Glyphosate for Weed Control in Plantains[1]

Lii-Chyuan Liu, José Rodríguez-García and Nelson Semidey-Laracuente[2]

ABSTRACT

This paper summarizes the results obtained on weed control, phytotoxicity, and yield of plantain as affected by Glyphosate and Paraquat treatments. Postemergence activity of Glyphosate and that of Paraquat on weeds in plantain fields were compared at the Corozal and Gurabo Substations. All plots, with the exception of the checks, received initially a preemergence application of Ametryn at the rate of 4.48 kg/ha. Glyphosate rates of 4.68, 9.36 and 18.72 L/ha, and Paraquat at the rates of 2.34, 4.68 and 9.36 L/ha, were subsequently applied to weeds four times at an approximately 2-month interval. Postemergence weed control was excellent at all three rates of Glyphosate application. Weed control with Paraquat was not as effective. As to drift effect of the herbicides, plantains appeared to be more susceptible to Glyphosate than to Paraquat. Fruit production as indicated by the number and weight of fruits increased with the increments of Glyphosate concentrations at the Corozal Substation. Yield was not proportionately increased with Glyphosate concentrations at the Gurabo Substation. The differential response to Glyphosate could be attributed to the fact that more severe plantain injuries occurred at the Gurabo Substation than at the Corozal Substation. Glyphosate at 4.68 L/ha rate can be used effectively to control weeds in order to achieve high yields with no noxious effect on plantains.

INTRODUCTION

Plantain (*Musa acuminata* × *M. balbisiana*, AAB) is a staple food which provides a carbohydrate source in the diet for people in the tropics. In 1977–78, plantain growers contributed $24.1 million to the economy of Puerto Rico. One of the major factors limiting plantain production has been the high production cost. In a cost and income study on intensive production of plantain in the mountain region of Puerto Rico, Vicente and Irizarry (12) indicated that weed control amounted to approximately one-fifth of the total production cost. Counting weed control expenses as a whole, they found the two handweedings used in their studies accounted for 77% of the total weed control costs. Two applications of herbicides, including material and cost of application used only 23% of the total. Consequently, it is possible to reduce production costs through intensified herbicide usage.

As plantain is a widely spaced crop with a long cycle of growth, a single application of Ametryn (2 (ethylamino)-4-(isopropyl-amino)-6-(methylthio)-s-triazine) or Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea) as a preemergence herbicide does not provide the sustained weed control

[1] Manuscript submitted to Editorial Board May 30, 1980.

[2] Plant Physiologist, Assistant Agronomist and Research Assistant, respectively, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico. Río Piedras, P.R. 00928.

required by this crop. The repeated postemergence applications of herbicides are needed until the canopy of the plant is completely closed in. Paraquat, commercially known as Gramoxone, is a widely used postemergence herbicide registered in Puerto Rico. As this herbicide is recently being placed on the pre-RPAR list of EPA, the search for an effective substitute is justified. During the past two years, the Agricultural Experiment Station has successfully completed two field trials comparing the postemergence activity of Paraquat (1,1-dimethyl-4,4′-bibipyridinium ion) and Glyphosate (N,-(phosphonomethyl) glycine) for weed control in plantain.

REVIEW OF LITERATURE

In 1968, Caro (4) investigated the effect of plant population and distribution on plantain yield. He obtained adequate weed control with Simazine. Algarín (1) compared the efficacy of Ametryn, Diuron, Methazole (2-(3,4-chlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione) and Secbumeton (N-ethyl-6-methoxy-N′(1-methylpropyl)-1,3,5,triazine-2,4 diamine) for preemergence weed control in plantain at the Corozal Substation. Among the four herbicides tested, Ametryn and Methazole were found to be highly effective against the major weeds encountered in the plantain field. Neither the number nor the weight of fruits was affected by the application of Ametryn and Methazole.

In 1977, Vélez-Ramos and Vega-López (11) tested Ametryn, Metribuzin (4-amino-6-tert-butyl-3-(methylthio)-s-triazine-5(4H)-one), Diuron, and Prometryn (2,4-bis(isopropylamino)-6-(methylthio)-s-triazine) at 2.24, 4.48 and 8.96 kg/ha rates for preemergence weed control in plantain. They found that Metribuzin and Diuron at rates higher than 4.48 kg/ha caused plantain injuries. Ametryn and Prometryn at the three rates tested were relatively safe. None of the herbicide treatments significantly reduced plantain yield, except Metribuzin and Ametryn at 8.96 kg/ha rate. In the same year, Almodóvar (2) evaluated Paraquat, Dalapon (2,2-dichloropropionic acid), and Diuron as to the timing and frequency of application needed for effective weed control in plantain. He reported that six applications of Paraquat at 2.34 l/ha rate gave the best weed control performance and highest yield production. Since its introduction in 1971 (3), Glyphosate commercially known as Roundup, has gained wide acceptance for weed control in a large number of crops in North, Central and South America. The effectiveness of Glyphosate as a postemergence herbicide for weed control is well documented (3, 6, 7, 8, 10). In Puerto Rico, there exists the need to get Glyphosate registered for the special local need.

MATERIALS AND METHODS

Two herbicide experiments were conducted at the Corozal and Gurabo Substations during 1977 and 1978. Plantain cultivar Maricongo was

planted for both experiments. The Corozal experiment was established on a Corozal clay, Aquic Tropudults clayey, mixed, isohyperthermic with a soil pH of 5.7 and organic matter content of 2.5%. The corms of Maricongo cultivar were peeled and immersed for 5 min in an insecticide-nematicide solution consisting of 25 ml of Aldrin and 11 ml of DBCP in 3.8 liters of water. At planting, 56 g of Chlordecone[3] 5% dust was applied per hole. The treated corms were planted October 26, 1977. The individual experimental plots were 7.3 × 7.3 m, with 16 plants 1.8 m apart both between rows and within the row. The experimental design was randomized complete blocks with four replications. All plots, with the exception of checks, received initially a preemergence application of Ametryn at the rate of 4.48 kg/ha immediately after planting. Glyphosate at the rate of 4.68, 9.36 and 18.72 l/ha, and Paraquat at the rate of 2.34, 4.68 and 9.36 l/ha were directed to weeds 5 weeks after preemergence herbicide application (table 1). Four postemergence applications of both herbicides were made December 5, 1977; February 24, 1978; May 17, 1978 and July 28, 1978. All postemergence herbicides were applied with a knapsack sprayer fitted with a 8004 nozzle tip. The spray volume was 468 l/ha. In the meantime, weeded checks were weeded with a hoe. A total of 3.5 tons of fertilizer 10-5-20 was applied at the 2nd, 5th, 8th and 10th month after planting. Pesticide control practices used by local farmers were adopted in this experiment. Weed control ratings and phytotoxicity evaluations were made four times. Table 1 shows the average of four evaluations. The marketable bunches were harvested at the mature/green stage during a time span of 12 to 18 months after planting. Each bunch was weighed and the number of fruits counted (table 2).

The Gurabo experiment was established on a Mabí clay, Vertic Eutropepts, fine montmorillonitic, isohyperthermic with a soil pH of 6.7 and organic matter content of 1.73%. The same plantain cultivar Maricongo was planted January 25, 1978. The individual plots were 5.5 × 5.5 m with 9 plants with the same spacings as in the Corozal experiment. The experimental design was randomized complete blocks with four replications. Ametryn at the rate of 4.48 kg/ha was applied on January 30, 1978 as a preemergent. Postemergence application of Glyphosate at rates of 4.68, 9.32 and 18.72 l/ha and Paraquat at rates of 2.38, 4.68 and 9.36 l/ha were applied four times: January 2, April 3, August 7, and October 6, 1978 (table 1). The same type of sprayer, as well as the same spray volume, was used in this experiment. All fertilization and pest control practices were similar to those used at the Corozal Substation. Data on weed control ratings and phytotoxicity evaluations were similarly re-

[3] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

TABLE 1.—*Effect of postemergence herbicide treatments on weed control and crop injury of plantains at the Corozal and Gurabo Substations*

Herbicide treatment	Corozal Substation		Gurabo Substation	
	Weed control[1]	Crop injury[2]	Weed control[1]	Crop injury[2]
Glyphosate 4.68 l/ha (4 times)	86	3	91	5
Glyphosate 9.36 l/ha (4 times)	92	7	91	10
Glyphosate 18.72 l/ha (4 times)	96	10	90	21
Paraquat 2.34 l/ha (4 times)	48	2	50	3
Paraquat 4.68 l/ha (4 times)	69	5	55	5
Paraquat 9.36 l/ha (4 times)	79	5	73	8
Weeded check	90	0	90	0
Nonweeded check	0	0	0	0

[1] Weed control rating is based on a scale of 0 to 100, 0 = no control; 100 = complete control.

[2] Crop injury evaluation is based on a scale of 0 to 100, 0 = no crop injury; 100 = completely affected. Each value is the mean of four evaluations.

corded. The fruit production data on the number of fruits and weight of bunches were also gathered at the end of harvest (table 2).

RESULTS

COROZAL EXPERIMENT

The predominant weed species present in the experimental plots, listed in their decreasing order of abundance were Guinea grass (*Panicum maximum* Jacq.), para grass (*Brachiaria purpurescens* (Raddi) Henr.), scarlet bean (*Phaseolus lathyroides* L.), woodsorrel (*Oxalis intermedia* L.), Bermuda grass (*Cynodon dactylon* (L.) Pers.), jungle rice (*Echinochloa colonum* (L.) Link.), caesarweed (*Urena lobata* L.), spiderflower (*Cleome aculeata* L.), pigweed (*Amaranthus dubius* Mart.), Mexican weed (*Caperonia palustris* (L.) St.Hil.), spurge (*Euphorbia heterophylla* L.), spreading dayflower (*Commelina diffusa* Burn. f.), and purple nutsedge (*Cyperus rotundus* L.). The herbicidal action of Glyphosate was characterized by slow yellowing of affected plants as contrasted with rapid desiccating and burning manifested by Paraquat. It took Glyphosate about 2 to 3 weeks to kill the weeds. Glyphosate at 4.68 l/ha rate gave excellent control of grass and broadleaf weeds. The only weakness of Glyphosate was its failure to give a complete control of spreading dayflower. Increasing rates of Glyphosate hastened the killing action of weeds and slightly improved weed control performance. Paraquat at 2.34 l/ha rate did provide good initial kill of weeds. However, the rapid regrowth of grass species lowered its weed control rating. Increasing the rates of Paraquat slightly improved its weed control performance. As far as phytotoxicity is concerned, Glyphosate at 4.68 l/ha caused only slight

TABLE 2.—*Effect of postemergence herbicide treatments on the commercial fruit production of plantains at the Corozal and Gurabo Substation*

Herbicide treatment	Fruit production per hectare					
	Corozal Substation			Gurabo Substation		
	Number[1]	Weight (kg)[1]	Mean weight of fruits	Number[1]	Weight (kg)[1]	Mean weight of fruits
Glyphosate 4.68 l/ha (4 times)	81,196 ab	20,403 b	0.25 a	60,235 a	13,115 a	0.22 a
Glyphosate 9.36 l/ha (4 times)	98,249 a	27,172 a	0.28 a	40,115 ab	9,123 ab	0.23 a
Glyphosate 18.72 l/ha (4 times)	107,265 a	30,332 a	0.29 a	23,795 bc	5,264 bc	0.22 a
Paraquat 2.34 l/ha (4 times)	64,144 b	15,574 b	0.25 a	27,595 b	5,836 bc	0.20 a
Paraquat 4.68 l/ha (4 times)	90,540 ab	25,943 a	0.28 a	27,533 b	5,892 bc	0.22 a
Paraquat 9.36 l/ha (4 times)	96,800 a	28,395 a	0.29 a	39,929 ab	9,491 ab	0.23 a
Weeded check	98,295 a	25,346 a	0.26 a	42,358 ab	10,360 ab	0.23 a
Nonweeded check	3,551 c	932 c	0.07 b	0 c	0 c	0 b

[1] Plantain production is based on the average of four replications; values in columns followed by the same letter do not differ statistically at $p = 0.05$.

plantain injury. As the Glyphosate concentration was raised to 18.72 l/ha, plantain injury was somewhat increased. The plantain injury was primarily caused by the drift effect during the herbicide application. Paraquat injury to plantain was also noted, but plantain injury was minor at 2.34 l/ha rate. Increasing rates of Paraquat application tended also to increase plantain injury, but the injury recovered much faster than that caused by Glyphosate.

According to the yield data presented in table 2, Glyphosate at 4.68 l/ha apparently outyielded Paraquat at its equivalent rate of 2.34 l/ha in the number of fruits as well as in the weight of the bunches. Increasing the rate of Glyphosate tended also to increase proportionately fruit production. The same trend of increase in yield was apparent with Paraquat treatments. Although the weeded check produced 17,099 more plantains (4,943) than that of Glyphosate at 4.68 l/ha rate, handweeding is far too expensive to be economically feasible under local conditions. It is estimated that the weeded check treatment based on four handweedings per crop would cost up to $1,730/ha, while that of Glyphosate at 4.68 l/ha would require only $510. A similar trend of increasing yield with increasing rate of Paraquat application was also noted. The non-weeded check yielded poorly both in the number as well as the weight of fruit. On the basis of mean weight of fruits harvested at Corozal and Gurabo Substations, the fruits produced at the Corozal Substation are of a quality superior to that of plantains harvested at the Gurabo Substation.

GURABO EXPERIMENT

The predominant weed species present, listed in decreasing order of abundance were Guinea grass (*Panicum maximum* Jacq.), para grass (*Brachiaria purpurascens* (Raddi) Henr.), red sprangle top (*Leptochloa filiformis* (Lam.) Beauv.), Bermuda grass (*Cynodon dactylon* (L.) Pers.), spurge (*Euphorbia heterophylla* (L.), little bean (*Desmanthus virgatus* (L.) Willd.), scarlet bean (*Phaseolus lathyroides* L.), spiderflower (*Cleome aculeata* L.), hemp sesbania (*Sesbania exaltata* (Raf.) Cory.), brown top panicum (*Panicum fasciculatum* Sw.), morning glory (*Ipomoea tiliacea* (Willd.) Choisy), purslane (*Portulaca oleracea* L.), niruri (*Phyllanthus niruri* L.), and purple nutsedge (*Cyperus rotundus* L.). Postemergent application of Glyphosate gave excellent weed control, regardless of its rate of application (table 1). Postemergence application of Paraquat at 2.34 l/ha rate provided only fair weed control. As the rate of Paraquat application was raised to 9.36 l/ha, weed control was correspondingly improved. The higher rate of Paraquat impeded the regrowth of guinea grass and para grass, but the weed population shifted to the predominating little bean. Paraquat was ineffective in controlling little bean. Table 1 also shows that Glyphosate caused more severe plantain

injuries at Gurabo Substation than at the Corozal Substation. As the rate of Glyphosate was raised to 18.72 l/ha, plantain injury was greatly increased. Although plants recovered somewhat from injury later on, a detrimental permanent effect on yield might have already been inflicted.

The highest number of fruits and the greatest bunch weight were obtained with plants treated with Glyphosate at the rate of 4.68 l/ha at Gurabo Substation (table 2). The increasing rate of Glyphosate did not bring about a similar increase as in the Corozal Substation. Instead, an increase in the rate of Glyphosate resulted in a decrease in plantain fruit production. This differential response to Glyphosate could be attributed to the increased plantain injury observed at the Gurabo Substation. The reason for more severe plantain injury at Gurabo was probably that one of the four postemergence applications was done under adverse weather conditions. On the contrary, increasing the rate of Paraquat brought about a corresponding increase in yield. However, yield was lower than that with the 4.68 l/ha rate of Glyphosate. The weeded check produced the second highest yield of all treatments. The higher cost of manual labor and scarcity of labor supply may limit this alternative. The non-weeded checks produced small fruits, which were not considered marketable.

DISCUSSION

Herbicide drift during application apparently accounted for the observed Glyphosate and Paraquat injuries. As a result of herbicide drift, plantain plants appeared to be more susceptible to Glyphosate than to Paraquat. The greater susceptibility of plantain to Glyphosate could be attributed to its systemic action within the plant (3, 9). The toxic action of Glyphosate could reach any part of the plant through translocation, whereas Paraquat acts only as a contact herbicide killing only plant tissues in direct contact with it.

In the present study, Glyphosate and Paraquat were compared on the basis of an equal number of applications. The fair weed control achieved by Paraquat could be greatly improved by increasing frequency of application. As indicated above, Almodóvar reported that six applications of Paraquat at 2.34 l/ha rate provided the best weed control and highest fruit yield (2). On the other hand, the frequency of Glyphosate applications might be reduced to get weed control comparable to that achieved by Paraquat. Subsequent studies should be directed to determine the best timing and frequency of application for Glyphosate.

The cost of the four handweedings of the check plots in this experiment during the first 8 months was estimated at $1,730 per hectare. On the contrary, four applications of Glyphosate during the same time period would cost $510 per hectare. A difference of $1,220 represents the benefit

of intensified Glyphosate usage. If Paraquat is used for weed control in plantain, the frequency of herbicide application may have to be increased to six applications, with a cost (product plus six applications) of $486 per hectare. A difference of $1,244 represents the benefit of intensified Paraquat usage. There is hardly any difference in whether the use of Glyphosate or Paraquat is intensified. Under the present economic and social conditions of the Island, handweeding plantains even if laborers were available would be costly.

RESUMEN

La producción de plátanos en el 1977–78 generó un ingreso agrícola total de $27.8 millones. Debido a la importancia de este cultivo y al alto costo de la mano de obra, es necesario conseguir un yerbicida posemergente que permita reducir el costo de la producción de tan importante renglón. Se estableció un experimento en la Subestación de Corozal y otro en la Subestación de Gurabo con el propósito de comparar el efecto posemergente de los yerbicidas Glyphosate y Paraquat. Se utilizó la variedad Maricongo y se aplicó el yerbicida Ametryn a razón de 4.48 kg/ha como preemergente. Transcurridas entre 4 y 5 semanas, se inciaron las aplicaciones de Glyphosate a razón de 4.68, 9.36 y 18.72 litros en 468 litros de agua por hectárea. También se incluyó el yerbicida Paraquat a las concentraciones de 2.34, 4.68 y 9.36 litros en 468 litros de agua por hectárea. En total se hicieron cuatro aplicaciones a intervalos de 2 meses durante el ciclo de siembra a cosecha.

Los resultados demostraron que apenas hay diferencia entre Glyphosate y el Paraquat si se usan intensamente para controlar los yerbajos que afectan el plátano. El Glyphosate a razón de 4.68 l/ha fue eficaz para el control de malezas, tanto las gramíneas como las de hoja ancha. Se logró aumentar la producción de plátanos incrementando la dosis de Glyphosate en la Subestación de Corozal, pero no se logró un aumento similar en la de Gurabo. Esta diferencia en rendimiento podría atribuirse a que el herbícida les causó daño. Todo indica que Glyphosate a 4.68 l/ha es suficiente para lograr un buen control de yerbajos y un alto rendimiento de frutas sin efectos nocivos de importancia a la plantación.

LITERATURE CITED

1. Algarín, P. J., 1973. Valor comparativo de yerbicidas en la producción de plátanos en Puerto Rico, Master thesis submitted to the Graduate School, College of Agricultural Sciences, University of Puerto Rico, Mayagüez Campus.
2. Almodóvar, L. A., 1977. Control of weeds in crops of economic value, Ann. Prog. Rep., Agric. Exp. Stn., Univ. P. R. Mayagüez Campus, Río Piedras, P.R.
3. Baird, D. D., Upchurch, R. P., Homesley, W. B., and Franz, J. E., 1971. Introduction of a new broad spectrum postemergence herbicide class with utility for herbaceous perennial weed control, Proc. North Cent. Weed Conf. 26: 64–8.

4. Caro-Costa, R., 1968. Effect of plant population and distribution on yield of plantains. J. Agric. Univ. P.R. 50(3): 256–9.
5. Departamento de Agricultura, Anuario de Estadísticas Agrícolas de Puerto Rico: Estimados Preliminares del Ingreso Agrícola de Puerto Rico para 1977–78.
6. Jordan, T. N. and Baker, R. S., 1975. Control of Bermuda grass in cotton. Miss. Agric. For. Exp. Stn. Res. Rep. 1(20).
7. McWhorter, C. G., 1972. Toxicity of Mon-0468 to Johnsongrass and Soybeans, Proc. South. Weed Sci. Soc. 25: 117.
8. Norton, K. R. and Merkle, M. G., 1976. Fall applied herbicides for controlling Johnsongrass, Proc. South. Weed Sci. Soc. 29: 61.
9. Sprankle, P., Meggitt, W. F., and Penner, D., 1975. Absorption action and translocation of glyphosate, Weed Sci. 23: 235–40.
10. Will, G. D., 1975. Evaluation of glyphosate for postemergence control of purple nutsedge in cotton, Proc. South. Weed Sci. Soc. 28: 54–7.
11. Vélez-Ramos, A. and Vega-López, J. A., 1977. Chemical weed control of weeds in plantains (*Musa acuminata* × *M. balbisiana* AAB). J. Agric. Univ. P.R. 61 (2): 259–61.
12. Vicente-Chandler, J., Irizarry, H. and Llorens, A. A., 1980. Costos e ingresos en la producción intensiva de plátanos en la región montañosa de Puerto Rico, Publ. 137, Esta. Exp. Agric. Univ. P.R.