Evaluation of Chemical Ripeners for Sugarcane[1]

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INTRODUCTION

The need for chemical compounds to increase the sucrose content of sugarcane before harvesting is very great in Puerto Rico, especially to offset the decreasing sucrose content of the material ground at the sugar mills which has taken place during the past 5 years due mainly to mechanization of the sugarcane industry. Sugarcane-ripening chemicals have a multiple role to play. A compound is needed with the ability to induce ripening of sugarcane to increase sucrose in varieties still in the growing stage at the beginning of the harvest season, because of high nitrogen and moisture conditions. A compound which may be the same one used at that stage, or a different one perhaps, also is needed to prevent a drop in sucrose near the end of the harvest season when rains and raising temperature stimulate inversion and growth. In addition, ripening chemicals should help achieve the full quality potential of the cane even when natural conditions are favorable.

Since the pioneering work of Beauchamp (8), increasing attention has been paid to the manipulation of sugarcane physiology through the application of chemicals to induce ripening of the crop. The literature on this subject is now extensive, and has been reviewed from time to time by Yates & Bates (20), Vlitos and Lawrie (18), Yates (21), and Sookashthan and Subba Rao (17). More recent publications include reports from Hawaii by Nichell (12), Nickell and Maretzki (13), Nickell and Tanimoto (14,15), U.S. Patents 3,482,958, 3,482,961, 3,505,056; from Puerto Rico by Alexander (1,2,3); from the Tate & Lyle Ltd. Research Organization (5,6,7); from Taiwan (19); from Queensland (9); and from the manufacturers of agricultural chemicals such as E. I. Du Pont de Nemours & Co., U.S. Patent 3,291,592, U.K. Patents 1,161,189, 1,170,951; and Monsanto Co., U.K. Patent 1,171,516.

Field trials reported in the earlier literature often gave conflicting results. Some workers, therefore, initiated experiments under controlled conditions in environmental chambers or glasshouses. Screening experiments of this nature were carried out by Tate and Lyle Ltd. Research Centre and by the University of Puerto Rico, Agricultural Experiment Station, Mayagüez

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Campus, Río Piedras. The results obtained from these experiments indicated that a few chemicals merited field evaluation.

These chemicals were tested in a series of 13 replicated small-plot experiments which were installed in Puerto Rico in May–June 1970. The experiments were performed cooperatively between Tate & Lyle Ltd. and this Station under the sponsorship of the Sugar Industry Rehabilitation Program of the Commonwealth of Puerto Rico, Department of Agriculture, with the cooperation of the Land Authority of Puerto Rico, Central Aguirre and Central Mercedita. The results are described herein.

TABLE 1.—*Information on the experimental sites and treatments*

Site	Chemical	Variety	Age	Replications	Date applied	Time of sampling after spraying,
			Months	*Number*		*Weeks*
Loíza	GA/Dalapon	P.R. 980	8	6	5/7/70	4, 6, 8
	GA/Silicon		8½	6	5/11/70	4, 6, 8
	Ethrel 68-250		8½	6	5/13/70	2, 3, 4
	Pesco 1815		8½	6	5/12/70	2, 3, 4
	C.P. 41845		9	6	5/19/70	2, 4, 6
	Banvel		9	6	6/3/70	3, 4
	Cycocel		9½	6	6/11/70	2, 4
Mercedita	GA/Dalapon	P.R. 641791	9½	4	5/12/70	2, 4, 6
	C.P. 41845	P.R. 641791	9½	4	5/12/70	2, 4, 6
	Pesco 1815	C.P. 5243	9	4	6/5/70	3, 4
	Banvel	C.P. 5243	9	4	6/5/70	3, 4
Aguirre	C.P. 41845	P.R. 62258	8½	6	6/1/70	2, 4, 6
	Cycocel		8½	6	6/1/70	2, 4, 6

METHODS

The field trials were conducted at the Miñi-Miñi Farm in Loíza, Land Authority of Puerto Rico Sugarcane Program, as representative of sugarcane growing in the humid northern coast, and the Mercedita Farm, Central Mercedita and Destino Farm, Central Aguirre, as representatives of the irrigated sugarcane of the southern coast. The experimental sites were selected to comply with two criteria: That the cane was erect, to make spraying with knapsack sprayers practicable and to minimize inter-cane variability (22); and that the cane approximated harvest age at the termination of the trial, i.e., that it was at least 8 months of age at spraying. Details of the sites and various treatments are given in table 1.

The experimental designs were arranged to allow statistical analysis as paired plots (10) or as randomized blocks. The latter system proved most selective in the majority of individual analyses of variance, so it was used throughout in the statistical analyses of results. Six replicates were employed, except at Mercedita (table 1), where the area available was insufficient.

Each plot consisted of five sprayed rows, the total sprayed area being 0.01 acre. Spray drift between plots was largely eliminated by leaving guardspaces of at least 10 feet (or two unsprayed interrows) between plots, and by spraying only under virtually wind-free conditions in early morning. The spray was applied above the cane canopy through a single wide-angle nozzle mounted on a long lance. This nozzle was carried down the center of an interrow to spray the near sides of the two adjacent rows. Each plot, therefore, had three fully-sprayed and two half-sprayed rows.

TABLE 2.—*Chemicals and rates used in ripening experiments*

Site	Chemical	Source	Rate of active ingredient per acre
			Pounds
Loíza	Gibberellic acid (GA)	ICI	0.110 (GA/Dalapon)
		Merck	0.041 (GA/Silicon)
	Dalapon (Na salt of 2.2 dichloropropionic acid) 85%	Dow	3
	Sodium silicate	Merck	0.106
	Ethrel 68-250 (2-chloroethanephosphonic acid)	Amchem	2, 4, 6
	Pesco 1815 (150 gm./l. of 2 methyl, 4-chloro-phenoxy-acetic acid plus 48 gm./l. of 2,3,6-trichlorobenzoic acid)	Fisons	1.5, 3
	Banvel 60CS16 (Methyl-2-methoxy 3,6-dichlorobenzoate)	Velsicol	0.25, 0.5, 1
	Cycocel (2-chloroethyltrimethylammonium chloride)	Cyanamid	3, 6
	C.P. 41845 (N,N-bis (phosphonylmethyl)-glycine)	Monsanto	2, 4 (lb. actual)
Mercedita	Dalapon	Dow	3
	Gibberellic acid	ICI	0.110
	C.P. 41845	Monsanto	2, 4
	Pesco 1815	Fisons	1.5, 3
	Banvel (60CS16)	Velsicol	0.5, 2
Aguirre	C.P. 41845	Monsanto	2, 4 (lb. actual)
	Cycocel	Cyanamid	3, 6

The chemicals applied are listed together with their common names and sources of supply in table 2. All were applied in an aqueous solution at the rate of 50 gallons per acre,[3] and all solutions included 0.5 percent of the wetting agent Chevron X-77 (Alkylaryl polyoxyethyleneglycol). This volume of spray required two passes.

The three fully-sprayed rows were used for sampling and growth measurements. At each sampling date, 20 canes per plot were selected by a random number method. The first sample was taken from the central row and the subsequent two samples from the two outer rows. The third sample row was also used for measurement of elongation growth; 10 canes per plot (in each of four replicates) were marked at 50 cm. below the T.V.D. (top visible dewlap) at the time of spraying. Measurement from this mark to the new T.V.D. at weekly intervals gave the measure of elongation growth.

The cane samples were transported to the laboratory area where all leaves and sheaths were stripped to the last extended internode and the tops broken off. The 20-cane samples were weighed and hand-refractometer readings were taken from five canes per sample. Each of these five canes was punched in the second internode from the bottom and in the topmost mature internode (identified by color change); these Brix readings gave the "maturity index," i.e., the top-bottom Brix ratio as a percentage. The 20-cane samples were then passed through a silage-chopper, and a representative 500 g. sample (collected with a baffle) rapidly deep-frozen. The frozen samples were later analyzed by the "pol ratio" method (16) to obtain pol-percent-cane, Brix-percent-cane, fibre-percent-cane, sucrose-percent-cane (rendiment), and purity.

WEATHER

The ripening trials were established at the end of the harvest season with the intent of maintaining normal sucrose levels when the spring rains and high temperatures normally cause a decline. Weather conditions prior to, and during the experiments, must be considered in the evaluation of the responses obtained. Rainfall and temperature records are given in table 3.

The Island experienced a severe drought during February, March and April causing severe moisture stress at the Loíza site, and some moisture stress at the irrigated sites at Mercedita and Aguirre due to irrigation water shortage. Rain in early May induced active growth and the experiments were initiated. Growth rates in the control plots averaged 6 to 10 cm. per week during the first week of the experiments. Sugar contents were low, averaging about 10 pol-percent-cane in fresh, clean cane samples.

Showery weather continued for most of the experimental period but did not interfere with actual spraying operations. In the worst instance, some

[3] The use of 50 gallons of solution per acre is about ⅙ that needed to simulate greenhouse screening, but about 6 times greater than commercial aerial application.

TABLE 3.—*Weather data for Loiza, Mercedita, and Aguirre*

Week ending	Rain inches/week	Temperature °F.		Span of experiments[1]
		Maximum	Minimum	
LOIZA				
4/25	0.34	85	71	
5/2	.92	86	68	
5/9	3.30	88	71	a
5/16	1.40	83	70	a b c d
5/23	0	85	70	a b c d e
5/30	0	86	71	a b c d e
6/6	2.57	85	71	a b c d e f
6/13	1.59	86	72	a b c d e f g
6/20	11.13	85	73	a b e f g
6/27	.90	87	74	a b e f g
7/4	1.40	87	72	a b e f g
7/11	1.10	87	74	b g
7/18	1.26	87	74	g
MERCEDITA				
5/2	0	89	67	
5/9	3.80	88	71	
5/16	1.81	87	70	a e
5/23	.12	88	70	a e
5/30	0	88	72	a e
6/6	.15	91	72	a d e f
6/13	.02	86	74	a d e f
6/20	5.81	89	72	a d e f
6/27	1.20	88	73	a d e f
7/4	.28	86	72	a d f
7/11	3.23	89	73	a d f
AGUIRRE				
5/23	0.20	90	69	
5/30	.10	91	72	
6/6	.30	89	73	e g
6/13	.25	91	74	e g
6/20	6.55	83	75	e g
6/27	1.05	88	74	e g
7/4	1.60	87	74	e g
7/11	.85	87	75	e g

[1] a = GA/Dalapon, b = GA/Si, c = Ethrel, d = Pesco 1815, e = C.P. 41845, f = 60CS16, g = Cycocel.

light rain fell about 1 hour after spraying was completed. Heavy rains during the third week of June caused severe flooding at all sites and prevented sampling on one occasion in each of four trials. Details of actual sampling intervals are given in table 3. Some lodging occurred after the rains, so that lodged canes were unavoidably included in some later samples.

There were varying trends in sucrose quality from May to July at the various sites. The cane at Loíza showed a declining quality whereas that at Aguirre had an increasing quality. Mercedita was intermediate, showing little change to moderate declines. For example, the percent purity values of the control plots in C.P. 41845 trials were:

	Weeks after application		
Site	*2*	*4*	*6*
Aguirre	73.5	76.7	79.8
Loíza	82.5	88.3	76.3
Mercedita	78.0	81.1	76.1

Increases in sucrose and purity at the Loíza and Mercedita trials would imply that the applied compounds were able to prevent sucrose decline under unfavorable weather conditions; whereas, increases at Aguirre would imply that these compounds could cause increases in sucrose and purity even with favorable ripening conditions.

RESULTS

Graphical presentation has been used to summarize the data from all trials. The data for maturity index, weight of 20 canes, and fiber-percent-cane are not presented, as these indices failed to give any significant differences among treatments, except in 3 trials, nor did they give any trends which might be used in the interpretation of the data. Instances in which these indices show a significant difference in relation to the control are mentioned in the text. A circle is used in the graphs to indicate where a significant difference (at the 5-percent level) of a treatment occurred on a given sampling date compared to the control.

Changes in purity-percent-cane are not further discussed because there were no significant differences.

C.P. 41845 (FIGS. 1, 2, AND 3)

Growth rates were depressed significantly by both application rates of C.P. 41845 at Aguirre starting at the 4-pound rate at 2 weeks after application and then at 4 weeks with both rates with a significant recovery at 6 weeks for the 2-pound rate (fig. 3). Despite the severe reduction in growth rate at the 4-pound level, the weight of 20 canes for the various sampling

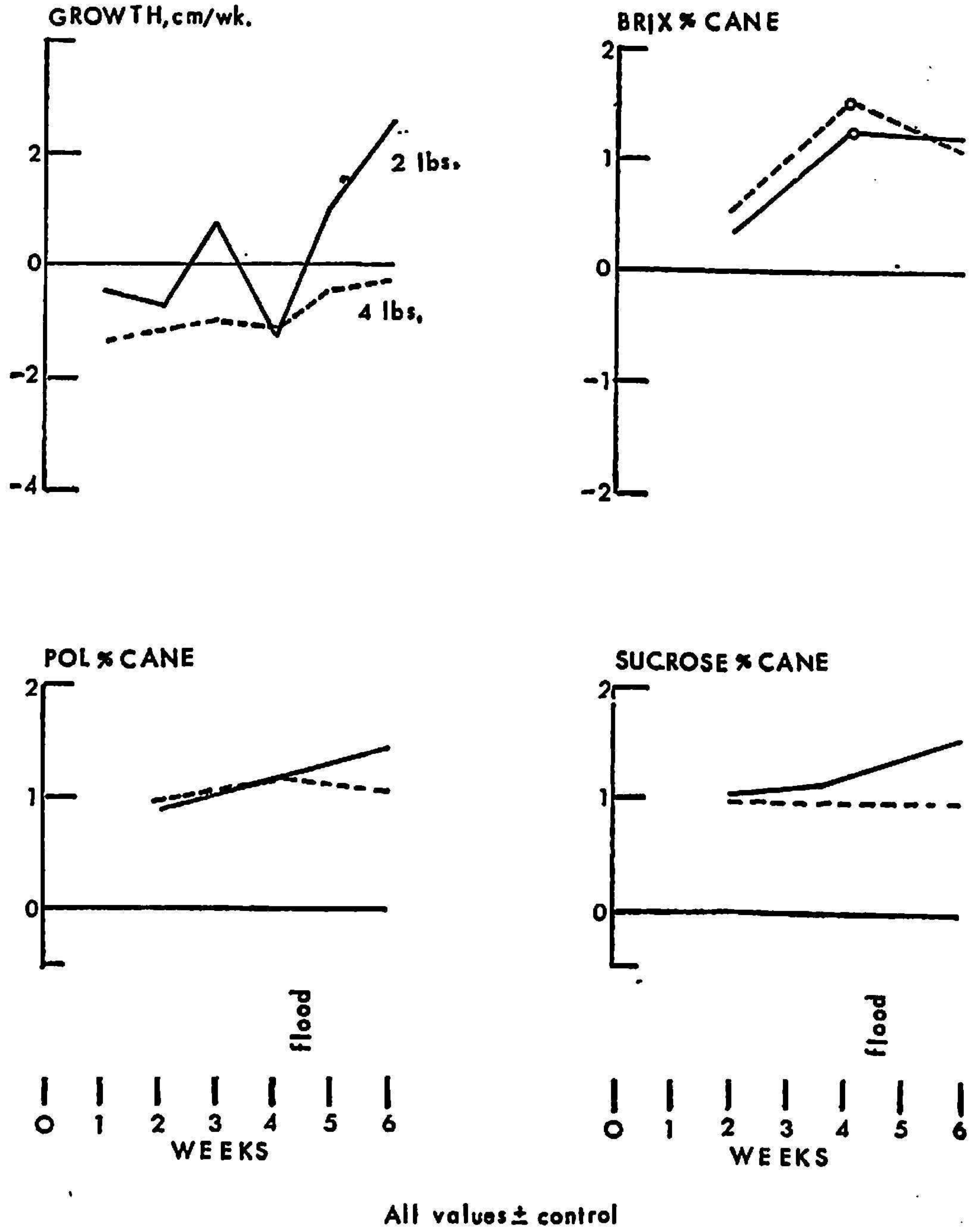

FIG. 1.—Effect of C.P. 41845 on cane at Loíza.

dates did not show any significant difference from that of the control treatment.

Improvement in levels of pol, Brix, and sucrose-percent-cane varied with site of experiment and time of planting. The means of all three sampling dates indicated significant increases for pol, Brix, and sucrose-percent-cane values at Loíza and Mercedita, but not at Aguirre (table 4). Percent purity showed no significant changes at the three sites.

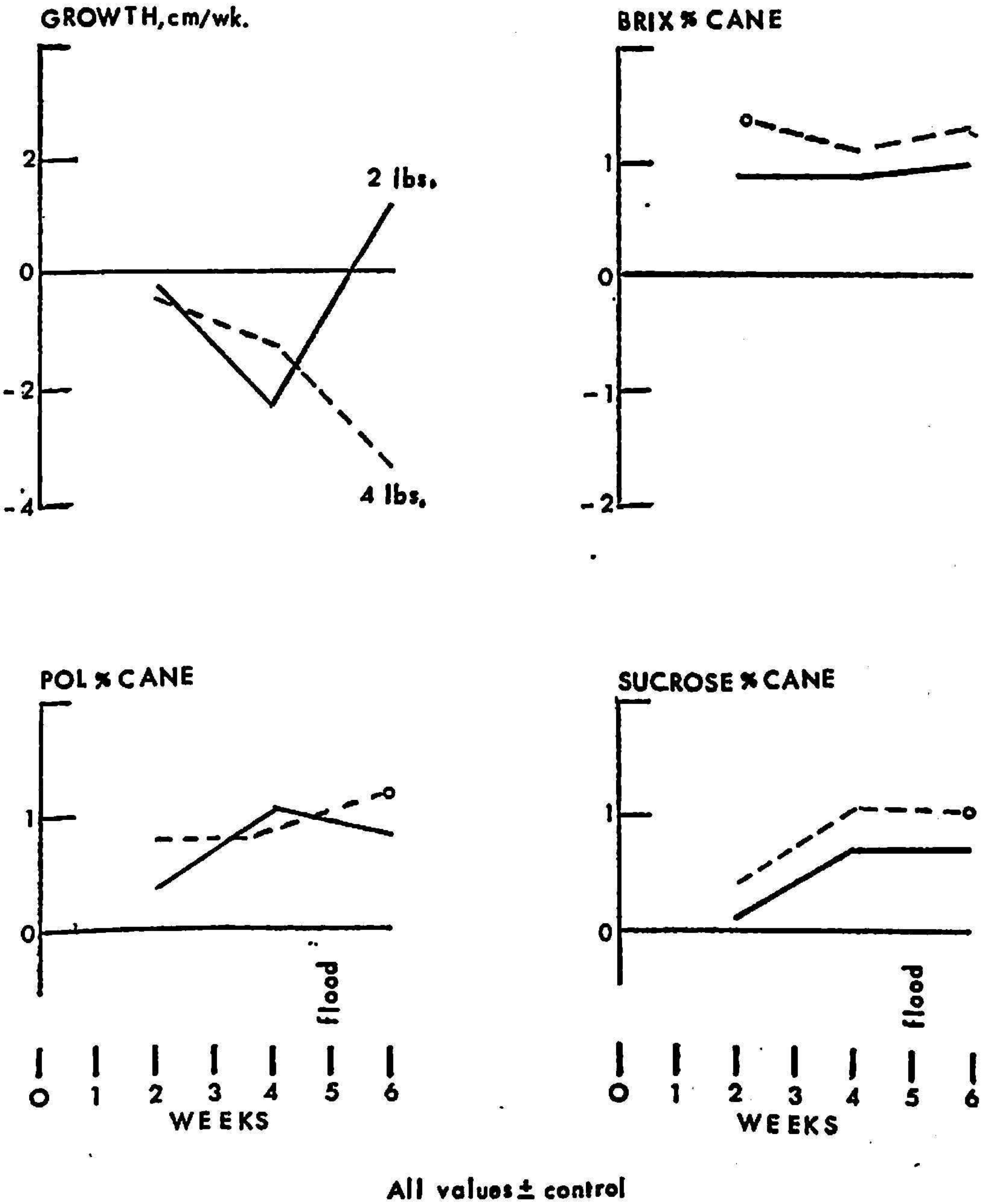

FIG. 2.—Effect of C.P. 41845 on cane at Mercedita.

For the individual sampling dates, Brix values were higher for both rates at 4 weeks after application at Loíza and at 2 weeks for the 4-pound date at Mercedita. Pol and sucrose-percent-cane levels were higher for the 4-pound rate at 6 weeks after application at the Mercedita trial.

CYCOCEL (FIGS. 4 AND 5)

Neither trial showed any indication of a ripening response for any of the sucrose components at the 3- and the 6-pound rate per acre of Cycocel applied.

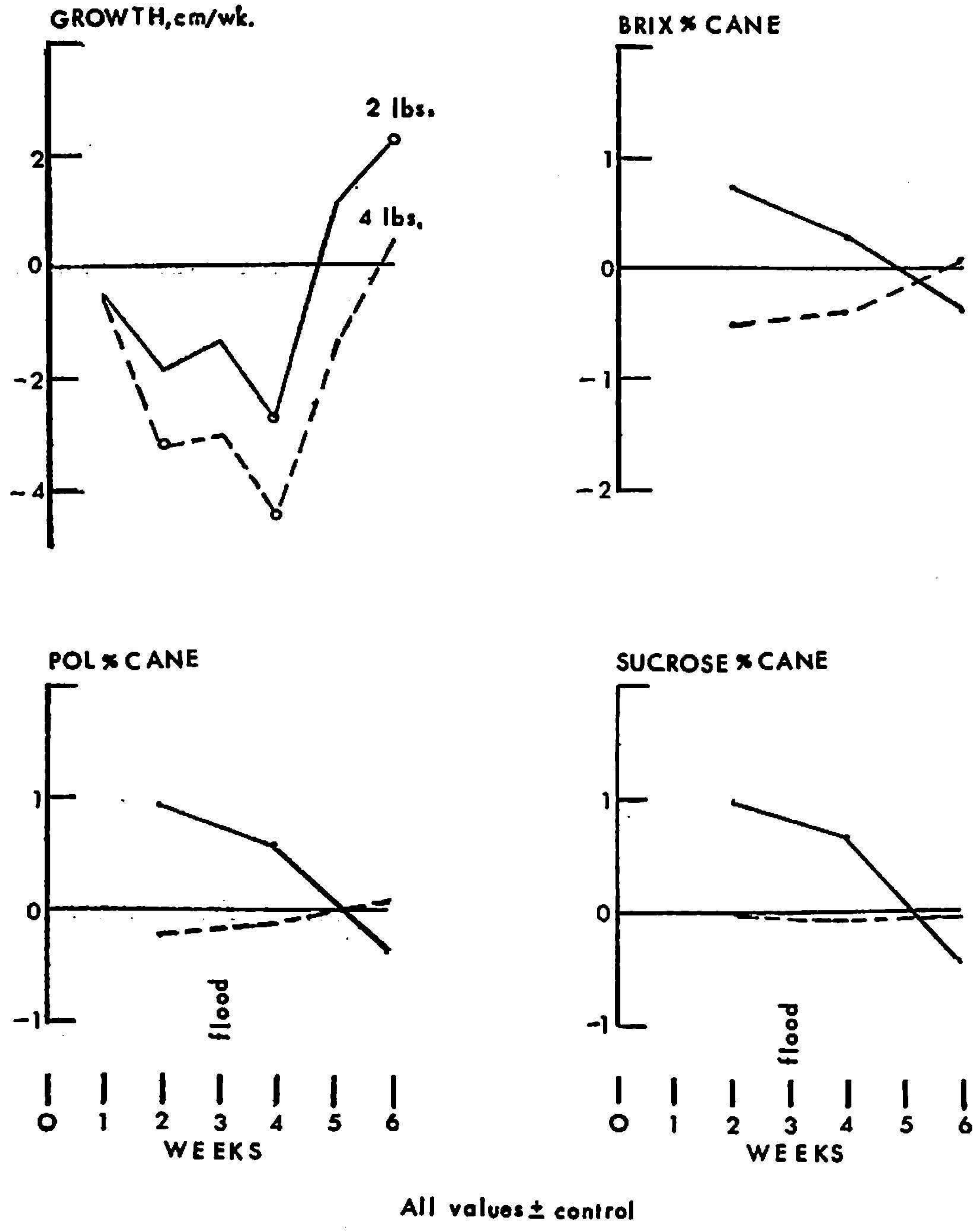

FIG. 3.—Effect of C.P. 41845 on cane at Aguirre.

ETHREL (FIG. 6)

Significant depressions in growth rate occurred with all rates at the first week after application, with recovery of growth being slower as the rate of application increased. The growth depression continued for 3 weeks at the 6-pound rate. Following the recovery from growth depression, the Ethrel-treated canes showed a significant stimulation of growth for all rates at 4 weeks after application. The influence of Ethrel as a growth depressant and stimulant of sugarcane was also noted by Alexander and Montalvo in green-

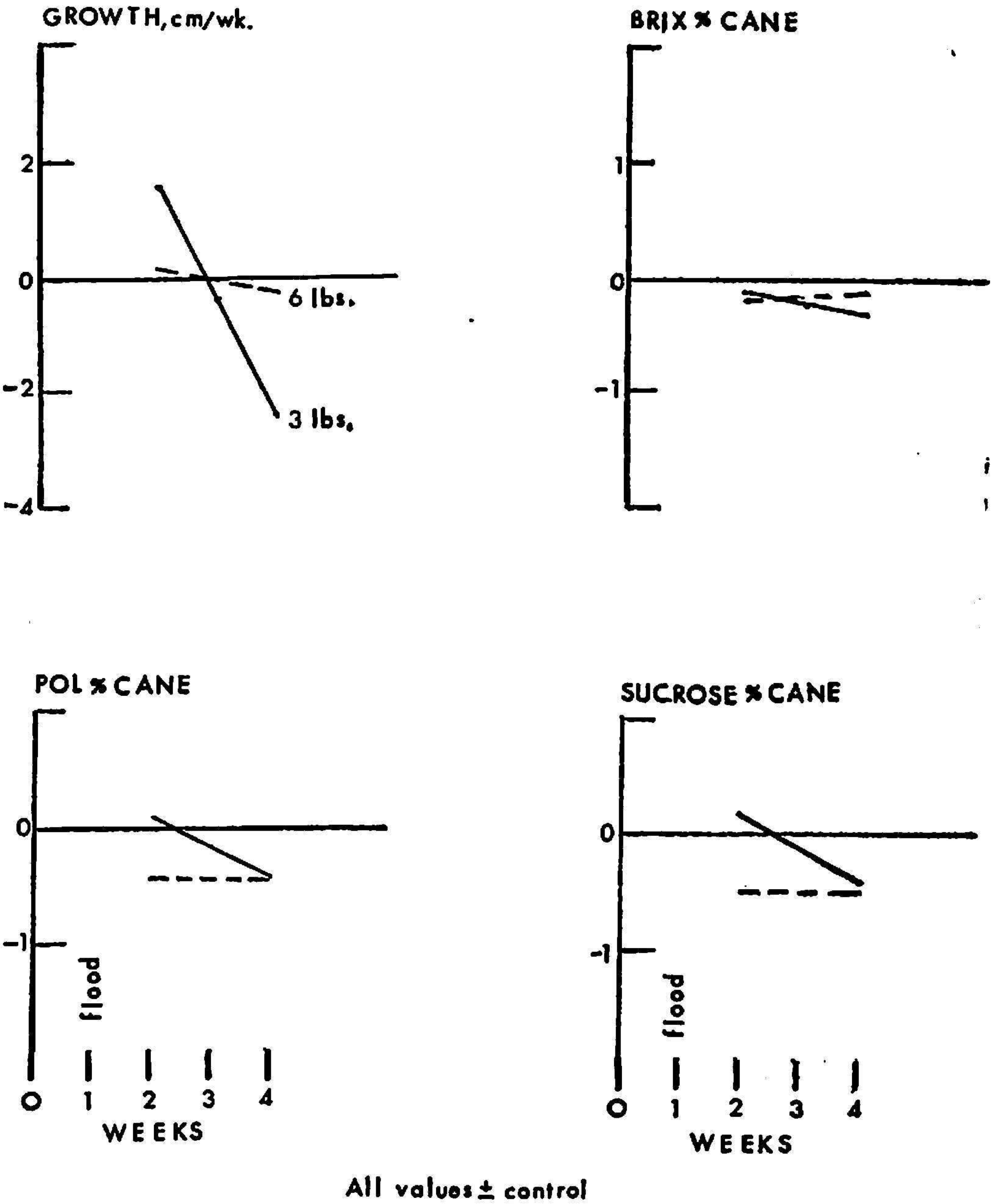

FIG. 4.—Effect of Cycocel on cane at Loíza.

house experiments (3). The depressant and stimulatory growth effects apparently cancelled out as far as influence on cane weight, because there was no significant effect on weight of 20 canes for the Ethrel applications.

The most obvious visual effect, however, was a partial desiccation and defoliation; for example, the number of green leaves per stalk at 2 weeks were:

Control	*2-pound rate*	*4-pound rate*	*6-pound rate*
8.5	6.4	5.6	5.4

(Least significant difference between means 0.88 at the 5-percent level).

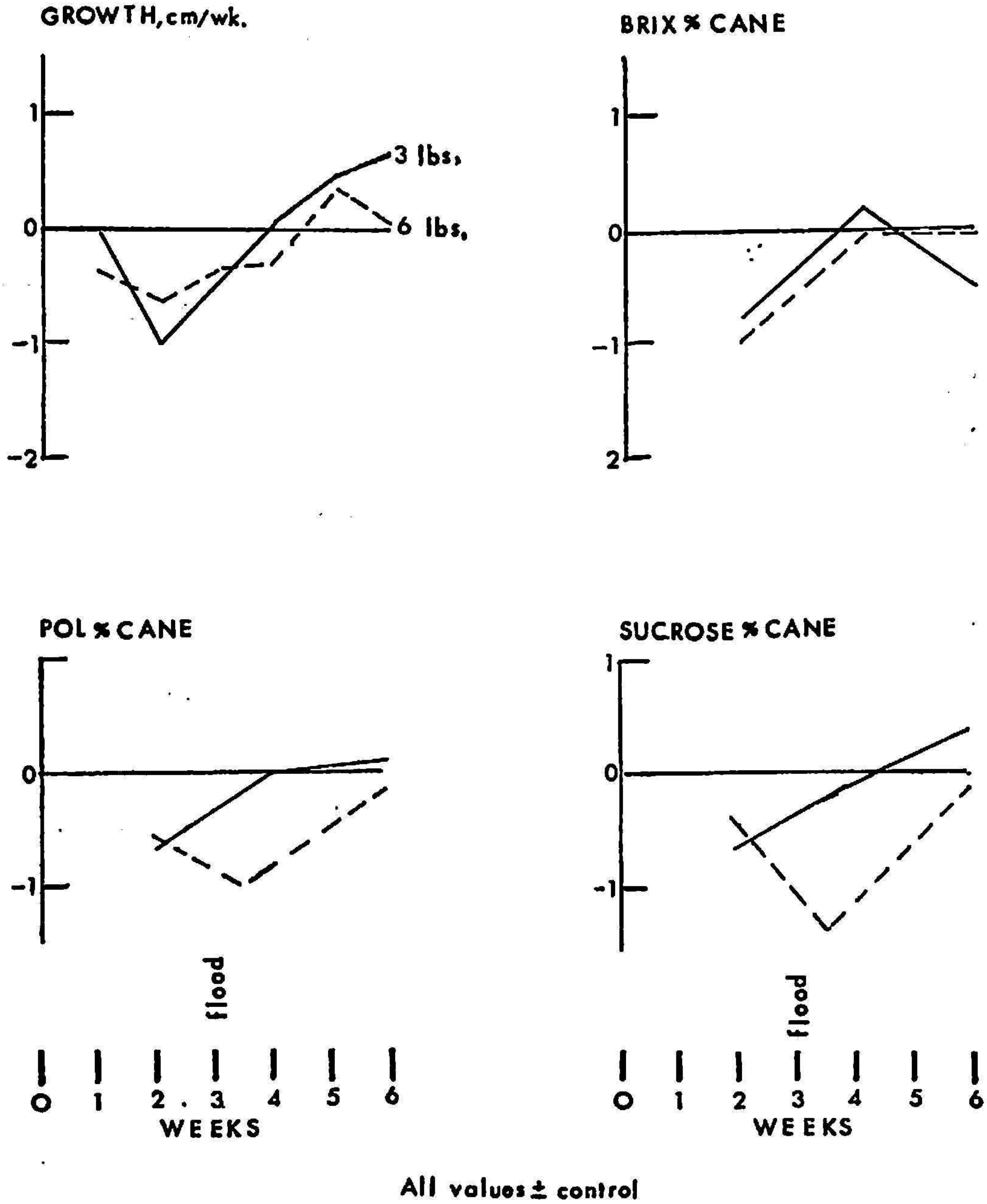

FIG. 5.—Effect of Cycocel on cane at Aguirre.

Sucrose components were severely reduced throughout the span of the trial with significant reduction in pol, Brix, sucrose-percent-cane and purity, varying for the sampling dates and rates applied.

GIBBERELLIC ACID (GA)/DALAPON (FIGS. 7 AND 8)

Growth curves were somewhat similar for Dalapon at both trial sites with growth suppression significant at 4 and 8 weeks after application at Loíza (fig. 7) and 6 weeks at Mercedita. Weight of cane was significantly depressed at Loíza at 4 weeks after application. Dalapon had a marked

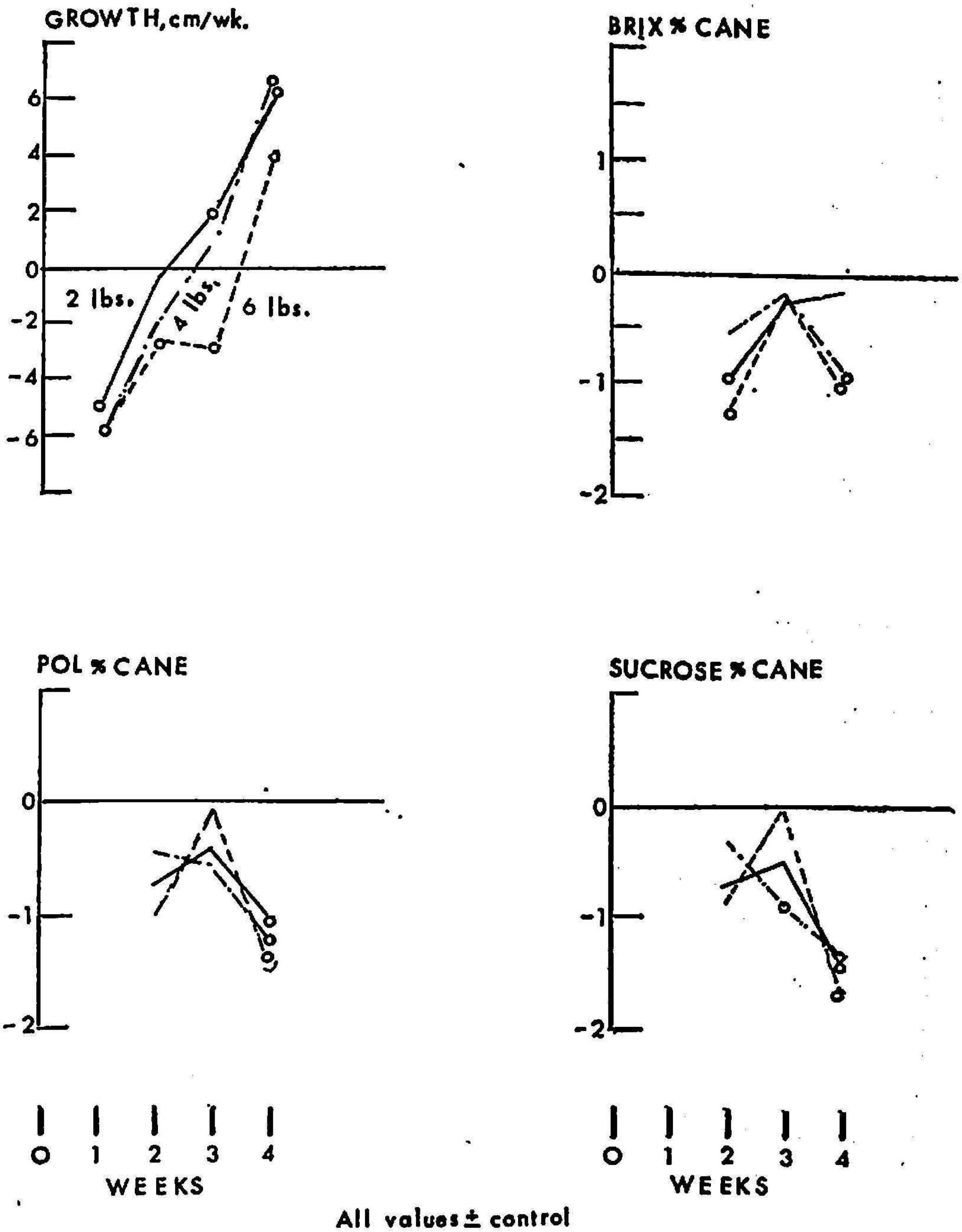

FIG. 6.—Effect of Ethrel on cane at Loíza.

depressing effect on growth and cane weight at Loíza, yet failed to induce ripening in any of the sucrose components. The Brix level was significantly increased at 4 weeks after application at Mercedita, but levels dropped sharply at 6 and 8 weeks after. No significant increases were found at Mercedita for pol, sucrose-percent-cane, or purity. Thus, the increase in Brix at 4 weeks must be considered an isolated instance.

GA alone strongly stimulated growth rates at 1 week after application at both sites. The stimulation in growth was followed by retardation to

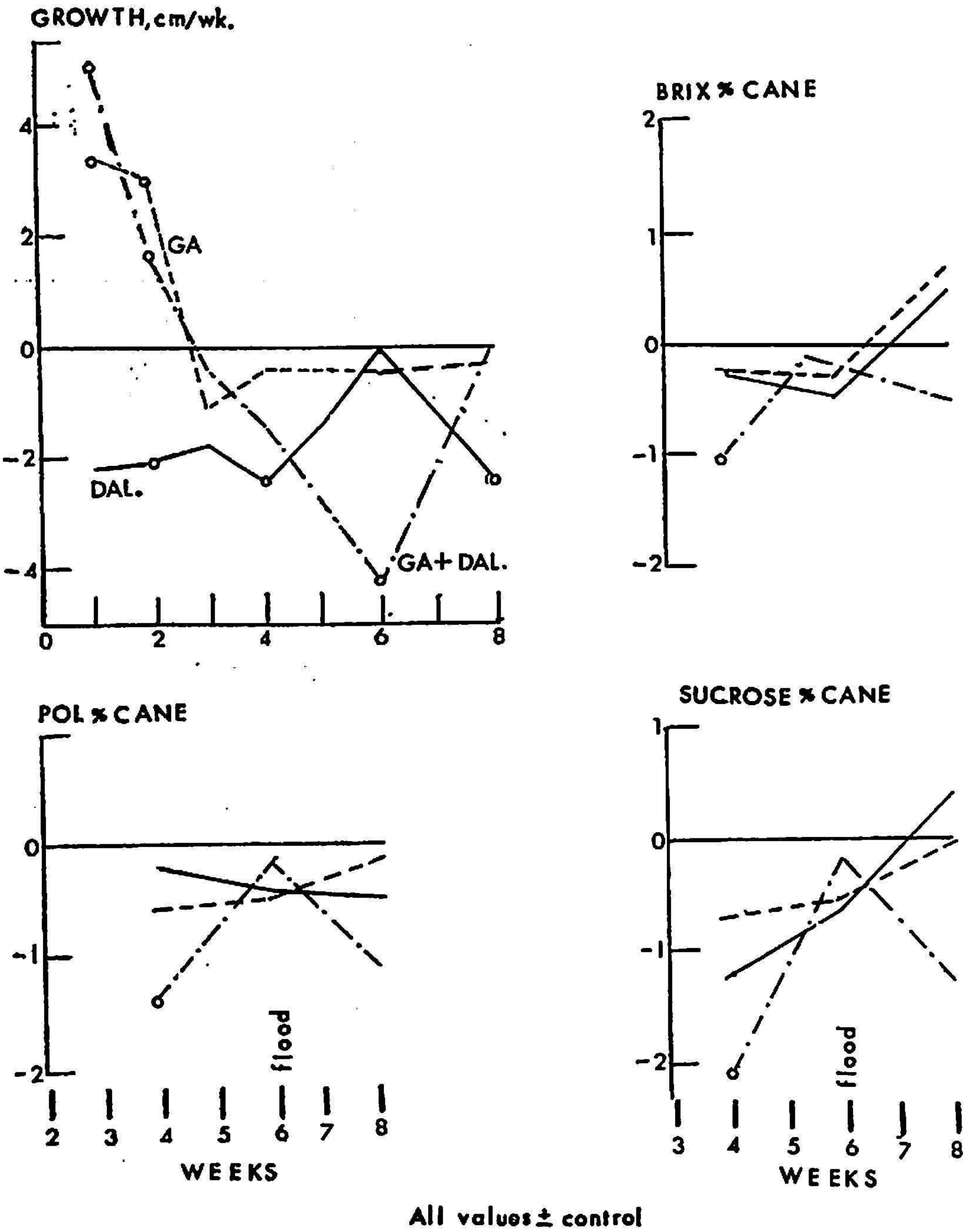

FIG. 7.—Effect of GA and Dalapon on cane at Loíza.

levels no different than the control 2 weeks after application for Loíza and to levels significantly lower than the control at 6 weeks at Mercedita (fig. 8).

Weight of cane was significantly depressed at Mercedita at 4 weeks after GA application although growth rates were still above those of the control (fig. 8). Apparently, the growth stimulation of GA on the cane at Mercedita was not of sufficient magnitude to give an accompanying gain in cane weight. GA failed to induce ripening at either trial, and it produced a

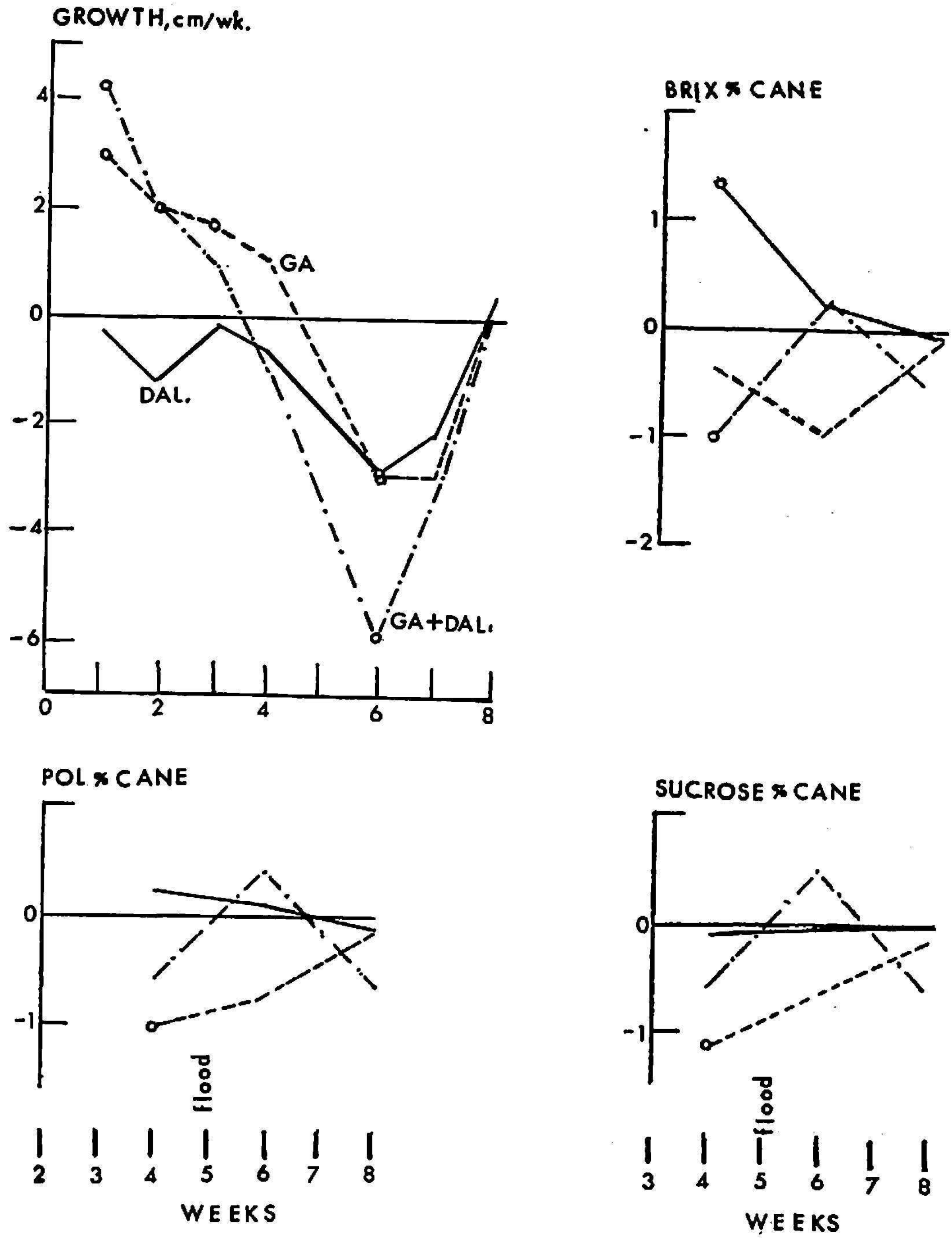

FIG. 8.—Effect of GA and Dalapon on cane at Mercedita.

significant decrease in pol at 4 weeks after application at Mercedita, and a decrease in maturity index at 6 weeks at Loíza.

The GA plus Dalapon mixture gave growth responses similar to GA alone rather than intermediate between the GA or the Dalapon growth curves for the first week after application. After the first week of application the growth rates were suppressed for GA plus Dalapon to levels below those of the control. Significant decreases of pol, Brix, sucrose-percent-cane were obtained at 4 weeks after application of GA plus Dalapon with no recovery of any of the sucrose components to values greater than the control. The maturity index was significantly decreased at 6 weeks at Mercedita and fiber-percent-cane at Loíza also at 6 weeks after application.

GA/SILICON (FIG. 9)

Growth responses to the low rate of GA applied in the trial at Loíza were very similar to those obtained from the higher application rate in

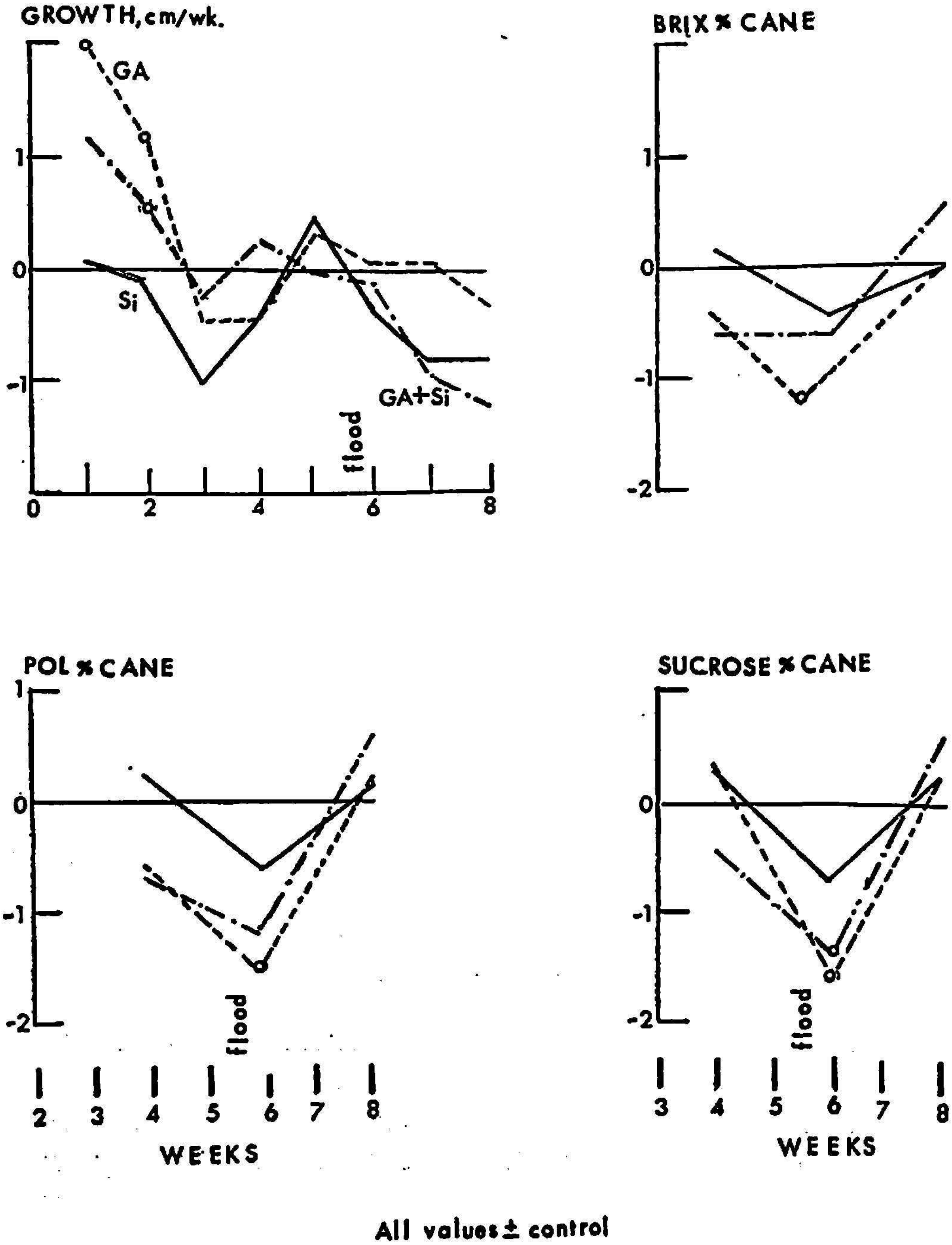

FIG. 9.—Effect of GA and silicon on cane at Loíza.

the GA/Dalapon trial (fig. 7). The increase in growth was significant at the first week after application. Quality was adversely affected by the GA application giving significant decreases at 6 weeks after application for pol, Brix, and sucrose-percent-cane.

The application of silicon failed to give any positive growth effects nor increases in cane weight. There was a significant decrease in sucrose-percent-cane at 6 weeks after application.

The GA plus silicon treatment was intermediate in its action on growth and sucrose when compared to the action of the GA or silica treatments alone. The only significant response obtained for the GA plus silica treatment was increase in fibre-percent-cane at 4 weeks after application.

PESCO 1815 (FIGS. 10 AND 11)

Growth rates were significantly reduced 1 week after application of both rates of Pesco 1815 at both sites, but thereafter growth rates returned to values similar to that of the control. Weight of 20 canes showed a significant increase at 4 weeks after application at Mercedita for both rates.

Ripening effects were variable. At Loíza there was a significant decrease in sucrose-percent-cane at 2 weeks after application for the 1.5-pound rate. Maturity index values indicated lower values for the control for the 3-pound rate, but not 1.5 for the same date. There were no favorable increases in any of the sucrose components at Loíza, whereas at Mercedita, Brix values at 4 weeks after application of the 1.5-pound rate were significantly higher than the control (fig. 11).

60CS16 (FIGS. 12 AND 13)

Growth rates responses were significantly higher 1 week after application for the 1-pound rate at Loíza, otherwise no significant changes in growth were influenced by the materials applied.

Quality changes of the sucrose components were negative as compared to the control, with a significant decrease in Brix and sucrose-percent-cane 3 weeks after application and 1 week after flooding at Loíza and for Brix at Mercedita. Fibre-percent-cane was significantly increased at Mercedita for both rates at 3 weeks after application.

DISCUSSION

EXPERIMENTAL RESULTS

In two of the three field trials C.P. 41845 proved to be a good sugarcane ripener, giving significant increases in cane quality. The percent increases in sucrose components using C.P. 41845 as a sugarcane ripener are given in table 4.

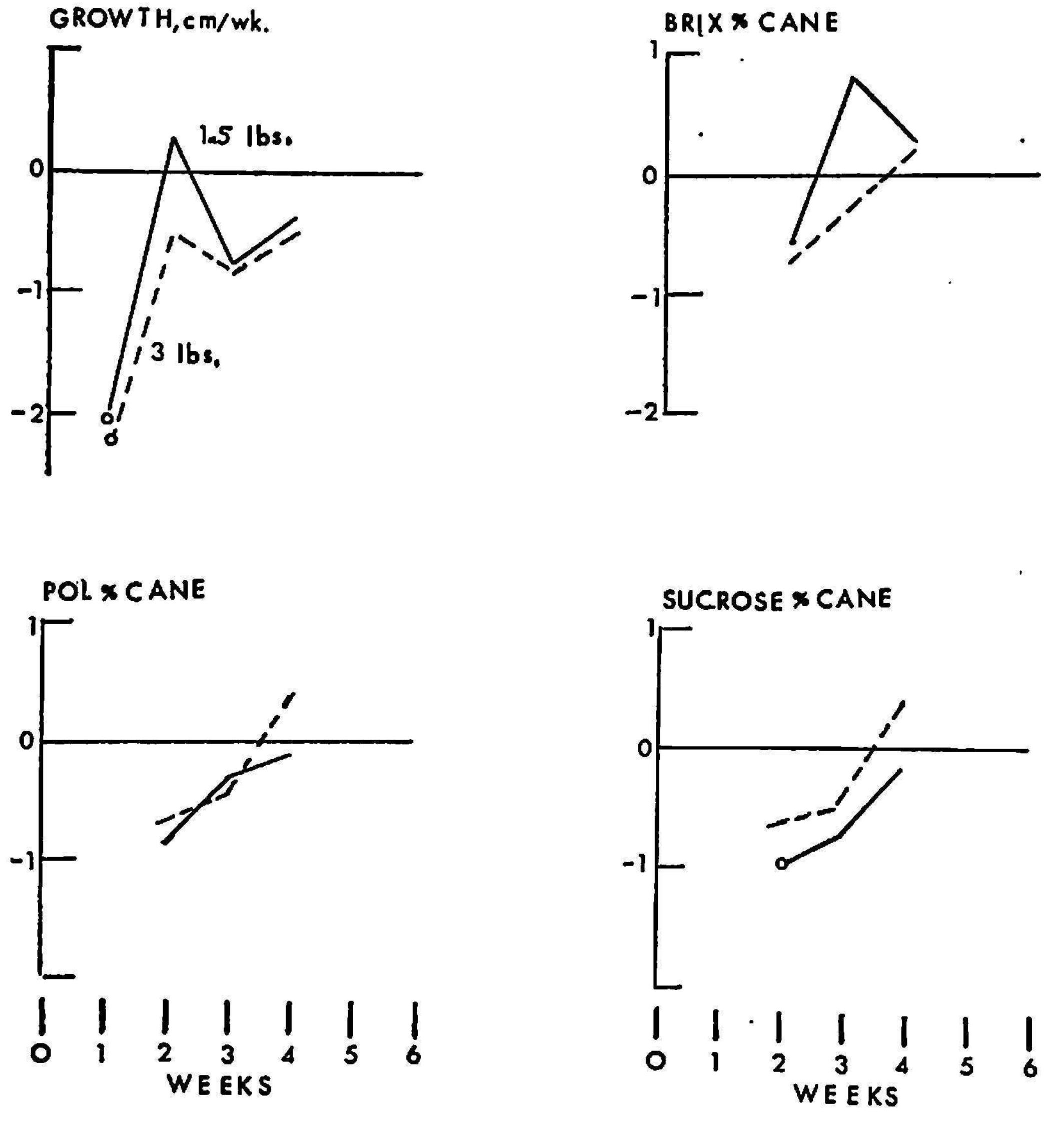

FIG. 10.—Effect of Pesco 1815 on cane at Loíza.

The question arises as to why increases in sucrose components were obtained with C.P. 41845 applications at Loíza and Mercedita, but not at Aguirre. Differences in varietal response might be an answer, as a different variety was presented at each site (table 1) due to circumstances beyond the control of the authors. Differences in varietal responses to sugarcane ripening compounds have not been noted, however, by other research workers (18).

Another factor to consider in the differences in ripening responses to C.P. 41845 is that the natural ripening of the control plots at Aguirre was different as compared to Loíza and Mercedita. The percent purity values of the control plots for the 2, 4, and 6 weeks after sampling are given in the weather section.

The control plots at Aguirre had increasing purity values as time of sampling increased from 2 to 6 weeks. This happened despite a rainfall of 5.81 inches at 3 weeks which caused local flooding. The Loíza and Mercedita trials control plots increased in purity for the 2- to 4-week interval, but then decreased with the 4- to 6-week interval. This decrease occurred during the period when rainfall caused severe local flooding at the two sites (table 1 and figs. 1 and 2).

A possible explanation of the differences in response to C.P. 41845 application at the various sites might be that under conditions of favorable

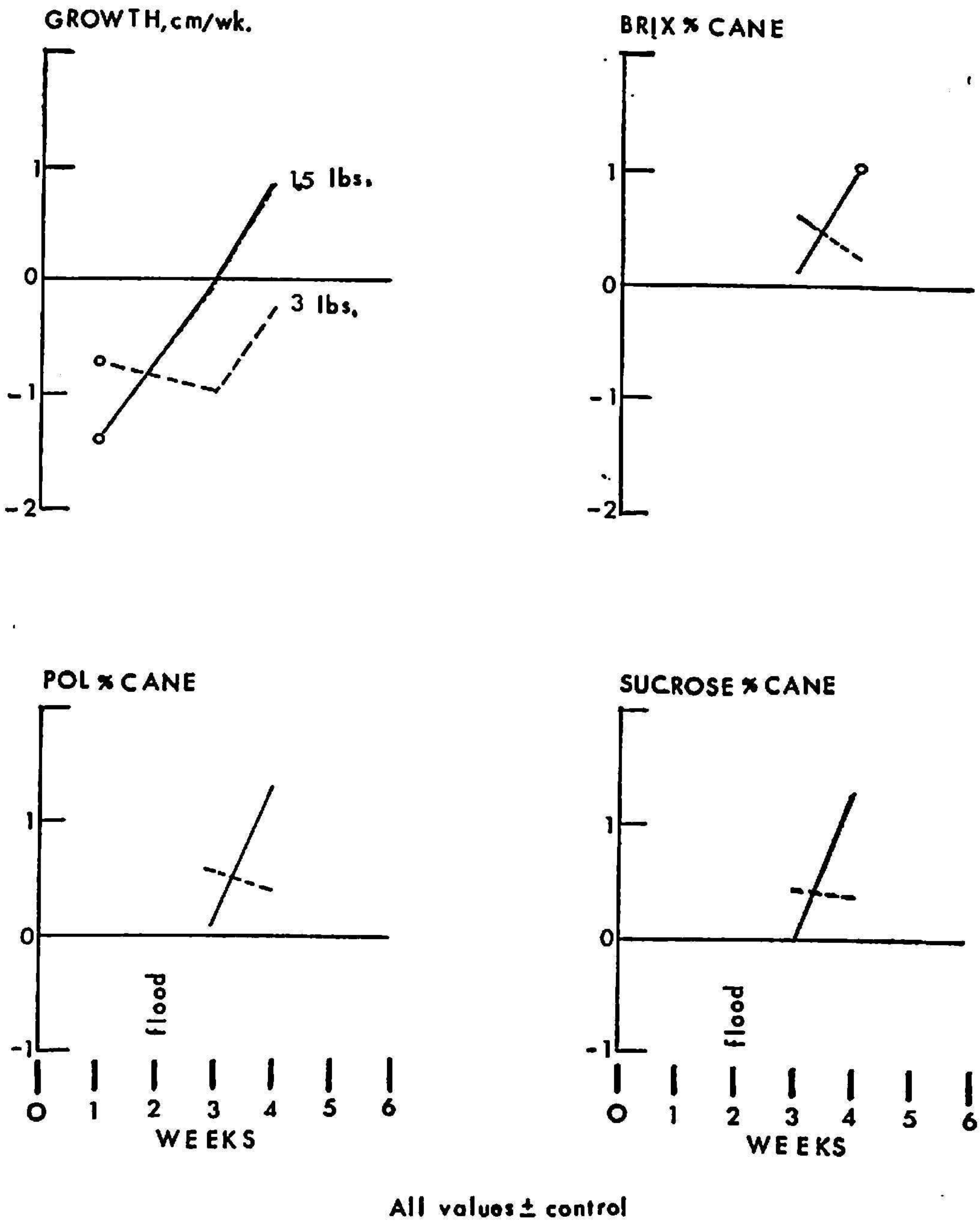

FIG. 11.—Effect of Pesco 1815 on cane at Mercedita.

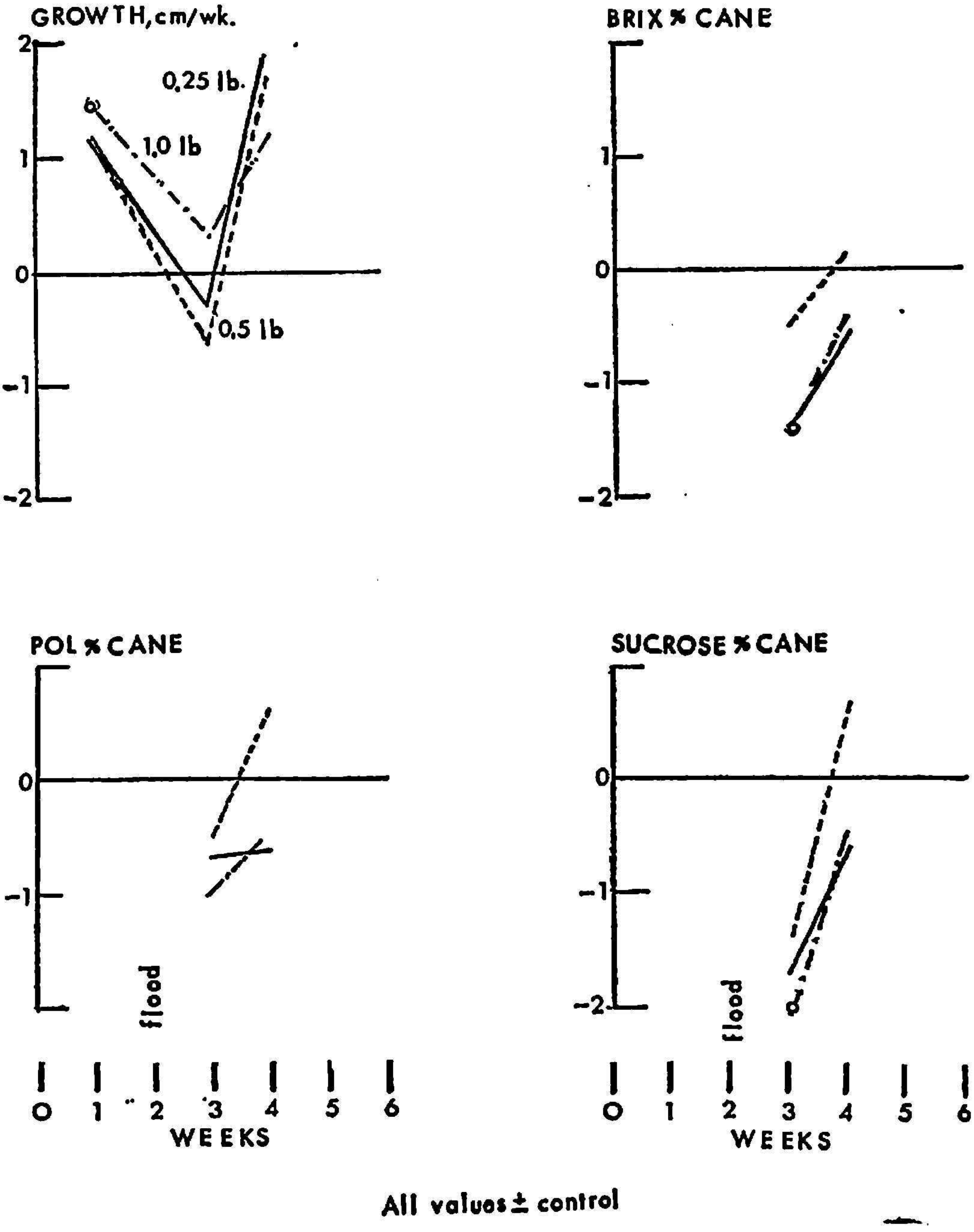

FIG. 12.—Effect of 60CS16 on cane at Loíza.

natural ripening (Aguirre) C.P. 41845 was not able to make any significant contribution to ripening. However, when natural ripening did not proceed normally (Loíza and Mercedita), C.P. 41845 could make a significant contribution to the ripening of the cane.

Pesco 1815 was the only other ripener compound tested which caused positive increases in all sucrose components (table 5). The ripening effect was evident at the Mercedita trial, but not at Loíza. A different variety was used at each site, thus a variety-compound interaction might have

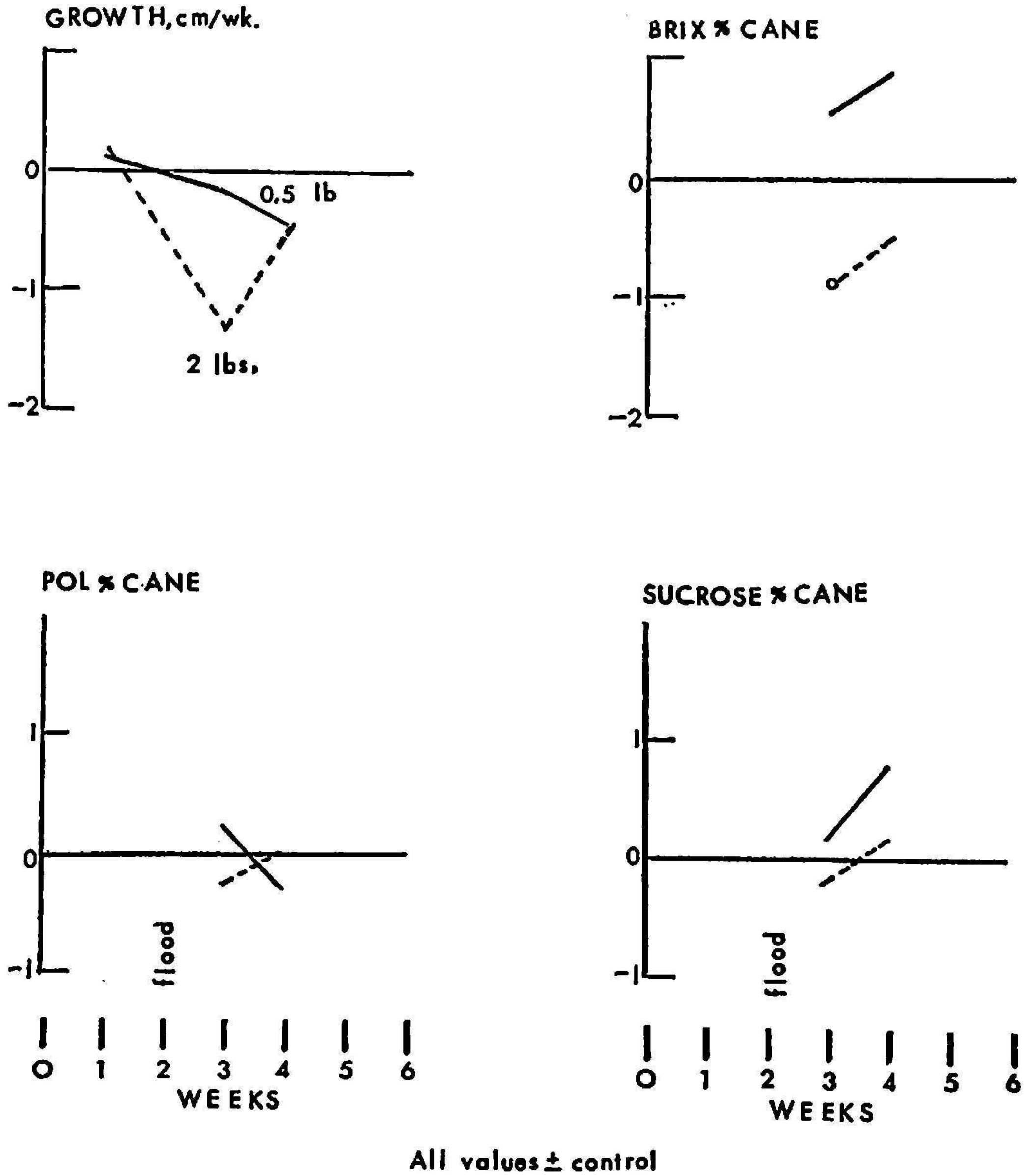

FIG. 13.—Effect of 60CS16 on cane at Mercedita.

taken place. Yet, such varietal-compound interaction was not noted by Yates with Pesco 1815 in Jamaica (23).

There were some differences in rainfall for the two trial sites (table 3) with heavy rainfall and resulting flooding occurring before the Loíza trial and in the middle of the Mercedita trial, thus preventing the taking of the 2-week-after application sample. Purity values increased in the control plots at both sites 4 weeks after application.

	Weeks after application		
Site	*2*	*3*	*4*
Loíza	79.5	80.0	82.3
Mercedita	—	61.2	65.9

The Mercedita trial had very low purity values as well as sucrose-percent-cane compared to the Loíza trial for the mean of the three sampling dates.

Site	*Sucrose-percent-cane*	*Purity*
Loíza	9.47	80.8
Mercedita	5.00	63.6

For the Pesco 1815 trials there were rising purity values as described for C.P. 41845 at Aguirre and no increase in sucrose components might have been expected. Yet, at Mercedita, the level of sucrose components were so low that even natural ripening did not have a chance to make its full effects felt. The ripening influence of Pesco 1815 could have value under these conditions.

TABLE 4.—*The influence of C.P. 41845 as a sugarcane ripener for mean of all sampling dates*

Treatment per acre	Pol percent cane	Brix percent cane	Sucrose percent cane	Purity percent
		Loíza		
Control	10.88 a[1]	13.17 a	9.03 a	82.4 a
2 lbs.	12.02 b	14.03 b	10.28 b	85.6 a
4 lbs.	11.90 b	14.13 b	10.06 b	84.2 b
		Mercedita		
Control	10.58 a	13.48 a	8.62 a	78.5 a
2 lbs.	11.34 b	14.36 b	9.34 b[2]	79.0 a
4 lbs.	11.51 b	14.77 b		78.0 a
		Aguirre		
Control	10.32 a	8.73 a	8.61 a	76.7 a
2 lbs.	10.73 a	9.41 a	9.03 a	78.5 a
4 lbs.	10.25 a	9.27 a	8.55 a	77.9 a

[1] A different letter alongside the treatment indicates a significant difference at the 5-percent level between this treatment and others not having this letter.
[2] The mean of the 2- and 4-pound treatment.

Banvel 60CS16 showed positive increases in Brix, sucrose-percent cane, and purity at Mercedita, and none at Loíza. Here again control plot sucrose components were very low for the Mercedita trial for the mean of all three sampling dates

Site	*Sucrose-percent-cane*	*Purity*
Loíza	8.23	77.6
Mercedita	5.08	63.7

TABLE 5.—*The percent increase in sucrose components over unsprayed control when using chemical ripeners for sugarcane*

Experiment	Site[1]	Chemical, pounds per acre		Percent increase over control, average of all samplings for— Pol percent cane	Brix percent cane	Sucrose percent cane	Purity percent
C.P. 41845	L	C.P. 41845	2	+10.5**[2]	+6.6*	+14.1*	+4.1
			4	+9.4**	+7.3*	+11.4*	+2.3
	A		2	+4.0	—	+4.7	+2.0
			4	−0.7	—	−0.7	+1.6
	M		2	+7.2*	+6.5*	+7.9*[3]	+0.6
			4	+8.7*	+9.6*	+10.5*	−0.7
Cycocel	A	Cycocel	3	−2.0	—	−1.5	+0.8
			6	−6.1	—	−11.9	−3.5
	L		1.5	−1.5	−1.8	−1.2	0
			3	−4.4	−1.2	−6.3	−3.2
Ethrel	L	Ethrel	2	−7.9	−3.8	−11.2	−5.2
			4	−7.5	−4.5	−11.1	−3.5
			6	−8.9	−6.2	−11.0	−2.8
GA/Dalapon	L	Dalapon	3.0	−0.5	−0.8	−4.5	+0.5
		GA	0.11	−3.1	+0.7	−5.2	−3.2
		GA+Dalapon		−9.5	−4.5	−15.5	−4.3
	M	Dalapon	3.0	+0.6	+8.6	−0.5	−2.9
		GA	0.11	−6.1	−4.0	−7.2	−2.0
		GA+Dalapon		−2.8	−3.7	−2.5	+0.8
GA/Silicon	L	Silicon	0.11	0	−0.5	−1.2	0
		GA	0.041	−6.0	−4.5	−9.1	−2.0
		GA/Silicon		−2.8	−1.5	−6.0	−0.5
Pesco	L	Pesco	1.5	−3.5	+1.1	−6.5	−3.5
			3.0	−2.1	−2.0	−2.1	+0.8
	M		1.5	+8.4	+4.6	+12.0	+3.9
			3.0	+6.0	+3.8	+8.1	+3.0
Velsicol	L	60CS16	0.25	−7.5	−8.0	−11.7	−1.8
			.5	0	+0.8	−4.5	0
			1.0	−7.2	−7.2	−11.7	−3.1
	M		0.5	−0.7	+10.5	+9.5	+3.0
			2.0	−1.5	−6.8	0	+2.7

[1] A = Aguirre, L = Loíza, M = Mercedita.

[2] ** Significant difference at the 1-percent level; * significant difference at the 5-percent level.

[3] Significant difference at the 5-percent level for chemical (2 and 4 pounds averaged together) vs. the control.

The differences in response to 60CS16 at the two sites may be explained by the same mode of action suggested for the Pesco 1815 experiments.

It is not to be implied that reasoning for differences in responses to the ripening compounds C.P. 41845, Pesco 1815, and 60CS16, because of weather conditions and natural ripening levels, can explain the action of all compounds tested. Falling sucrose and purity levels were present at Loíza at the GA/Dalapon and GA/silicon trials, but no positive responses were found.

The Cycocel experiment failed to achieve any positive increases in any of the sucrose components at Loíza (table 5). It must be assumed that these compounds lacked the capability to increase sucrose components under the rates and conditions applied, although room existed for ripening to proceed.

One point merits further consideration. Bieske (9) mentioned that the use of C.P. 41845 showed a detrimental residual effect in the next crop in relation to shoot population although stalk length was increased. Final effects on harvest results were not given. Waud in Romana, Dominican Republic,[4] also reported a decrease in germination of the ratoon after C.P. 41845 treatment, although final effects on harvest results are not yet available.

Alexander and Montalvo-Zapata (3) in a greenhouse experiment evaluation of C.P. 41845 as a chemical ripener found severe restriction in shoot weight but not in number of shoots. Samuels[5] found no loss in shoot count with a ratoon crop of P.R. 980 which had been treated with 2, 4, and 6 pounds of this compound per acre. The shoot counts per foot were:

Rate per acre C.P. 41845	*Shoot count per foot*
0	5.4
2	5.3
4	5.8
6	5.2

The possible factor of decreasing shoot population should be evaluated in future experiments.

EXPERIMENTAL TECHNIQUES

Application of sprays to the canopy of full grown cane, on a scale suited to small-plot experimentation, is very difficult. The techniques adopted have varied from micro application in specially erected tents (11), through using standard knapsack sprayers fitted with "goal-post" booms (18), to aerial spraying (20). In the series of experiments here described, the

[4] Personal communication.

[5] Unpublished data.

simplest possible equipment was utilized: A small pneumatic knapsack sprayer fitted with a long lance to spray through a single nozzle above the canopy. The pneumatic sprayer obviated the inconvenience of a pumping handle inside tall cane. The long lance was strong and light but had only a small liquid storage capacity as the spray liquid was fed up a narrow-diameter plastic tube. The wide-angle nozzle sprayed from row center to row center without the necessity for a cumbersome boom. All these items were readily available as standard commercial equipment.[6] This equipment proved highly reliable and, under the wind-free conditions following dawn, spray application could be limited precisely to plot boundaries.

Field application was made at a dilution of 50 gallons per acre, which is considerably in excess of normal aerial-spray volumes. This volume differ-

TABLE 6.—*Average standard errors of differences between means, based on variances of treatment × sampling data interaction*

Item	6 replicates (from 7 trials)	4 replicates (from 4 trials)	Desired level of precision
Weight/20 canes	4.59	4.44	4
Maturity index	3.39	4.18	3
Pol percent cane	0.54	0.54	0.5
Brix percent cane	0.48	0.56	0.5
Fibre percent cane	0.72	0.85	0.75
Rendiment	0.61	0.61	0.5
Purity cane	2.54	2.65	3
		(from 10 trials)	
Growth (cm./week)	—	1.18	1.5

ence is unlikely to affect results for two reasons: First, some potential ripeners may be expected to be readily translocated (for example, those expected to affect the growing points after leaf application); second, aerial spraying is normally done in the early morning when leaves are often wet with dew, in an amount equivalent to 200 gallons per acre.

The precision of the data obtained is of interest. The sample size of 20 canes per plot was based on the work of Yates (22). This was expected to give accurate estimates of quality (in erect cane), but not of cane weight. Only 10 canes per plot were selected for growth measurements, and these were limited to four replicates.

Inspection of figures 1 to 13 indicate that somewhat greater precision was desirable. The average standard errors for the various parameters are given in table 6 for 4-replicated and 6-replicated trials, respectively. Estimates of desired levels of precision (i.e., levels of difference which should become

[6] From Cooper, Pegler & Co. Ltd., Burgess Hill, Sussex, England.

significant) are also listed in this table. It is apparent that it is desirable to reduce standard errors by about 25 percent. The comparison of 4- and 6-replicate trials is incorrect, as this is confounded with site, but increased replication does appear to have reduced the standard errors for maturity index, Brix, and fibre. The degree of difference would suggest that doubling the replication (to about 12) would improve precision to the desired extent. Precision per replicate could, however, be improved in a less crowded experimental program. The series of trials described here involved the selection of 238 plots in a limited period of time, so that some replicates inevitably spread into imperfect stands of cane. Lodging caused by heavy rains also may have reduced precision.

The maturity index values proved of little value or were distinctly misleading. They failed to reveal the ripening effect of C.P. 41845 at Loíza as well as the severity of the adverse effect of Ethrel.

SUMMARY

Eight chemical compounds were evaluated in 13 field experiments to determine if they could ripen sugarcane at the end of the harvest season, May–June 1970, on the humid northern coast (Loíza) and the irrigated southern coast (Aguirre and Mercedita) of Puerto Rico.

C.P. 41845 (Monsanto) ripened sugarcane at Loíza and Mercedita when the control plots indicated dropping sucrose and purity values due to rainy weather. There were significant increases with the 2- and 4-pound per acre applications for pol, Brix and sucrose-percent-cane for the mean of the 6-week period after application. At Aguirre, there were no significant increases in sucrose components for individual samples or mean of all sampling dates. The control plots for this trial showed increasing sucrose and purity levels for the 6-week period. Pesco 1815 at 1.5-pound and 60CS16 at 0.5-pound per acre rates gave positive increases in the sucrose components, Brix, sucrose-percent-cane and purity at Mercedita, but not at Loíza.

The results suggest that the success or failure of these three compounds to ripen the cane at the various experimental sites may depend on the degree and tendency of maturity of the cane. Cane with low or dropping sucrose and purity levels responded to the ripening compounds, whereas cane with naturally high or increasing sucrose or purity values failed to respond.

Gibberellic acid, Dalapon, Silicon, Ethrel 68-250 and Cycocel failed to give significant increases in pol-percent-cane, Brix, sucrose-percent-cane, or purity.

The experimental techniques of applying sprays with a pneumatic-type tank equipped with a long lance for small-plot experimentation was dis-

cussed. To reduce the standard error it is suggested that the number of replications be increased and care taken in selecting plots for uniform stand and with a minimum of lodged cane.

RESUMEN

Se evaluaron ocho compuestos químicos en 13 experimentos de campo para determinar su potencialidad para madurar la caña a fines de zafra, de mayo a junio, 1970. Los experimentos se llevaron a cabo en la costa húmeda del norte (Loíza) y en terrenos de regadío en la costa sur (Aguirre y Mercedita).

El C.P. 41845 (Monsanto) maduró la caña en Loíza y Mercedita cuando los valores de sacarosa y pureza en el testigo disminuyeron debido al tiempo lluvioso. Aplicaciones de 2 y 4 libras del compuesto por acre aumentaron significativamente los porcentajes de pol, Brix (sólidos totales en solución) y sacarosa durante un período de 6 semanas después de la aplicación. En Aguirre no hubo aumentos significativos en los diferentes componentes de la sacarosa cuando se compararon muestras individuales o en el promedio de las muestras para todas las fechas de corte. Los valores de sacarosa y pureza de las parcelas testigo en este experimento aumentaron durante el período de 6 semanas. Los compuestos Pesco 1815 y 60GS16 aplicados a razón de 1.5 libras y 0.5 libra por acre, respectivamente, aumentaron el Brix, la sacarosa y la pureza en Mercedita, pero no así en Loíza.

Los resultados sugieren que el éxito o fracaso de estos compuestos para madurar la caña en los lugares donde se realizaron los experimentos puede depender del grado de madurez y tendencia a madurar, de la caña; entendiéndose que, en la caña cuyos valores de pureza y sacarosa son bajos o suelen disminuir, la repuesta fue positiva. Por el contrario, en la caña cuyos valores son altos inicialmente o tienden a subir, los tratamientos no surtieron efecto.

No se obtuvieron aumentos significativos en los porcentajes de pol, Brix, sacarosa o pureza con el uso del ácido giberélico, Dalapon, silicio, Ethrel 68-250 o Cycocel.

Se discute la técnica experimental para asperjar parcelas pequeñas usando una asperjadora neumática con una extensión. Para lograr los niveles de precisión deseados, los errores reconocidos (estándares) deben reducirse por lo menos en un 25 por ciento. Para lograr esto se sugiere duplicar el número de repeticiones a 12 y hacer una selección cuidadosa de las parcelas para obtener una población uniforme y con un número mínimo de cañas encamadas.

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