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EVALUATION OF HERBICIDES FOR WATER RING TREATMENTS IN CITRUS[1]

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Abstract. **A newly planted grove of Hamlin orange [*Citrus sinensis* (L.) Osb.] on Carrizo citrange [*C. sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.] rootstock on Astatula fine sand in central Florida was selected to evaluate potential herbicides for weed control in water rings. Herbicides included in the study as preemergence treatments were: trifluralin at 6.3, 12.5, 25.0 and 50.0 lb./acre, napropamide, EPTC, oxadiazon, oryzalin and pendimethalin at 8.0 and 16.0 lb./acre and norflurazon and oxyfluorfen at 4.0 and 8.0 lb./acre. The studies were conducted over a 2-yr period. Weed control varied with herbicide and rates and improved with increased number of applications. Treatments were more effective during the first 3 months than in the latter 3 months following each application. Trifluralin at 12.5 lb./acre and higher, oryzalin at 16.0 lb./acre, norflurazon and oxyfluorfen at 8.0 lb./acre provided excellent control of weeds without apparent phytotoxicity to trees. Napropamide and EPTC were less effective. Norflurazon was especially effective in controlling nutsedge and bermudagrass.**

Large numbers of new citrus trees are planted as resets in existing Florida groves each year replacing trees that have declined or died from a variety of causes. In groves without permanent irrigation, trees have traditionally been planted with soil water rings erected around them for the purpose of holding irrigation water applied by tank trucks. One popular method of weed control has been the application of herbicides in this irrigation water, a simple procedure which provides immediate incorporation into the soil. Here herbicide is added to a known volume of water in the truck tank and 10 to 15 gal applied to each water ring. Thus, a 500-gal tank can supply water up to 50 trees. The rate to be applied per acre is determined and the amount of herbicide needed to treat the area of 50 rings is added to the tank. Critical factors to be considered in such applications include herbicide solubility, soil type and volume of water applied. Herbicides with a high safety tolerance for citrus and a low water solubility are most suitable for this method of application. Such applications should not be made at planting time, but in the second or third irrigation when the soil has settled and no airpockets remain around the tree roots. This reduces the chances of the herbicide contacting the tree roots directly. However, applications must be made before weed emergence since most herbicides suggested for such usage have no postemergence activity.

Florida citrus growers have been using trifluralin at 1.0 lb./500 gal tank which is equivalent to 69.3 lb. per treated acre of trifluralin. Though it provided excellent weed control, the rate is much too high and may be restricting the root growth. Our previous studies (3) indicated that trifluralin at 4.0 lb./acre slightly restricted the root growth of containerized Hamlin sweet oranges budded on Carrizo citrange and Milam (*Citrus jambhiri* Lush hybrid) rootstocks.

The objectives of these studies were to evaluate the suitability of 8 preemergence herbicides as water ring treatments and to examine the effect of these herbicides on weed control and citrus tree phytotoxicity. Herbicides for these studies were selected on the spectrum of weeds found in Florida citrus groves and herbicide safety to citrus trees (1, 2, 4).

Materials and Methods

A newly planted grove of 'Hamlin' sweet orange budded on Carrizo citrange rootstock was selected near Haines City in Polk County for these studies. The herbicides included in the study were: EPTC, napropamide, norflurazon, oryzalin, oxadiazon, oxyfluorfen, pendimethalin and trifluralin. The application rates were: trifluralin at 6.3, 12.5, 25.0 and 50.0 lb./acre, napropamide, EPTC, oxadiazon, oryzalin and pendimethalin at 8.0 and 16.0 lb./acre, and norflurazon and oxyfluorfen at 4.0 and 8.0 lb./acre. Initially water rings of 4 ft in diameter were prepared at the time of grove planting using a standard mechanical ringer and subsequently they were improved manually before each application. Appropriate amount of herbicide was added to 10 gal of water and applied to each ring individually. Treatments were initiated at the third watering in October 1981 and repeated at 6-month intervals for 2 yr. Each ring was evaluated 3 and 6 months after treatment for weed control and visual symptoms of phytotoxicity. A rating scale of 0-100% was used for weed control where 0% indicated no weed control and 100% total weed control. Weed control 75% and higher was considered acceptable. Phytotoxicity was evaluated on a 0-10 scale where 0 equaled no symptoms and 10 indicated the death of tree due to herbicide injury. Tree height, trunk diameter and canopy volume were measured at the end of the experiment. Canopy volume was calculated using the equation for one half of a prolate spheriod (5). $V = 0.5236\ HD^2$, where V = volume, H = height and D = diameter. Each treatment was applied to 3 rings in each replication and an average of 3 rings was used as an observation. All 19 treatments were replicated 3 times in randomized complete block design and data were subjected to analysis of variance and least significant difference (L.S.D.) was used to separate treatment means.

Calculation of herbicide rates. Since this is not a common procedure of herbicide application, it is appropriate to show the calculation procedure. The amount of herbicide needed for a 500 gal tank is calculated.

Ring diameter = 4.0 ft, thus radius (r) = 2.0 ft.
Area of ring (πr^2) = 3.142 x 2.0 x 2.0 = *12.6* sq ft
Volume of water/ring = 10 gal
No. of rings water/tank = 500 ÷ 10 = 50
Area of 50 rings = 50 x 12.6 = 630 sq ft
Area of 50 rings in acres = 630 sq ft ÷ 43560 sq ft/acre = 0.01446 acre
Herbicide (a.i.) needed @ 8.0 lb./acre = 0.01446 x 8.0 = 0.1157 lb.
*Herbicide (80WP) needed = 0.1157 x 100 ÷ 80 = 0.1446 lb.
Herbicide needed in oz = 0.1446 x 16 = 2.3 oz

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Amount of herbicide needed for 500 gal tank = 2.3 oz
*If the herbicide formulation is liquid as in the case of trifluralin which contains 4.0 lb./gal trifluralin, the amount of product would be:

$$= \frac{0.1157 \text{ lb. x 1 gal}}{4 \text{ lb.}} \times \frac{128 \text{ oz}}{1 \text{ gal}} = 3.7 \text{ oz (liquid).}$$

Results and Discussion

The major weed species recorded in water rings were grasses and broadleaf weeds. The grasses and sedges included: bermudagrass [Cynodon *dactylon* (L.) Pers.], guineagrass (*Panicum maximum* Jacq.), sandspur (*Cenchrus echinatus* L.), purple nutsedge (*Cyperus rotundus* L.) and yellow nutsedge (*C. esculentus* L.). The broadleaf weeds included: camphor weed [*Heterotheca subaxillaris* (Lam.) Britt. and Rusby], common ragweed (*Ambrosia artemisiifolia* L.), dogfennel [*Eupatorium capillifolium* (Lam.) Small], Florida pusley (*Richardia scabra* L.), goatweed (*Scoparia dulcis* L.), pepperweed (*Lepidium virginicum* L.), smooth pigweed (*Amaranthus hybridus* L.), redroot pigweed (*A. retroflexus* L.), spanishneedles (*Bidens pilosa* L.) and teaweed (*Sida acuta* Burm. f.).

All herbicide treatments provided some degree of weed control as compared to untreated controls (Table 1). Weed control was better 3 months after application than 6 months after because herbicides were more effective during first 3 months and activity of herbicides declined in the latter 3 months. The reduction in activity was probably due to the loss of herbicides as a result of frequent irrigations and degradation of herbicides in the soil. Weed control improved with increased frequency of herbicide applications.

Trifluralin at 25.0 and 50.0 lb./acre rates provided 100% weed control throughout the experiment. Trifluralin at lower rates (6.3 and 12.5 lb./acre) failed to control bermudagrass and nutsedge, thereby reducing the overall weed control. Napropamide and EPTC were less effective than other herbicides providing only 20-30% weed control initially. Control improved to 50-60% towards the end of the test period. Oxadiazon at 8.0 lb./acre provided 55-70% weed control, whereas at 16.0 lb./acre weed control varied from 70-90%. Oxadiazon did not control bermudagrass. Oryzalin at 8.0 lb./acre provided less than satisfactory weed control, however, at 16.0 lb./acre provided acceptable control after 3 applications. Norflurazon at 4.0 lb./acre took 4 applications to provide acceptable weed control. The 8.0 lb./acre applied 3 times provided 100% weed control for the remainder of the experimental period, giving excellent control of bermudagrass and nutsedge. Oxyfuorfen at 4.0 lb./acre provided poor weed control (60% or less), but at 8.0 lb./acre weed control varied from 80-95%. Pendimethalin, added to the study in the April 1983 application did not provide acceptable weed control at 8 lb./acre but at 16.0 lb./acre, it provided satisfactory weed control for the first 3 months after application. Average weed control over the experimental period for trifluralin at 25.0 and 50.0 lb./acre, oxadiazon at 16.0 lb./acre, oryzalin at 16.0 lb./acre, norflurazon at 8.0 lb./acre, oxyfluorfen at 8.0 lb./acre and pendimethalin at 16.0 lb./acre was 75% or higher. Napropamide and EPTC at both rates provided 44% or less average weed control throughout the experiment.

None of the treatments caused any visual foliar phytotoxicity. Tree height, trunk diameter and canopy volume as parameters of tree growth were significantly affected by various treatments (Table 2). Treatments had greater effect on trunk diameter and canopy volume than on the tree height. Trifluralin at 50.0 lb./acre, oxidazon and EPTC at 8.0 lb./acre, significantly reduced tree height whereas oryzalin at 8.0 lb./acre increased tree height. Other treatments did not affect tree height significantly as compared to untreated controls. Trunk diameter and canopy volume were similarly affected by treatments. Reduced tree growth at higher herbicide rates was probably due to phytotoxicity whereas at low rates it was due to weed competition.

All herbicides tested were relatively safe for weed control in water rings in citrus. However, napropamide and EPTC provided extremely poor weed control. Trifluralin at 50.0 lb./acre provided 100% weed control but it adversely affected tree height, trunk diameter and canopy volume. Norflurazon and trifluralin are presently registered in Florida for use in water rings for weed control in newly planted groves and for resets in established groves.

Table 1. Effect of water ring herbicide treatments on weed control of various rating dates.

Herbicide	Rate (lb./acre)	Weed control (%) Jan z82	Apr 82	Jul z82	Oct 82	Jan z83	Apr 83	Jul z83	Oct 83	Jan z84	Mar 84	Avg.
Trifluralin	6.3	45	35	50	40	60	55	70	62	80	75	57
Trifluralin	12.5	52	45	55	50	75	70	82	75	90	85	68
Trifluralin	25.0	100	100	100	100	100	100	100	100	100	100	100
Trifluralin	50.0	100	100	100	100	100	100	100	100	100	100	100
Napropamide	8.0	20	5	40	25	45	25	50	30	55	40	34
Napropamide	16.0	30	15	50	40	52	45	55	47	60	50	44
EPTC	8.0	25	20	30	25	30	28	40	30	50	40	32
EPTC	16.0	30	35	35	30	40	35	50	45	60	55	41
Oxadiazon	8.0	55	40	60	50	60	55	65	60	70	60	58
Oxadiazon	16.0	75	60	80	65	80	75	80	75	90	80	76
Oryzalin	8.0	40	45	60	55	70	65	70	65	75	65	61
Oryzalin	16.0	65	60	75	70	85	80	80	60	90	88	75
Norflurazon	4.0	55	50	60	60	70	65	80	70	90	80	68
Norflurazon	8.0	80	75	90	90	100	100	100	100	100	100	94
Oxyflurofen	4.0	40	38	50	48	60	52	60	50	60	52	51
Oxyflurofen	8.0	75	65	84	80	90	80	90	85	95	92	84
Pendimethalin	8.0	—y	—	—	—	—	—	65	43	70	64	61
Pendimethalin	16.0	—	—	—	—	—	—	82	71	90	72	79
Untreated control	—	0	0	0	0	0	0	0	0	0	0	0
L.S.D. (5%)		14	11	13	11	14	13	12	17	15	18	

zApplication dates = October 1981, April and October 1982, April and October 1983. The rings were rated 3 and 6 months after treatment application. Six-month rating was done just before the following treatment.
yNot included initially.

Table 2. Effect of water ring herbicide treatments on tree growth (expressed as percent of untreated control).

Herbicide	Rate lb./acre	Tree height	Trunk diameter	Canopy volume
Trifluralin	6.3	100	138	141
Trifluralin	12.5	109	152	157
Trifluralin	25.0	94	92	94
Trifluralin	50.0	82	74	82
Napropamide	8.0	93	93	95
Napropamide	16.0	93	91	90
EPTC	8.0	88	85	83
EPTC	16.0	94	84	88
Oxadiazon	8.0	87	71	73
Oxadiazon	16.0	99	87	83
Oryzalin	8.0	111	144	149
Oryzalin	16.0	100	113	123
Norflurazon	4.0	98	86	88
Norflurazon	8.0	103	159	166
Oxyfluorfen	4.0	94	129	131
Oxyfluorfen	8.0	95	122	128
Pendimethalin	8.0	91	110	113
Pendimethalin	16.0	102	162	178
Untreated control	—	100	100	100
L.S.D. (5%)		9	13	14

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USE OF DOUBLE STRANDED RNAs TO DIAGNOSE CITRUS TRISTEZA VIRUS STRAINS[1,2]

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Abstract. **Double stranded ribonucleic acids (dsRNAs) were examined as a possible way to diagnose citrus tristeza virus (CTV) strains. The dsRNAs were purified from CTV-infected bark tissue by the use of CF-11 cellulose followed by polyacrylamide gel electrophoresis. The sizes of dsRNAs purified from 5 CTV isolates which differed widely in their biological activity were compared. Each CTV isolate had a 13 X 10^6 dalton dsRNA corresponding to the reported full-length replicative form as well as several shorter (subgenomic) dsRNAs. The number and sizes of the subgenomic dsRNAs for each CTV isolate were unique from each host but seemed to be affected by the citrus cultivar used as the host.**

Citrus tristeza virus is the most economically important citrus virus (2). Millions of trees on sour orange rootstock have been killed worldwide, and the situation is becoming worse as more severe CTV strains appear in new areas and spread by aphids and budwood increases. In Florida most CTV-tolerant or resistant rootstocks are susceptible to citrus blight, a serious disease of unknown etiology, which has become a major production problem in recent years.

Several serological methods have been developed to diagnose the presence of CTV in infected tissue (8). These serological methods provide a rapid, reliable means to detect the presence of CTV, however, they do not distinguish between mild and severe strains (8, 12).

A 1979 survey conducted by the serologically based enzyme linked immunosorbent assay (ELISA) of registered budwood sources which were being commercially propagated on sour orange (*Citrus aurantium* L.) rootstocks indicated that about 89% of the sweet orange [*C. sinensis* (L.) Osb.] budwood was infected with CTV (12). At the time the survey was conducted, there was no obvious CTV-induced decline problems associated with plants being propagated on sour orange. However, recently in Florida, there have been increasing instances where very dwarfed, stunted trees have resulted due to the presence of severe CTV strains in the budwood source trees.

The only means presently available to determine the severity of CTV strains is by evaluating the reaction produced on a number of indicator plants which takes 3 to 18 months. The recent occurrences of stunting of young trees underscores the inadequacy of serology assays to differentiate CTV strains and the problems with the long period of time needed to obtain information on severity by the use of index plants.

Most plant viruses contain a positive sense, single-stranded RNA genome. When a virus infects a host cell, the virus will begin to replicate or increase in number. To replicate, the virus must make more copies of its RNA genome. It does this by a process called transcription. Transcription results in the production of a double strand-

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