Weed Control for Growing Sorghum in Puerto Rico[1]

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INTRODUCTION

Sorghum bicolor (L.) Moench. is a species of tropical origin. Although sorghum is grown widely in the Temperate areas of the world, the major part of the acreage is grown in the Tropics. During 1934–38 about 90 percent of the world crop was reportedly grown in tropical areas of China, India, Manchuria, and Africa (*2*).[3] This distribution pattern has changed little during the past few years.

Weed control is a major production problem in the United States, and probably a greater problem in the Tropics. Puerto Rico is tropical and has a wide range of rainfall conditions with uniform temperatures (table 1). Production of agricultural products is difficult and often limited because of the many grasses and broadleaf weed species which abound in cultivated fields here.

Sorghum is grown in Puerto Rico, both commercially and experimentally, when day lengths are less than 12 hrs. (September 29 to March 13). This period is usually dry, and supplemental irrigation is necessary for adequate plant growth. Most tropical sorghums have a critical photoperiod below 12 hrs. of light (*3*), and can be grown for seed production only when plantings are made during short-day periods. However, forage production is increased during the long-day periods. Most sorghums adapted to conditions in the United States are not adversely affected by day lengths and flower, regardless of planting date. Thus, a variety of conditions must be considered in a weed-control program where sorghums of widely different maturities are grown in Tropical Zones.

Wiese and Rea (*5*) indicated that sorghum tolerated 2-chloro-4,6-bis-(isopropylamino)-*s*-triazine (Propazine) better than other herbicides evaluated in Texas. In Nebraska (*4*) 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (Atrazine), applied as a pre-emergent, produced more effective weed control than Propazine, although injury to sorghum was expected on

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[3] Italic numbers in parentheses refer to Literature Cited, p. 206.

coarse-textured soils. Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea) is recommended at present by the USDA and Texas for use (*1*) as a directed postemergence only.

The objectives of this study were to produce weed-free nurseries of sorghum in the Tropics, with a minimum of expense and man-hours, and to evaluate effectiveness of methods in wet and dry seasons.

MATERIALS AND METHODS

Rainfall conditions during the dry season at the Federal Experiment Station, Mayagüez, P.R., are similar to those of the drier areas of the sorghum belt in the United States. During the wet season (June to October),

TABLE 1.—*Monthly mean day length and weather conditions during the last 67 years at the Federal Experiment Station in Mayagüez, P.R.*

Month	Day length	Rainfall	Temperature
	Hours	*Inches*	*Mean F°.*
January	11.2	1.98	74.4
February	11.6	1.82	74.7
March	12.0	3.39	75.2
April	12.6	5.25	76.4
May	13.0	8.16	78.0
June	13.2	8.61	78.9
July	13.1	10.14	79.1
August	12.8	10.76	79.4
September	12.2	10.84	79.4
October	11.7	9.04	79.0
November	11.3	5.84	77.5
December	11.1	2.52	75.9

the soil remains at field capacity or near saturation, producing a strikingly different environment for crop and weed growth. Soil (Toa silty clay) in the test area is similar to the fine-textured soils of the United States sorghum-growing areas, and was expected to respond to weed-control chemicals in like manner, particularly during the dry season. The following herbicides used for weed control in sorghum (*1*) were selected for evaluation in tropical Puerto Rico: Propazine, Atrazine, and Diuron.

EXPERIMENT I

Sorghum variety SA 406, a 4-dwarf Martin derivative, was planted in 36-in. rows on May 26, 1966. Propazine, Atrazine, and Diuron were applied as a preemergence spray at 0, 1, 3, and 9 lb./A. active ingredient immediately after planting on plots 6 ft. x 10 ft. Each treatment was replicated two times. Visual observations were made 1 month after treatment on per-

centage weed control and injury to the sorghum. We used *Avena sativa* (L.) var. Markton, a species sensitive to these herbicides, to test for persistence. Oats were seeded directly to treated plots and allowed to grow for 1 month before data were collected.

EXPERIMENT II

Atrazine and Diuron were discarded from further study after Experiment I, but Propazine was subjected to more stringent evaluation. On April 2,

TABLE 2.—*Average percentage weed control in sorghum after application of 3 herbicides at 3 rates as pre-emergence sprays at Mayagüez, P.R., 1966*

Treatments	Rates	Control 1 month after treatment			Effect on sorghum
		Grasses	Broadleaf species	Sedges[1]	
	Lb./A.	*Percent*	*Percent*	*Percent*	
Propazine	1	75	95	80	No damage
	3	90	100	85	2–5 percent kill
	9	100	100	80	20-percent kill
Atrazine	1	90	95	70	No damage
	3	95	100	50	10-percent kill, some stunting
	9	100	100	75	35-percent kill
Diuron	1	85	80	90	No damage
	3	95	60	50	Do.
	9	100	100	95	60-percent kill, severe stunting
Check	0	0	0	0	Severe stunting[2]

[1] *Cyperus rotundus* L. and *C. esculentus* L. were only slightly affected. Percentage control based on seedlings of *Fimbristylis dichotoma* (L.) Vahl.

[2] Resulted from weed competition.

1968, SA 406 was planted in rows 36-in. apart and Propazine at 1, 3, and 9 pounds per acre (hereafter abbreviated thus: lb./A.) was applied as a pre-emergence treatment to a 6 ft. x 10 ft. area over the rows of sorghum. Hand-weeded and weedy treatments were included. Each treatment was replicated five times in a completely randomized design. The test was planted in the dry season and received only sufficient supplemental irrigation to maintain good growth. Counts of weeds per w. o. were made at weekly intervals on 9 sq. ft. and averaged. Percentage injury to sorghum was recorded 3 weeks after application of herbicide, and yields of sorghum fodder and weeds were obtained 60 days after planting. The plants were allowed to ratoon.

EXPERIMENT III

On May 16, 1968, a final test of Propazine was made in the rainy season. The treatments and procedures of Experiment II were duplicated. Plots were harvested 70 days after planting.

Natural infestations of grasses and broadleaf plants on the test sites were predominantly 'Jungle Rice' (Arrocillo), *Echinochloa colonum* (L.) Link; 'Wiregrass' (Pata de gallina), *Eleusine indica* (L.) Gaertn.; 'Bower' (Blero), *Amaranthus dubius* Mart.; 'Bower' (Blero espinoso), *Amaranthus spinosus* L.; (Verdolaga de hoja ancha), *Trianthema portulaeastrum* L.; 'Nutgrass' (Coqui), *Cyperus rotundus* L.; and a 'Sedge', *Fimbristylis dichotoma* (L.) Vahl.

RESULTS

Data collected 1 month after treatment of Experiment I are shown in table 2. Based on visual evaluations, Propazine and Atrazine at 3 lb./A. effectively controlled broadleaf weeds and grasses, but Atrazine injured the sorghum. Diuron at 3 lb./A. controlled weedy grasses, but did not control broadleaf weeds as effectively as Propazine or Atrazine. The lowest herbicide rate (1 lb./A.) was not as effective as the higher rates in controlling weeds. All the herbicides injured sorghum at 9 lb./A.

We planted oats (*Avena sativa* (L.) var. Markton), a species sensitive to these herbicides, in rows across treated and untreated plots (10 replications), to determine whether herbicide residues existed 6 months after application. We observed neither reduction in stand nor abnormal growth in plots treated with less than 9 lb./A. of herbicide 1 month after seeding the oats. It should be noted that leaching may have moved the herbicide downward far enough to escape the bioassay with oats, particularly with respect to Atrazine and Diuron at 3 lb./A.

These results suggest that Propazine could be used in the Tropics as an effective weed control herbicide on sorghum. Therefore, we initiated more elaborate tests to obtain additional information on the effectiveness of Propazine.

The results of Experiment II planted during the dry season, are given in table 3. A large number of grass and broadleaf weeds germinated in the untreated plots. The number of emerging weeds increased through the 3rd week after planting, but became stable thereafter. Weed counts per sq. ft. and weed green weight (lb./A.) show striking reductions when 1 lb./A. of Propazine was applied. Greater reductions occurred at 3 and 9 lb./A., respectively.

Visual observations and yield data indicate that Propazine at 3 and 9 lb./A. injured sorghum; however, the 3 lb./A. rate did not statistically re-

duce sorghum fodder yield when compared to the hand-weeded check. Weed competition reduced fodder yields more than the preemergence treatment of Propazine at 9 lb./A. Days to anthesis of the sorghum indicated that no weed control could delay sorghum maturity as well as reduced yields. Weed yields were strikingly reduced with 1 lb./A. of Propazine or more.

To obtain information on a longer growing season the crop was ratooned and harvested 58 days after the first cutting. Sorghum fodder yields were reversed from those of the first crop (table 3). For example, the hand-weeded check was not the most effective treatment, but it was significantly

TABLE 3.—*Effect of Propazine at 1, 3, and 9 lb./A. on* ***S. bicolor*** *and weed development in a dry season planting at Mayagüez, P.R., 1968*

Treatments	No. of weeds per sq. ft. after treatment			Injury to sorghum[2]	Yield first crop[1]			Yield first ratoon[1]		
	2 wk.	3 wk.	4 wk.		Sorghum fodder, green weight	Weeds, green weight	Anthesis at harvest	Sorghum fodder, green weight	Weeds, green weight	Anthesis at harvest
				Percent	*Lb./A.*	*Lb./A.*	*Percent*	*Lb./A.*	*Lb./A.*	*Percent*
Control Hoed	0	0	0	0	23,200ab[2]	0b	50	13,000bc	0b	11
Control Weedy	27.8	37.6	37.6	0	17,800d	17,800a	13	7,050e	8,500a	0
Propazine 1 lb./A.	4.3	2.7	2.3	0	24,600a	700b	45	11,210cd	2,200b	5
3 lb./A.	.3	.5	.5	5	22,100abc	600b	42	14,030b	1,500b	11
9 lb./A.	.2	.2	.2	10	19,100d	200b	35	18,660a	400b	42
LSD (5 percent)					2,514	3,683		2,261	2,771	

[1] Yields followed by the same letter are not significantly different at the 5-percent level (Duncan's Multiple Range Test).

[2] Based on visual ratings 3 weeks after application.

better than the weedy check. Treatments which produced highest fodder yields in the first crop produced proportionately lower yields in the ratoon crop. This reversal is the result of greater remaining soil fertility and available moisture, with less inhibition from the herbicide. Weed yields were higher for all the treatments except the weedy check, indicating that herbicidal dissipation had occurred.

Data in table 4 indicate that herbicidal effectiveness of Propazine was reduced during the higher rainfall period (Experiment III). However, adequate weed control was obtained at 3 lb./A. Propazine at 9 lb./A. injured the sorghum more than during the dry season. Yield of sorghum fodder was significantly less from the weedy check than all other treatments, whereas

the hand-weeded control yielded significantly more fodder than any Propazine treatment. Greater herbicidal injury was indicated during the wet season at the higher rates.

DISCUSSION

Results obtained from these studies suggest that several broadleaf weeds and grasses can be effectively controlled with Propazine, without significant injury to sorghum in tropical Puerto Rico. The effectiveness of Propazine during the dry season has permitted field adaptation to chemical weed control during the important winter nursery season.

Our sorghum nursery was treated with 2.5 lb./A. of Propazine on No-

TABLE 4.—*Effect of Propazine at 1, 3, and 9 lb./A. when applied to S. bicolor during a wet season at Mayagüez, P.R., 1968*

Treatments	No. of weeds per sq. ft. after treatment		Percent injury[1] to sorghum	Percent anthesis at harvest	Yield—green weight/A.	
	2 wk.	4 wk.			Sorghum fodder	Weeds
					Lb./A.	*Lb./A.*
Control, hoed	0.0	0.0	0	100	16,960a[2]	0d
Control, weedy	43.1	51.3	0	45	7,600d	12,890a
Propazine, 1 lb./A.	7.2	5.5	0	100	12,930b	3,030b
Propazine, 3 lb./A.	3.6	2.9	5	95	12,710b	1,620c
Propazine, 9 lb./A.	.8	.5	15	85	10,160c	410d
LSD (5 percent)					1,523	1,093

[1] Based on visual ratings 3 weeks after application.

[2] Yields followed by the same letter are not significantly different at the 5-percent level (Duncan's Multiple Range Test).

vember 15, 1966 and on October 3, 1967. Emergence and seedling growth appeared normal for the 1,000 widely diverse sorghum varieties and breeding types planted. The fields were free of weeds except for 2-row strips left as check plots. A single cultivation at the time of fertilizer application resulted in excellent weed control. Overhead irrigation was used three times before the sorghum flowered. Emergence of weedy grasses first occurred 70 to 80 days after planting followed by broadleaf weeds 10 to 20 days later. This indicated that the effectiveness of the chemical was dissipating, but that the control period was sufficient for crop production.

The rapid disappearance of the chemical as indicated by the oats and sorghum nursery observations, allows the planting of susceptible crops on treated soils, without concern for residues in regular seasonal planting schedules. The low cost of Propazine makes a 2-to-3 lb./A. treatment an

economical method of weed control in sorghum for tropical Puerto Rico, without much concern for long-range residual problems.

SUMMARY

Herbicides 2-chloro-4,6-bis(isopropylamino)-*s*-triazine (Propazine), 2-chloro-4-ethylamine-6-isopropylamino-*s*-triazine (Atrazine) and 3-(3-4-dichlorophenyl)-1,1-dimethylurea (Diuron) were evaluated on sorghum (*Sorghum bicolor* (L.) Moench.) var. SA 406 at the Federal Experiment Station, Mayaguez, Puerto Rico. Applied as a pre-emergence spray, both Propazine and Atrazine at 3 lb./A. controlled broadleaf weeds and grasses, and were more effective than Diuron for control of broadleaf weeds in the initial test. Propazine was less injurious to sorghum than Atrazine.

Effectiveness of Propazine was greater during the dry season (with supplemental irrigation) than during the wet season. Hand-weeded sorghum yielded significantly more fodder than plots treated with Propazine at 1 and 3 lb./A. during the wet season, but not during the dry season. Oats (*Avena sativa* (L.)) grew without apparent injury from herbicide residues when planted in plots 6 months after treatment with Propazine at rates of 1 and 3 lb./A.

Propazine used at 2 to 3 lb./A. appears to be a safe and economical method of weed control in sorghum for the Tropics where soil type, rainfall, weed species, etc., are similar to those described herein.

RESUMEN

Los herbicidas 2-cloro-4,6-bis(isopropilamino)-*s*-triazine (Propaziné), 2-cloro-4-etilamino-6-isopropilamino-*s*-triazine (Atrazine) y 3-(3-4-dicloro-fenil)-1,1-dimetilurea (Diuron) fueron evaluados en siembras de sorgo (*Sorghum bicolor* (L.) Moench.) de la variedad SA 406 en la Estación Experimental Federal de Mayagüez, Puerto Rico. Las pruebas preliminares indicaron que las aspersiones de Propazine o de Atrazine aplicados como preemergente, a razón de 3 libras por acre, fueron eficaces para combatir los yerbajos de hoja ancha y las gramíneas, mientras que el Diuron fue menos eficaz contra los yerbajos de hoja ancha. El Propazine fue menos nocivo al sorgo que el Atrazine.

Pruebas adicionales demostraron que la eficacia del Propazine fue mayor durante la sequía (usando riego) que durante la temporada lluviosa. Durante la estación seca, un predio testigo desyerbado con azada produjo la mayor cantidad de forraje, pero este rendimiento no fue significativamente mayor que la que se produjo mediante los tratamientos con 1 y 3 libras de Propazine por acre. Sin embargo, durante la estación lluviosa, el rendimiento del predio testigo desyerbado fue significativamente mayor que el de los predios sometidos a otros tratamientos. No se notaron efectos re-

siduales del herbicida en las siembras de avena (*Avena sativa* (L.)) hechas 6 meses más tarde en los predios que habían sido tratados con 1 y 3 libras de Propazine por acre.

La eficacia demostrada por el Propazine cuando se aplicaron de 2 a 3 libras por acre, unido a su bajo costo, parecen hacer de este herbicida un medio económico para combatir los yerbajos en las siembras de sorgo en los trópicos, siempre que el tipo de suelo, la precipitación pluvial, los yerbajos, etc. sean similares a los que prevalecieron en estos estudios.

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