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# Tolerance of Citrus Rootstocks to Preemergence Herbicides<sup>1</sup>

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### Abstract

Seven preemergence herbicides, Lasso (alachlor), Surflan (oryzalin), Devrinol (napropamide), Solicam (norflurazon), Goal (oxyfluorfen), Treflan (trifluralin), and Ronstar (oxadiazon) all at 1.1 and 2.2 kg/ha (1.0 and 2.0 lb/A) were evaluated for weed control and phytotoxicity to Carrizo citrange [*Citrus sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.], Trifoliolate orange [*Poncirus trifoliata* (L.) Raf.] and Swingle citrumelo [*Poncirus trifoliata* (L.) Raf. x *Citrus paradisi* Macf.] citrus rootstock seedling. Goal (oxyfluorfen) was most effective in controlling weeds, but was also phytotoxic to all 3 rootstocks. Surflan (oryzalin) provided satisfactory weed control (about 70%) without any phytotoxicity to citrus rootstocks but Lasso (alachlor) and Devrinol (napropamide) did not effectively control the weeds. Carrizo citrange was most susceptible to Goal (oxyfluorfen), while Swingle citrumelo was more sensitive to Treflan (trifluralin) and Ronstar (oxadiazon). Trifoliolate orange was intermediate in tolerance to all herbicides. Some herbicide treatments reduced the plant height but not the trunk diameter of Carrizo citrange and Swingle citrumelo. Trunk diameter of Trifoliolate orange was significantly reduced by herbicide treatments, but was unaffected in Carrizo citrange and Swingle citrumelo.

**Index words:** Carrizo citrange, Trifoliolate orange, Swingle citrumelo, citrus, rootstocks, herbicide

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### Introduction

Citrus nursery practices in Florida vary with the individual nursery operation. Weed control is the most expensive practice in the nursery operation (12), accounting for 10 to 20% of the cost of production (1). Weeds are highly competitive with citrus seedlings under the growing conditions of central Florida. Due to the scarcity and high cost of manual labor for hand weeding, many nursery operations are turning to chemical weed control. Lasso (alachlor) at 1.1 kg/ha (1.0 lb/A) applied

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once a month through overhead sprinklers has been used by some citrus nurseries for weed control under field conditions in Florida, but has yielded inconsistent results.

Herbicides suitable for weed control in citrus groves are usually not registered for use on nursery stock. The relatively small market and high risk in commercial nurseries make it difficult to get a herbicide registered for this specialized purpose. In addition, rapidly changing growth stages and numerous scion/rootstock combinations make data for the registration process difficult to acquire. Research work done on the use of herbicides in Florida citrus nurseries has been limited to container-grown trees (1,2,9). Results from these studies cannot be used for weed control in trees temporarily grown in the soil (liners) due to differences in tree age and growing media. Chemical weed control data on such citrus trees is therefore urgently needed. Information on chemical weed control is available for other crops (5,6,7,10).

Castle and Tucker (1) reported that susceptibility of citrus nursery trees to herbicides is influenced by rootstock and scion cultivar. Further, our recent preliminary studies on citrus nursery trees have indicated that herbicidal response varied among citrus rootstocks (unpublished data). Differential herbicide responses have also been reported in potato (3), soybeans (4), azaleas (8), and tomato (11).

The objectives of this study were to evaluate 7 pre-emergence herbicides for weed control in citrus liners and to determine the phytotoxicity of these herbicides and effects on growth of 3 citrus rootstocks.

## Materials and Methods

The experimental work was done during 1983 on Astatula fine sand with 1.25% organic matter at a commercial citrus nursery in Central Florida. Seeds of citrus rootstocks treated with thiram [Bis (dimethyl thiocarbamoyl) disulfide] were soaked in water for 24 hr. The lighter seeds which floated were discarded and healthy seeds which sunk were planted in January 1983 in Speedling flats [styrofoam flats of 66 x 33 x 12.7 cm (26 x 13 x 5 in) with individual plots of 3.8 cm<sup>2</sup> (1.5 in<sup>2</sup>)] using Promix-BX [commercial blend of peat, perlite and vermiculite (3:1:1 v/v)] growing media covered with 0.6 cm (0.25 in) vermiculite. The seedlings were grown in the greenhouse for 3 months with flats fertilized and irrigated as needed. Seedlings in the greenhouse were kept free of insects and fungal diseases and were treated with metalaxyl [N-(2,6-dimethylphenyl)-N-(methoxycetyl)-alanine methylester] solution before transplanting in the field.

Three-month-old seedlings of Carrizo citrange [*Citrus sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.], Trifoliolate orange [*Poncirus trifoliata* (L.) Raf.] and Swingle citrumelo [*Poncirus trifoliata* (L.) Raf. x *Citrus paradisi* Macf.] were transplanted in the field in April 1983 at 94 x 15 cm (37 x 6 in) spacing. The seedlings were allowed to grow for 30 days, at which time all the weeds were removed manually. Herbicide treatments were applied as preemergence to new weeds on May 15, 1983. Herbicides included in the study were: Lasso [alachlor-[2-chloro-2'-6'-diethyl-N-(methoxymethyl) acetanilide]]; Surflan [oryzalin-(3,5-dinitro-N<sup>4</sup>, N<sup>4</sup>-dipropylsulfanilamide)]; Devrinol [napropamide-[2-(*α*-

naphthoxy)-N,N-diethylpropionamide]]; Solicam [norflurazon-[4-chloro-5-(methylamino)-2-(*α,α,α*-trifluoro-m-tolyl)-3 (2H)-pyridazinone]]; Goal [oxyfluorfen-[2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene]]; Treflan [trifluralin-(*α,α,α*-trifluoro 2,6-dinitro-N,N-dipropyl-p-toluidine)]; and Ronstar [oxadiazon-[2-*tert*-butyl-4-(2,4-dichloro-5-isopropoxyphenyl)-Δ<sup>2</sup>-1,3,4-oxadiazolin-5-one]]. The herbicide formulations used in the study were: emulsifiable concentrate (E.C.) for Lasso, Devrinol, Goal, Treflan, and Ronstar; flowable (A.S.) for Surflan and wettable powder (w.p.) for Solicam. All 7 herbicides were evaluated at 1.1 and 2.2 kg/ha (1.0 and 2.0 lb/A). These rates were selected on the basis of the efficacy of these herbicides in other crops. Treatments were applied with tractor mounted power sprayer using Teejet 8002 nozzles at 2.1 kg/cm<sup>2</sup> (30 psi) pressure and a carrier volume of 374 L/ha (40 gal/A).

Phytotoxicity of herbicides to all 3 citrus rootstocks was recorded 3 weeks after treatment application. The plants were visually rated on a 0 to 10 scale based on visible foliar phytotoxic symptoms. (0—no phytotoxicity; 10—plant died due to herbicide phytotoxicity.) The plots were irrigated, fertilized, and sprayed as required according to standard practices used by the nursery. The weeds were manually removed from all plots 3 months after the treatment application and fresh and dry weights were recorded. Plant height and trunk diameters were also measured at the end of the experiment. All herbicide treatments were replicated 4 times with a plot size of 3.0 m x 2.7 m (10 ft x 9 ft). Each plot had 20 seedlings of each rootstock.

## Results and Discussion

Major weed species recorded in the experiment were: spotted spurge (*Euphorbia maculata* L.) common purslane (*Portulaca oleracea* L.), Florida pusley (*Richardia scabra* L.), redroot pigweed (*Amaranthus retroflexus* L.), slender amaranth (*Amaranthus viridis* L.), yellow nutsedge (*Cyperus esculentus* L.), purple nutsedge (*Cyperus rotundus* L.), common lambsquarter (*Chenopodium album* L.), southern sida (*Sida acuta* Burm. f.), bermudagrass (*Cynodon dactylon* (L.) Pers.) and goosegrass (*Eleusine indica* (L.) Gaertn.).

All herbicide treatments reduced fresh and dry weight of weeds as compared with weedy control (Table 1). Goal (oxyfluorfen) was the most effective herbicide at both application rates with a 96% reduction in weight of weeds over the weedy control. Lasso (alachlor) and Devrinol (napropamide) at both rates provided very poor weed control (32% or less). Surflan (oryzalin) and Solicam (norflurazon) at 2.2 kg/ha (2.0 lb/A), Treflan (trifluralin), and Ronstar (oxadiazon) at both rates reduced weed weight by 70% or greater of the weedy control. The most tolerant weed species were common purslane, Florida pusley, purple nutsedge and bermudagrass.

Lasso (alachlor), Surflan (oryzalin), and Devrinol (napropamide) did not produce any visible foliar phytotoxic symptoms at any rate on any of the 3 citrus rootstocks (Table 2). The phytotoxicity symptoms of Solicam (norflurazon) were expressed as a chlorosis of midrib and veins particularly on older leaves. The phytotoxicity symptoms caused by Goal (oxyfluorfen), Tref-

Table 1. Effect of preemergence herbicides on fresh and dry weight of weeds.

Herbicide	Rate kg/ha (lb/A)	Weight of weeds (g/plot)		Weight of weeds % of control)		Weed weight reduction (% of control)	
		Fresh	Dry	Fresh	Dry	Fresh	Dry
Lasso (alachlor)	1.1 (1.0)	3802	1489	74	85	26	15
Lasso	2.2 (2.0)	3503	1235	68	70	32	30
Surflan (oryzalin)	1.1 (1.0)	1648	889	32	51	68	49
Surflan	2.2 (2.0)	1377	570	27	32	73	68
Devrinol (napropamide)	1.1 (1.0)	3900	1640	76	94	24	6
Devrinol	2.2 (2.0)	3421	1186	67	68	37	32
Solicam (norflurazon)	1.1 (1.0)	2706	1024	53	58	47	42
Solicam	2.2 (2.0)	1560	626	30	36	70	64
Goal (oxyfluorfen)	1.1 (1.0)	213	70	4	4	96	96
Goal	2.2 (2.0)	15	4	0.3	0.2	> 99	> 99
Treflan (trifluralin)	1.1 (1.0)	1351	440	26	25	74	75
Treflan	2.2 (2.0)	1262	363	25	21	75	79
Ronstar (oxadiazon)	1.1 (1.0)	1448	628	28	36	72	64
Ronstar	2.2 (2.0)	796	346	16	20	84	80
Weedy control	—	5130	1754	100	100	0	0
L.S.D. (5%)		532	276	—	—	—	—

Table 2. Phytotoxicity of preemergence herbicides and their effect on growth of citrus rootstock seedling liners.

Herbicide	Rate kg/ha (lb/A)	Plant height (cm)			Trunk diameter (mm)			Phytotoxicity <sup>2</sup>		
		Carrizo citrange	Trifoliolate orange	Swingle citrumelo	Carrizo citrange	Trifoliolate orange	Swingle citrumelo	Carrizo citrange	Trifoliolate orange	Swingle citrumelo
Lasso (alachlor)	1.1 (1.0)	69	53	66	7.6	7.2	6.8	0	0	0
Lasso	2.2 (2.0)	74	52	67	7.1	7.9	7.3	0	0	0
Surflan (oryzalin)	1.1 (1.0)	84	61	77	8.2	8.8	7.2	0	0	0
Surflan	2.2 (2.0)	89	59	75	8.4	8.7	7.6	0	0	0
Devrinol (napropamide)	1.1 (1.0)	76	57	72	8.4	9.4	8.2	0	0	0
Devinol	2.2 (2.0)	66	53	74	7.4	8.2	7.7	0	0	0
Solicam (norflurazon)	1.1 (1.0)	66	54	68	7.1	7.5	6.9	0.50	0.50	0.50
Solicam	2.2 (2.0)	66	52	70	7.7	7.3	7.0	1.00	1.10	1.20
Goal (oxyfluorfen)	1.1 (1.0)	63	51	61	8.0	8.5	7.1	1.25	1.05	1.50
Goal	2.2 (2.0)	57	52	59	8.1	8.4	6.6	3.10	2.30	2.50
Treflan (trifluralin)	1.1 (1.0)	59	53	64	8.0	8.6	7.4	0.50	0.61	0.65
Treflan	2.2 (2.0)	59	57	61	8.2	7.8	7.0	1.00	1.25	1.50
Ronstar (oxadiazon)	1.1 (1.0)	55	55	61	7.3	8.3	7.1	1.00	0.50	1.50
Ronstar	2.2 (2.0)	56	54	59	7.9	8.3	7.3	1.75	0.55	2.50
Weedy Control	—	68	56	69	7.8	7.7	7.1	0	0	0
L.S.D. (5%)		10.2	N.S.	9.9	N.S.	1.2	N.S.	—	—	—

<sup>2</sup>Phytotoxicity was recorded by visual rating on a 0 to 10 scale. (0—no phytotoxicity and 10—plant died due to herbicide injury.)

lan (trifluralin), and Ronstar (oxadiazon) were observed as necrosis on the young leaves. Goal (oxyfluorfen) at both rates was phytotoxic to all 3 rootstocks with the phytotoxicity being higher at 2.2 kg/ha (2.0 lb/A) than 1.1 kg/ha (1.0 lb/A). The degree of phytotoxicity of Goal (oxyfluorfen) at the low rate was similar for all 3 rootstocks. At the higher rate Carrizo citrange was more sensitive than Trifoliolate orange and Swingle citrumelo. Phytotoxicity of Solicam (norflurazon) at both rates did not differ for different rootstocks which indicated that all 3 rootstocks were equally tolerant. Swingle citrumelo was most susceptible to Treflan (trifluralin) and Ronstar (oxadiazon). Carrizo citrange was less tolerant to Ron-

star (oxadiazon) but more tolerant to Treflan (trifluralin) than Trifoliolate orange.

Herbicide treatments did not significantly affect the plant height of Trifoliolate orange but did affect the height of Carrizo citrange and Swingle citrumelo. Treflan (trifluralin) and Ronstar (oxadiazon) at both rates and Goal (oxyfluorfen) at 2.2 kg/ha (2.0 lb/A) restricted plant height on both Carrizo citrange and Swingle citrumelo (Table 2). Plant height was greater than weedy control in plots treated with Surflan (oryzalin) at both rates. Goal (oxyfluorfen) at 2.2 kg/ha and Ronstar (oxadiazon) at both rates restricted plant height of Carrizo citrange liners as compared to the

weedy control. The differences in the plant height of Swingle citrumelo due to herbicides were not as dramatic as that of Carrizo citrange. Goal (oxyfluorfen) and Ronstar (oxadiazon) at both rates restricted the plant height of Swingle citrumelo; Surflan (oryzalin) and Devrinol (napropamide) treated plants were generally taller.

Herbicide treatments did not significantly affect the trunk diameter of Carrizo citrange and Swingle citrumelo (Table 2). In Trifoliate orange only Devrinol (napropamide) at 1.1 kg/ha (1.0 lb/A) produced plants larger in trunk diameter than weedy control. The plants treated with Lasso (alachlor), and Solicam (norflurazon) at both rates and Treflan (trifluralin) at 2.2 kg/ha (2.0 lb/A) had smaller trunk diameter than the rest of the treatments.

This study shows that Goal (oxyfluorfen) at both tested rates provided excellent weed control in citrus rootstock liner plantings in Central Florida nurseries. This herbicide, however, was also the most phytotoxic to all citrus rootstocks. Lasso (alachlor) and Devrinol (napropamide) provided very poor weed control. Surflan (oryzalin) provided fair weed control and did not show any phytotoxicity to the 3 rootstocks. Solicam (norflurazon), Treflan (trifluralin), and Ronstar (oxadiazon) had some degree of phytotoxicity on all 3 rootstocks. Three months after application most of the phytotoxicity symptoms disappeared and negative effects were noticed only on height and trunk diameter of the plants. It was interesting to note that herbicide treatments did not significantly affect the trunk diameter of Carrizo citrange and Swingle citrumelo but their effects on plant height were statistically significant. The results with Trifoliate orange were reversed. Though the phytotoxicity was not very severe and it was mainly due to foliage contact—it can be further reduced by washing off the foliage with irrigation. Phytotoxicity also varied according to rootstocks. Therefore, it appears that citrus rootstocks vary in tolerance to herbicides. This variation may be due to genotypic and/or phenotypic characteristics of the plant. Since such differences in herbicide tolerance exist, specific recommendations must be dependent on the rootstock. Additional research in this area needs to be done in order to evaluate additional rootstocks for potentially more general recommendations.

### Significance to the Nursery Industry

Currently there are no herbicides registered for weed control in the citrus nursery. The relatively small market

and high risk in commercial nurseries make it difficult to get a herbicide registered for this specialized purpose. This study will provide the efficacy data needed to obtain the registration. Once the registration is obtained, the following results will be directly applicable to citrus nursery operations. Goal (oxyfluorfen) at 1.1 kg/ha (1.0 lb/A) and 2.2 kg/ha (2.0 lb/A) provided 96 and nearly 100% weed control, respectively. The phytotoxicity at both rates and to all 3 citrus rootstocks was minor and acceptable to the grower. The other effective treatments (which provided 70% or greater weed control) included Treflan (trifluralin) and Ronstar (oxadiazon) at both rates 1.1 and 2.2 kg/ha (1.0 and 2.0 lb/A); Surflan (oryzalin) and Solicam (norflurazon) at 2.2 kg/ha (2.0 lb/A). Lasso (alachlor) and Devrinol (napropamide) both at rates 1.1 and 2.2 kg/ha (1.0 and 2.0 lb/A) did not provide adequate control of weeds.

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