Research Note

CHEMICAL RIPENER EFFECTS ON SUGAR DIFFUSION FROM SUGARCANE STORAGE TISSUE[1]

The view that growth decline is an essential feature of sugarcane ripening is widely held by sugar planters and scientists. Screening programs for chemical ripeners frequently include growth restriction as a positive parameter of test compounds. In theory, however, an authentic chemical ripener should induce or enhance ripening via a range of source-to-sink activities, that is, by altering those processes of sugar synthesis, transport and storage which are operating at suboptimal levels. By this view the decline of growth and its attendant tonnage restriction is less a prerequisite for ripening than an incidental feature of natural maturation and ripening processes. This concept is supported by recent findings with the micronutrient boron (B),[2] the plant hormone gibberellic acid (GA_3),[3] and the chemical ripener C.P. 41845[4] which suggest that increased sugar accumulation in sink tissue involves major biochemical changes in leaf tissue having little connection with growth changes induced by the same agents. In the present study the compounds C.P. 41845 (Monsanto) and 60-CS-16 (Velsicol) produced major effects on sucrose movement in bathing storage tissues totally divorced from in vivo growth processes.

Plants of the interspecific variety P.R. 980 (*S. officinarum* X *S. spontaneum* X *S. sinense*) were propagated in sand culture with a complete nutrient supply,[5] or with B withheld, as described in earlier reports. Rind-free tissue slices were incubated in aqueous ripener solutions for 2 hours at 2°–4° C. and subsequently bathed in fresh solutions with continuous swirling for 24 hours. Details of tissue preparation, chemical pretreatment, sampling, and sugar analyses for tissues and bathing media were given earlier by Acín-Díaz and Alexander.[6] Data were analyzed statistically in accordance with Student's *t* test or the Duncan new multiple range method.

[1] Manuscript submitted to the Editorial Board December 26, 1972.

[2] Montalvo-Zapata, R., Studies on the roles of boron in growth and sugar-transport processes of sugarcane, J. Agr. Univ. P.R. 57(1): 9–23, 1972.

[3] Alexander, A. G., Montalvo-Zapata, R., and Kumar, A., Gibberellic acid activity in sugarcane as a function of the number and frequency of applications, J. Agr. Univ. P.R. 54(3): 477–503, 1970.

[4] Alexander, A. G., and Montalvo-Zapata, R., Ripening activity of C.P. 41845 in sugarcane having nitrate- and gibberellic acid-stimulated growth regimes, Crop Sci. 12: 654–7, 1972.

[5] Alexander, A. G., and Montalvo-Zapata, R., Evaluation of chemical ripeners for sugarcane having constant nitrogen and water regimes, Tropical Agr. 50(1): 35–44, 1973.

[6] Acín-Díaz, N., and Alexander, A. G., Studies on sugar diffusion from sugarcane storage tissues, J. Agr. Univ. P.R. 56(3): 253–66, 1972.

TABLE 1.—*Sucrose diffusion from mature storage tissue propagated with complete and boron-free nutrient regimes and bathed in aqueous solutions of 60-CS-16 and C.P. 41845*

Nutrient regime	Bathing medium	Sucrose content of bathing medium (as percent of total tissue content) at hour—					
		0	2	6	12	18	24
Complete	Control (water)	0	0.39 b	0.82 b	0.79 bc	1.06 b	0.87 b
	60-CS-16 ($2X10^{-6}M$)	0	.52 bc	1.05 b	.85 bc	1.21 b	1.02 bc
	60-CS-16 ($2X10^{-4}M$)	0	.89 c	1.38 cd	1.49 d	1.91 c	1.75 d
	C.P. 41845 ($2X10^{-6}M$)	0	.49 bc	1.19 c	.74 b	1.10 b	.81 bc
	C.P. 41845 ($2X10^{-4}M$)	0	1.51 a	2.74 a	2.29 a	2.65 a	1.99 a
Minus boron	Control (water)	0	.59 cd	1.19 cd	.96 bc	1.16 b	1.07 c
	60-CS-16 ($2X10^{-6}M$)	0	.57 cd	.94 b	1.25 cd	1.08 b	.90 bc
	60-CS-16 ($2X10^{-4}M$)	0	.85 cd	1.34 c	1.51 d	1.79 c	1.99 a
	C.P. 41845 ($2X10^{-6}M$)	0	.48 bc	.98 bc	1.04 bc	1.19 b	.98 b
	C.P. 41845 ($2X10^{-4}M$)	0	1.47 a	2.71 a	2.52 a	2.58 a	2.08 a

[1] Each figure is the mean of three replicates.

* Mean values in the same column bearing unlike letters vary significantly ($P < .05$).

TABLE 2.—*Sucrose diffusion from immature storage tissue propagated with complete and boron-free nutrient regimes and bathed in aqueous solutions of 60-CS-16 and C.P. 41845*[1]

Nutrient regime	Bathing medium	Sucrose content of bathing medium (as percent of total tissue content) at hour—					
		0	2	6	12	18	24
Complete	Control (water)	0	0.63 bc	0.86 b	2.04 c	0.63 b	0.34 b
	60-CS-16 ($2X10^{-6}M$)	0	.74 bc	1.61 ab	2.51 c	.44 b	.49 b
	60-CS-16 ($2X10^{-4}M$)	0	1.09 c	2.24 ac	3.69 ab	2.06 a	2.30 a
	C.P. 41845 ($2X10^{-6}M$)	0	.81 b	1.56 ab	4.05 a	.80 b	.30 b
	C.P. 41845 ($2X10^{-4}M$)	0	1.99 a	2.21 a	2.13 c	1.37 c	.25 b
Minus boron	Control (water)	0	.74 bc	1.30 bc	1.77 bc	1.12 c	.87 c
	60-CS-16 ($2X10^{-6}M$)	0	.51 c	1.32 bc	1.27 c	1.39 c	.77 bc
	60-CS-16 ($2X10^{-4}M$)	0	.47 b	1.09 b	1.69 c	1.46 c	1.48 c
	C.P. 41845 ($2X10^{-6}M$)	0	.44 bc	1.12 bc	1.24 c	.85 b	.79 b
	C.P. 41845 ($2X10^{-4}M$)	0	2.05 a	2.59 a	3.09 ab	2.41 a	1.46 c

[1] Each figure is the mean of three replicates.

* Mean values in the same column bearing unlike letters vary significantly ($P < .05$).

Samples of the bathing media taken at 2- or 6-hour intervals revealed an increased efflux of sucrose from both mature (table 1) and immature tissues (table 2) as a function of 60-CS-16 and C.P. 41845 concentration. Both compounds produced their maximum effect at the highest level tested

(2X10^{-4}M). Sucrose movement was also affected by tissue maturity, usually cresting at 6 hours for immature tissue and 12 hours for mature tissue (fig. 1). The principal effect of low B was to increase the rate and magnitude of sucrose diffusion from immature, C.P. 41845-treated tissue. It also repressed the stimulatory effect of 60-CS-16 noted in immature, B-sufficient tissue. The confinement of borate action to immature tissue

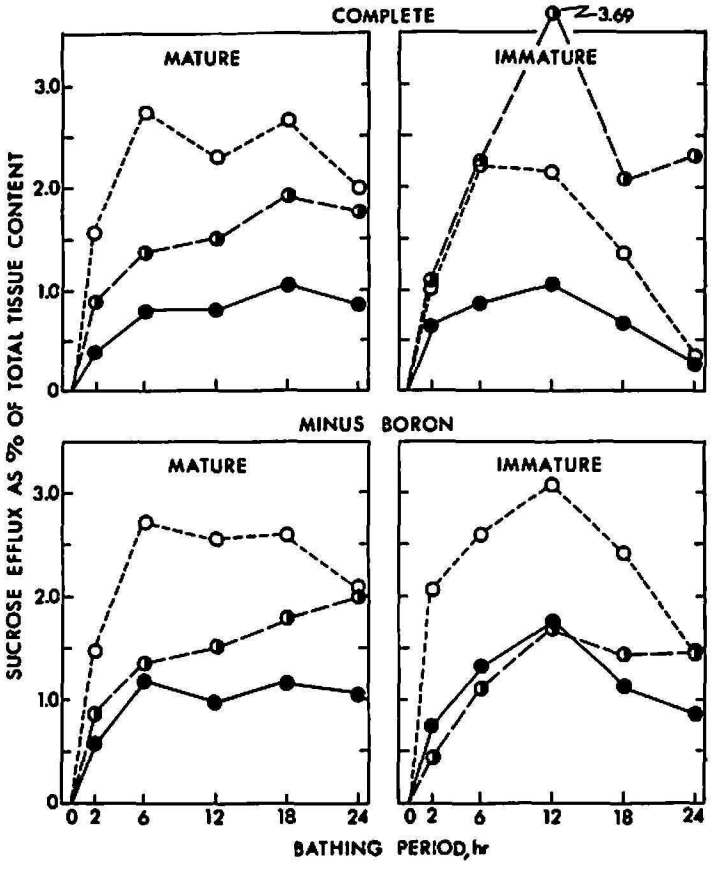

FIG. 1.—Effects of tissue maturity and borate-nutritional history on sucrose diffusion from sugarcane storage tissues treated with chemical ripeners. Rind-free tissue slices were bathed in aqueous solutions of 60-CS-16 and C.P. 41845. Symbols: (—●—) Control; (- -◑- -) 60-CS-16, 2X10^{-4}M; (- -○- -) C.P. 41845, 2X10^{-4}M. Complete data and statistical analyses are presented in tables 1 and 2 for mature and immature tissues, respectively.

is not explained by the present data, but this may relate to the acid invertase predominantly localized therein. Loss of sucrose from the bathing solution after the twelfth hour occurred mainly with immature tissues treated with C.P. 41845 (fig. 1), and is accountable to the passive uptake processes described by Bieleski.[7] The role of C.P. 41845 in this movement remains obscure. Sucrose loss from the external solution was not an inversion process as is shown by a simultaneous decline of reducing sugars (fig. 2).

[7] Bieleski, R. L., The physiology of sugarcane. III. Characteristics of sugar uptake in slices of mature and immature storage tissue, Aust. J. Biol. Sci. 13: 203–221, 1960.

Recent findings by Montalvo-Zapata[8] suggest that borate is active in discrete and spatially separated processes of sugarcane growth (lateral stem expansion) and sugar production (foliar sucrose synthesis, invertase regulation, formation of sugar-borate complexes). Present data are consistent with a tissue structure role as evidenced by reduction of 60-CS-16 activity in low-B tissues and confinement of the B effects to actively ex-

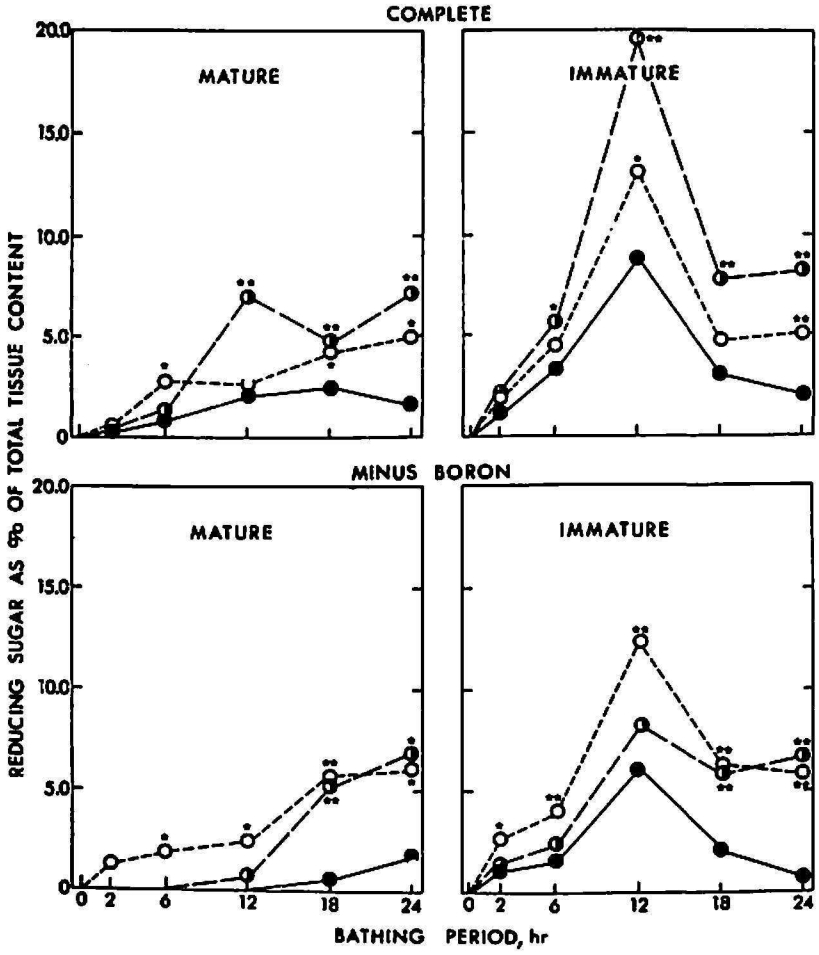

FIG. 2.—Reducing sugar diffusion from sugarcane storage tissues propagated with complete and boron-free nutrient regimes. Rind-free tissue slices were bathed in aqueous solutions of 60-CS-16 and C.P. 41845. Symbols: (—●—) Control; (- -◑- -) 60-CS-16, $2X10^{-4}M$; (- -○- -) C.P. 41845, $2X10^{-4}M$; (*) significant deviation from control, $P < 0.05$; (* *) $P < 0.01$.

panding internodes. However, a sugar-carrier role supporting sugar transport processes is currently favored over an invertase or permanent structural effect in view of the following evidence: (a) Low-B tissues did not yield higher quantities of invert sugar, (b) the low-B regime did not appreciably change the tissues' efflux characteristics per se, i.e., of tissues not treated with ripeners, (c) both 60-CS-16 and C.P. 41845 increased sucrose

[8] Montalvo-Zapata, loc. cit.

diffusion as immediate chemical effects in "complete" tissues, (d) the latter effects were altered differentially in low-B tissue.

The present results support the theory that chemical ripeners can affect sugar storage processes without repressing growth. Differential responses to 60-CS-16 and C.P. 41845 by tissues propagated with variable B suggest a variety of sites for chemical activity in passive sugar transport.

A. G. Alexander
R. Montalvo-Zapata
Department of Agronomy