Efficiency of Chemical Ripener Action in Sugarcane. V. Superior Efficiency of CP 70139 (Monsanto) in Direct Comparisons with Polaris[1]

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ABSTRACT

Growth and ripening effects of Polaris [N,N-bis (phosphonomethyl) glycine] and CP 70139 were examined in early-adult sugarcane. Both materials, products of the Monsanto Company, were tested at concentrations of 100, 300, 900 and 2700 p/m, applied until runoff as aqueous foliar sprays. Similar responses were obtained relative to foliar injury symptoms, growth repression, juice quality improvement, acid invertase inhibition, and tissue sugar and protein changes. Optimal Polaris responses were at 2700 p/m. CP 70139 produced comparable effects at 300 or 100 p/m. The magnitude of invertase repression and juice quality improvement was identical for the two compounds, suggesting that CP 70139 is more efficient rather than more active than Polaris. It is suggested that, at concentrations equal to Polaris, CP 70139 should produce a greater degree of ripening under field conditions where chemical penetration of the closed-in canopy is limited. Both materials gave evidence that growth repression and ripening occur as independent processes.

INTRODUCTION

Although chemical ripening of sugarcane is largely a physiological phenomenon, the attainment of the maximum effect possible for a given stand of field cane poses a serious technical problem relative to chemical administration. The closed-in canopy of a maturing crop tends to minimize the wettable leaf area of individual plants. The aircraft available for chemical application are themselves limited, both logistically and economically, as to the volume of solution that can be applied.

Aside from the engineering of superior field equipment, two approaches can be taken toward improving the effectiveness of chemical administration: a) Development of field methodology in closer conformation with the ripener's physiological requirements; and b), the discovery of new chemicals so highly active that their maximum possible effect is attained with very limited foliar penetration. The present series of ripener efficiency studies has stressed the first approach using a single level of Monsanto's Polaris[3, 4] as a model treatment. However, a more

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[4] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

recent Monsanto product, identified as CP 70139, appears to simulate Polaris activity at considerably lower concentrations. The relative performances of the two compounds at widely-divergent concentrations are presented in this report.

MATERIALS AND METHODS

Polaris and CP 70139 concentrations in the geometric order of 100, 300, 900 and 2700 p/m were administered to young-adult plants of the interspecific hybrid PR 980. All plants were propagated in quartz sand as previously described (2). At 14 weeks, test plants were sprayed until runoff with aqueous ripener solutions containing 0.10% Tween 20 as wetting agent. Control plants received wetting agent in distilled water. Application time was between 0930 and 1030 h on "day 0". There were three replications of each treatment arranged in an incomplete randomized block design.

Samples consisting of six uniform plants/replicate were harvested at 0700 h on day 0, and at the same hour 28 days thereafter. Green weight measurements were taken for whole plants, tops, and millable stems. Appropriate leaf, meristem, and stalk samples were frozen for tissue component analyses as described in a prior publication (2). Chlorophyll content of leaf blade +1 was determined in accordance with Arnon (7). At 28 days, the number of viable leaves (still green with the sheath fully encircling the stem) was recorded for each plant. Leaf rank +2 was retained for blade area measurements. All data were analyzed by the Duncan New Multiple Range test.

RESULTS

Polaris and CP 70139 produced similar effects for each of the parameters measured. Polaris activity was generally additive up to 2700 p/m, while CP 70139 attained comparable responses at 300 p/m, and in some

TABLE 1.—*Numerical ratings for leaf injury symptoms in young-adult sugarcane treated with variable concentrations of Polaris and CP 70139*[1]

No.	Treatment, p/m	Numerical rating[2]
1	Control	1.0
2	Polaris, 100	1.3
3	Polaris, 300	1.7
4	Polaris, 900	2.3
5	Polaris, 2700	3.7
6	CP 70139, 100	2.0
7	CP 70139, 300	3.7
8	CP 70139, 900	4.3
9	CP 70139, 2700	5.0

[1] Plants were rated by visual inspection 27 days after chemical application.

[2] On a scale of 1 to 5: 1 = no symptoms, 5 = general yellowing and desiccation.

TABLE 2.—*Growth responses of young adult sugarcane treated with variable levels of Polaris and CP 70139*

No.	Treatment (p/m)[1]	Green weight changes (g/plant) from 0 to 28 days, for–								
		Total green weight			Top weight			Stem weight		
		0	28	% change	0	28	% change	0	28	% change
1	Control	183 a[2]	205 bc	12.0 ab	119 a	125 a	5.0 ab	64 a	80 bc	25.0 bc
2	Polaris, 100	178 a	219 ab	23.0 a	111 a	128 a	15.3 a	67 a	91 b	35.8 ab
3	Polaris, 300	179 a	243 a	35.8 a	112 a	125 a	11.6 ab	67 a	118 a	76.1 a
4	Polaris, 900	169 a	177 bc	4.7 ab	106 a	88 ab	−17.0 ab	63 a	89 b	41.3 ab
5	Polaris, 2700	191 a	142 de	−25.7 cd	123 a	78 cd	−36.6 cd	68 a	64 c	−5.9 c
6	CP 70139, 100	179 a	169 cd	−5.6 bc	110 a	98 b	−10.9 bc	69 a	71 bc	2.9 bc
7	CP 70139, 300	179 a	131 ef	−26.8 cd	114 a	68 de	−40.4 cd	65 a	63 c	−3.1 bc
8	CP 70139, 900	162 a	114 ef	−29.6 cd	101 a	52 e	−48.5 de	61 a	62 c	1.6 bc
9	CP 70139, 2700	167 a	94 f	−43.7 d	107 a	41 f	−71.0 e	60 a	63 c	5.0 bc

[1] Polaris and CP 70139 were administered as aqueous foliar sprays containing 0.10% Tween 20 as wetting agent. Application time was from 0930 to 1030 h on day 0.

[2] Mean values in the same column with one or more letters in common do not differ significantly ($P < .05$).

TABLE 3.—*Juice-quality responses to variable levels of Polaris and CP 70139*

No.	Treatment (p/m)[1]	Mean values at day 0 and 28 days, for—											
		Brix			Polarization			Sucrose (mg/ml)			Reducing sugars (mg/ml)		
		0	28	% change	0	28	% change	0	28	% change	0	28	% change
1	Control	11.0 a[2]	11.8 d	7.3 cd	16.4 a	19.1 c	16.5 b	129 a	135 d	4.7 cd	10.3 c	12.1 a	17.5 a
2	Polaris, 100	11.8 a	11.9 d	0.9 d	16.2 a	17.9 c	10.5 b	148 a	146 cd	−1.4 d	16.7 bc	12.3 a	−26.4 b
3	Polaris, 300	11.1 a	13.5 cd	21.6 bc	15.5 a	21.7 bc	40.0 ab	132 a	181 bc	37.1 abc	19.6 ab	2.3 b	−88.3 c
4	Polaris, 900	10.8 a	14.4 bc	33.3 abc	15.6 a	23.4 b	50.0 ab	137 a	195 b	42.3 abc	23.5 ab	3.9 ab	−83.4 c
5	Polaris, 2700	12.2 a	18.2 a	49.2 ab	18.0 a	31.2 a	73.3 a	147 a	250 a	69.6 a	17.6 abc	0.6 b	−96.6 c
6	CP 70139, 100	10.4 a	14.5 bc	39.4 ab	14.7 a	21.8 bc	48.3 ab	112 a	177 bc	58.0 abc	23.6 ab	2.3 b	−90.3 c
7	CP 70139, 300	10.7 a	16.1 b	50.5 a	14.8 a	25.5 b	72.3 a	119 a	200 b	68.1 ab	23.2 ab	1.9 b	−91.8 c
8	CP 70139, 900	10.6 a	14.6 bc	37.7 ab	14.6 a	22.1 bc	51.3 ab	126 a	185 bc	46.8 abc	24.8 a	9.6 ab	−61.3 c
9	CP 70139, 2700	11.0 a	13.3 cd	20.9 bcd	15.9 a	18.3 c	15.1 b	117 a	139 d	18.8 bc	15.5 bc	12.0 a	−22.6 ab

[1] Polaris and CP 70139 were administered as aqueous foliar sprays containing 0.10% Tween 20 as wetting agent. Application time was between 0930 and 1030 h on day 0.

[2] Mean values in the same column with one or more letters in common do not differ significantly ($P < .05$).

TABLE 4.—*Effects of variable Polaris and CP 70139 concentrations on sugar and protein components of expanding stem tissue*

No.	Treatment (p/m)[1]	Mg/g dry wt, at 0 and 28 days, for—											
		Sucrose			Reducing sugars			Soluble protein			Acid invertase (units/mg protein/h)		
		0	28	% change	0	28	% change	0	28	% change	0	28	% change
1	Control	59 a[2]	82 g	35.6 f	67 e	181 a	170.2 a	34 bc	31 bc	−8.8 ab	4.3 a	4.8 a	11.6 a
2	Polaris, 100	66 a	111 fg	68.2 ef	106 d	176 a	66.0 c	35 abc	38 a	8.6 a	4.3 a	3.1 b	−27.9 b
3	Polaris, 300	67 a	128 ef	91.0 de	71 e	176 a	147.9 b	42 a	37 ab	−11.9 ab	3.7 c	2.7 bc	−31.0 bc
4	Polaris, 900	63 a	155 e	146.0 de	229 ab	172 b	−24.9 d	37 abc	27 c	−27.0 bc	3.9 bc	2.2 c	−43.6 c
5	Polaris, 2700	62 a	246 c	296.8 b	253 a	177 a	−30.0 d	38 abc	12 d	−68.4 d	3.8 bc	.6 de	−84.2 de
6	CP 70139, 100	67 a	238 c	255.2 bc	211 bc	177 a	−16.1 d	44 a	15 d	−65.9 d	3.6 c	.9 d	−69.4 de
7	CP 70139, 300	62 a	309 b	398.0 a	187 c	157 b	−37.4 d	41 ab	12 d	−70.7 d	3.7 c	.3 e	−91.9 e
8	CP 70139, 900	64 a	370 a	478.0 a	183 c	52 d	−71.6 e	33 c	15 d	−54.6 cd	4.0 b	.7 de	−82.5 de
9	CP 70139, 2700	69 a	192 e	178.3 cd	182 c	71 c	−61.0 e	33 c	16 d	−51.5 cd	4.3 a	2.9 b	−32.6 c

[1] Polaris and CP 70193 were administered as aqueous foliar sprays containing 0.10% Tween 20 as wetting agent. Application time was between 0930 and 1030 h on day 0.

[2] Mean values in the same column with one or more letters in common do not differ significantly ($P < .05$).

TABLE 5.—*Effects of variable Polaris and CP 70139 concentrations on leaf canopy parameters*

Treatment no.	Treatment (p/m)[1]	Chemical effects, at day 28, for—					
		No. of green leaves/plant	Chlorophyll (mg/g)	Sucrose (mg/g)	Area/blade (cm^2)	Photosynthetic area/ plant (m^2)	Photosynthetic area (as % of control)
1	Control	7.0 a[2]	1.31 ab	57 cd	205 ab	1.44 a	100.0 a
2	Polaris, 100	6.8 a	1.52 a	61 cd	227 a	1.54 a	106.9 a
3	Polaris, 300	6.2 ab	1.30 ab	57 cd	225 a	1.40 a	97.2 a
4	Polaris, 900	5.9 b	1.31 ab	95 c	196 ab	1.16 a	80.6 a
5	Polaris, 2700	3.9 cd	0.87 de	216 ab	198 ab	.77 b	53.5 b
6	CP 70139, 100	4.1 c	1.17 bc	179 b	164 b	.67 b	46.5 b
7	CP 70139, 300	3.2 d	1.01 cd	234 a	155 b	.50 bc	34.7 bc
8	CP 70139, 900	1.8 e	0.68 e	191 ab	91 c	.34 c	23.6 c
9	CP 70139, 2700	—[3]	—	28 d	—	—	—

[1] Materials were administered as aqueous foliar sprays containing 0.10% Tween 20. Application time was from 0930 to 1030 h on day 0).

[2] Mean values in the same column with one or more letters in common do not differ significantly ($P < .05$).

[3] CP 70139 completely desiccated the foliar canopy at this concentration.

instances at 100 p/m. This trend was observed with foliar injury symptoms (table 1), green weights (table 2), juice quality (table 3), tissue components (table 4), and foliar canopy parameters (table 5). The maximum changes produced for soluble protein, acid invertase, and juice-quality parameters were virtually equal for both materials (fig. 1).

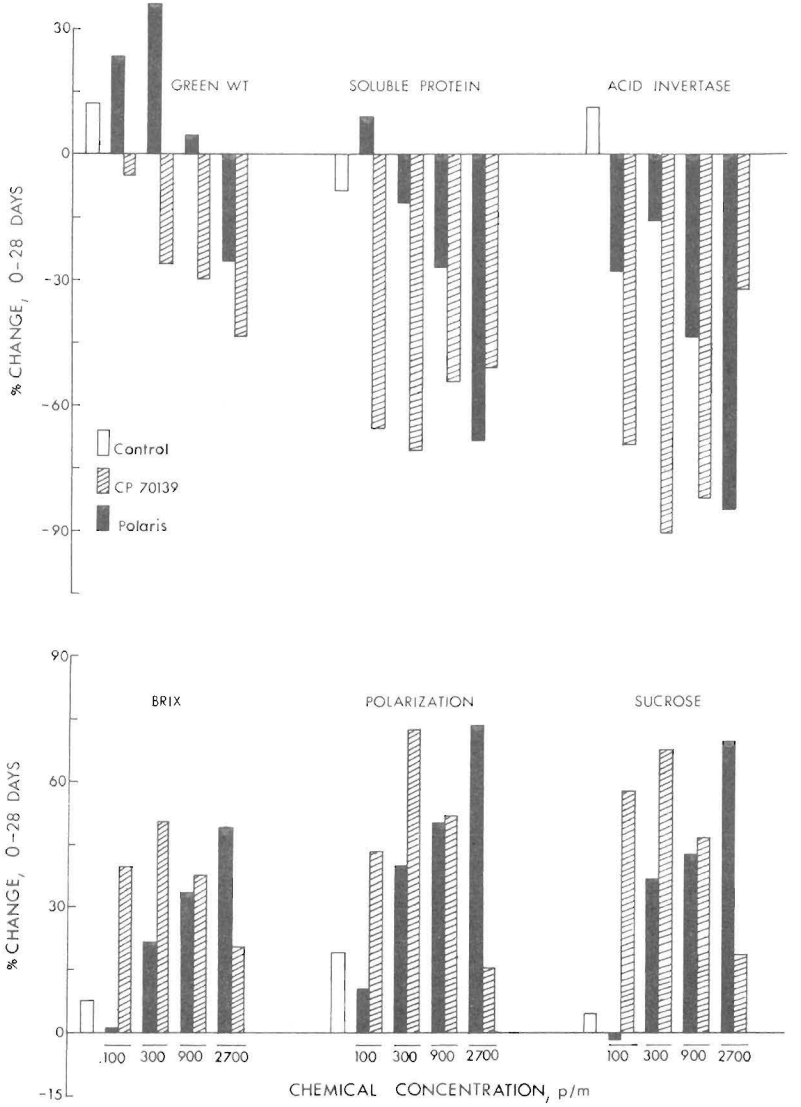

FIG. 1.—Comparative effects of Polaris and CP 70139 on parameters for growth and soluble protein (top) and juice quality (bottom) in early-adult sugarcane. Sucrose was determined by the resorcinol method (1) using clarified juice samples.

Polaris was growth-stimulatory at 100 and 300 p/m (table 2, fig. 1) while CP 70139 action was terminal at 2700 p/m.

DISCUSSION

ABSOLUTE ACTIVITY VS EFFICIENCY OF RIPENER ACTION

In theory, chemical ripening is possible because natural ripening processes fall short of the upper quality limits established by a given set of cultural conditions. An authentic ripener such as Polaris can "close in" on these upper limits when administered under greenhouse conditions, i.e., where the culture and treatment of individual plants is closely controlled. Alternately, an important task of the sugarcane agronomist is to assure the ripener its best possible opportunity to close this gap under field conditions.

In the present study, CP 70139 attained optimal invertase repression and juice quality improvement at levels 1/9 to 1/27 of that required by Polaris (fig. 1). The maximum responses were virtually identical for both materials and appear to represent the upper limits possible for this population of plants. It is therefore more nearly correct to say that CP 70139 was "more efficient" rather than "more active" than Polaris.

In a practical vein, the sugar planter might profit from this greater efficiency by using less material, that is, where he is afforded a suitable control of the individual cane plant. In actual practice his real benefit will derive from using an equal concentration of CP 70139, and allowing its superior efficiency to close some of the ripening "gap" posed by incomplete penetration of the field canopy. In other words, given an equal but limited wetting of absorptive leaf surface, an equimolar solution of CP 70139 should accomplish more than Polaris toward attaining the upper quality limits for that particular crop.

GROWTH REPRESSION VS. RIPENING BY POLARIS AND CP 70139

Although technically a growth-regulatory material, the ripening action of Polaris appears to occur independently of its performance as a growth repressant. In each preceding study on Polaris efficiency (3, 4, 5, 6), this distinction between ripening and growth restriction has emerged incidentally to the investigation's main objective. Present findings with Polaris and CP 70139 are consistent with this interpretation.

Lowering Polaris to 300 p/m produced a growth stimulation rather than repression (fig. 1). This response was statistically significant for total green weight but was mainly attained via increased stem expansion (table 2). Similar effects were recorded with the growth inhibitor 6-azauracil when administered in low concentrations (1). It is interesting to note that the plant's inclination is to produce growth effects opposite

to those intended when a viable growth potential survives the inhibitor's penetration. More importantly, juice quality was also improved by 300 p/m Polaris (fig. 1), an effect attaining statistical significance for juice sucrose content (table 3). On the other hand, CP 70139 at 2700 p/m produced a far greater growth inhibition than Polaris (table 2), but this response was accompanied by a pronounced deterioration of juice quality. The growth inhibition was directed mainly against the green top (table 2) and underscores the importance of retaining a viable source-to-sink system for ripening cane.

These distinctions between chemical growth regulation and ripening are of more than academic interest. It is hoped that at some future date a superior ripener will emerge whose activity is entirely divorced from growth repression, and hence from the threat of a reduced tonnage of millable stalks. For the present, an optimal ripening performance by Polaris or CP 70139 will be accompanied by some growth reduction. In this connection, field-development trials with both materials should include internode expansion measurements for joints laid down during the first three or four weeks of treatment. Normal or increased growth at this time will indicate that an inadequate level of ripener has been absorbed by the plant.

RESUMEN

Los efectos de crecimiento y madurez de Polaris (N,N-bis [fosfonometil] glicina) y CP 70139 se examinaron en caña de azúcar adulta, pero joven. Ambos materiales, producto de la Compañia Monsanto, se probaron en concentraciones de 100, 300, 900 y 2700 partes por millón, aplicadas hasta chorrear como aspersiones foliares acuosas. Se obtuvieron reacciones similares relativas a síntomas de lesiones foliares, represión del crecimiento, mejoría en la calidad del jugo, inhibición de la invertasa ácida y cambios en los tejidos sacaríferos y en la proteína. Las reacciones óptimas de Polaris fueron con 2700 partes por millón y las de CP 70139 con 300 ó 100 partes por millón. La magnitud de la represión de la invertasa y la mejoría en la calidad del jugo fueron idénticas para los dos compuestos, sugiriendo que CP 70139 es más eficiente más bien que más activo que Polaris. Se sugiere que, en concentraciones bajas e iguales, CP 70139 producirá un grado mayor de maduración que Polaris, bajo condiciones de campo donde la penetración química en el cogollo es limitada. Ambos materiales evidenciaron que la represión en el crecimiento y la madurez ocurren como procesos independientes.

LITERATURE CITED

1. Alexander, A. G., Interrelationships of nitrate and 6-azauracil in the growth, enzymology, and sucrose production of immature sugarcane, J. Agr. Univ. P.R. 53(2): 81–92, 1969.
2. Alexander, A. G., and Montalvo-Zapata, R., Evaluation of chemical ripeners for sugarcane having constant nitrogen and water regimes. I. Growth, quality and enzymic responses to nine potential ripeners, Tropical Agr. 49: 35–44, 1973.
3. Alexander, A. G., Efficiency of chemical ripener action in sugarcane. I. Growth and quality responses to Polaris applied at different hours of the day, J. Agr. Univ. P.R. 60(4): 460–8, 1976.
4. ——, Efficiency of chemical ripener action in sugarcane. II. Time-course for the

induction of growth, sucrose, and enzymic changes by Polaris in early-juvenile sugarcane, J. Agr. Univ. P.R. 60(4): 469–78, 1976.

5. ——, Efficiency of chemical ripener action in sugarcane. III. Growth and qualitative effects of Polaris as a function of the number and frequency of applications, J. Agr. Univ. P.R. 61(1):11–18, 1977.
6. ——, Efficiency of chemical ripener action in sugarcane. IV. Growth and qualitative responses to Polaris under variable solar radiation regimes, J. Agr. Univ. P.R. 61(1): 19–25, 1977.
7. Arnon, D. I., Copper enzymes in isolated chloroplasts. Polyphenol-oxidase in *Beta vulgaris*, Plant Physiol. 24: 1–15, 1949.