

Influence of glyphosate and paraquat pre-transplant treatments on weed control and peppers yields¹

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ABSTRACT

Two field experiments, both with Cubanelle and Yollow Wonder peppers (*Capsicum annuum* L.), were conducted at the Juana Díaz Research and Development Center in 1981-82. Weeds were induced to grow through periodic irrigations for 16 days before peppers were transplanted. Either glyphosate or paraquat at 1.12 kg ai/ha were then applied to control emerging weeds in two separate experimental areas 5 days before setting out transplants. Oxyfluorfen at 1.12 kg ai/ha applied 2 days before transplanting peppers caused the highest phytotoxicity (significant at $P=0.05$) as recorded during 14, 28 and 42 days after treatment in both experiments. Neither alachlor (1.68 kg ai/ha), oxadiazon, trifluralin nor pendimethalin applied 2 days before transplanting at 1.12 kg ai/ha was phytotoxic to peppers. There were no significant differences in Cubanelle or Yollow Wonder pepper yields among herbicide treatments and hand-weeded check. The highest pepper yields (47,771 and 44,964 kg/ha) were obtained in plots treated initially with glyphosate and later by either paraquat directed postemergence spray or oxadiazon pre-transplant at 1.12 kg ai/ha each, respectively. In the other experiment, hand-weeded check and preplant application of paraquat at 1.12 followed by oxyfluorfen at 1.12 kg ai/ha were the highest yielders with 47,771 and 44,964 kg/ha, respectively.

INTRODUCTION

Peppers (*Capsicum annuum* L.) are one of the most important vegetable crops in Puerto Rico. Pepper production was around 6,624 t in 1983-84 for a total gross income of \$4.38 million (1). More than 70% of the crop was supplied from the southern coastal area. Weed infestation in this area usually limits pepper production during the whole year. Recent investigations have demonstrated that weeding peppers represented 27.1% of the total labor costs (5). Llorens et al. (8) have concluded that the weeding of furrow irrigated peppers in the southern coastal area accounted for around 19% of the total labor costs. A weed competition study revealed that the critical period in drip irrigated peppers ranged from 24 to 36 days after transplanting (7). This information

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could be used as a guide for improving weed management systems in pepper production.

Herbicides are among the most efficient and economical weed control methods for vegetable production. Diphenamid (N, N-dimethyl-2-diphenylacetamide) is a preemergence herbicide recommended for peppers (2, 14). According to Serrano-Pérez (11), a monthly weeding beginning 30 days after diphenamid application is necessary for efficient weed control in peppers. Many herbicides have been evaluated for weed control in peppers in the United States (3, 4, 9, 10). Although this information from the United States is useful, some factors in Puerto Rico such as weed species, climate and soil characteristics differ from those in the States. In Puerto Rico Liu (6) also evaluated napromide, diphenamid and trifluralin for weed control in peppers. However, none of these herbicides provided full-season control of weeds. Glyphosate and paraquat are two nonselective herbicides widely used as pre-plant treatment against actively growing weeds prior to transplanting or germination of many vegetable crops. An important property of these herbicides is their rapid inactivation by soils following their use without detrimental effects to crops (12, 13, 14). The objective of this study was to evaluate the performance of postemergence glyphosate or paraquat on weeds as pre-transplant treatments to emerged weeds in a sequential application with several pre- or postemergence herbicides to late emerging weeds.

MATERIALS AND METHODS

Two field experiments with both Cubanelle and Yollow Wonder pepper cultivars were conducted at the Juana Díaz Research and Development Center in 1981-82. The experiments were conducted on a Mollisol soil (38% sand, 37% silt, 24% clay, 2.1% organic matter and pH 7.2). The soil was carefully prepared according to recommended practices before the pepper seedlings were transplanted. Weeds were induced to grow through periodic irrigation for a period of 16 days. At this time glyphosate and paraquat at 1.12 kg ai/ha were applied in two separate experimental areas with an A-Z sprayer at 2.11 kg/cm² pressure and a spray volume of 300 L/ha. Preemergence herbicides were applied 2 days before transplanting in both trials. Glyphosate and paraquat directed post-emergence treatments were applied 30 days after transplanting. Pepper seedlings were transplanted December 22, 1981 (5 days after application of paraquat and glyphosate) in a split plot design with four replications. Each plot consisted of 30 pepper plants from each cultivar. Plant spacing was 0.3 m in the row and 0.9 m between rows. Fertilizer, irrigation and pest control practices were preformed according to the recommendations of the Agricultural Experiment Station (2). Hand-weeded checks were hoed as necessary in both experiments.

Phytotoxicity and weed control data were recorded 14, 28 and 42 days after transplanting peppers. Weed weights by species in 0.5 m² were taken 56 days after transplanting. Peppers were harvested in five pickings from March 4 to May 12, 1982.

RESULTS AND DISCUSSION

Experiment No. 1

Oxyfluorfen for preemergence weed control at 1.12 kg ai/ha applied 2 days before transplanting peppers caused the highest phytotoxicity as recorded 14, 28 and 42 days (table 1). Dyphenamid at 5.88 kg ai/ha was also phytotoxic to peppers at 14 and 28 days, but phytotoxicity was lower at 42 days. Glyphosate and paraquat, both at 1.12 and 2.24 kg ai/ha in a directed application to weeds at 30 days, caused significant phytotoxicity to peppers. This phytotoxicity recorded 12 days after treatment (42 days after transplanting) occurred when herbicide drift reached foliage of peppers. Neither alchlor (1.68 kg ai/ha), oxadiazon, trifluralin nor pendimethalin at 1.12 kg ai/ha was not phytotoxic to peppers.

Weed control was good to excellent (80-90% or more) in all treated plots until 42 days. Since glyphosate at 1.12 kg ai/ha was applied as pre-transplant treatment to emerged weeds, the improved weed control can be attributed mainly to its performance. Table 1 shows data on yields of the two pepper cultivars. There were no significant differences in Cubanelle or Yollow Wonder yields among herbicide treatments and the hand-weeded check. Paraquat directed treatment at 1.12 kg ai/ha and oxadiazon 1.12 kg ai/ha contributed to the highest yields of peppers with 46,130 and 44,192 kg/ha, respectively. Table 2 shows weed number and weed weight 56 days after transplanting peppers. Pigweed (*Amaranthus dubius* L.), small spider flower (*Cleome gynandra*) and horse purslane (*Trianthema portulacastrum* L.) were among the most predominant weed species in the experimental area.

Experiment No. 2

As in the glyphosate experiment, oxyfluorfen at 1.12 kg ai/ha caused the highest initial phytotoxicity to peppers but at a lower index (table 3). Diphenamid at 5.88 kg ai/ha ranked second in phytotoxicity but at a lower index at 28 and 42 days. Glyphosate (1.12 kg ai/ha) and paraquat (2.24 kg ai/ha) directed treatment also caused some phytotoxicity to peppers, significant ($P=0.05$) when compared to that caused by oxadiazon, trifluralin, pendimethalin and alachlor, which were not phytotoxic to peppers.

Oxyfluorfen (1.12 kg ai/ha), glyphosate (1.12 and 2.24 kg ai/ha) and paraquat (1.12 and 2.24 kg ai/ha) controlled weeds excellently until 42 days after transplanting. At this time pendimethalin (1.12 kg ai/ha) and diphenamid (5.88 kg ai/ha) were ineffective. Most of the herbicides

TABLE 1.—Effect of herbicides on pepper phytotoxicity, weed control and yield (experiment no. 1)¹

Treatment	Rate	Phytotoxicity ²			Weed control ³			Pepper yield ⁴		Average
		14	28	42	14	28	42	Cubanelle	Yollow Wonder L.	
	kg/ha							kg/ha	kg/ha	kg/ha
Diphenamid	5.88	1.75 b	0.50 b	0.12 b	96	95	85	36184 a	43658 a	39921 a
Oxadiazon	1.12	0.00 c	0.00 c	0.00 b	95	95	86	42472 a	45913 a	44192 a
Oxyfluorfen	1.12	7.50 a	3.00 a	2.25 a	98	98	97	28394 a	30608 a	29501 a
Trifluralin	1.12	0.00 c	0.00 c	0.00 b	97	94	85	36975 a	29145 a	33060 a
Pendimethalin	1.12	0.00 c	0.00 c	0.00 b	95	98	88	30490 a	34642 a	32566 a
Alachlor	1.68	0.00 c	0.00 c	0.00 b	98	92	80	29462 a	33060 a	31261 a
Hand-weeded	0.00	0.00 c	0.00 c	0.00 b	98	90	95	42947 a	41919 a	42314 a
Glyphosate ⁵	1.12	0.00 c	0.00 c	2.25 a	98	90	96	35235 a	36461 a	35848 a
Glyphosate ⁵	2.24	0.00 c	0.00 c	2.00 a	96	87	98	41721 a	40574 a	41147 a
Paraquat ⁵	1.12	0.00 c	0.00 c	1.50 a	96	88	97	48562 a	43698 a	46130 a
Paraquat ⁵	2.24	0.00 c	0.00 c	2.00 a	96	90	97	33377 a	43342 a	38439 a

¹ Glyphosate at 1.12 kg ai/ha was applied 5 days before transplanting to emerging weeds as initial treatment in all plots.

² Phytotoxicity at 14, 28 and 42 days after transplanting, with 0 representing no visual injury and 10 complete plant kill.

³ Weed control at 14, 28 and 42 days after transplanting, with 0 representing no control and 100 complete weed control.

⁴ No significant differences in yield between treatment means was detected.

⁵ Direct application to weeds 50 days after transplanting.

TABLE 2.—Effect of herbicides on weed number and weight 8 weeks after transplanting peppers (experiment no. 1)¹

Treatment	Rate	Number of weeds ²								Weed fresh weights (kg) ²							
		A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H
Diphenamid	5.88	2	25	16	0	9	3	0	0	0.57	0.80	1.00	0.00	0.15	0.05	0.00	0.00
Oxadiazon	1.12	0	4	39	19	18	1	0	5	0.00	0.16	4.04	0.08	0.28	0.01	0.00	0.03
Oxyfluorfen	1.12	1	0	43	23	5	0	0	1	0.02	0.00	1.73	0.13	0.09	0.00	0.00	0.01
Trifluralin	1.12	2	17	16	0	3	0	0	5	0.29	1.28	1.11	0.00	0.02	0.00	0.00	0.32
Pendimethalin	1.12	2	21	20	20	7	0	0	0	0.03	0.78	2.22	0.08	0.14	0.00	0.00	0.00
Alachlor	1.68	1	19	36	0	1	2	0	0	0.02	1.54	3.74	0.00	0.02	0.06	0.00	0.00
Hand-weeded	0.00	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glyphosate	1.12	10	6	35	0	0	0	0	0	0.22	0.06	0.06	0.00	0.00	0.00	0.00	0.00
Glyphosate	2.24	20	18	49	0	2	0	0	0	0.18	0.11	0.11	0.00	0.01	0.00	0.00	0.00
Paraquat	1.12	12	3	59	0	3	4	1	0	0.31	0.01	0.01	0.00	0.02	0.05	0.01	0.00
Paraquat	2.24	5	12	88	0	0	0	0	0	0.08	0.05	0.05	0.00	0.00	0.00	0.00	0.00

¹ Glyphosate at 1.12 kg ai/ha was applied to emerged weeds 5 days before transplanting as initial treatment in all plots.

² Weed species in 0.5 m² were as follows:

A — Pigweed (*Amaranthus dubius*)

B — Small spider flower (*Cleome gynandra*)

C — Horse purslane (*Trianthema portulacastrum*)

D — Purple nutsedge (*Cyperus rotundus*)

E — Junglerice (*Echinochloa colomum*)

F — Large crabgrass (*Digitaria sanguinalis*)

G — Red sprangletop (*Leptochloa filiformis*)

H — Gossegrass (*Eleusine indica*)

TABLE 3.—Effect of herbicides on pepper phytotoxicity, weed control and yield (experiment no. 2)¹

Treatment	Rate	Phytotoxicity ²			Weed control ³			Pepper yield ⁴		Average
		14	28	42	14	28	42	Cubanelle	Yellow Wonder L.	
	kg/ha							kg/ha	kg/ha	kg/ha
Diphenamid	5.88	1.87 b	1.62 b	0.50 bc	77	77	66	29699 a	30529 a	30114 a
Oxadiazon	1.12	0.12 c	0.12 c	0.00 c	91	90	77	36579 a	30648 a	33614 a
Oxyfluorfen	1.12	5.55 a	3.25 a	1.62 ab	99	99	96	41721 a	48206 a	44694 a
Trifluralin	1.12	0.00 c	0.00 c	0.00 c	92	88	75	31399 a	36817 a	34108 a
Pendimethalin	1.12	0.25 c	0.00 c	0.00 c	91	86	65	24004 a	29501 a	26753 a
Alachlor	1.68	0.37 c	0.25 c	0.00 c	88	88	70	32665 a	30806 a	31739 a
Hand-weeded	—	0.00 c	0.00 c	0.00 c	86	78	92	52082 a	43461 a	47771 a
Glyphosate ⁵	1.12	0.00 c	0.00 c	2.00 a	71	66	98	28354 a	30134 a	29224 a
Glyphosate ⁶	2.24	0.00 c	0.00 c	0.75 bc	87	82	98	35473 a	37648 a	36560 a
Paraquat ⁶	1.12	0.00 c	0.00 c	1.25 abc	81	77	98	39388 a	33812 a	36600 a
Paraquat ⁶	2.24	0.00 c	0.00 c	2.00 a	77	70	98	36641 a	36105 a	36373 a

¹ Paraquat at 1.1 kg ai/ha was applied 5 days before transplanting to emerging weeds as initial treatment in all plots.

² Phytotoxicity at 14, 28 and 42 days after transplanting, with 0 representing no visual injury and 10 complete plant kill.

³ Weed control at 14, 28 and 42 days after transplanting, with 0 representing no control and 100 complete weed control.

⁴ No significant differences in yield between treatment means was detected.

⁵ Direct application to weeds 30 days after transplanting.

showed good to excellent weed control during the initial period; thus the paraquat pre-transplant treatment contributed to the improved weed control in all plots. There were no significant differences in Cubanelle or Yollow Wonder pepper yields among herbicide treatments and the hand-weeded check. However, hand-weeding contributed to the highest yield with 47,771 kg/ha. Oxyfluorfen (1.12 kg ai/ha) ranked second with 44,964 kg/ha. Table 4 shows weed number and weight on plots 56 days after transplanting peppers. Plots with high broadleaf weed population also showed the higher weed weight in 0.5 m².

Weed control by pre- or postemergence herbicides after transplanting was improved with glyphosate and paraquat pre-transplant treatments, which contributed to good pepper yields in both experiments. For this reason probably no significant differences in yields were detected between post transplanting herbicide treatments on peppers. The glyphosate or paraquat pre-transplant herbicide treatment to the emerged weeds seems to be a good agronomic practice recommended for commercial plantings of peppers and other vegetable crops to reduce early weed competition and to improve performance of later herbicide application or mechanical cultivation. Reduced weed competition will result in better crop yields and quality.

RESUMEN

Glifosato y paraquat en tratamientos pretrasplante para controlar yerbajos en pimiento

En el Centro de Investigación y Desarrollo de Juana Díaz en 1981-82 se realizaron dos experimentos de campo para controlar malezas en parcelas de las variedades de pimiento Cubanelle y Yollow Wonder. Se estimuló el desarrollo de malezas por un período de 2 semanas con dos riegos por aspersión semanales luego de haber preparado y surcado el terreno antes de trasplantar las plantas de pimiento. Luego se aplicaron los herbicidas glifosato o paraquat a 1.12 kg.pa./ha. en cada uno de los dos experimentos. El herbicida oxyfluorfen a 1.12 kg.pa./ha. aplicado 2 días antes de trasplantar causó la fitotoxicidad más alta ($P=0.05$) a los 14, 28 y 42 días en los dos experimentos. Alachlor (1.68 kg.pa./ha.), oxadiazon, trifluralin y pendimetalin a 1.12 kg.pa./ha., respectivamente, no fueron fitotóxicos al pimiento. El control de las malezas con la mayoría de los herbicidas resultó de bueno a excelente durante el período de 6 semanas, lo cual indica que el tratamiento pretrasplante de glifosato o paraquat controlaron mejor las malezas en ambos experimentos. No hubo diferencias significativas en rendimiento entre las dos variedades ni entre los tratamientos. Con la aplicación dirigida del herbicida paraquat a 1.12 kg.pa./ha., 30 días después del trasplante y la del oxadiazon a la misma dosis aplicada 2 días pretrasplante se obtuvieron los mejores rendimientos de pimiento con 46,130 y 44,192 kg./ha., respectivamente. En el experimento donde se usó paraquat (pretrasplante), el desyerbo a mano y oxyfluorfen a 1.12 kg.pa./

TABLE 4.—Effect of herbicides on weed number and weight 8 weeks after transplanting peppers (experiment no. 2)¹

Treatment	Rate	Number of weeds ²								Weed fresh weights (kg) ²							
		A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H
Diphenamid	5.88	1	13	17	20	5	2	0	8	0.22	0.58	1.78	0.09	0.13	0.02	0.00	0.16
Oxadiazon	1.12	0	4	21	4	9	7	0	0	0.00	0.28	2.87	0.02	0.23	0.34	0.00	0.00
Oxyfluorfen	1.12	0	0	28	0	4	4	0	0	0.00	0.00	3.06	0.00	0.14	0.24	0.00	0.00
Trifluralin	1.12	1	27	18	5	3	0	0	2	0.01	0.99	1.00	0.01	0.16	0.00	0.00	0.10
Pendimethalin	1.12	3	12	1	3	0	5	0	5	6.07	1.66	0.05	0.01	0.00	0.05	0.00	0.20
Alachlor	1.68	2	8	8	0	8	3	0	1	0.81	0.57	0.07	0.00	0.07	0.24	0.00	0.02
Hand-weeded	—	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glyphosate	1.12	1	10	34	2	15	0	2	8	0.01	0.16	0.55	0.02	0.04	0.00	0.01	0.13
Glyphosate	2.24	21	17	26	0	2	0	0	2	0.42	0.19	0.64	0.00	0.01	0.00	0.00	0.01
Paraquat	1.12	0	7	38	7	5	2	4	3	0.00	0.03	0.96	0.03	0.05	0.01	0.02	0.18
Paraquat	2.24	3	21	26	15	12	0	0	0	0.08	0.18	0.54	0.07	0.03	0.00	0.00	0.00

¹ Paraquat at 1.12 kg ai/ha was applied to emerging weeds 5 days before transplanting as initial treatment in all plots.

² Weed species in 0.5 m² were as follows:

A — Pigweed (*Amaranthus dubius*)

B — Small spider flower (*Cleome gynandra*)

C — Horse purslane (*Trianthema portulacastrum*)

D — Purple nutsedge (*Cyperus rotundus*)

E — Junglerice (*Echinochloa colonum*)

F — Large crabgrass (*Digitaria sanguinalis*)

G — Red sprangletop (*Leptochloa filiformis*)

H — Gossegrass (*Elyusine indica*)

ha. fueron los mejores rendimientos: 47,771 y 44,964 kg./ha., respectivamente.

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