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GLYPHOSATE FOR WEED CONTROL IN TWO TROPICAL ROOT-CROPS

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SUMMARY

Four herbicide field experiments were conducted in 1979 and 1980 at the Corozal and Isabela Agricultural Substations to evaluate glyphosate /N-phosphonomethyl) glycine/ at 1, 2, and 4% applied as pre-plant, preemergence, pre-plant plus postemergence or preemergence plus postemergence for weed control in taniers (Xanthosoma spp.) and yams (Dioscorea spp.). For the preemergence treatment of glyphosate, the vines of yams and aerial part of tanier plants were trimmed to avoid direct contract with the chemical. All the experiments were carried out on small plots arranged in randomized complete block designs with four replications. Weed control ratings and phytotoxicity evaluations were made periodically. The edible tubers were harvested and the data were analyzed statistically.

In taniers, glyphosate at 1% applied as a preemergent provided good to excellent weed control with no visible crop injury in one experiment. Also, highest tuber yield was obtained, outyielding all other treatments. In another experiment, two applications of glyphosate (preemergence plus postemergence) gave better sustained weed control than a single application (preemergence only). However, two applications of glyphosate caused greater crop injury than a single one. Consequently, when plots received two applications they did not outyield plots with a single preemergence application.

In yams, best weed control was achieved with two applications of glyphosate (pre-plant at 1% plus postemergence at 4%). A single pre-plant glyphosate application at 1 to 4% caused no visible crop injury. The second follow-up postemergence treatment was responsible for the observed crop injury. When two applications of glyphosate (pre-plant 1% plus postemergence 4%) were used the highest tuber yield was obtained. Plots with a single application of glyphosate as preplant yielded poorly. In another experiment, two applications of glyphosate at 1 to 4% (preemergence plus postemergence) gave better sustained weed control than a single preemergence application. However, final tuber yield production did not reflect the difference in weed control performance.

INTRODUCTION

Glyphosate /N-(phosphonomethyl) glycine/ known commercially as Roundup has been used widely as a postemergence herbicide for weed control in a large number of crops in the United States since its introduction in 1971 (1). In Puerto Rico, Beale (2) first used glyphosate for postemergence weed control in taniers (Xanthosoma spp.) and encountered excessive crop injury problem in 1975. Subsequently, Liu (3,4) tested the same herbicide in taniers and yams (Dioscorea spp.) and encountered the similar crop injury problem as a consequence of herbicide drift during the postemergence application process. Consequently, the timing of glyphosate application was changed from postemergence to pre-plant or preemergence in an attempt to avoid crop injury. This paper reports our findings on weed control, phytotoxicity and yield of taniers and yams as influenced by the modified timings of glyphosate applications.

METHOD AND MATERIALS

Tanier experiment no. 1

This experiment was established on a Coto clay (Oxisol with soil pH 4.8 and organic matter 2.5%) at the Isabela Substation located in the northwestern part of Puerto Rico. A randomized complete block design with four replications was used. The individual plots consisted of four 6.1 m long rows spaced at 0.9 m between rows. The planting distance within the row was 0.6 m. Tanier cultivar Blanca (X. sagittifolium L.) was planted July 24, 1980. Fertilizer 8-8-13 was applied once at the rate of 60 grams per plant. Supplementary irrigation were made thrice during the growing season. Both weeds and taniers were allowed to grow for nearly a month. About one fourth of taniers were germinated and most weeds became established at the time of glyphosate application. The aerial part of tanier shoots were trimmed with a knife to permit the preemergence application of the glyphosate. Glyphosate at 1, 2, and 4% of the product was applied over-the-top of the entire plot on August 19, 1980. A spray volume equivalent to 468 l/ha was sprayed with a knapsack sprayer. The check plots were handweeded thrice at approximately two months interval. All pesticide managements followed the commercial practice for the region. Weed control ratings and phytotoxicity evaluations were made periodically. The marketable tubers were harvested on June 25, 1981.

Tanier experiment no. 2

This experiment was established on a Corozal clay (Ultisol with soil pH 5.3, and organic matter 3.7%) at the Corozal Substation situated at the northcentral part of the Island. A randomized complete block design with four replications was used. The individual plots consisted of three 6.1 m long rows spaced at 0.9 m between the rows. The planting distance was the same as in the first

experiment. Tanier cultivar Morada (Xanthosoma nigrium (Velloso) Stellfeld) was planted July 21, 1980. The same fertilization and pesticide management were used in this experiment as in the previous one. Supplementary irrigations were made thrice during the growing season.

Glyphosate at 1, 2 and 4% as a preemergence treatment was applied September 23, 1980 to all plots except weeded and non-weeded checks. Half the number of plots received only one single preemergence glyphosate application and the other half received both preemergence and postemergence applications. Postemergence applications of glyphosate was made with a portable wick rope (commercially known as chemihoe). The rope application was repeated thrice at approximately two months interval. The weeded check was handweeded thrice with a hoe. Weed control ratings and phytotoxicity evaluations were made periodically. The tuber production was recorded July 7, 1981.

Yam experiment no. 1

This experiment was established on the same Coto clay (an Oxisol with soil pH 6.3 and organic matter 2.6%) at the Isabela Substation. A randomized complete block design with four replications were used. The individual plots consisted of four 6.1 m long rows spaced at 1.2 m between rows. The planting distance was 0.6 m within the row. The same fertilization and pesticide management were used in this experiment as in the previous one.

The plots were prepared in the middle of March, 1980 and weeds were allowed to grow for five weeks. Pre-plant application of glyphosate at 1, 2, and 4% was made April 18, 1980. Yam cultivar Guinea (Dioscorea rotundata L.) was planted 11 days after herbicide application. About half the number of plots received only one pre-plant application of glyphosate. The other half received one pre-plant and one postemergence application of glyphosate. The application was made

with a knapsack sprayer. The same spray volume equivalent to 468 l/ha rate was used as previously. The postemergence application of glyphosate at 1, 2, and 4% was made June 10, 1980. Weed control ratings and phytotoxicity evaluations were made periodically. The tuber yield of yams was harvested January 21, 1981.

Yam experiment no. 2

This experiment was established on a Corozal clay (an Ultisol with soil pH 4.3 and organic matter 2.3%) at the Corozal Substation. A randomized complete block design with four replications was used. The individual plots consisted of three 6.1 m long rows spaced at 1.5 m between rows. The same planting distance as in the first yam experiment was used. The same fertilization and pesticide management were used in this experiment as in the previous one.

The same yam cultivar Guinea (Dioscorea rotundata L.) was planted May 14, 1980. Both weeds and yams were allowed to grow for about a month. On June 3, 1980, glyphosate at 1, 2, and 4% was applied over the top of the weeds. The vines of yam plants were trimmed prior to the glyphosate application. About half the number of plots received only one preemergence application. The other half received a preemergence and a postemergence application. The postemergence application of glyphosate was made September 16, 1980. Weed control ratings and phytotoxicity evaluations were made periodically. The tubers were harvested January 28, 1981.

RESULTS

Tanier experiment no. 1

The predominant weed species present in the experimental plots are listed in their decreasing order of abundance; southern sandbur (Cenchrus echinatus L.), Panamá paspalum (Paspalum fimbriatum H.B.K.), spurge (Euphorbia heterophylla L.), jungle rice (Echinochloa colonum (L.) Link.), woodsorrel (Oxalis intermedia A. Rich.),

morning glory (Ipomoea tiliacea (Willd.) Choisy), Alexander grass (Brachiaria plataginea (Link.) A Hitchc.), little bean (Rhynchosia minima (L.) DC.), scarlet bean (Phaseolus lathyroides L.), red tasselflower (Emilia sonchifolia (L.) DC.), and purple nutsedge (Cyperus rotundus L.). Glyphosate at 1% applied as a preemergent gave excellent control of the above-mentioned weeds (table 1). Increasing glyphosate concentration to 4% improved weed control only slightly. Slight chlorosis appeared on the leaves of germinating taniers two weeks after glyphosate treatment, but this effect was no longer evident by the time of phytotoxicity evaluation. Table 1 also shows that with glyphosate applied at 1% we obtained the highest tuber yield. The weeded check outyielded slightly the plots treated with glyphosate at 1%. However, the difference in tuber production between the two was not statistically significant. The non-weeded check produced the lowest tuber yield of all.

Tanier experiment no. 2

The predominant weed species present in the experimental plots are listed in their decreasing order of abundance; guinea grass (Panicum maximum Jacq.), para grass (Brachiaria purpurancens (Raddi.) Hnr.), Bermuda grass (Cynodon dactylon (L.) Pers.), smooth crotalaria (Crotalaria striata DC.), caesarweed (Urena lobata L.), scarlet bean (Phaseolus lathyroides L.), dayflower (Commelina diffusa Brn. f.), goose grass (Eleusine indica (L.) Gaertn.), jungle rice (Echinochloa colonum (L.) Link.), morning glory (Ipomoea tiliacea (Willd.) Choisy), red tasselflower (Emilia sonchifolia (L.) DC.), and smallflower morning glory (Jacquemontia tamnifolia (L.) Griseb.). Single preemergence application of glyphosate at 1 to 4% provided excellent control of the above-mentioned weeds for about two months (table 2). Apparently, preemergence application of glyphosate regardless of its concentrations used did not give sustained weed control.

Premergence plus postemergence applications of glyphosate continued to provide excellent weed control throughout this experiment. No apparent crop injury problem existed for plots receiving only one preemergence application of glyphoasate. However, when plots receiving both preemergence and postemergence applications of glyphosate irrespective of its concentrations, a varying degree of crop injury was encountered. It was apparent that postemergence application of glyphosate was responsible for said crop injury. The same table shows that tuber yield produced in this experiment was considerably lower than that of the first experiment. The dry rot disease, of an unknown pathogenicity, had adversely affected this experiment and caused the tuber yield to decline drastically. The plots with a single preemergence application of glyphosate at 4% produced the highest tuber yield of all treatments. Plots receiving preemergence application of glyphosate at 1% plus postemergence rope application of glyphosate at 20% ranked second. There is a trend for the yield to decrease as the concentration of postemergence application of glyphosate was increased from 20% to 40%. With glyphosate at 1% applied as preemergence the third highest tuber yield was obtained. The weeded check ranked fourth in yield. The non-weeded check produced the lowest tuber yield.

Yam experiment no. 1

The predominant weed species present in the experiment plots were essentially the same as those mentioned in the tanier experiment no. 1. A single pre-plant application of glyphosate at 1% provided excellent control of the above-mentioned weeds (table 3). Increasing pre-plant glyphosate concentration to 4% improved weed control only slightly. All the pre-plant applications of glyphosate failed to provide sustained weed control. Two applications of glyphosate (pre-plant 1% plus postemergence 4%) gave best sustained weed control. Other two applications

of glyphosate at different concentrations also provided good sustained weed control. No apparent crop injury was noted for all pre-plant application of glyphosate at all concentrations. However, slight crop injury was encountered in plots receiving two applications of glyphosate. Apparently, the second application of glyphosate was chiefly responsible for the observed injury.

All plots receiving two applications of glyphosate regardless of its concentration outyielded those receiving a single pre-plant application of glyphosate at 1 to 4%. The severe weed competition which occurred during the later part of season caused tuber yield to decrease drastically in plots receiving only a pre-plant application of glyphosate. The two applications of glyphosate (pre-plant 1% and postemergence 4%) produced the highest tuber yield. The weeded check ranked fourth in yield, outyielding all the plots receiving only a single pre-plant application of glyphosate at all concentrations tested.

Yam experiment no. 2

The predominant weed species present in the experimental plots were similar to those mentioned in tanier experiment no. 2. A single preemergence application of glyphosate at 1% controlled effectively most weeds encountered in the experimental plots for about two months. Increasing preemergence glyphosate concentration to 4% improved weed control only slightly (table 4). No crop injury was observed in those plots receiving only a preemergence application of glyphosate. Slight crop injury was noted resulting from glyphosate drift during the second postemergence application of glyphosate.

The highest tuber yield was registered with plots receiving glyphosate at 1% as preemergence and glyphosate at 1% as postemergence. It was then followed by a single preemergence application of glyphosate at 1%. There was a trend for the tuber yield to decrease as the glyphosate concentration was increased regard-

less of the number of glyphosate treatments applied. However, the yield differences among them were not statistically significant. There was no significant difference in tuber yield between all glyphosate treated and weeded plots. The only treatment which showed a significant lower yield was the non-weeded check.

DISCUSSION

Pre-plant or preemergence applications of glyphosate at 1 to 4% greatly minimized herbicide injury to taniers and yams. The crop injury encountered in our experiment was caused by the second postemergence application of glyphosate. As far as the optimum concentration of glyphosate for the pre-plant or preemergence application is concerned, it has been shown that glyphosate at 1% is sufficiently high enough to control most weeds encountered in the experiment area. Increasing glyphosate concentration to 4% hastened its killing action. Very little extra advantage was gained by using higher concentrations of this chemical.

Trimming the vines of yams and the aerial parts of the tanier plants to permit preemergence application of glyphosate is a new innovation successfully carried out in this investigation. No detrimental effect on resprouting and subsequent growth of both crops was attributable to the trimming. Since the seed pieces of both crops take 3 to 4 weeks to sprout, an effective preemergence weed control program can be devised to take advantage of its tardiness in sprouting. This program can include purposely delaying the planting of the seed pieces to the field for two weeks and allow weeds to sprout before the crops do. Consequently, the number of vines of yams and leaves of taniers to be trimmed at the time of glyphosate application can be greatly reduced or completely eliminated.

The excessive tenier injury encountered in experiment nº 2 was sgain caused by the subsequent postemergence rope applications. As the glyphosate concentration used in the rope applicator was quite high, a minor contac of the chemical with tanier plants could cause the death of the plant. In some cases the contac between the drooping leaves of the crop and glyphosate treated dying weeds resulted in crop injury. Apparently, the excellent weed control achieved by the rope applicator was cancelled by excessive crop injury. Therefore, the final tuber production did not reflect the excellent weed control achieved. Further experimentations should be directed to determine whether reduced glyphosate concentration in a rope applicator would provide good weed control with minimum crop injury.

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Table 1.-Effect of different concentrations of glyphosate on weed control, phytotoxicity and yield of taniers at the Isabela Substation

Herbicide treatment	Weed control at[1/] 9-19-80	Phytotoxicity at[2/] 9-19-80	Tuber yield (kg/ha)[3/]
1. Glyphosate 1% (preemergence)	87	0	11,168 a[4/]
2. " 2% "	91	0	10,540 a
3. " 4% "	93	0	9,167 a
4. Weeded check	90	0	11,571 a
5. Non-weeded check	0	0	3,050 b

1/ Weed control ratings are based on a scale of 0-100: 0 = no control, 100 = complete control

2/ Phytotoxicity evaluations are based on a scale of 0-100: 0 = no phytotoxicity, 100 = completely affected

3/ Tuber yield is the average of four replications

4/ Values followed by one or more letters in common do not differ significantly (P = 0.05)

Table 2.-Effect of different concentrations of glyphosate on weed control, phytotoxicity and yield of taniers at the Corozal Substation

Herbicide treatment	Weed control at 1/			Phytotoxicity at 2/			Tuber yield (kg/ha) 3/
	10-21-80	12-23-80	Ave.	10-21-80	12-23-80	Ave.	
1. Glyphosate 1% (preemergence)	97	35	66	0	0	0	5,160 a 4/
2. " 2% "	96	36	66	0	0	0	3,926 ab
3. " 4% "	98	39	69	0	0	0	5,757 a
4. Glyphosate 1% (preemergence) + Glyphosate 20% (postemergence)	96	95	96	0	20	10	5,533 a
5. Glyphosate 1% (preemergence) + Glyphosate 33% (postemergence)	97	97	97	0	28	14	4,584 ab
6. Glyphosate 1% (preemergence) + Glyphosate 40% (postemergence)	98	99	99	0	30	15	3,804 ab
7. Weeded check	100	90	95	0	0	0	4,991 a
8. Non-weeded check	0	0	0	0	0	0	712 b

1/ Weed control ratings are based on a scale of 0-100: 0 = no control, 100 = complete control

2/ Phytotoxicity evaluations are based on a scale of 0-100: 0 = no phytotoxicity, 100 = completely affected

3/ Tuber yield is the average of four replications

4/ Values followed by one or more letters in common do not differ significantly (P = 0.05)

Table 3.-Effect of different concentrations of glyphosate on weed control, phytotoxicity and yield of yams at the Isabela Substation

Herbicide treatment	Weed control at 1/			Phytotoxicity at 2/			Tuber yield (kg/ha) 3/
	6-10-80	7-18-80	Ave.	6-10-80	7-18-80	Ave.	
1. Glyphosate 1% (pre-plant)	91	19	55	0	0	0	12,368 b 4/
2. " 2% "	93	20	57	0	0	0	12,730 b
3. " 4% "	96	26	61	0	0	0	9,910 b
4. Glyphosate 1% (pre-plant) + Glyphosate 1% (postemergence)	90	90	90	0	10	5	22,565 a
5. Glyphosate 1% (pre-plant) + Glyphosate 2% (postemergence)	91	93	92	0	15	8	22,147 a
6. Glyphosate 1% (pre-plant) + Glyphosate 4% (postemergence)	88	96	92	0	18	9	23,022 a
7. Weeded check	95	95	95	0	0	0	21,156 a

1/ Weed control ratings are based on a scale of 0-100: 0 = no control, 100 = complete control

2/ Phytotoxicity evaluations are based on a scale of 0-100: 0 = no phytotoxicity, 100 = completely affected

3/ Tuber yield is the average of four replications

4/ Values followed by one or more letters in common do not differ significantly (P = 0.05)

Table 4.-Effect of different concentrations of glyphosate on weed control, phytotoxicity and yield of yams at the Corozal Substation

Herbicide treatment	Weed control at 1/			Phytotoxicity at 2/			Tuber yield (kg/ha) 3/
	6-17-80	9-30-80	Ave.	6-17-80	9-30-80	Ave.	
1. Glyphosate 1% (preemergence)	93	15	54	0	0	0	9,595 a 4/
2. " 2% "	95	20	58	0	0	0	8,782 a
3. " 4% "	100	24	62	0	0	0	8,091 a
4. Glyphosate 1% (preemergence) + Glyphosate 1% (postemergence)	94	83	89	0	9	5	9,940 a
5. Glyphosate 1% (preemergence) + Glyphosate 2% (postemergence)	91	85	88	0	11	6	8,578 a
6. Glyphosate 1% (preemergence) + Glyphosate 4% (postemergence)	93	90	92	0	15	8	7,929 a
7. Weeded check	90	90	90	0	0	0	7,385 a
8. Non-weeded check	0	0	0	0	0	0	3,130 b

1/ Weed control ratings are based on a scale of 0-100: 0 = no control, 100 = complete control

2/ Phytotoxicity evaluations are based on a scale of 0-100: 0 = no phytotoxicity, 100 = completely affected

3/ Tuber yield is the average of four replications

4/ Values followed by one or more letters in common do not differ significantly (P = 0.05)