Paraquat as a Preharvest Desiccant for Sugarcane in Puerto Rico[1]

George Samuels and Alberto Beale[2]

ABSTRACT

Nineteen sugarcane field trials in the semiarid irrigated, medium- and high-rainfall areas were performed from 1962 to 1974 to evaluate Paraquat (1, 1′ dimethyl-4, 4-dipyridinium-bis-dimethyl sulfate, commercially known as Gramoxone) as a desiccant for reducing sugarcane trash. The material was applied by airplane at rates from 0.5 to 4 pt/acre in 4 to 32 gal of water, 2 to 7 days prior to preharvest burning. Paraquat improved burning with significant trash reduction of 3.5% in the 1962–70 trials to 5.08% in 1974. Cane fiber percent cane was reduced by 0.72% in the 1974 trials, with a significant reduction of 1.09% at the four Central Aguirre trials which represented an increase of 4 lb recuperated sugar per ton of cane ground. In general, values for sucrose percent cane, Brix, and purity were not significantly affected by desiccation, especially in 1974 trials, involving 1 pt/acre Paraquat in 8 gal of water. Desiccant effectiveness was influenced by harvest method, the V-cutter exceeding the machine-loading and the machine cut-and-load methods.

INTRODUCTION

The non-millable, vegetative, above-ground part of the sugarcane plant is commonly referred to as sugarcane trash. It represents about 20% of the above-ground green weight of the mature plant. Trash is a problem in the field because it interferes with operation of mechanical cane harvesters and increases loading and transportation costs. Trash is a problem in the mill because it contributes fiber without contributing sugar, contains impurities which lower the quality of the cane juice, increases milling time, and adds to the wear on factory machinery (1, p. 489).

Preharvest burning of the cane is a standard practice to reduce the quantity of extraneous material shipped to the mill in many sugarcane growing areas. Incomplete burning, due to a high moisture content of the

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[2] Agronomist and Research Assistant, respectively, Agricultural Experiment Station, Mayagüez Campus; University of Puerto Rico, Río Piedras, P.R. The 1974 field trials were supported through the Chevron Chemical Co., Orlando, Fla. 32804, under Grant Z-14. The authors are grateful to the following staff members of the Puerto Rican Sugar Corp. for their help in the field work: J. A. Bernardi, R. Giles, R. Nogueras, P. Rodríguez, and J. Sánchez.

green cane tops, has been a serious problem. The use of chemicals as desiccating agents to insure better burning has gained interest throughout the sugarcane world.

Alexander (1, chap. 13) thoroughly reviewed chemical desiccation beginning with early desiccant studies generally centered around oils, applied either singly or "fortified" with inorganic salts, to the more successful quaternary ammonium compounds Paraquat and Diquat.[3]

Defoliants, which are successful on cotton and potato crops, can not be used on sugarcane because of inherent differences in the anatomical structure of cotton and potato plants as compared to sugarcane. Desiccating the attached leaves and disposing of them by fire is a practical means of leaf removal in sugarcane. Desiccants such as sodium chlorate, diesel oil, and pentachlorophenol have received minimal attention in Puerto Rico due to the poor results reported by Bates (5) and lack of success in preliminary field observations at Central Aguirre in 1961–62.

Beginning in 1962, Paraquat (1, 1′ dimethyl-4,4-dipyridinium-bis-dimethyl sulfate, commercially known as Gramoxone) was evaluated in Puerto Rico as a sugarcane desiccant, and for the next 8 years various trials were made. Results indicated that Paraquat did not perform well in reducing cane trash despite visual symptoms of good desiccation. Furthermore, some losses in sucrose were encountered.

Both greenhouse studies (2, 3) and field trials (7, 8) have shown losses in sucrose for cane receiving Paraquat application. Alexander and Montalvo (2) found that under greenhouse conditions the use of an aqueous 0.5% Paraquat solution caused rapid loss of sucrose-forming potential within 48 and 72 hr after application. Chen and Liu (7), studying Paraquat effects in Perú, stressed the importance of time of harvest after application. Too little time gave insufficient desiccation while prolonged delays led to juice deterioration. From Paraquat trials in Puerto Rico (6), in 1968–69, it was concluded that the use of more than 2 pt/acre or delay of more than 6 days before harvest would produce significant sucrose losses.

Paraquat-improved burning has lowered trash in the order of 5% in Queensland (10) to 50% in Argentina (9). More efficient hand-cutting has also been reported (9). In addition, Paraquat has given significant trash reductions for early and late harvests in Florida (10).

Conversion to mechanical cane harvesting, accompanied by persistent harvest and milling losses relating to trash, has prompted renewed

[3] 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.

interest in preharvest desiccants in Puerto Rico. Thus, in 1974 Paraquat was reevaluated as a desiccant on commercial fields during January and February when the cane foliage normally displays high moisture content and poor burning qualities incident to the heavy rains of November and December.

This paper reports the various results obtained from 1962 to 1974 in evaluating Paraquat as a preharvest desiccant for sugarcane.

MATERIALS AND METHODS

Paraquat was evaluated as a preharvest desiccant on commerical sugarcane fields using aircraft application. General data for the various Paraquat trials are given in table 1.

The selected field received the desiccant on one-half its area; the remaining portion was used as the control or check plot. Each plot was sampled for cane trash and sucrose for uniformity before the Paraquat was applied. Immediately after the field was burned they were sampled again for treatment differences. The only exception was the Humacao H

TABLE 1.—*Summary of data for surgarcane experiments with the desiccant Paraquat in Puerto Rico, 1962–74*

Year	Location	Paraquat/ acre	Water/ acre	Application		Variety	Crop[1]	Age	Method of harvesting
				Days to burning	Date				
		Pt	*Gal*					*Mo*	
1962	Fajardo	2.4	6.4	4	6/25	H 32-8560	R	13	Hand-cut
	Mercedita	2.4	6.4	2	6/23	PR 980	R	15	Hand-cut
1968	Cambalache	1, 2, 4	8, 16, 32	5	5/10	PR 1028	R	13	Hand-cut
	Cambalache	2	16	6	6/18	PR 980	R	12	Cary cut & load
1969	Cambalache	2	16	6	5/15	H 32-8560	P	21	Hand-cut
		2	16	5	5/29	PR 1028	P	22	Hart-Cameco
	Yabucoa	0.5, 1.5	8	5	5/29	B 37-172	P	19	Hand-cut
	Mercedita	0.5, 1.5	4, 8	5	6/7	B 49-119	P	12	Hand-cut
1970	Humacao	2	8, 16	5	1/23	H 32-8560	R	18	Hand-cut
1974	Aguirre	1	8	7	1/5	CP 45-32	P	15	V-cutter
		1	8	7	1/22	B 42-231	P	14	V-cutter
		1	8	7	1/29	B 42-231	P	20	V-cutter
		1	8	7	2/5	PR 980	R	12	V-cutter
	Cambalache	1	8	7	2/11	H 32-8560	P	18	Cary cut & load
		1	8	7	2/15	H 32-8560	P	18	Cary cut & load
	Yabucoa	1	8	7	4/12	PR 1059	R	12	V-cutter
		1	8	7	4/29	PR 1002	P	24	V-cutter
		1	8	7	5/6	PR 1059	R	12	Carry cut & load
	Humacao	1	8	7	5/13	H 32-8560	R	13	J & L cutter

[1] R = Ratoon; P = Plant Crop.

32-8560 ratoon trial, where the cane was cut, windrowed, and then burned. This is the usual procedure where the J & L cutter is used.

Paraquat was applied by aircraft at various rates in different quantities of water (table 2), using Ortho X-77 spreader at the rate of 38 ml/8 gal. The trials at Cambalache in 1968–69, where 2 or 4 pt of Paraquat were applied in 16 and 32 gal/acre of water, were conducted by spraying the material by airplane at the rate of 1 pt/acre in 8 gal of water in two or four passes, respectively.

Treatments were completed before 0700 hr if possible, when low wind velocities minimize drifting. Time elapsed between desiccant application and burning are given in table 1. The preharvest burning was ordinarily performed at about 1800 hr; harvesting, the next day excepting the Humacao H 32-8560 ratoon trial. Much improvement is needed in the general practice of burning fields prior to harvest. At times, variation in the degree of burning was due more to the way the fire was set than to the stage of dryness of the cane foliage. Care was taken in these instances to evaluate degree of burning and selection of field cane samples from representative portions of the field.

Beginning in 1969, the visual estimate of burning efficiency of each field plot was established on an ascending scale of 1 to 5: 1) Green leaves from top to bottom; 2) green tops, lateral leaves burned off; 3) top leaves singed but retained; 4) all but spindle leaves burned; and 5) all but millable cane burned.

The cane sample for post-burning trash evaluation consisted mainly of a grab sample taken with a cane loader and placed in a pick-up truck. Sample weights ranged from 350 to 1500 pounds. Samples were cleaned by hand to determine the amount of trash (tops, shoots, dried leaves). Soil weight was not included in trash calculations.

Cane harvested from field plots was subjected to commercial sampling at the mill for final evaluation of sucrose components in accordance with the commercial operation.

RESULTS AND DISCUSSION

Paraquat produced a visual desiccation of the sugarcane leaves, as evidenced by discolored lesions which appeared (1, p. 506) on the first day after application, wilting and curling of the foliage at 3 to 5 days, and a general brown appearance of the foliage at about 6 days. Improved burning was evidenced by a significant increase of 0.8 units in the burn rating in the 1969–70 trials, and 0.9 in the 1974 trials (table 3). Burn ratings attained significant linear correlations ($r = 0.76^*$) with percent trash percentages in the cane after burning in the 1974 trials. A one unit increase in the burn rating was associated with a decrease of 4.1% in cane trash. Thus, if the highest burn rating of 5 (all but the millable cane

TABLE 2.—*Influence of Paraquat on burning of trash and sucrose components of sugarcane, 1962–74*

Location	Treatment	Rate Paraquat to water	Trash content	Burn rating[1]	Mill values of sugar components			
					Sucrose in cane	Brix	Purity	Fiber
		Pt/gal	%		%	%	%	%
Fajardo	Check	0	17.2	—	9.71	16.98	90.32	—
1962	Paraquat	2.4/6.4	14.4	—	10.19	16.43	89.68	—
Mercedita	Check	0	18.2	—	10.50	18.35	88.10	—
1962	Paraquat	2.4/6.4	16.8	—	10.25	17.60	88.43	—
Cambalache	Check	0	18.0	—	11.39	19.1	—	—
1968	Paraquat	1/8	17.0	—	11.43	18.5	—	—
	Check	0	22.0	—	11.85	19.3	—	—
	Paraquat	2/16	19.0	—	11.77	19.0	—	—
	Check	0	15.0	—	11.87	19.6	—	—
	Paraquat	4/32	12.0	—	10.08	18.3	—	—
Cambalache	Check	0	19.0	—	—	—	—	—
1968	Paraquat	2/16	16.0	—	—	—	—	—
Cambalache	Check	0	23.8	1.5	6.50	12.7	81.16	—
1969	Paraquat	2/16	19.9	4.0	6.36	12.0	83.01	—
Cambalache	Check	0	18.1	3.0	8.62	15.3	86.35	—
1969	Paraquat	2/16	14.9	3.5	6.30	13.6	76.45	—
Yabucoa	Check	0	18.0	2.0	11.30	—	—	—
1969	Paraquat	0.5/8	21.0	3.0	10.31	—	—	—
	Paraquat	1.5/8	18.9	3.0	10.46	—	—	—
Mercedita	Check	0	11.1	3.0	11.11	17.1	89.15	—
1969	Paraquat	.5/4	5.1	3.5	11.33	18.6	90.03	—
	Paraquat	.5/8	8.7	3.5	10.98	18.0	89.85	—
	Paraquat	1.5/8	5.5	4.0	10.92	17.8	89.70	—
Humacao	Check	0	21.1	1.5	11.30	17.3	—	—
1970	Paraquat	2/8	18.0	1.5	10.31	16.1	—	—
	Paraquat	2/16	18.8	1.5	11.41	17.1	—	—
Aguirre	Check	0	11.12	2.5	7.69	16.09	81.3	19.17
1974	Paraquat	1/8	5.85	3.0	7.74	16.64	79.7	17.55
	Check	0	11.14	2.0	8.56	18.39	81.4	24.83
	Paraquat	1/8	8.13	4.0	8.55	17.47	82.9	24.34
	Check	0	7.91	3.5	6.04	14.68	75.6	21.36
	Paraquat	1/8	6.28	4.0	7.04	15.31	81.6	20.04
	Check	0	18.56	2.0	6.98	16.75	75.6	21.53
	Paraquat	0	8.53	3.0	6.94	15.24	77.9	20.62
Cambalache	Check	0	16.30	2.0	6.05	—	74.31	14.95
1974	Paraquat	1/8	13.40	2.5	6.11	—	73.07	15.28
	Check	0	20.90	1.0	4.95	—	59.50	16.41
	Paraquat	1/8	16.20	2.5	5.68	—	64.75	16.50
Yabucoa	Check	0	17.20	2.0	7.10	16.08	78.10	20.86
1974	Paraquat	1/8	11.92	3.0	7.51	14.96	84.24	18.48
	Check	0	12.58	3.0	9.37	16.14	86.76	24.54
	Paraquat	1/8	1.72	4.0	7.76	15.03	85.77	21.23
	Check	0	13.07	3.7	7.33	14.70	84.23	21.68
	Paraquat	1/8	11.03	4.5	7.31	14.79	83.98	22.52
Humacao	Check	0	—	3.0	8.68	15.40	90.71	20.33
1974	Paraquat	1/8	—	3.0	7.71	14.98	85.11	21.92

[1] See material and methods for evaluation of burn ratings.

burned) could have been achieved in the 1974 trials, the trash in the cane would have been 3.2%. This value is below the 5% trash minimum allowed without penalty in the factory.

The Paraquat-treated cane retained less trash after burning than that of the check plots. The data of the individual trials are given in table 2, and summaries of the influence of Paraquat application for various years and factors are given in table 3. For 24 trials, 1962–74, there was a significant reduction in cane trash of 3.54%, with the smallest reduction being 2.59% for the 15 trials of 1967–70 and the largest 5.08% for the 9 trials of 1974.

TABLE 3.—Summary of field trials with Paraquat and its effects on trash-burning and sucrose component parameters in Puerto Rico, 1962–74

Years[1]	No. of field trials	Treatment[2]	Rate Paraquat to water	Trash content	Burn rating[3]	Mill values of sugar components			
						Sucrose in cane	Brix	Purity	Fiber
			Pt/gal	%		%	%	%	%
1962–70	15	C	0	19.60	—	10.64	14.80	—	—
		P	1 to 4/6.4 to 32	17.01**[4]	—	10.15	14.49	—	—
1968–70	8	C	0	23.88	—	9.96	16.74	—	—
		P	2/16	20.73**	—	9.51	15.96**	—	—
1969–70	9	C	0	20.44	2.3	—	—	—	—
		P	0.5 to 2/8 to 16	17.66*	3.1*	—	—	—	—
1962–70	7	C	0.5 to 2/8 to 16	20.20	—	9.80	16.37	87.62	—
		P		16.20**	—	9.47	16.29	86.66	—
1962–74	24	C	0.5 to 4/6.4 to 32	17.59	—	10.07	—	—	—
		P		14.05**	—	10.88	—	—	—
1974	9	C	1/8	14.30	2.5	7.28	16.02	78.75	20.56
		P		9.22**	3.4**	7.24	15.55	79.90	19.84

[1] Grouping of treatments for comparison as made to clarify the influence of certain factors which were available only in some of the experiments.

[2] C = Control; P = Paraquat.

[3] See Material and Methods for burn rating description.

[4] ** Significant at 1% level; * Significant at 5% level.

The desiccant's effectiveness was significantly affected by method of harvest. The differences between the check and Paraquat-treated fields for percent trash are as follows:

Harvesting method	*Reduction in % trash*
V-cutter	6.0 (sig. p = 0.05)
Cut and load	2.9
Hand-cutting	3.1 (sig. p = 0.05)

The greater reduction in cane trash and fiber using the V-cutter, as

compared to the cut and load harvester and hand cutting, might be explained by the mode of operation in handling the cane and its trash. The V-cutter severs the stalk at its base and the entire above-ground portion is collected by the grab loader. Thus, any reduction in cane trash by better burn would be reflected in a lower trash content in the cane to be cut and loaded. The cut and load harvester cuts the cane stalk at its base, cuts off the top, and chops the cane stalk into sections. All of the chopped material is subjected to blasts of air, as it moves up a conveyor, which removes the trash as it is being loaded into the transport trailer. Thus, the amount of trash in the cane is reduced by the machine as it harvests. The desiccant treatment further reduces the trash to be handled by the cut and load harvester, but to a lesser degree than by the V-cutter. Hand-cut cane has the tops removed by the cane cutter; however, if the operator is not careful, the grab loader usually collects some of the severed cane tops in the loading process. Therefore, the reduction in percent trash in hand-cut cane treated with desiccants is due to a lessened amount of trash available for the grab loader to pick up in the loading operation.

Trash reduction in field cane was reflected in lower fiber values when this factor was evaluated in 1974. This reduction was 0.72 fiber percent cane for the average of the nine trials (table 3). The four trials at Aguirre averaged a significant reduction of 1.09 fiber percent cane which represents approximately 4 lb more sugar per ton of cane ground.

The 6.0% reduction in trash in Paraquat-treated, V-cutter-harvested cane resulted in a significant reduction of 1.67 fiber percent cane in the ground cane.

The question arises as to whether the average reduction of 5.08% trash obtained in the 1974 trials (table 3) is of economic value to the farmer and to the mill. For an average field producing 40 tons/acre of cane, a 5.08% reduction in trash represents a saving of 2 tons of non-sugar bearing material that does not require loading, transporting, or grinding. Calculations based on the local prices and field costs indicate that savings in trash reduction by Paraquat-preharvest application cover the costs of its use. However, benefits at the mill derived from lower percent trash and fiber content of the ground cane would provide definite economic advantages both to the mill and to the farmer (4).

The overall effect of Paraquat on cane sucrose content has been minimal over the 1962–74 period of these trials (table 3,) except in the 1962–70 period when with relatively high rates of application the sucrose percent cane dropped from 10.64 to 10.15 and in 1968–70 when percent Brix dropped from 16.74 to 15.96 (table 3).

The 1968 trial at Central Cambalache, where 1, 2, and 4 pt/acre of

Paraquat were applied (table 1), showed the following differences compared to the check:

Paraquat	*Sucrose percent cane*	*Percent Brix*
1	+0.04	−0.6
2	−0.08	−0.3
4	−1.79	−1.3

The use of 4 pt/acre of Paraquat gave large decreases in sucrose percent cane and percent Brix, but the 1- and 2-pt levels produced minimal changes. Use of 1 pt/acre in 1974 produced no significant decreases in sucrose percent cane or Brix (table 3).

The anti-sucrose activity of Paraquat should not be minimized. It can only be assumed that the low rate of desiccant, short elapsed time between application and burning, and prompt grinding after burning kept the sucrose losses at nonsignificant values, especially in the 1974 trials.

RESUMEN

En el período comprendido entre 1962 y 1974 se llevaron a cabo 19 experimentos en la zona semiárida de regadío, en la que hay temporadas tanto de moderada como de copiosa precipitación, con el fin de avaluar el Paraquat (1, 1 dimetil-4,4-dipiridio-bis-dimetil sulfato) conocido comercialmente por Gramoxone (Chevron Chemical Co.) como agente desecante de la caña de azúcar. El compuesto de aplicó por avión en cantidades entre 0.5 y 4 pintas (.24 a 1.88 litros) por acre en un volumen de agua que fluctuó entre 4 y 32 galones (15.24 litros y 1.21 hectolitros) por acre. Las aplicaciones se hicieron entre 2 y 7 días antes de la quema previa al corte de la plantación. Con la aplicación de Paraquat se logró una quema mejor, la cual disminuyó significativamente (3.5%) la cantidad de paja en la caña cortada en los experimentos realizados de 1962 a 1970 y en 5.08% en los de 1974.

El contenido de fibra en la caña cortada disminuyó 0.72%, como promedio, en 1974, lo cual representa una disminución significativa de 1.09% en los cuatro experimentos efectuados en Aguirre. Esto, a la vez, representa un aumento de cuatro libras (1.8 kg.) de azúcar recuperada por tonelada de caña molida. En general, los valores obtenidos en el contenido en sacarosa, Brix y pureza de los jugos no se afectaron en forma significativa por la desecación del follaje al usar 1 pinta en 8 galones de agua (.47 litro de Gramoxone en 30.28 litros) por acre, especialmente en los experimentos de 1974.

El agente desecante fue más eficaz cuando se usó la cosechadora

"V-cutter" que con la otra maquinaria diseñada para el corte mecanizado de la caña de azúcar.

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