the change in shape measured as a function of the unstressed shape. For a specimen which is under tension, i.e. being pulled apart, the strain can be written as

$= l/_{Lo}$ where l is the increase in length for a known stress S.

The relationship between the strain produced by a known applied stress will be a function of the intrinsic properties of the material and a typical stress-strain curve is shown in Figure 1.

a. PROPORTIONAL LIMIT c. UPPER YIELD POINT
b. ELASTIC LIMIT d. LOWER YIELD POINT

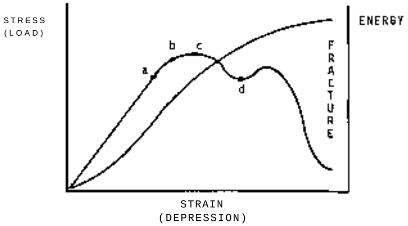

Figure 1. Typical stress strain curve for sugarcane in bending.

For the majority of materials the initial portion of the curve is linear and under these conditions the slope of the curve is defined as Youngs Modulus, i.e.

$$\text{Youngs Modulus } E = \frac{\text{Stress}}{\text{Strain}} = \frac{P}{Ao}\frac{Lo}{l} \text{ lb. in}^{-2}$$

The linear portion of this curve is known as the elastic region and that beyond the elastic region is known as the plastic zone.

The properties which can be determined from such a set of curves are:

1. Youngs Modulus
2. Toughness
3. Modulus of Rupture
4. Energy of Rupture
5. Energy of Fracture

The toughness is the ability to absorb high strain energy in the plastic range and is measured *i* the amount of energy absorbed per unit volume in stressing to fracture.

The modulus of rupture is measured by the stress required to the point of failure, under these conditions it is calculated using the maximum stress obtained (upper yield point).

The energy at rupture and at fracture can be obtained directly from the energy-strain curve.

Experimental techniques - Various authors, Chang (1), Cochran (2), Fanguy (3), Martin and Cochran (4), and Skinner (5) have studied the mechanical properties of cane under different conditions and using different techniques. In general the methods used have been static systems where the strain has been applied to the cane very slowly, e.g. 4 feet per minute. In the present experiments however an attempt was made to simulate the effect of the rupturing of cane in knives or shredder and this was accomplished by using impact testing methods.

Figure 2 shows a schematic diagram while Figures 3 and 4 show pictures of the system where the cane is supported on two anvils a distance of 3 inches apart. The hammer which is located midway between the anvils moves vertically downward at a speed of 2 1/2 ft./sec. striking the cane stalk. The anvil continues to move at the same speed until the cane is fractured. During the fracture process, continuous measurements of depression of the hammer, load applied and total energy are recorded and plotted automatically. Figure 5 shows a typical set of curves obtained by this system.

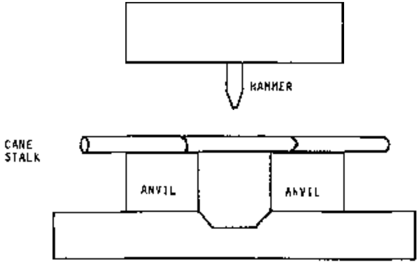

Figure 2. Schematic diagram of bending equipment.

Figure 3. Cane stalk resting on anvils before fracture.

Figure 4. Cane stalk resting on anvils after fracture

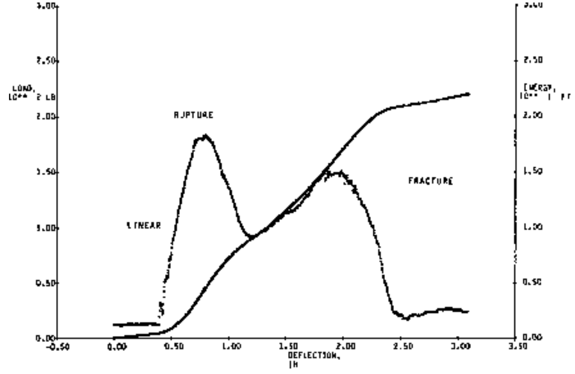

Figure 5. Typical load depression curve for sugarcane.

Analysis of experimental data - Nine samples of each of the five cane varieties were tested and the load vs depression and energy vs depression curves analyzed to determine the structural properties of each stalk.

The Modulus of Rupture can be calculated from the equation

$$M.O.R = \frac{Pl}{r^3} \quad \text{where} \quad \begin{array}{l} P = \text{maximum load} \\ l = \text{span} \\ r = \text{radius} \end{array}$$

Similarly Youngs Modulus or the stiffness can be expressed as

$$E = k_b \frac{Pl^3}{dI}$$

$$= \frac{l^3}{12 r^4} \quad \frac{P}{d} \qquad \text{where } d = \text{depression at load } P.$$

The toughness of the specimen which is the ability to absorb high strain energy in the plastic or non-linear region is defined as

$$T = \frac{2\ Pd}{3Al} \qquad \text{where } A = \text{Cross sectional area.}$$

One further parameter which has been determined is the energy to complete fracture. This is obtained from the data as a value of energy, but has to be normalized to take into account the difference in the radii of the stalks. Thus the fracture energy is defined as

$$E_F = E_{T/A} \text{ where } E_T = \text{total energy to fracture and } E_F \text{ is fracture energy.}$$

Table 1 shows the values of Youngs Modulus and Modulus of Rupture for the cane varieties while Table 2 shows the values of toughness and fracture energy.

From Table 2 it is clear that the high fiber cane variety L 79-1003 has much greater values of Young's Modulus and Modulus of Rupture as would be expected. The only other variety which exhibits similar values is CP 65-357.

Table 1. Values of Youngs Modulus and Modulus of rupturfi for selected cane varieties.

Cane variety	Youngs Modulus P.S.I.	Modulus of Rupture P.S.I.
CP 65-357	11057	1882
NCo 310	8469	1566
L 60-25	9252	1767
CP 70-321	8643	1739
L 79-1003	15332	2388

Table 2. Values of: toughnejs and fracture energy for selected cane variellies.

Cane variety	Toughness in lb./cu. in.	Energy of fi in lb./sq. in.
CP 65-357	43.9	31.6
NCo 310	50.2	29.7
L 60-25	38.1	32.9
CP 70-321	59.4	28.5
L 79-1003	58.2	40.6

CP 65-357 is the standard variety in Louisiana and is known for its good milling properties and while it has a high Youngs Modulus, the other parameters do not differ significantly from poor milling varieties.

CONCLUSIONS

The limited analysis of mechanical properties has shown that there are significant differences in the values of Youngs Modulus for the cane varieties studied. These differences appear to be related to both fiber content and milling characteristics.

As exprected the high fiber cane L 79-1003 has much higher stiffness and modulus of rupture, while CP 65-357 has a higher Youngs Modulus than other normal varieties but in this case the difference is not related to fiber content.

Based on this survey further analysis should be carried out using higher velocity hammers on other varieties of cane. More detailed analysis of fracture energy should also be undertaken using the swinging pendulum technique and an analysis of the microscopic structure of the individual fibers in the different varieties should also be made.

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RAW SUGAR FACTORY ANALYTICAL CONTROL

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ABSTRACT

The importance of good analytical and weight data for raw sugar factory control is discussed in the light of data obtained in Louisiana over several seasons. More consistent procedures will produce benefits for individual mills and for the industry collectively. The limitations and inconsistencies of some analyses are outlined and suggestions made for improved practices.

INTRODUCTION

The purpose of this paper is to discuss certain aspects of process monitoring and control in the raw sugar factory. The ideal system is one in which the analyses and weights of all process streams, especially raw materials and final products, are known accurately. In reality we can only approach this ideal situation and the system used will reflect the individual character of the local industry or mill.

In Louisiana, for example, where the crop is short and intense, it may not be so easy to justify the cost of equipment for properly weighing juice, filter cake, etc. Under these circumstances, particular attention must be paid to those areas in which physical loss of sucrose occurs. The quality of the analytical data becomes very important and this is the main subject of this paper. Good factory housekeeping is assumed and also that the chemical loss of sucrose by conversion to polysaccharides or by inversion is minimal.

There is a growing need for more information on process control as non-traditional factors become more important, e.g., energy and changing product quality standards. Factors such as grain size, filterability and dextran content have an impact upon quality and must be measured, but are outside the scope of this paper.

Factory operating reports usually contain data showing the analyses of raw materials, intermediate materials and finished products. These analyses include the purity of the materials and the solids content expressed as Brix. The analytical data is only as good as the sample upon which it was determined and is dependent upon the care taken by the analyst and, in many cases, the method used for measurement (21). These aspects of process control are the main topic of this paper.

Critical control areas and operational targets - The assumption is made that the major losses in the factory are due to failure to recover the sucrose from the non-sugar streams leaving the factory, i.e., from the bagasse, filter cake and final molasses. Data from sugar mills in Louisiana confirm that the loss of sucrose by inversion, etc., is negligible compared with that not recovered. The other area in which the quality of the analytical data is critical is for cane in that the expected yield and throughput of the factory are based on analyses for fibre, sucrose and total solids. Bagasse analysis for sucrose content gives the mill extraction and for moisture is important for its combustion. Filter cake analysis for sucrose gives the losses in filter cake. Final molasses analyses should include sucrose, Brix, ash and reducing sugars, the latter two being useful since they can be used to estimate the level of exhaustion of the molasses. Without good weight data for each of the streams it is not possible to properly estimate the losses and the goal must be to minimize the sugar content of each of these streams, based on the analytical data of their composition. Losses in Louisiana mills for the period 1979 - 1983 are given in Table 1. The data in the table are from the mill reports, irrespective of the methods of analysis. As will be shown later in the paper, variations in the analytical procedures could significantly alter (increase) the reported losses.

Measurement of the mixed juice weight is necessary if the extraction by the mill and the performance of the boiling house are to be separated for reporting purposes. However, in Louisiana, this is rarely done satisfactorily and the mill extraction and boiling house figures are obtained indirectly (2). The core analysis technique separates the analysis of cane for payment purposes from factory operation. Cane washing makes difficult the estimation of cane throughput and improves the quality of material processed over that brought into the factory.

Given both the wide diversity of analytical procedures and equipment used in the factories, especially the number of mills, vacuum pans and crystallizers, it is very difficult to establish general targets for factory performance. Targets may be set which depend upon the composition or character of the material being processed and may not be equipment limited, e.g., final molasses purity, filter cake pol and purity changes at clarification or between first and last expressed juices. Other performance criteria will be determined to a significant extent by the process equipment available, e.g., mill extraction, evaporation and handling of heavy massecuites in the crystallizers and centrifugals. Some operational targets may be set by choice, e.g. purity drops at each stage of crystallization, limited by the constraints of incoming syrup purity and desired final molasses purity. Target losses for bagasse, filter cake and molasses are given in Table 1.

Table 1. Pol losses % pol in cane in Louisiana.

Year		Bagasse	Filter cake	Molasses
1979 -80		9.3 - 14.1	1.0 - 2.2	7.4 - 9.5
	Average	11.5	1.7	8.4
1981		8.2 - 12.3	1.1 - 1.9	6.9 - 8.3
	Average	10.0	1.5	7.7
1982	Range	9.7 - 14.5	1.1 - 2.1	6.6 - 7.5
	Average	10.9	1.5	7.2
1983		8.1 - 14.9	1.0 - 2.8	5.9 - 8.9
	Average	10.4	1.5	7.2
Target		5 - 6	0.5 - 1	5 - 6

Basis for analytical control - The basis for process control in the sugar factory is the determination of the quantity of sugar present in the various process streams and, with liquid samples, the measurement of total solids content, or Brix. The first use of a polariscope for sugar determination in the Western hemisphere was in Louisiana by Valcour Aime who also introduced the then new, now classical, method for sucrose analysis by Clerget (16). Although not originating in Louisiana, there was early recognition of the need for scientific equipment and control in the factory. Work by Guilford Spencer at Magnolia plantation led to the publication of his first handbook in 1889.

The measurement of sucrose by polarization remains standard although there are inherent errors in the method due to the presence of other optically active materials. Advantages of the measurement of sucrose as pol are the speed, simplicity and reproducibility, given consistent procedures, of the analysis. Alternatives in current use include sucrose by classical chemical methods (Layne and Eynon), sucrose by classical methods but with corrections for other hydrolysable sugars, e.g., maltose and kestose, and sucrose by instrumental analysis, e.g., gas and liquid chromatography (5,19). The differences between pol and true sucrose are small for high purity material but become very significant for low purity streams such as molasses and examples of this discrepancy are given in Table 2. Much of the variation in a number of cane quality, factory balance and performance values can be attributed to the inaccuracy of direct pol as a measurement of sucrose (20). Pol underestimates sucrose by a varying ratio not easily explained by varying extraction or geographical considerations, but dependent mainly on the glucose and fructose. Changes in polarization due to non-sucrose will change through the process and lead to significant errors in undetermined loss, the factor used to balance the mill report, which is largely determined by the inadequacy of the analytical procedures.

Table 2. Pol/sucrose ratios.

Source Year ±/	Material	Pol/sucrose Ratio	Standard Deviation	High	Low
SMRI (1981)	Juice	0.993	0.003	0.997	0.986
SMRI (1981)	Molasses	0.969	0.087	1.022	0.899
ASI (1981)	Molasses	0.820	0.037	0.914	0.732
ASI (1982)	Molasses	0.902	0.046	1.005	0.794
ASI (1983)	Molasses	0.913	0.033	0.989	0.855
ASI (1983)-/	Molasses	0.836	0.040	0.879	0.740

— SMRI - Sugar Milling Research Institute (South Africa).
ASI - Audubon Sugar Institute.

2/
— Pol at individual mill laboratories, sucrose at ASI.

Anomalous undetermined gains have been reported as a result of the underestimation of sucrose as pol and anomalous values for recoveries of impurities across a factory and explained in terms of inaccuracy of method and analytical error. Overall performance yardsticks that adjust for purity content or purity of incoming material are particularly affected by differences between pol and sucrose values. Values for undetermined loss based on sucrose are given in Table 3. Replacement of pol with chemical sucrose results in some cases in a decreased, even negative, undetermined loss, but replacement of pol by sucrose by gas chromatography increases the undetermined loss.

Table 3. Effect of analytical data on undetermined loss.

Source	% Undetermined OSS Pol	Sucrose
Jamaica (Caymanas) — 1945	0.90	0.12
Jamaica (Monymusk) — 1974	1.03	-0.29
SMRI (South Africa) 1981	1.60	2.03
Louisiana — 1983	1.33	0.00

-' Based on mixed juice (22).

2/ — Based only on the recalculation of the losses in molasses using the statistical correlations obtained at ASI.

In South Africa attempts have been made to locate the area(s) of undetermined loss. Losses in mixed juice to syrup have been accurately monitored (by gas chromatography) and accounted for more than half the total undetermined loss. However, during periods when the total loss was high, the loss in the mixed juice to syrup stage did not increase accordingly (23).

Additional variations in pol values are introduced in the method used for clarification, especially the quantity of lead subacetate used with low purity materials. Even the polarization of raw sugars in influenced by the basicity of the lead subacetate solution used (1). Introduction of non-toxic clarifying agents will lead to further uncertainty in pol values (6).

The direct measurement of total solidi. content by drying is too cumbersome for routine work and indirect measurements are used, based on either density by hydrometer or refractive index by refractometer. Both are calibrated for pure sucrose and suffer from increasing error with low purity material, especially those with high non-sugar content. Hydrometer (spindle) Brix measurements suffer significantly from problems with air bubbles and suspended solids and are no longer considered satisfactory by ICUMSA. Refractometer Brix is generally lower than hydrometer Brix but may be higher (8). RefTactometer Brix has been shown to be a satisfactory measure of dry solids in mixed juice (11). Other methods e.g. Karl-Fisher titration, gas chromatography, nuclear magnetic resonance and conductivity have been reviewed (13). Total solids content by refractometer is the recommended routine method for all liquid streams, even undiluted molasses. Filtration of samples to remove suspended solids is desirable since it results in a clearer line between the light and dark fields. If filter aid (Kieselguhr) is used in the filtration then it may be necessary to discard the first portion of the filtrate. Automatic digital refractometers which remove operator errors are preferred. Several statistical studies have been made of solids determination by refractometer (12).

Common practice is for Brix and pol data to be given to two decimal places. The accuracy of these measurements does not justify this practice and only one decimal place is appropriate. Many instruments with digital display only give readings to one decimal place.

Cane and bagasse analysis - Core sampling is the method used for incoming cane analysis at most mills in Louisiana. Although quite satisfactory prediction of sugar recovery by the mill is achieved, there are several problems with the procedure and these have been studied in some detail. A significant problem is the presence of field soil in the cane which is expressed with the juice. Loss of field soil ("fibre") from the press cake into the juice inflates the predicted sugar yield. Tests in Louisiana with field soil added to shredded cane resulted in lower pol extraction by the press and higher expressed juice purity (3). Another potential problem in Louisiana with this analysis is the determination of the moisture of the press cake on only a small fraction of the cake. Also, shortened press time (and lower pressure) result in lower extraction by the press and higher expressed juice Brix and pol than absolute juice Brix and pol, and therefore an overprediction of the sugar yield. Typical results of tests in Louisiana are given in Table 4. The purity did not change significantly. Similar conclusions have been reached in South Africa concerning the relationship between the ratio of the Brix of the absolute juice to that of the expressed juice and the fibre % cane, although doubts were expressed about the analytical procedures used (4). These relationships depend also upon the degree of preparation of the cane and the fibre content. There were also variations between different categories of cane in the relationships necessary to calculate pol and fibre % cane from the press juice and cake mass.

Table 4. Relationship between pol extraction and juice data.

Pol Extraction	Brix abs. j./ Brix exp. j.	Pol abs. j./ pol exp. j.	Purity exp. j.
10.4	0.903	0.902	91.8
21.0	0.907	0.906	91.8
31.3	0.914	0.914	91.7
42.2	0.922	0.920	91.8
51.1	0.928	0.925	91.9
56.7	0.931	0.929	91.9
62.9	0.940	0.939	91.8
67.1	0.947	0.947	91.7

Among other recommendations, ICUMSA has recommended further comparison of press and disintegrator methods in attempts to eliminate variations from effects of extraneous matter and cane variety (10).

The liquidation factor is the ratio of the actually recovered sugar (CRS) to the theoretically recoverable sugar (TRS), as predicted from the core analysis. The lower the liquidation factor, the greater the difference between actual and predicted recovery, and a statistical relationship between liquidation factor and reported losses may be expected. Correlation coefficients for liquidation factor vs. overall factory loss and major individual sources of loss are given for Louisiana in Table 5. There is no significant correlation in any case. This may be explained by incomplete weights for sugar produced and the shortcomings of the analytical and calculation procedures.

Table 5. Correlation between liquidation factor and losses.

Correlation between -	Adjusted correlation coefficient
Liquidation factor and total losses % cane	0.22
Liquidation factor and mill pol extraction	0.53
Liquidation factor and boiling house efficiency	0.13

The composition of the cane being ground is rarely determined directly in Louisiana but is calculated (2). During tests to measure cane preparation at several mills, the composition of prepared cane was measured and compared with the reported values for the cane ground at the time of the test and the results are given in Table 6. In almost all cases the actual fibre % cane was lower than reported and the pol % cane higher than reported. The impact of these differences upon the mill extraction are given in Table 7. In general, the mills were underestimating their extraction.

Cane washing makes difficult the correct estimation of the weights and composition of cane entering the mill. A measure of the effect of cane washing may be obtained from a comparison of the pol and fibre content of cored and washed (prepared) cane. These results were obtained in a comparative test of the milling qualities of two cane varieties, CP 65-357 and CP 70-321, for which the analytical data is given in Table 8. The pol % prepared cane is 91.0% of that for cored cane with CP 65-357 and 91.4% for CP 70-321. If the pol loss on washing (less than 1%) is neglected, then the pol decrease is accounted for by approximately 10% water being carried through with the cane (9.9% for CP 65-357 and 9.4% for CP 70-321). The fibre % prepared cane is 81.4% of that for cored cane with CP 65-357 and 83.5% for CP 70-321. This greater decrease than for pol may be accounted for by the removal of "fibre" (dirt and trash) at washing. The material removed by washing is 10.5% on cane (as delivered) for CP 65-357 and 8.7% for CP 70-321 in these tests.

Table 6. Cane analytical data.

Mill	Fibre % cane				Pol % cane			
	ASI Mean	S.D.	Mill Mean	S.D.	ASI Mean	S.D.	Mill Mean	S.D.
1	14.9	0.6	17.2	1.0	12.2	1.2	10.0	0.6
2	13.9	0.9	17.1	1.4	11.8	1.4	10.9	0.9
3	14.7	1.0	15.0	1/	12.1	1.0	11.3	0.6
4	15.4	1.0	16.1	1.0	11.8	0.9	12.3	0.6
5	14.1	0.9	14.9	0.1	12.3	0.3	11.2	0.5
6	14.1	1.1	12.7	2.0	11.2	1.1	11.1	0.3
7	12.5	1.4	10.9	2.2	11.4	1.4	11.5	0.4
Mean	14.2		14.8		11.8		11.2	

1/ Assumed to be 15.0%.

Table 7. Mill extraction data.

Mill	Pol % fibre in cane		Pol % fibre in bagasse 1/	Pol extraction 2/	
	ASI	Mill		ASI	Mill
1	82.3	58.7	6.9	91.5	88.2
2	85.8	64.4	6.2	92.8	90.4
3	82.0	75.2	7.0	91.5	90.7
4	73.6	76.6	8.3	88.7	89.2
5	87.7	74.8	7.1	91.9	90.5
6	80.1	89.5	8.2	89.8	90.8
7	91.5	112.2	7.0	92.3	93.7
Mean	83.3	78.8	7.2	91.4	90.9

1/ – Mill analytical data, used in both sets of calculations.

2/ - 100 (pol % fibre in cane - pol % fibre in bagasse)/(pol % fibre in cane.)

Table 8. Effect of cane washing on composition.

		CP 65-357	CP 70-321
Cored cane	% pol	13.4	11.6
	% fibre	18.2	17.0
Prepared cane	% pol	12.2	10.6
	% fibre	15.0	16.2

There is no standard method for the determination of pol % bagasse in Louisiana and the older procedure of digestion generally gives results 1 point lower than by total disintegration with a blender. The already serious problems of sampling are compounded in some cases by no or poor use of preservatives for composits and the selection of small bagasse particles for ease of analysis. Bagasse samples for several mills were separated into coarse and fine bagasse and each analyzed for pol using a Rietz disintegrator. The results are given in Table 9, and show clearly the problems of poor preparation and preferential subsampling. In Hawaii fibre figures by analysis were found to be 2.7 to 4.0% lower than by calculation, due to error in estimating refractometer solids content of the bagasses, the soil content of the bagasse and the "solubilized fibre loss" (9).

Filter cake analysis - Over the last few years the pol % filter cake for Louisiana mills has been reported to be in the range 4 - 5 % and the cake 3 - 4% on cane. In several cases the reported pol % filter cake was significantly lower than that determined by analysis of samples taken and analyzed immediately, e.g., report 3.5% pol and analysis of fresh sample, 8.4% pol. Compositing and storage of samples is unsatisfactory since deterioration occurs rapidly (17). Better data would be obtained if samples were analyzed immediately. This might hinder the number of analyses but would give more representative data.

Table 9. Variations in pol % bagasse.

Source of last mill bagasse	Difference in pol % bagasse between coarse and fine samples
Mill with knives and shredder - no very coarse bagasse	0.1% - not significant
Mill with two sets of knives (one new) - some coarse bagasse	1.5%
Mill with two sets of knives - much coarse bagasse	6.0%

A simple test to evaluate filter operation is to measure the Brix of the residual juice in the filter cake as it is discharged from the filter. The small quantities of juice obtained, by squeezing in a cloth or filter paper, necessitate the use of a refractometer for this measurement. If good washing of the filter is achieved then this Brix value should be near one tenth of that of the clarified juice. The filter wash index (ratio of mixed juice Brix to clarified juice Brix) is used in South Africa as a measure of filter operation. Applying this test to Louisiana (typical results are given in Table 10) gave no correlation (R = 0.02) between filter wash index and pol losses in filter cake. Reasons for this include evaporation and concentration of the juice at the flash tank and the use of hydrometers to determine the Brix of the mixed juice.

Table 10. Filter wash index and pol losses in filter cake.

Mill	Filter wash index 1/	Pol lost in filter cake % pol in cane 2/
1	99.9	1.53
2	101.4	1.18
3	94.2	1.48
4	96.8	2.11
5	96.1	1.67
6	103.1	1.66
7	103.5	1.11
8	99.6	1.01
9	99.5	0.99
10	96.4	2.02

1/ Brix of mixed juice/Brix of clarified juice.

2/ Taken from final reports for 1983 Louisiana crop.

Molasses analysis - The increased circulation of factory reports in Louisiana has resulted in considerable discussion and areas of much interest are the purity of final molasses and how certain mills could get the results presented in their reports. There are no standardized procedures for molasses analysis used across the state and variations in method could be a cause. Such variations in procedure could be in the degree of dilution (and the final multiplier used), whether spindles or refractometers are used for Brix measurements, quantities of lead subacetate used and whether manual or electronic polariscopes are used. To get an idea of the variation in results, two unidentified samples of final molasses (X and Y) were collected from two factories on the Teche and each analyzed at five factory laboratories and at ASI. Each laboratory ran the analyses in their usual way and the results are given in Table 11.

The results are consistent in that the same laboratory gave the highest results for both samples and another both lowest results. For sample X the standard deviation in Brix value was 1.1% of the mean and for sample Y, 1.4% of the mean. The difference between highest and lowest, 2.8 for sample X and 4.1 for sample Y. Three of the data points are close together, suggesting a best value for the Brix of the samples. As well as the use of both spindles and refractometers, differences may be due to varying procedures for dilution and how long insoluble sediment is allowed to settle before the measurement is taken with a hydrometer, or whether the solution is filtered for measurement with a refractometer. South Africa has reported persistent inter-laboratory differences in the Brix values of final molasses - as much as 2 units. Investigation showed the importance of the amount of filtrate that should be rejected and of the type of filter aid used. The moisture content of final molasses has been determined by gas chromatography (7,15).

Table 11. Final molasses analytical data.

Mill	Sample X			Sample Y		
	Brix	Pol	Purity	Brix	Pol	Purity
1	85.4	25.7	30.1	89.8	23.4	35.6
2	85.4	27.1	31.7	90.2	31.0	34.4
3	87.7	24.2	27.8	92.2	28.4	30.8
4	85.6	27.7	32.4	89.9	29.7	33.1
5	84.9	30.0	35.3	88.1	32.8	37.2
ASI	86.4	30.0	34.7	91.0	32.6	35.9
Mean	85.9	27.4	32.0	90.2	30.5	33.8
S.D.	0.9	2.1	2.6	1.3	1.8	2.3
S.D. (%)	1.1	7.7	8.0	1.4	6.0	6.7

The variations in pol measurements are much greater than for Brix, the standard deviation in pol values for X being 7.7% of the mean and for Y, 6.0% of the mean. The difference between highest and lowest is 5.8 for sample X and 4.4 for sample Y. A major source of differences in results could be the number of dilutions made to obtain the solution measured in the polariscope. It is difficult to read a manual polariscope to more than 0.15 and such a difference, when multiplied by 6.6 (necessary if 26.0 g of 1:1 dilution molasses is diluted into a 330 ml flask and read using a 200 mm tube), could give an error of 0.7 in the final result. These levels of dilution may be necessary when poor clarity and high color are obtained in the lead clarification, and could be minimized with good clarification. However, all the variations in pol shown in Table 11 can be accounted for in variation in the quantity of lead subacetate used and this is discussed in some detail later. The use of acetic acid to remove turbidity after lead subacetate clarification can significantly decrease the polariscope readings.

The variations in molasses purities are dominated by variations in the pol values. The standard deviation in pol value for molasses sample X is 8.0% of the mean and for Y is 6.7% of the mean. The difference between highest and lowest purity value is 7.5 for sample X and 6.5 for sample Y, and the value obtained at ASI is high, as has been found for past data.

The use of instruments which remove operator error, e.g. digital refractometers and polariscopes, is desirable, but it does not remove variations introduced in sample preparation. The major source of variation is in the quantity of lead subacetate used. This has been noted previously (14) but there is no prior data available from studies on Louisiana molasses. The X and Y samples of molasses were treated with varying amounts of dry lead subacetate and lead subacetate solution. The dilutions were so calculated that the molasses % pol would be read directly on the digital polariscope (Rudolph) set on 2X using a 200 mm tube. The details of procedure and results are given for both dry and wet lead subacetate in Tables 12 and 13. The laboratory procedure used is presented immediately following each table. A wide range of values were obtained which cover those obtained at the different laboratories. The pol values may be extrapolated to zero lead, which would be closer to the cases where more dilute solutions were used, thus requiring less lead subacetate for clarification. Previous results with a reagent based on aluminum always gave lower pol values than with lead subacetate (22). The effect of the increasing quantities of lead subacetate has been observed previously and may be explained by the preferential precipitation of levorotary fructose, leaving the dextrorotary sucrose and glucose in solution.

Table 12. Molasses clarification with increasing amounts of dry lead subacetate.

g Dry lead subacetate per 100 ml molasses solution	Pol readings	
	Sample X	Sample Y
3	28.1 1/	Turbid
5	28.9	33.4
10	32.8 2/	36.1 2/
15	35.9	38.6
20	37.1	39.3
25	36.9	38.6
30	36.2	37.5
35	35.3	36.2
40	34.4	35.2

1/ Instrument booster light on.

2/ Solutions with best clarity.

The laboratory procedure used to obtain the results presented above are as follows: 130.0 g of each molasses sample was diluted to 1.00 liters with distilled water and well mixed. 100 ml samples of this solution were treated with increasing amounts of dry lead subacetate (Fisher), stirred well and allowed to stand for 10 minutes before being filtered with filter aid (acid washed Kieselguhr) through prefolded filter paper (Schleicher and Schuell).

Table 13. Molasses clarification with increasing amounts of lead subacetate solution.

ml Lead subacetate solution per 50.0 ml dilute molasses solution	Pol readings Sample X	Pol readings Sample Y
3	Turbid	31.2 1/
5	28.8 1/	32.1
10	32.1	34.3 2/
15	35.6 2/	36.9
20	38.8	38.8
25	42.2 2/	39.1
30	40.0	39.2
35	39.5	38.9 2/
40	41.4 1/	38.5

1/ Instrument booster light on.

2/ Solutions with best clarity.

The laboratory procedure used to obtain the results presented above are as follows:

> 260.0 g of each molasses sample were diluted to 1.00 liter with distilled water and well mixed. 50.0 ml samples of the molasses solution were pipetted into 100.0 ml volumetric flasks. Increasing volumes of lead subacetate solution (54.3 Bx) were added, the flasks shaken well and the solution made up to the mark, a few drops of alcohol being used to remove foam at the surface of the liquid. After shaking and standing for 10 minutes the solutions were filtered using filter aid (acid washed Kieselguhr) through prefolded filter paper (Scheicher and Schuell).

For sample X the pol value extrapolated to zero lead is about 26 for both dry and wet lead, and for sample Y, about 30 with both reagents. The maximum value for X with dry lead was about 37 and, with wet lead, about 41, an anomalous result since the maximum for Y was about the same, 39, with both reagents. The experiment was repeated on three molasses samples from the 1983 survey, one with high molasses purity, one with low and the third in between. Similar results were obtained as for samples X and Y and these are given in Table 14, along with other analytical data from the survey. Again, a wide range of pol readings were obtained and, in each case, the true sucrose concentration, as determined by Layne and Eynon titration, lay in this range. The quantities of dry lead subacetate and of lead subacetate solution required to get this value were similar for the three samples, averaging 13 g of dry lead and 10 ml of solution. These quantities of reagent were tested on 15 different molasses from the October 31 and December 5 molasses survey samples to determine whether a pol value reasonably close to the sucrose concentration is feasible. It must be stressed that this is not a means of determining sucrose but of getting a value of apparent purity which is more useful for factory control purposes. Each test with dry and wet lead subacetate was performed in quadruplicate. Variations were 0.1 in pol value with dry lead subacetate and 0.4 with lead subacetate solution.

Neither case is very satisfactory but statistical analysis of the data show that these, especially the dry lead, give a better approximation to the true sucrose than either the factory reported pol or the method routinely used at ASI. The linear regression equations and correlation coefficients are given in Table 15. The worst case is for sucrose as estimated by the factory laboratories and the best case involves using a fairly large quantity (13 g) of dry lead subacetate. Pol determination on factory products may be a reasonable substitute for sucrose analysis but these results and those in South Africa support the view that "the pol of final molasses is practically meaningless" (20). If reproducible pol readings are to be achieved the quantity of lead in the clarification stage must be constant.

Other statistical correlations of molasses analytical data obtained at ASI are given in Tables 16 and 17. Such empirical correlation data are useful for estimation of, for example, true purity from apparent purity, and such calculations are in general not too far from the correct value but, on ocassion, can be very misleading. Table 16 lists the correlation equations for true and apparent purity and Table 17 the relationship between refractometer Brix and hydrometer Brix for final molasses (1:1 dilution in each case). There is considerable variation in the slopes of the lines, especially for the purity relationships, demonstrating the effect of changing (improving?) the sample preparation procedures over the period 1981-1983.

Table 14. Molasses analytical data using varying quantities of lead subacetate on factory molasses.

	Mill 1	Mill 2	Mill 3
ASI spindle bx	88.0	91.8	91.2
ASI refractometer bx	84.2	86.4	87.0
ASI pol	27.5	34.8	30.6
ASI apparent purity	31.3	37.9	33.6
ASI true sucrose (% molasses)	30.4	36.0	33.8
Mill spindle bx (after dilution for pumping and storage)	85.4	84.3	87.8
Mill pol	25.1	31.4	27.0
Mill apparent purity	29.4	37.3	30.8
Pol extrapolated to that with zero dry lead subacetate	23.2	30.2	26.3
Pol extrapolated to that with zero lead subacetate solution	22.3	30.4	25.1
Pol with 5 g dry lead	25.2	33.2	29.6
Pol with 5 ml lead subacetate solution	26.0	33.7	29.1
Maximum pol with dry lead subacetate	35.6	41.2	38.1
Maximum pol with lead subacetate solution	39.8	43.8	41.1
Wt (g) dry lead subacetate required for pol reading close to true sucrose	14	9	15
Vol (ml) lead subacetate solution required for pol reading close to true sucrose	9	8	12

Table 15. Correlation data for true sucrose and polarization.

True sucrose =	Adjusted correlation coefficient	Standard error of estimate
(1) 0.718 (mill pol) + 14.0	0.82	1.3
(2) 0.865 (ASI pol) + 7.6	0.91	1.0
(3) 0.946 (10 g dry lead) + 1.5 1/	0.94	1.0
(4) 0.808 (10 ml solution) + 7.7 2/	0.90	1.3

1/ Procedure as in Table 12.

2/ Procedure as in Table 13.

Table 16. Correlation between true and apparent purities (AP).

Year	True purity -	Adjusted correlation coefficient	Standard error of estimate
1980	0.682 (AP) + 20.6	0.91	1.2
1981	0.668 (AP) + 21.9	0.91	1.2
1982	0.730 (AP) + 18.1	0.87	1.1
1983	0.829 (AP) + 12.0	0.92	1.3

Table 17. Correlation between refractometer and spindle Brix.

Year	Refractometer Brix =	Adjusted correlation coefficient	Standard error ot estimate
1980	0.879 (sp. bx.) + 5.1	0.88	1.4
1981	0.823 (sp. bx.) + 10.7	0.82	1.4
1982	0.902 (sp. bx.) + 4.1	0.91	1.2
1983	0.930 (sp. bx.) + 1.0	0.91	1.1

SUMMARY

The data presented in this paper show clearly the need for consistent and reproducible inter-laboratory analytical procedures in the Louisiana sugar industry. A committee has been formed to recommend standard procedures for the analysis of bagasse, filter cake and molasses. The measurement of sucrose by polarization will form the basis of the methods and uniformity of sample preparation will be emphasized.

Developments in instrumentation, e.g., automatic refractometers and dark field polariscopes are being investigated for application to the Louisiana industry. Further developments should include rationalization of the number and types of analyses being performed (18).

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FACTORS AFFECTING MILL EXTRACTION

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BACKGROUND

The goal of all sugar factories is to maximize the sugar yield from the cane received. A look at the magnitude of the factory losses for Louisiana is shown below in Table 1:

Table 1. Sugar losses (Louisiana).

	Lbs, pol per ton cane	
Year	1969-70	1982-83
Cane	204	224
Sugar yield	160	181
Losses		
Bagasse	22.3	23.7
Final molasses	18.6	16.1
Filter cake	2.9	3.4

The first column is fairly typical of the conditions existing 15 years ago, while the second column is typical of present conditions. In spite of the richer cane being processed, final molasses losses have decreased due to higher purity juices and also to improved molasses exhaustion. Sugar losses in filter cake have fluctuated around 3 lbs pol/ton cane with a slight upward trend that parallels the increase in cane pol. In the last 15 years the bagasse losses have remained virtually unchanged, and are currently about 50% greater than those occurring in the final molasses.

Since the pol extractions in Louisiana are relatively low (averaging only 89.5% last year), there is clearly much scope for improving the quality of the mill work. With this in mind, several Brix curves were performed on mills last crop. Additionally, one complete mill test involving bagasse and juice analyses around each mill in the tandem were conducted. In analyzing the data several apparent anomalies were observed. It was therefore decided to investigate, from a theoretical standpoint, what were the important parameters that influence mill work.

One of the first people to analyze mill performance from a rigorous standpoint was Douwes Dekker (1) while working with the South African Milling Research Institute. Douwes Dekker discussed the operations involved in milling and presented suggestions for improving milling. He presented data and calculations to show that the efficiency of the mixing of remarceration juices with those in the bagasse mat was far from ideal. More recently, Riviere (2) in Mauritius has done similar work using Ponchon-Savarit diagrams and extended the analysis to include cane diffusers. Riviere reached similar conclusions to Douwes Dekker.

Using the techniques employed by Douwes Dekker and Riviere it is difficult to simulate a mill operation where remaceration juice streams are not returned in sequence (i.e. to the mill ahead), or where cush-cush is returned to various points in the milling tandem. As a result, we have therefore developed a computer model that can take these effects into accounts easily, while producing rigorous solutions rapidly.

MATHEMATICAL MODEL

Figure 1 shows the typical streams for one mill in a milling tandem. The feed consists of bagasse (or cane if this were a first mill), the return of cush-cush from any of the mills of the tandem, the return of remaceration mill juice from any mill in the tandem, and the possible application of water to the feed entering the mill. Leaving the mill is a juice stream, a bagasse stream, and a cush-cush stream.

Let us now consider a term "imbibition efficiency" as defined in Figure 1. The minimum juice Brix possible is the weighted average Brix of the liquid being applied to the mill (i.e. remaceration juices and/or water). The maximum juice Brix is the weighted average liquid phase Brix in the combined feed to the mill and consisting of bagasse, the cush-cush, the remaceration juices, and the water.

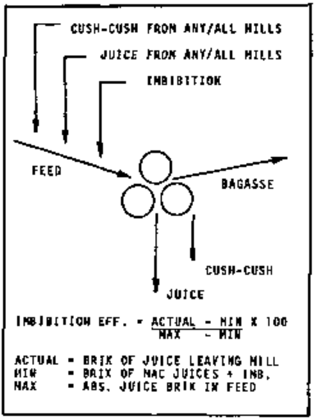


Figure 1. Mill Model.

If we assume the weight and composition of the feed, the cush-cush, the remaceration juices, and the water entering a mill, and also the quantity of fiber being dropped in the cush-cush, as well as the fiber % cush-cush, and also make assumptions concerning the imbibition efficiency and the fiber % bagasse leaving a mill, we can then calculate the weight and complete analysis of the juice leaving the mill, the cush-cush dropped by the mill, and the bagasse exiting the mill. Note that the assumption is made that the cush-cush leaving a mill contains juice having the same composition as that of the juice extracted.

In the method employed assumptions are made for each mill in the tandem, and then the input and output from each mill are calculated in turn. After one complete pass of these calculations, the entire set of calculations are repeated using the calculated values of the previous run as the starting assumptions for the second run. This iterative method can be repeated until a steady state solution is achieved.

BASE CASE ASSUMPTIONS

In order to completely solve the materials flow and analyses of each stream, several items of data (or assumptions) are required. Table 2 lists the assumptions required, together with the values used as the base case in all of the results.

Note that we could allow each mill in the tandem to have a different imbibition efficiency, a different cush-cush droppage, and a different cush-cush fiber content. However, our base case considers these to be the same for each mill.

Table 2. Base case assumptions.

Item	Base Case Value
Number of mills in tandem	5
Fiber % cane	14.0
Brix % cane	13.5
Imbibition % cane	25.0
Imbibition efficiency, %	60.0
Imbibition system	compound
Cush-cush droppage, (fiber % fiber in feed)	1.0
Cush-cush, % fiber	5.0
Point of cush-cush return	Mill no. 1
Fiber % bagasse leaving mill	
Mill no. 1	26.0
Mill no. 2	33.0
Mill no. 3	37.0
Mill no. 4	40.0
Mill no. 5	44.0

RESULTS

Based on the model described earlier and the base conditions given in Table 2, each of the individual variables were varied one at a time to show its effect. The results of this analysis are presented and discussed below.

Effect of fiber % cane - Figure 2 shows the cumulative Brix extraction for each mill in the tandem as the fiber % cane is varied over the range of 10 to 18%. For a cane having a fiber content of 10% the extraction is approximately 94.5. For the base case fiber content of 14%, the extraction predicted is 90, while for a cane having a fiber content of 18 the extraction would be approximately 84.6.

Effect of Brix % cane - In Figure 3, extraction is plotted as a function of the Brix % cane. This plot indicates that the Brix content of the cane does not affect the extraction.

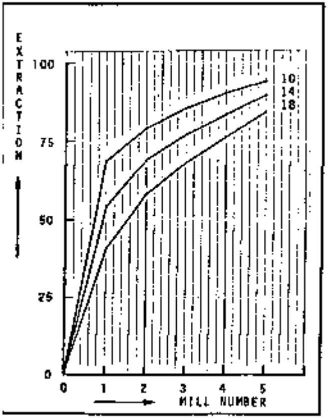
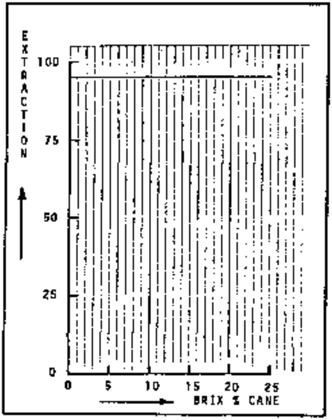


Figure 2. Extraction vs fiber % cane.



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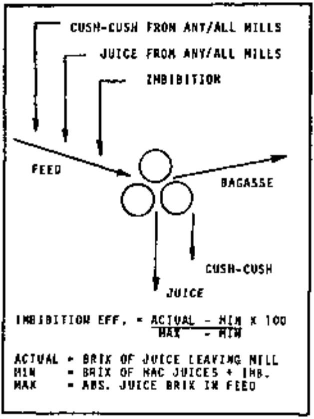

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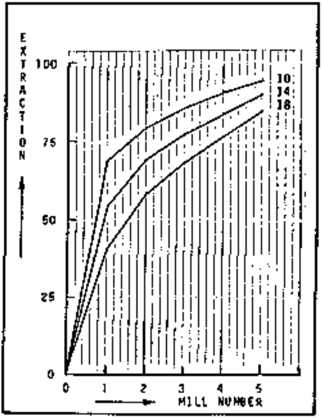

Figure 2. Extraction vs fiber % cane.

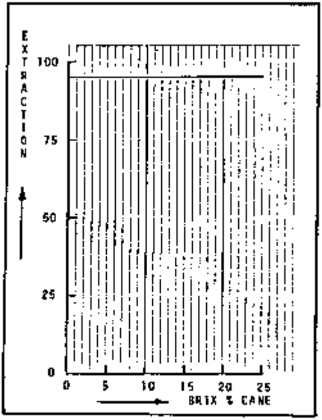

Figure 3. Extraction vs Brix % cane.

<u>Imbibition % cane</u> - In Figure 4 the extraction is plotted as a function of the imbibition % cane, with base case assumptions for all variables except for the imbibition % cane. For an imbibition % cane of 5% the predicted extraction is 81. For the base case condition with 25% imbibition, the extraction increases to 90, while for an imbibition % cane of 60% the extraction increases to 95. This plot does not take into account grinding rate, mill slippage, imbibition efficiency, etc., which could alter the results shown. Grinding rate influences mill performance, while high levels of imbibition in the absence of adequate mill feeding provisions can result in mill slippage. The model does not take these effects into consideration.

<u>Imbibition efficiency</u> - The effect that imbibition efficiency has on extraction is shown in Figure 5. For an imbibition efficiency of 40% at each mill, the predicted extraction is 85. At the base case condition with an imbibition efficiency of 60%, the extraction increases to 90. For an imbibition efficiency of 100%, the predicted extraction would increase to 96.

It is interesting to consider what the gain in extraction would be if the imbibition efficiency of an individual mill were increased. For the base case where all the mills have an imbibition efficiency of 60%, the predicted extraction is 90.03. If the imbibition efficiency of Mill No. 2 is increased to 80% (leaving the imbibition efficiency of the other mills at 60%), the extraction of the tandem increases to 91.08. On the other hand, if instead the imbibition efficiency of Mill No. 5 is increased to 80% (leaving the imbibition efficiency of all the other mills at 60%), the extraction predicted is 91.53. This indicates that an increase in the imbibition efficiency is more beneficial in the later mills in a tandem than it is at the earlier mills in the tandem. Obviously, imbibition efficiency is very important, and should be the subject of future investigation.

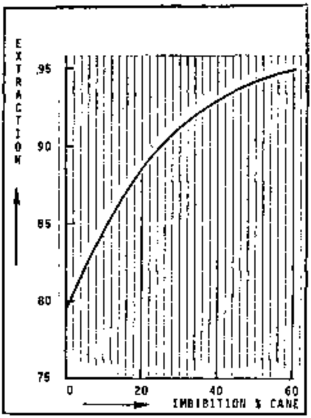

Figure 4. Extraction vs imbibition % cane.

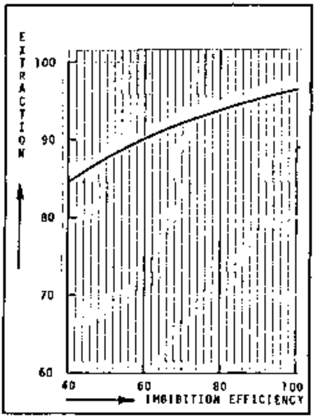

Figure 5. Extraction vs imbibition efficiency.

<u>Brix curve</u> - In Figure 6 the Brixes of the juice leaving a mill as a function of the imbibition % cane are plotted. For an imbibition % cane of zero (in other words "dry milling") the Brix of the juice leaving each mill is constant and equal to the Brix of the absolute juice, i.e. just under 16 Brix for all mills. On the other hand, if an imbibition % cane of 5% is applied, then the Brixes decline for each succeeding mill and drop to just over 7 Brix in the case of the last mill. If 25% imbibition on

cane is used, the Brixes drop more rapidly down to a value of about 3 Brix for the last mill. On the other hand, for the very high imbibition % cane value of 65%, the Brix of the last mill juice declines to a value of less than 1 Brix.

The curves for the low imbibition have a convex shape, while the one for 25% imbibition approaches a straight line, and the ones for very high levels of imbibition are concave in shape. Thus, from the shape of the Brix curve it is possible to get an idea of the imbibition level. Note that this is not a conventional Brix curve since it plots the Brix of the composite mill juice, rather than that of the front rolls or the back rolls.

Extraction versus number of mills - The influence that the number of mills has on extraction is presented in Figure 7. In the case of a tandem consisting of three mills, the expected extraction would be 83. For 5 mills the extraction increases to 90. While in the case of seven mills an extraction of 93 would be expected.

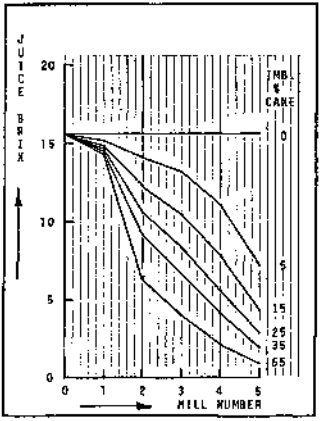

Figure 6. Brix curve.

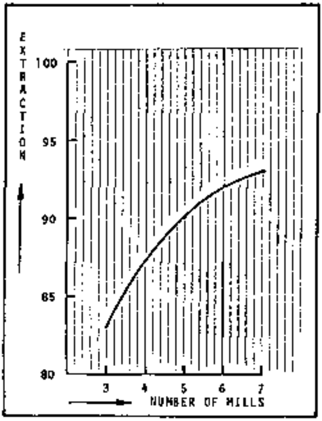

Figure 7. Extraction vs number of mills.

Effect of point of cush-cush return - In Figure 8 the effect of the point of cush-cush return on the extraction is plotted. The top horizontal line is for the case in which the cush-cush is returned to the preceding mill. This condition would apply to the case where chokeless pumps were used to transport both the remaceration juice and the cush-cush. In this case it will be noted that even for extremely large quantities of cush-cush droppage the extraction is basically constant at 90.2.

The middle line is for the case where the cush-cush from all mills are returned ahead of the first mill. In this case it will be noted that as the quantity of cush-cush dropped increases, the extraction drops. In the absence of cush-cush droppage, an extraction of 90.2 is achieved. For the base case where 1% of the fiber in the feed to the mill is dropped, the extraction drops very slightly to 90. For extremely high droppages such as 5%, the extractions decline to 87.7.

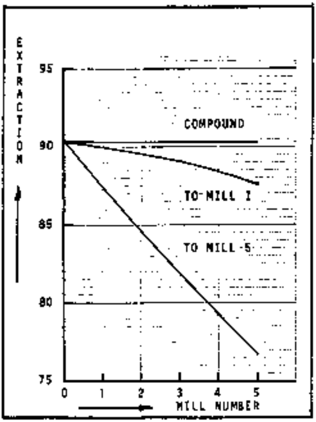

Figure 8. Extraction vs cush-cush return point.

The lowest curve showing a sharp downward trend is for the case where the cush-cush from all of the mills is returned ahead of the last mill. In this case it will be noted that there is a drastic reduction in the extraction achieved as the quantity of cush-cush dropped increases, and that for a cush-cush droppage of 5%, the mill's extraction drops to under 77. It should be noted that a typical quantity of fiber in cush-cush dropped per mill is 1% of the fiber feed to the mill.

The influence of the point of cush-cush return is exaggerated since the model assumes that the cush-cush liquid phase composition is identical to the juice from the corresponding mill. In reality, the composition of the juice in the cush-cush will be modified by the juices from other mills flowing over it in the cush-cush drag.

Effect of fiber % bagasse leaving a mill - Table 3 summarizes the effect that fiber *X* bagasse has on the mill's extraction. Assuming that the fiber % bagasse out of each mill is increased by 1%, (i.e. each mill is producing a drier bagasse), the extraction would increase from 90.02 to 90.70. On the other hand if only the fiber % bagasse out of the first mill is increased by 2%, an extraction of 90.38 is predicted. If the fiber % bagasse leaving the last mill (rather than the first mill) was increased by 2%, the extraction would have been increased to 90.51.

Table 3. Extraction versus fiber % bagasse.

	Extraction
Base case	90.03
Raise all mills by 1%	90.70
Raise first mill by 2%	90.38
Raise last mill by 2%	90.51

Effect of imbibition system employed - Figure 9 shows five imbibition schemes. In all of these schemes, the base case assumption of a total imbibition % cane of 25% is assumed. In the first case, the standard base case compound imbibition scheme is employed. This scheme results in an extraction of 90. In the second case a simple imbibition scheme is considered. In this case the 25% imbibition applied is distributed equally between the last four mills. None of the mill juices are returned to the tandem, but flow to the mixed juice collection tank. This scheme results in an extraction of 81.8. Here, the division of the imbibition between four mills has resulted in very little liquid flow to the mills, resulting in poor extraction.

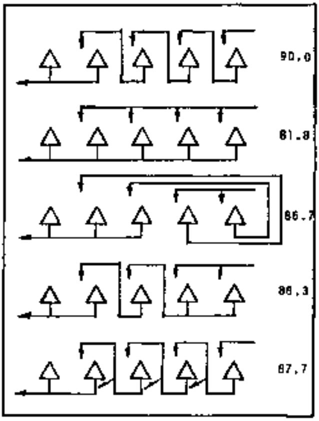

Figure 9. Extraction vs imbibition scheme.

The third case considers a modified simple imbibition system where the imbibition applied is distributed equally between the last two mills. The fifth mill's juices are returned ahead of the third mill, while the fourth mill's juices are returned ahead of the second mill. The juices from the first three mills go to process. This Imbibition scheme results in an extraction of 86.7.

Let us now look at a variation of the above case where the imbibition is divided equally between the last two mills, but where the entire juice leaving Mills 4 and 5 is combined and returned ahead of Mill No. 3, and all of Mill No. 3's juice is returned ahead of Mill No. 2. The juice from Mills 1 and 2 goes to process. This system results in an extraction of 88.3.

Finally, let us consider the case of compound imbibition, but assume that half of the juice extracted by the last three mills overflow to the juice tank of the preceding mill. Assuming complete mixing of the juices in the mill tanks, this arrangement results in an extraction of 87.7. Note that the base case compound imbibition scheme yields the highest extraction with the model used.

CONCLUSIONS

The model as described is quite flexible, however, additional refinements can be incorporated into the model if desired. Nevertheless, the main conclusions reached from this theoretical analysis of mill operation are that the major factors influencing the extraction of a mill tandem are:

1. The quantity of imbibition water applied.
2. The imbibition efficiency.
3. The imbibition scheme employed (simple, compound, etc.).

To a lesser extent, extraction is influenced by

4. The fiber % cane.
5. The number of mills in the tandem.
6. The point of cush-cush return to the milling tandem.

While

7. The Brix content of the cane has no effect on the extraction.

RECOMMENDATIONS

Mills that are interested in improving tneir mill work should conduct routine tests to determine the performance of each mill in the tandem. It is felt that Brix curves alone are of marginal use in determining which mills are not performing well. It is recommended that both pol and moisture determinations on the feed and discharge from each mill, together with the analysis of the front roll, back roll, and combined juices leaving the mill be made. This data could then be analyzed to evaluate the performa of each mill.

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SUGAR CANE RUST (PUCCINIA MELANOCEPHALA) SUSCEPTIBILITY AND THE PLANT NUTRIENT STATUS

D. L. Anderson, University of Florida, Belle Glade, Florida
J. L. Dean and P. Y. P. Tai, U. S. Department of Agriculture, Canal Point, Florida

In Florida, it appears that certain soil and growing conditions may favor rust development on sugar cane, although these conditions have not been qualified. In 1983, the degree of rust development of 12 sugar cane cultivars was evaluated in relation to the nutritional status within leaves of different maturity. Nutrient imbalances and high or low nutrient contents within the plant were highly related to rust susceptibility. The single most important nutrient related to rust development was phosphorus.

SUGAR CANE CULTIVAR RESPONSE TO PHOSPHORUS APPLICATION IN FLORIDA

D. L. Anderson, University of Florida, Belle Glade, Florida
M. Ulloa, New Hope Sugar Cooperative, Pahokee, Florida
W. Browning, A. Duda & Sons, Moore Haven, Florida

Response of CP 70-1133 and CP 72-1210 to furrow-applied P was measured from plant-crop data on one organic and two mineral soils. Brix and sucrose were highest on cane having the lowest metric tons of cane/ha and on the mineral soil with the least organic content. At all locations, CP 70-1133 had optimum sugar yield response at 30 kg P/ha, whereas CP 72-1210 had optimum yield response at levels ranging from 0 to 90 kg P/ha. On mineral soils and at the 30 kg P/ha rate, CP 70-1133 out yielded CP 72-1210 by as much as 31.8 kg sugar/metric ton of cane and 2360 kg sugar/ha. However on the organic soil location and 30 kg P/ha rate, CP 72-1210 out yielded CP 70-1133 by 11.6 kg in sugar/metric ton of cane, but 1640 kg less in sugar/hectare. On the organic soil CP 70-1133 produced 16 metric tons more fresh weight per hectare than CP 72-1210.

Plant crop response of CP 70-1133 to rates of broadcast and furrow applied P was also studied. Optimum sugar per metric ton of cane and sugar per hectare corresponded to furrow applications of 7.5 and 15 kg P/ha. When P was broadcast up to 45 kg P/ha, Brix, sucrose, purity and sugar per ton declined while sugar per hectare remained unchanged.

SUGAR CANE YIELD OF CONSTANT INITIAL POPULATIONS AT DIFFERENT ROW SPACINGS

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Row-spacing experiments, in Louisiana and elsewhere, have shown that cane sugar yields increase as the distance between rows decreases. Increased yields on closer row-spacings may result from a more efficient utilization of light and water throughout the growing season by 1) a more even spacing of plants, or 2) a greater plant population per unit area that is more likely to occur with closer rows. To distinguish between these alternatives, potted sugar cane plants (variety CP 65-357) were transplanted to the field so that the number of plants per plot (7.2 m x 7.2 m) was held constant at 625. The transplants were arranged to provide interrow spacings of 30, 60, 90, 120, 144, 180, or 240 cm, one spacing per plot. Sugar cane was transplanted from greenhouse to field in March, grown in a non-cultivated culture, and hand-harvested by cutting and topping stalks and stripping leaves in late fall of the same year. These plantings were repeated for three years. An analysis of variance indicated no significant difference in cane or sugar yields due to spacing. Stalk number was highest at the 30-cm spacing and decreased linearly as row spacing increased. The data from this single experiment with one variety and one initial population suggest that, since there were no significant differences in yield with varied interrow spacings when the initial population was held constant, the published higher yields at closer row spacings may be related to plant populations rather than to more even plant spacing.

THE ROLE OF SACCHARUM SPONTANEUM L. CLONES FOR SUGAR CANE IMPROVEMENT IN LOUISIANA

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Commercial varieties of sugar cane grown in Louisiana can be traced to two forms of Saccharum spontaneum L., Coimbatore and Glagah. Each is susceptible to strain H of sugar cane mosaic virus (SCMV), the dominant Louisiana strain for the last two decades. Nineteen new breeding lines of S. spontaneum, showing resistance to SCMV, have been established at the U. S. Sugar Cane Field Laboratory at Houma.

Five of these new lines have been advanced to the third or fourth backcross generations (BC_3 or BC_4). Mosaic resistant progeny from the most promising line of S. spontaneum, US 56-15-8, has been tested in replicated field trials where they have been equal to the commercial varieties in yield of sugar per unit area. Four additional lines developed from S. spontaneum clones, identified in India as smut resistant, have also been advanced to the BC_2 and BC_3 generations. Progenies from these lines show an acceptable frequency of smut resistance, even though no selection pressure was applied as they were developed. Now that smut is found in Louisiana, clones of mosaic-resistant lines are being intercrossed with clones of the smut resistant lines and selection applied for both diseases. Still other lines of S. spontaneum are being developed for resistance to the sugar cane borer, Diatraea saccharalis (F.) and Tor enhanced cold tolerance, although progress in identifying cold tolerant progenies has proven to be difficult.

EXPERIMENTS REAFFIRM THAT SUBSURFACE DRAINAGE INCREASES SUGAR YIELDS

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Two field experiments, one in St. James Parish and another in St. Mary Parish, Louisiana, were conducted in 1982 and 1983 to determine the yield response of sugar cane to subsurface drainage. In St. James experiment, four subsurface drain lines were installed at 80, 120, and 160 feet separations, four feet deep in a ten-acre tract of Commerce silt loam. A similar area, adjacent to the drained area, but without subsurface drains, was used as a check. Cane variety CP 70-321 was planted in the fall of 1981 and harvested in the fall of 1982 and of 1983. Sugar yields from the drained areas were 7,777 pounds per acre (lbs/A) in 1982 and 7,477 lbs/A in 1983. The check plot yielded 7,563 lbs/A and 6,610 lbs/A in 1982 and 1983, respectively. Thus subsurface drainage increased sugar yields 4 percent in 1982 and 13 percent in 1983. The value of this yield increase was $47 per acre in 1982 and $191 per acre in 1983 at the current sugar price of 22 cents per pound. Rainfall was 57.5 inches in 1982, which was 5.0 inches below normal. Rainfall was 68.1 inches in 1983, which was 5.6 inches above normal.

In the St. Mary Parish experiment, subsurface drains were spaced 45 feet apart and 3 feet deep in one block of Baldwin silty clay and 90 feet apart and 3 feet deep in another block. A similar area located nearby with the same soil type, but without subsurface drains, was used as a check. Cane variety CP 70-321 was planted in the fall of 1981 and harvested in 1982 and 1983. Sugar yields from the 45- and 90-foot drain spacing treatments were 9,009 and 7,812 lbs/A, respectively, in 1982 and 7,214 and 6,769 lbs/A, respectively, in 1983. The check plot yielded 7,701 lbs/A of sugar in 1982 and 6,278 lbs/A in 1983. Thus, subsurface drainage increased sugar cane yields a maximum of 17 and 15 percent in 1982 and 1983, respectively. The value of the increased yields due to subsurface drainage was $288 per acre on the 45-foot drain spacing treatment and $24 per acre on the 90-foot drain spacing treatment in 1982 at the current sugar price. The value of the increased yields was $206 per acre on the 45-foot drain spacing treatment and $108 per acre on the 90-foot drain spacing treatment in 1983. Rainfall was 60.4 inches in 1982, which was 2.4 inches below normal. Rainfall was 69.7 inches in 1983, which was 6.9 inches above normal.

SPATIAL DISTRIBUTION OF WHITE GRUBS IN FLORIDA SUGAR CANE

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The spatial distribution of third instar grubs of two white grub species was measured in forty Florida sugar cane fields. Ninety-six percent of Cyclocephala parallela grubs and 90 percent of Ligyrus subtropicus grubs were found at the stool base, rather than in the row between stools or in soil between rows of stools. Eighty-six percent of C. parallela grubs and 82 percent of L. subtropicus grubs were found 0 to 6 inches deep and both species declined rapidly in number at greater soil depths. A variance to mean index showed that both species were aggregated in distribution among sugar cane stools in greater than 90 percent of the fields sampled. Analyses with Duncan's Multiple Range Test showed C. parallela was more evenly spread throughout fields than C. subtropicus which infested field edges most heavily. Implications of these grub distributions are discussed.

SUGAR CANE PRODUCTION SYSTEMS TO REDUCE FUEL USAGE

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There are possibilities for large savings in fuel costs by improving sugar cane tillage, planting, harvesting and transportation systems. For instance, the cost of sugar cane transportation could be decreased by chopping the sugar cane transportation in shorter lengths to improve the density. This

could have an adverse effect on the amount or quality of sugar produced from the sugar cane. Introduction of minimum or reduced tillage practices could reduce tractor costs significantly and would likely increase the use of chemical weed control. Modeling and simulation techniques will provide methods of analyzing production options and indicate other data needed for management decisions.

POPULATION VARIATION AMONG STRAINS OF THE RATOON STUNTING DISEASE BACTERIUM IN SUGAR CANE

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Populations of 14 strains of the ratoon stunting disease bacterium, Clavibacter xyli subsp xyli, were examined in the sugar cane varieties H 60-6909 and CP 44-101. The strains were originally isolated from different sugar cane varieties and locations in Florida. Single-bud cuttings of H 60-6909 and CP 44-101 were inoculated with the strains and populations of the strains were determined in sap extracted from stalks eight months later by a fluorescent-antibody direct-count technique. Mean populations in extracts from six plants of each treatment ranged from 3.6 x 104 cells/ml to 7.0 x 10^5 cells/ml in H 60-6909, and from 7.4 x 106 cells/ml to 8.4 x 10? cells/ml in CP 44-101. Populations of the 14 strains were not significantly different in H 60-6909 (minimum significant difference = 6.2 x 10^6 cells/ml, Waller Duncan K-ratio t-test, K-ratio = 100), but two of the 14 strains had significantly lower populations in CP 44-101 (minimum significant difference = 2.0 x 10^6). The inability to differentiate strain populations in H 60-6909 could have been due to insensitivity of the counting technique at lower population levels. Overall, H 60-6909 and CP 44-101 were easily distinguished on the basis of pathogen populations regardless of the pathogen strain. Thus, strain differences may not be a limiting factor when attempting to determine varietal susceptibility to ratoon stunting disease on the basis of pathogen population dynamics.

IMPROVED SP0RULATI0N OF BIPOLARIS SACCHARI THE CAUSAL FUNGUS OF EYE SPOT OF SUGAR CANE

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Bipolaris sacchari, sporulates poorly on most culture media under laboratory lighting. Therefore mycelial inoculum has been used since 1974 to screen several acres of sugar cane selections each year in the Florida cooperative ARS-IFAS-Industry breeding program. Mycelial inoculum is difficult to standardize, tends to clog spray nozzles, and probably is less infective than spore inoculum. It was found that growth of the eye spot fungus on lactose-casein hydrolysate medium under the proper intensity of ultraviolet light leads to abundant sporulation. Highly standardized inoculum is now available for research purposes and spore inoculum was used successfully in the screening program in 1984.

THE EFFECT OF FREEZE DAMAGE UPON THE GERMINATION OF 12 COMMERCIAL AND 3 EXPERIMENTAL SUGAR CANE CLONES

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The Sugar Cane Demonstration Plots of the Everglades Research and Education Center in Belle Glade were exposed to temperatures of 28°F for four hours on December 25, 1983. The plots were harvested on February 23, 1984, and 30 stalks per clone were stored in a shaded, cool, outdoor location for one week. The stalks were then divided into three sections - bottom, middle and top - and a total of 100 eye-pieces were cut per section. The eye-pieces were planted in flats and placed in a greenhouse March 12, 1984.

Each week, germination was recorded by the number of emerging shoots. CP 72-2086 had the highest rate of germination 25 days after planting. Approximately 54 percent of the shoots from CP 72-2086 germinated from the top section. Generally, the highest germination occurred with eye-pieces cut from the top section. CP 70-1133 and CP 56-59 had the second and third highest rate of germination with 37 percent and 9.7 percent respectively.

Germination ranged from a low of 0 for CP 69-1052 to a high of 54 percent for CP 72-2086 with the different varieties in between.

PREDICTING THE HARVESTABILITY OF EXPERIMENTAL SUGAR CANE VARIETIES IN LOUISIANA

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The adaptability of experimental varieties to mechanical harvesting is of major concern to the Louisiana Sugar Cane Variety Improvement Program. Louisiana sugar cane farmers will not accept a new sugar cane variety that cannot be handled mechanically. During the 1982 and 1983 harvesting seasons, the hypothesis that adaptability to mechanical harvesting is inversely associated with the percent stalks broken by a soldier-type mechanical harvester was tested. To test this hypothesis the percent broken stalks were estimated for each check variety in the outfield variety trials. Also a special test was planted at St. Gabriel in which five varieties of known reaction to mechanical harvesting were monitored. Plot sizes of 16' x 3 rows (infield size) were compared to 32' x 3 rows (outfield size) for each of the five varieties. The order of varieties across experiments was exactly that expected from previous harvesting experiences. These differences were exhibited even at those locations where the cane was erect. Plot size had little effect on the percent broken stalks. The results of this study indicate that the ability of an experimental variety to be harvested mechanically can be predicted by estimating the percent stalks broken by the mechanical harvester.

GROWTH REGULATOR EFFECTS ON SUGAR CANE GERMINATION AND TILLERING

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Eleven growth regulator compounds were used in two greenhouse studies on germination and tillering. Three levels of each compound were applied to two cane varieties (CP 70-1527, CP 72-1210) by dipping the seedpieces in a solution. Six compounds were applied to single-eyed seedpieces with 24 hours of harvest while five compounds were applied three days later. Improvement in germination resulting from some of the compounds was observed in the second planting. A large difference in germination and emergence of the control treatments was observed between the different planting dates. Unusual growth characteristics were observed in some treatments. A significant reduction in germination was observed for specific levels of some compounds.

TIME TO CUT BY HAND, A CHARACTERISTIC MEASURED IN SUGAR CANE CULTIVAR EXPERIMENTS

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During the 1982-1983 harvest season in Florida, the time to cut different sugar cane (trispecies hybrids of *Saccharum* sp.) cultivars by hand was analyzed. At the cooperative cultivar selection program of the USDA, University of Florida, and Florida Sugar Cane League, Inc., measurements were taken in the final phase of the replicated plant-crop through second-ratoon crop experiments, conducted at eight locations. There were significant differences among cultivars and locations in all three crops. Location-cultivar interaction was significant only in the first-ratoon crop. The time to cut CP 63-588 was significantly lower than 68 percent of the cultivars studied. No cultivar had significantly less time to cut than CP 63-588. CP 70-1133 was only planted in the plant-crop experiments where its time to cut was significantly higher than all other cultivars. Correlation coefficients for time versus cane per hectare, stalk number, and stalk weight were .74, .56, and -.16, respectively. The multiple correlation coefficient was .76, thus 58 percent of the variability in time to cut was accounted for by these three variables. In summary, it was shown that significant differences in time to cut were distinguished in replicated experiments, and that although tonnage, stalk number, and stalk weight significantly affected time to cut, 42 percent of the variation in time to cut was caused by other factors.

HERITABILITY OF RESPONSE TO THE SYNTHETIC CHEMICAL RIPENER GLYPHOSATE IN SUGAR CANE

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The progenies of four crosses of sugar cane (*Saccharum* interspecific hybrids) were evaluated for changes in sucrose content, stalk density, fiber content and stalk weight after treatment with the chemical ripener glyphosate. The differences between treated and untreated plots for each yield component formed a continuous, apparently normal, distribution over a broad range. Such a distribution

is typical for a quantitatively-inherited trait. Further, the data showed that for individual clones the heritability estimates (h^2) for the response variables of D-sucrose and D-stalk weight were 0.01 and 0.02, respectively. The crosses between parents known to respond to glyphosate produced a lower percentage of responding offspring than crosses between non-responding parents. These results indicate that little progress would be made in breeding for response to glyphosate, and suggest that all progeny must be evaluated in advanced stages of variety development.

INFLUENCE OF 2,4-D ON SUGAR CANE EMERGENCE

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In Louisiana, several species of morningglory infest sugar cane fields late in the season, often causing yield reductions by interfering with mechanical harvesting. Late summer applications of 2,4-D [(2,4-dichlorophenoxy) acetic acid] improve harvestability of the crop for seed cane or sugar. However, the effects of 2,4-D on the germination of sugar cane used as seed cane has not been documented. A study was initiated to investigate the influence of 2,4-D on germination of ten sugar cane varieties grown in Louisiana. 2,4-D was applied at 2.24 kg/ha to sugar cane two and five weeks prior to planting. Sugar cane population densities in the fall of 1983 indicated that the sensitivity of sugar cane to 2,4-D varied with variety and time of application. CP 76-301 and CP 70-356 were not affected by 2,4-D applications. CP 74-383, CP 72-370, and CP 76-331 showed reduced populations when 2,4-D was applied five weeks prior to planting, while CP 72-331 and CP 78-304 showed reduced populations when 2,4-D was applied two weeks prior to planting. Both application times caused reduction in emergence of CP 70-321, CP 78-303, and CP 65-357. The research will be repeated to further clarify 1983 results.

POST-FREEZE DETERIORATION OF SUGAR CANE VARIETIES FOLLOWING FREEZES OF DIFFERENT INTENSITY

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In replicated field-plot tests at the U. S. Sugar Cane Laboratory in Houma, Louisiana, sugar cane varieties were exposed to minimum temperatures of 23°F (1974), 25°F (1975), 26°F (1976), 24^{0}4 (1977), 19°F (1981) and 13°F (1983), respectively. Deterioration was measured by changes in Brix, pol, purity, sugar content, pH, titratable acidity and dextran content of the juice. Significant prefreeze differences were evident among varieties for Brix, pol, purity, sugar content and titratable acidity, but not for pH and dextran content; post-freeze varietal differences were evident for all parameters. The best indicators of deterioration were changes in pH, titratable acidity and dextran content. There was fair agreement in the response of varieties in tests conducted in different years. The variety L 65-69 was consistently poor in post-freeze quality, while NCo 310 was good. The variety CP 70-321 was included in four of the six tests, and was as good as or better than NCo 310. This variety is the progeny of two cold tolerant parents, CP 61-39 and CP 57-614.

DIRECT DEVELOPMENT OF PLANTLETS FROM SUGAR CANE LEAF TISSUE INFECTED WITH SUGAR CANE MOSAIC VIRUS

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Direct production of plantlets from leaf tissue has been suggested as efficient method of producing plants without the variability possibly induced by callus culture. The question whether such plantlets would be free of sugar cane mosaic virus (SCMV) if grown from a diseased donor has not yet been answered.

An immature leaf tissue of sugar cane variety CP 72-356, both healthy and mosaic infected, was cultured on Murashige-Skoog medium. Callus formation was minimized by using a combination of cytokinin and auxin, and plantlets developed on both infected and healthy leaf tissue after two to six weeks. Neither cytokinin nor auxin alone were effective in plantlet production, nor was the mixture effective when the ratio of cytokinin to auxin was greater than one. Plantlets from mosaic-infected donors will be observed for symptoms of mosaic, and juice from the plantlets will be assayed for SCMV on sorghum (variety Rio).

To compare the effect of virus stains on plantlet production, a replicated experiment was initiated with the sugar cane variety POJ 234, infected with SCMV strain, A, B, D, H, I, or M. Healthy plants of POJ 234 were used as a control. The regenerative rate of leaf tissue was related to virus strain. All mosaic strains were transmitted through plantlets to Rio sorghum.

FEASIBILITY OF LAYBY HERBICIDE APPLICATION FOR SUGAR CANE WEED MANAGEMENT

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Although layby application of herbicides is a relatively common practice throughout the sugar cane growing regions of Louisiana, its feasibility has not been tested. Research was initiated in 1981 in Assumption Parish and Pointe Coupee Parish to monitor the long term effects of layby herbicide application on sugar cane weed control and yield enhancement. Herbicides were applied with a standard gas pressurized backpack sprayer calibrated at 216 L/ha for preemergence applications and 93 L/ha for layby applications. Preemergence applications were applied in April while layby applications were applied as a directed spray in late June when the sugar cane was 1 - 2 m high. Weed infestations were evaluated as percent foliar cover or the percent of the ground surface covered by weed foliage.

Results indicate that layby application of herbicides does not enhance sugar production by sugar cane. Layby applications may be recommended in cases of extreme weed infestations or to prevent late season infestation of morningglories (*Ipomoea* sp.). Research shows that the use of layby herbicide application would prevent infestation of weeds as a limiting factor if sugar cane is grown for a cycle longer than three years. Future research will be conducted to determine if layby application of herbicides will allow cane to be economically grown for four to six years.

FACTORS AFFECTING SEED SET IN SUGAR CANE

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Data are presented for crossing seasons 1979-1980 through 1983-1984 for the production and distribution of true sugar cane seed. The production of true seed was influenced by many factors. The effects of season, temperature, humidity, pretreatment of tassel (photoperiodic induction or delay) and condition of stalk (air-layered vs acid) are discussed.

Seed set per gram of fuzz ranged from a high of 74.4 in 1979-1980 to a low of 34.8 in 1981-1982 for all sources of air-layered tassels. Seed production on tassels maintained in the Hawaiian weak acid solution ranged from a high of 29.7 to a low of 15.4 per gram of fuzz.

ALTERNATIVE METHODS FOR CONTROL OF ITCHGRASS *ROTTBOELLIA EXALTATA* (L.F.) IN SUGAR CANE

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Trifluralin at 2.2 kilograms per hectare (kg/ha), the standard herbicidal treatment for controlling itchgrass in Louisiana sugar cane, requires soil-incorporation. An alternative that does not require incorporation is needed. In several field experiments, pendimethalin, a dinitroaniline herbicide similar to trifluralin, controlled itchgrass and a wide range of other grass weeds without incorporation.

Pendimethalin as a nonincorporated treatment was more efficient at rates of 3.3 to 4.5 kg/ha than at 2.2 kg/ha, a rate that is effective when this type of herbicide is soil-incorporated. Weed control appeared to be most effective when rain occurred soon after treatment, probably indicating that pendimethalin, without mechanical incorporation or movement into the soil by rain, is subject to loss by photodecomposition and/or volatilization. In most experiments, rain of 1.25 cm or more occurred within ten days after treatment. Pendimethalin at 2.2 kg/ha incorporated into soil with a rolling cultivator generally gave 5 to 10% better control of itchgrass than did pendimethalin at 3.3 kg/ha moved into soil by rain. Sugar cane yields were not adversely affected by any treatment.

Both the preemergence control and early postemergence control of seedling weeds was improved when pendimethalin at 2.2 to 3.3 kg/ha was mixed with one of the following: hexazinone at 0.8 to 1.6 kg/ha, terbacil at 1.1 to 1.6 kg/ha, metribuzin at 1.1 to 1.6 kg/ha, diuron at 2.7 kg/ha, or atrazine at 2.7 kg/ha. Season-long control was improved when preemergence pendimethalin treatments were followed several weeks later by a postemergence treatment with asulam at 3.7 kg/ha or with a mixture of asulam at 3.7 kg/ha and dalapon at 4.5 kg/ha, or with MSMA at 3.3 kg/ha. These postemergence treatments were most effective when applied to itchgrass that was less than 15 cm tall.

AN EXPERIENCE WITH ALL NATURAL VS ARTIFICIAL LIGHT SUPPLEMENT FOR THE PHOTOPERIOD INDUCTION OF FLOWERING IN SUGAR CANE

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During the 1983 photoperiod campaign at St. Gabriel, Louisiana, 216 cane cultures of 47 varieties, which were considered to be easy to induce, were given 16 days of 12 hours, 25 minutes induction from July 1 to July 15. The photoperiod was decreased by one minute per day from July 16 to September 8. The photoperiod was then held at 11 hours, 30 minutes until September 15, when the entire group was again subjected to natural photoperiod. The 216 cane cultures were distributed across four photoperiod bays so there were two pairs of bays with identical genetic material. One bay of each pair was exposed to natural light for the entire photoperiod. The other was exposed to eight hours of natural light supplemented with artificial light at the beginning and end of the photoperiod. The artificial lights were controlled manually to insure that both bays of each pair received identical photoperiod. On September 16, the first tassel was cut from the bay induced with only natural light. The material on the two bays exposed to natural light flowered profusely. On the other hand, only the very easy to induce varieties flowered on those bays supplemented with artificial light. Besides very poor flowering, the flowers that emerged on the bays supplemented with artificial lights did so on an average of 17 days later than those with natural light. Although all bays were equipped with exhaust fans, it is speculated that higher late afternoon temperatures in the bays with artificial lights inhibited flower initiation in these bays. It is concluded that controlling photoperiod with supplementary lights is not satisfactory in these new facilities.

INSECTICIDE SELECTION IN SUGAR CANE: USE OF SPECIFIED RESEARCH CRITERIA

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An 8-point list of research criteria has been formulated and used at Louisiana State University to help select the most appropriate insecticides for integration into sugar cane pest management systems. The program was developed in response to a former heavy use of insecticides for integration into sugar cane pest management systems. The program was developed in response to a former heavy use of insecticides, pesticide-related ecosystem disruptions, and control failures caused by insecticide resistance to the key pest, the sugar cane borer _Diatraea saccharalis_ (F.). It stresses considerations of long-term environmental, practical control. Recent research presented (to include the anticipated label for Pydrin) in addition to efficacy of control will address length of control period, detrimental effects on beneficial arthropods, fish and wildlife, and the potential for causing insecticide resistance. Additional considerations address pesticide hazard, the potential for causing build-up of secondary pests and the long-term forecast of being able to use the particular pesticide within the context of pest management.

FACTORS AFFECTING STUBBLE LONGEVITY

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The longevity of stubble cane crops is a serious problem in Louisiana. Generally the crop of most growers in the state consists of 40 percent plant cane, 40 percent first stubble and 20 percent second stubble cane. A large acreage of unproductive fallow land is planted each year.

Previous experiments have indicated that the progressive decline in yield with stubble age is apparently due to several factors. Cane varieties have an inherited difference in their potential to produce acceptable yield of stubble cane. Cultivation experiments have indicated that low stubble yield with minimum cultivation was due principally to poor weed control. Fertilizer tests have shown that the yield responses to fertilizers were greater with stubble than plant cane indicating a depletion of soil nutrients during a crop cycle. Tests on date of harvesting indicated that the harvesting of plant cane early in the season reduced the stubble yield of some varieties. Recent studies on the stubble protection from freeze damage have shown that covering cane stubbles with soil after harvesting a crop increased yield in the following crop. In addition, other researchers have reported that stubble yield decline is partially due to high water table levels and poor drainage, machinery damage, weeds, diseases, insects and nematodes.

TOLERANCE OF SELECTED SUGAR CANE CULTIVARS TO PREEMERGENCE HERBICIDES: AN UPDATE

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The response of eight sugar cane cultivars to three preemergence herbicides was evaluated in the plant-cane and first-ratoon stubble crops. The following cultivars were tested: CP 48-103, CP 65-357, CP 70-330, CP 70-321, CP 72-356, CP 72-370, CP 73-351, and CP 74-383. Preemergence herbicides were applied at rates recommended for the control of seedling johnsongrass in Louisiana: metribuzin (2.7 kg/ha), terbacil (1.6 kg/ha), and hexazinone (1.6 kg/ha). Herbicides were applied, in a 91-cm band, to a loam soil in the fall immediately after planting sugar cane and again each spring. Tolerance was determined by comparing the yields of herbicide-treated and untreated (hand-hoed, weed-free) plots. With the exception of CP 72-370 in 1983, all cultivars tolerated metribuzin. Yields (tonnes per acre) in plant-cane were reduced by terbacil with CP 48-103 (50 percent) and CP 70-330 (16 percent) showing the greatest reductions. The least reduction occurred with the newer releases, CP 73-351 (1 percent), CP 72-356 (3 percent), and CP 74-383 (4 percent). Hexazinone was phytotoxic to all cultivars tested; the least damage occurred in the cultivars CP 70-321, CP 73-351, and CP 74-383. In the first stubble crop, there was no significant reduction in yield compared to the untreated control in any of the cultivars treated with metribuzin, and only CP 48-103 showed a significant reduction after treatment with terbacil. All eight cultivars showed a significant reduction after retreatment with hexazinone, compared both to the untreated control and to the sugar cane treated with the other herbicides. Yield reductions due to herbicides were primarily through reductions in stalk numbers, heights and/or weights.

PREPARING SUGAR CANE BUDGETS WITH MICROCOMPUTERS

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The paper describes a computerized enterprise budget developed for sugar cane operations. Budgets play a key role in farm management. The program was designed so that the production process is linked together into the sugar cane budget. It attempts to integrate production and economic decisions within a sugar cane farm. The use of microcomputers does not reduce the data requirements for an enterprise budget, but speeds up calculation and printing of results. In addition, it provides consistent and uniform information required for sound management decisions.

The sugar cane budget is divided into several logical sections: land use and its distribution, yields, payments per unit to the factors employed in the production process, machinery ownership costs, sugar cane operations and harvesting costs. The sections mentioned above are used to estimate production costs, total revenue, variable and fixed costs, and returns to factors of production.

The sugar cane budget is designed to test the profitability of the sugar cane farm as an economic unit. The paper presents a microcomputer package that generates sugar cane budgets for on-farm use. Sensitivity analysis can be performed in a fast and accurate manner. Budgeting with microcomputers should result in a more efficient and profitable sugar cane operation.

SOFTWARE OPTIONS FOR COMPUTERIZING SUGAR CANE FIELD RECORDS

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Due to recent advances in microelectronic technology, microcomputers are now capable of maintaining large amounts of information efficiently and at a relatively low cost. A number of microcomputer programs are now available to sugar cane growers for maintainance of field production records. Nearly all programs suitable for keeping field records can be classified into one of the three following categories: general data base management programs; general programs which combine the features of data base management, electronic spreadsheet, and graphics; and specific programs which only can be used to maintain and analyze sugar cane field records. One program of each of the three types is described in the paper, and the advantages and disadvantages of each are identified.

INSECT PARASITIC NEMATODES AS POSSIBLE BIOLOGICAL CONTROL ORGANISMS FOR THE WHITE GRUB LIGYRUS SUBTROPICUS IN SUGAR CANE

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Five entomogenous nematodes, Steinernema feltia Filipjev (All, Mexican, and Breton strains), S. glaseri Steier, and Heterorhabditis heliothidis (Khan, Brooks, and Hirschmann) were evaluated against the white grub Ligyrus subtropicus (Blatchley), a serious pest of sugar cane in Florida. Of these, S. glaseri inflicted 100 percent mortality to third instar larvae of L. subtropicus when applied at the rate of 5,000 nematodes per larva. At the lower rate of 250 nematodes per larva, 86 percent mortality was observed. L. subtropicus appeared to be an excellent host for L. glasseri, yielding a mean of 139,576 nematodes per larva when innoculated with 1,000 nematodes per larva. Therefore, it appeared tha S. glaseri could be an important biological control organism against L. subtropicus in sugar cane. It is suggested that tests be conducted to determine the efficacy of insect parasitic nematodes in controlling white grubs and possibly other soils pests of sugar cane under field conditions.

COMMERCIAL EVALUATION OF SUGAR CANE RIPENERS

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B. Glaz, U. S. Department of Agriculture, Sugar Cane Field Station, Canal Point, Florida

The effectiveness of ripeners on three sugar cane (trispecies hybrids of Saccharum sp.) cultivars was evaluated from October through November of 1983. The evaluation was carried out on all CP 56-59, CP 65-357, and CP 70-1133 of New Hope Sugar Cooperative which was due to be plowed out (all fields were at least in the second ratoon crop). The ripeners studied were N, N-bis (phosphono methyl) glycine (ripener #1) applied at 4 kg and 4.67 kg/ha and sodium on N-phosphonomethyl glycine (ripener #2) applied at .67 kg/ha. Ripener #1 and #2 were applied on 535.3 ha and 507.9 ha respectively in September and October. No treatment was applied to 382.7 ha. Overall, the two ripeners increased sugar per tonne of cane by 10.36 kg sugar per tonne when evaluated under optimum conditions (rain free days). Ripener #2 was the most effective treatment as it caused increases of 11.35 kg sugar per tonne of cane for all three cultivars. Ripener #1 resulted in increases of 9.18 kg sugar per tonne of cane. All three cultivars showed a positive response to ripeners. Using a sugar price of 42.95 cents per kg of sugar, both ripeners increased revenues by $4.40 per tonne of cane harvested. Ripener evaluations were made assuming no decrease in tonnes of cane per acre in the treated fields.

THE SUGAR CANE BEETLE, EUETHEOLA RUGICEPS (LeCONTE), IN LOUISIANA

W. H. White and S. D. Hensley
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The sugar cane beetle, Euetheola rugiceps (LeConte), an occasional pest of sugar cane in Louisiana, is found throughout the Louisiana sugar cane ecosystem. Economic damage (5 percent or more of the stand destroyed) appears to be rare, however, and most stand destruction occurs sporadically on farms in the Bayou Teche area from near Jeanerette to Breaux Bridge.

During late winter or early spring, the adult beetles appear to be attracted to sugar cane fields containing large amounts of rotting plant residues. Damage to live sugar cane tillers occurs at this time. They reduce crop stands by chewing through the apical meristem of developing tillers. Adult sugar cane beetles remain in the soil from late winter until early summer; stand destruction invariably does not cease until the apical meristems of all remaining tillers emerge from soil. Light trap data during 1983 indicated two peak dates of adult sugar cane beetle activity, May 2 and May 17. Although many sugar cane beetle eggs are often laid in sugar cane fields, the immature beetles fail to develop to adults unless sufficient rotting plant residues are present.

Insecticides for controlling this occasional pest have been tested in Louisiana, and have not been found to be satisfactory. Less than 50 percent control was obtained with conventional soil insecticides including carbofuran, bendiocarb, fensulfothion, and isofenphos. Applications of these soil insecticides enhanced problems in controlling the sugar cane borer, Diatraea saccharalis (F.), by causing destruction of fire ants and other beneficial arthropod predators.

THE EFFECT OF CANE DETERIORATION ON CORE SAMPLER CANE PAYMENT SYSTEM PARAMETERS

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Five independent studies performed during the 1983 cane harvest to determine the effect of cane deterioration on the various parameters which constitute the core sampler cane payment system are discussed. The parameters considered are: residue weight, percent moisture, fiber, juice Brix, juice sucrose (polarization), juice purity, cane Brix, cane sucrose (polarization), cane purity, theoretical recoverable sugar (TRS), and commercial recoverable sugar (CRS). Each parameter is considered not only independent of other parameters but also synergistically with other parameters. Furthermore, the relationship between these parameters and time after cutting, weight of the cane, and climatic conditions are addressed. Ultimately, credence is established to the adage that, "Cane quality improves three days after cutting", by illustrating a possible flaw in the core sampler cane payment system. This flaw may inevitably provide compensation for poor quality cane. Explanations for this phenomena, as well as possible resolutions and future work, are proposed. Finally, the financial impact of poor quality cane resulting from the aforementioned discrepancy in the core sampler cane payment system is reviewed.

JUICE QUALITY ANALYSES OF SUGAR CANE AND SWEET SORGHUM BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

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S. Kresovich, Texas and A & M University, Weslaco, Texas

Comparisons of standard methods of juice quality analyses and methods employing high performance liquid chromatography (HPLC) have been made In the Texas sugar cane and sweet sorghum selection programs for the past two years. On an annual basis, approximately 1,000 sample analyses have been performed. The advantages of HPLC are: improved accuracy, precision, minimal sample size and perparation needed, and time required for complete analyses (sucrose, glucose, fructose, and organic acids). The analyses of individual sugars and organic acids are critical when attempting to understand the basic mechanisms of sugar accumulation, by-product formation, and juice deterioration. Data from the Texas sugar cane and sweet sorghum selection programs are presented to highlight the application of HPLC.

A POSSIBLE ALTERNATIVE TO THE "HAZE" TEST FOR DEXTRAN IN RAW SUGAR

D. F. Day and D. Sarkar
Audubon Sugar Institute, Baton Rouge, Louisiana

Evaluation of dextran levels in raw sugar is of growing concern to the raw sugar house. To date, the only acceptable methods are the alcohol "Haze" test and the Roberts procedure. The authors are developing an alternative method which utilizes the physical separation of the dextran from sugar solutions by a simple ultrafiltration device. Specificity of the assay is provided for by the use of dextranase to produce reducing sugar which is measured chemically. The assay provides reproducible measurements of dextran and should be a useful addition to the analytical procedures available for dextran

DOUBLE FILTRATION OF CLARIFIER MUD

A. R. Mayo and B. M. Rodriguez
United States Sugar Corporation, Clewiston, Florida

The paper summarizes the full scale commercial application of a previously tested laboratory concept of double mud filtration to increase sugar recovery at United States Sugar Corporations's Clewiston mill. Belt presses for the second filtration following existing vacuum filters were used and resulted in an added recovery of 17,000 pounds per day of sucrose from clarifier muds. The 38 percent reduction of lost sucrose resulted in the equipment payback in less than a year.

THE UTILIZATION OF SUGAR CANE FIELD TRASH AS A BIOMASS FEEDSTOCK FOR ELECTRICAL PRODUCTION

George Samuels, Center for Energy & Environment Research, San Juan, Puerto Rico

Sugar cane field trash (cane tops, attached and fallen leaves) is usually considered a hindrance to be eliminated by burning to facilitate cane harvesting. Not burning the cane trash offers certain advantages of weed, erosion and moisture control which, in turn, can increase cane production. Aside from these advantages, not burning the cane trash makes available a biomass feedstock source for electrical production in the cane mill or in a bagasse electric-generating unit. Sugar cane trash accounts for up to 25 percent of the total dry matter yield of the cane plant. One ton of dry trash (6% moisture) has an energy equivalent of 15 million BTU's or 4,395 KWH of electricity equivalent or 2.5 barrels of fuel oil equivalent. The inclusion of cane trash aguments the total bagasse production which in turn increases the biomass feedstock for electrical production. Problems involved in harvesting cane trash in the field and its effect with milling in the factory are discussed.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
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Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

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Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized.

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Suggested Format (Examples Below)

EVALUATION OF SUGARCANE CHARACTERISTICS
FOR MECHANICAL HARVESTING IN FLORIDA

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Research Geneticists, SEA, USDA, Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS and METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrane pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

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AUTHOR INDEX