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EVALUATION OF HERBICIDES FOR AVOCADO GROVES[1]

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Abstract. **Several herbicide combinations were evaluated for control of lantana, coral vine, balsam apple and various grasses in mature avocado groves. Lantana was controlled by treatments which included glyphosate, or a combination treatment of bromacil, diuron and paraquat. All herbicides gave good to excellent control of balsam apple; however, treatments with glyphosate and 2,4-D were more effective when combined with soil residual herbicides. Most herbicide treatments gave good to excellent control of grass species, except 2,4-D and simazine. One treatment containing bromacil and diuron produced mild phytotoxic symptoms on a few older avocado leaves.**

A wide variety of annual and perennial weeds infest avocado (*Persea americana* Miller) groves in the shallow, calcareous soils of south Florida. Among the worst weed problems are woody perennials such as lantana (*Lantana camara* L.) which has a rapid regrowth capability under the Homestead subtropical conditions. Due to their ability to recover quickly, mowing or nonlethal concn of contact herbicides only have a temporary effect in suppressing their growth.

Several herbicides have been evaluated for controlling weeds in avocado groves. Spot treatments of 2,4-D have proven effective in controlling annual and perennial broadleaf weeds (1, 2). Monuron and diuron control annual weeds at rates which do not damage established trees (1, 2, 4, 5, 8, 9). Avocados tolerate atrazine and simazine at rates which control most annual broadleaf weeds (1, 2, 4, 5). Bromacil and terbacil have effectively controlled weeds particularly grasses, but often produce persistent phytotoxic symptoms on avocado foliage (3, 5). Paraquat is one of the few contact herbicides registered for use in avocados (5, 6). Glyphosate, a relatively new herbicide, is a non-selective, broad spectrum, systemic compound which shows considerable promise in the control of deep rooted perennials or stoloniferous grasses in orchard crops, including avocados. Injury has occurred, however, to some fruit trees when this herbicide contacts foliage or green trunks (7).

The purpose of this study was to evaluate several combinations of herbicides for efficacy in controlling annual and perennial weeds without damage to established avocado trees.

Materials and Methods

Experiments were conducted in two commercial groves growing on Rockdale soil at two locations. Grove 1 consisted of 10 year old 'Simmonds' and 'Pollock' trees infested with a dense stand of lantana and balsam apple (*Momordica charantia* L.). Large crabgrass (*Digitaria sanguinalis* L.), guineagrass (*Panicum maximum* Jacq.) and natalgrass (*Rhynchelytrum repens* (Willd.) C. E. Hubb) were also present in the test area. Single tree plot ground area was 3.5 by 6 m (11.5 x 19.5 ft) and treatments were randomized in a complete block design with 5 replications. The test area was mowed June 5-7, 1973 and 4 weeks later the initial herbicide treatments were applied to vigorously growing weeds 20-25 cm (8-10 in) high.

Grove 2 consisted of seedling trees over 15 years old with a severe infestation of coral vine (*Antignon leptopus* Hook & Arn.). Single tree treatment plots measuring 3.5 by 4.5 m (11.5 x 14.5 ft) were randomized in a complete block design with 4 replications. The test area was mowed July 5, 1973 and 2 weeks later the initial herbicide treatments were applied to vigorously growing coral vine 10-45 cm (4-18 in) high.

For the purpose of identifying the season of application of each herbicide the "timing" is shown as follows: ES = early summer (applications made July, 1973 and June, 1974), MS = mid summer (application made Aug., 1973), W = winter (application made Dec., 1973-Jan., 1974).

Herbicides were applied using a CO_2 pressurized hand sprayer with a boom containing 4 nozzles that gave a spray swath 1.8 m (6 ft) wide. The spray volume was 325 l/ha (34.5 gal/acre) and the spraying pressure was 2.5 kg/cm^2 (33 psi). A blend of phytobland oil plus surfactant was added to all spray mixtures at a rate of 5 l/ha (0.5 gal/acre) except those containing 2,4-D. In 1973 the early and

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midsummer applications of 2,4-D were at a rate of 3.5 kg/ha (3.0 lb/acre), thereafter rates were as shown in the tables. Bromacil and diuron were applied formulated as a single product, "Krovar II". The 2,4-D was an oil soluble amine formulation.

The "mowed" treatment was cut twice a year during the summer only, but the driveways between tree rows were mowed as needed to keep weed growth suppressed. Visual ratings of weed control and crop phytotoxicity were taken 6 times over an 18-month period.

Results and Discussion

Table 1 shows the average weed ratings (based on a system of 1-7) for the first six months of the experiment. Lantana was controlled by most treatments except simazine, applied either alone or combined with napropamide. All treatments gave good control of balsam apple. Grass control was also good in most treatments except with simazine, 2,4-D, simazine plus 2,4-D, and simazine plus napropamide. Several treatments gave fair to good control of coral vine during the first six months, however, none of them approached complete control.

Average weed ratings during the period 6 to 18 months following initial herbicide application are given in Table 2 (based on a rating system of 1-10). The best treatments for lantana control were those which included glyphosate by itself and with simazine applied twice a year (Treat. 4 and 6). Control was also good when simazine was applied with glyphosate in early summer and with 2,4-D in the winter (Treat. 16). Most of the treatments gave excellent control of balsam apple. Glyphosate and 2,4-D were not effective in controlling regrowth of this weed (Treat. 8) and performed better when combined with one of the soil-residual herbicides (Treat. 6 and 12). A bi-yearly application of 2.25 kg/ha of simazine combined with 9 kg/ha of napropamide was not as effective as a bi-yearly application of 4.5 kg/ha of simazine alone. Grass control was good in most treatments except those with 2,4-D, simazine, or a combination of the two. Several treatments which gave good grass control were not significantly different from the no-weed-control check. This was due to the reduction of grass population in the check plots exerted by the competition of lantana and other broadleaf weeds which gave the checks a higher rating for grass control.

Table 1. Average weed control ratings in 2 avocado groves for the first six months of the experiment (1973).

No.	Treatment	kg/ha	Timing[v]	Control rating[z] Grove 1[y] Lantana	Balsam apple	Grass	Grove 2[x] Coral vine
1	Simazine	4.5	ES,W	3.9 de[w]	5.9*a	4.6 b	2.9 c
2	Paraquat	0.5	ES,MS,W	6.3*ab	6.5*a	7.0*a	5.1*ab
3	2,4-D	1.0					
	Lo-drift	0.04%	ES,MS,W	6.5*a	6.5*a	5.7 ab	4.6*abc
4	Glyphosate	2.25	ES,W	6.4*ab	4.8*bc	6.3*a	3.5 bc
5	Simazine	4.5					
	paraquat	0.5	ES,W	5.3*abc	6.2*a	6.6*a	5.3*ab
6	Simazine	4.5					
	glyphosate	2.25	ES,W	6.1*ab	6.1*a	6.3*a	4.3*abc
7	Simazine	4.5					
	2,4-D	1.75	ES,W	5.5*abc	6.3*a	5.8 ab	6.0*a
8	Glyphosate	2.25					
	2,4-D	1.75	ES,W	5.7*abc	4.5*c	6.5*a	3.5 bc
9	Napropamide	9.0					
	paraquat	0.5	ES,W	5.1*bc	5.6*ab	6.9*a	4.0*abc
10	Napropamide	9.0					
	simazine	2.25	ES,W	2.9 e	5.7*ab	4.7 b	3.4 bc
11	Bromacil	1.5					
	diuron	3.0					
	paraquat	0.5	ES,W	5.6*abc	5.6*ab	7.0*a	4.6*abc
12	Bromacil	1.5					
	diuron	3.0					
	glyphosate	2.25	ES,W	5.6*abc	5.8*ab	7.0*a	5.0*ab
13	Diuron	5.5					
	paraquat	0.5	ES,W	5.3*abc	5.7*ab	7.0*a	4.4*abc
14	Simazine	4.5	ES,W				
	paraquat	0.5	ES				
	2,4-D	3.5	W	5.5*abc	6.2*a	6.7*a	4.5*abc
15	Simazine	4.5	ES,W				
	paraquat	0.5	ES				
	2,4-D	1.75	MS,W	6.4*ab	6.3*a	6.9*a	5.3*ab
16	Simazine	4.5	ES,W				
	glyphosate	2.25	ES				
	2,4-D	3.5	W	6.0*abc	6.5*a	6.2*a	4.3*abc
17	Napropamide	9.0					
	simazine	2.25	ES,W				
	paraquat	0.5	ES				
	2,4-D	3.5	W	4.7*cd	6.0*a	6.7*a	3.5 bc
18	Mowed			3.0 e	1.8 d	4.6 b	3.1 bc
19	No weed control			3.0	1.7	4.6	1.9

[z]1 = dense weed infestation, 7 = absence of weeds.
[y]Each mean is the average of 2 ratings taken July 10 and Aug. 20, 1973.
[x]Each mean is the average of 2 ratings taken July 30 and Oct. 9, 1973.
[w]Means within a column followed by an asterisk are significantly different from the no-weed-control mean by Dunnett's comparison procedure, 5% level. Mean separation in columns by Duncan's multiple range test, 5% level.
[v]ES = early summer, MS = mid summer, W = winter.

Coral vine was the most difficult weed species to control, presumably because it reproduces both by seeds and underground tubers. The best control was obtained with treatments which included glyphosate. One exception was a combination of glyphosate and 2,4-D, which appeared to be less effective than glyphosate alone (Treat. 8 and 4 respectively). A combination of bromacil, diuron and paraquat applied twice a year also gave satisfactory control of coral vine (Treat. 11).

The ratings show that approximately twice the number of treatments controlled lantana and coral vine during the first six months (Table 1) compared with the following six months and continuing until the eighteenth month after the initial herbicide application (Table 2). This suggests that field evaluations of herbicides for control of some perennial weed species should be conducted for a minimum of one year. The ability of some weed species to recover from herbicide applications plus the change in the nature of weed populations induced by the herbicide(s) may cause short term evaluations to be misleading.

The most complete weed control was obtained when glyphosate was applied twice a year in combination with soil residual herbicides such as simazine or Krovar II (Treat. 12). However, phytotoxic symptoms such as vein clearing on older avocado leaves in one replication of a treatment containing Krovar II (bromacil and diuron) were observed in these experiments.

Based on the experience of the authors and various growers, bromacil has generally proved quite phytotoxic to avocado trees. This is especially true in sandy and shallow Rockdale soils with low organic matter, where vein clearing of leaves (Fig. 1) and poor performance of trees have persisted for as long as 3 years in some cases. On the other hand, avocado trees appear relatively tolerant to glyphosate. Only direct leaf contact of spray rates higher than 4.5 kg/ha have caused burning and malformation of new growth.

Table 2. Average weed control ratings in two avocado groves made from six to eighteen months after initial herbicide applications (1974).

No.	Treatment	kg/ha	Timing[v]	Control rating[s] Grove 1[y] Lantana	Balsam apple	Grass	Grove 2[x] Coral vine
1	Simazine	4.5	ES,W	4.3 e[w]	9.3*a	7.0 bcd	3.8 cd
2	Paraquat	0.5	ES,MS,W	5.6 cde	8.7*abc	9.0 ab	4.8 bcd
3	2,4-D	1.0					
	Lo-drift	0.4%	ES,MS,W	7.4*abcd	6.8*cd	6.0 d	4.8 bcd
4	Glyphosate	2.25	ES,W	9.5*a	5.9*d	8.1 abcd	7.6*abc
5	Simazine	4.5					
	paraquat	0.5	ES,W	6.2 bcde	8.7*abc	9.3*a	5.9 abcd
6	Simazine	4.5					
	glyphosate	2.25	ES,W	9.5*a	8.8*ab	9.5*a	8.4*ab
7	Simazine	4.5					
	2,4-D	1.75	ES,W	6.1 bcde	8.3*abc	6.5 cd	5.6 abcd
8	Glyphosate	2.25					
	2,4-D	1.75	ES,W	7.6*abc	6.0*d	8.3 abc	3.9 cd
9	Napropamide	9.0					
	paraquat	0.5	ES,W	3.6 e	8.0*abc	9.5*a	3.9 cd
10	Napropamide	9.0					
	simazine	2.25	ES,W	3.5 e	6.9*bcd	7.9 abcd	4.1 cd
11	Bromacil	1.5					
	diuron	3.0					
	paraquat	0.5	ES,W	4.0 e	8.7*abc	9.7*a	7.1*abc
12	Bromacil	1.5					
	diuron	3.0					
	glyphosate	2.25	ES,W	8.8*ab	8.1*abc	9.6*a	9.3*a
13	Diuron	5.5					
	paraquat	0.5	ES,W	4.7 de	8.3*abc	9.7*a	4.8 bcd
14	Simazine	4.5	ES,W				
	paraquat	0.5	ES				
	2,4-D	3.5	W	5.4 cde	8.4*abc	9.2 a	5.3 abcd
15	Simazine	4.5	ES,W				
	paraquat	0.5	ES				
	2,4-D	1.75	MS,W	7.2*abcd	8.8*ab	8.9 ab	5.0 bcd
16	Simazine	4.5	ES,W				
	glyphosate	2.25	ES				
	2,4-D	3.5	W	8.6*ab	8.8*ab	7.7 abcd	6.1*abcd
17	Napropamide	9.0					
	simazine	2.25	ES,W				
	paraquat	0.5	ES				
	2,4-D	3.5	W	3.6 e	8.7*abc	9.6*a	2.5 d
18	Mowed			5.6 cde	5.5*d	6.6 cd	4.2 bcd
19	No weed control			4.2	3.3	7.0	1.9

[s]1 = dense weed infestation, 10 = absence of weeds.
[y]Each mean is the average of four ratings taken Jan. 28, May 21, July 24 and Dec. 3, 1974.
[x]Each mean is the average of four ratings taken Mar. 6, May 29, July 25 and Dec. 17, 1974.
[w]Means within a column followed by an asterisk are significantly different from the no-weed-control mean by Dunnett's comparison procedure, 5% level. Mean separation in columns by Duncan's multiple range test, 5% level.
[v]ES = early summer, MS = mid summer, W = winter.

Fig. 1. Avocado trees are very sensitive to bromacil toxicity especially in sandy or shallow Rockdale soils low in organic matter. Symptoms consist of leaf vein clearing and poor tree performance which may persist as long as three years.

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RESIDUES OF 2,4-DICHLOROPHENOXYACETIC ACID HERBICIDE IN PERSIAN LIMES AND THEIR PROCESSED PRODUCTS FOLLOWING PREHARVEST SPRAYING[1]

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Abstract. **2,4-D herbicide has been reported to be effective in a water soluble form (25 and 50 ppm as the alkanolamine salt) as an agent for prevention of stylar-end breakdown of mature limes. Following a single spraying, fruit were harvested at 0, 14, 21 and 42 days, then stored at 21°C for 0, 2 or 4 weeks prior to storage at −8°C and residue analyses. Residues ranged from 0.008 to 0.32 ppm in the peel. No residues could be found in the pulp nor in any processed samples.**

Research as early as 1948 by Stewart (4) and separately in 1949 by Gates (1) indicated that 2,4-dichlorophenoxyacetic acid (2,4-D) might be effective as a preharvest spray in the prevention of stylar-end breakdown of limes after harvest. Both workers used the butyl ester form of the herbicide and attributed the degree of irreproducibility observed to a possible water solubility problem of the formulation. Small scale experiments with a water soluble form (alkanolamine salt, Dow Formula 40) have indicated that improved protection might be realized (2).

This report describes the 2,4-D residues observed from samples resulting from a typical application of 2,4-D to 'Persian' limes preharvest.

Materials and Methods

A 'Persian' lime grove in good horticultural condition in Homestead, Florida was used for this experiment. Approximately 10 to 12 trees per treatment were sprayed with a 25 or 50 ppm solution of 2,4-D (Dow Formula 40, alkanolamine salt). A Hardie spray unit with a handgun was used to apply approximately 5 gallons per tree, until runoff. Approximately 5 pounds of fresh fruit for each storage interval (0, 2 and 4 weeks) were harvested at random for each treatment (0, 25 and 50 ppm) at day zero (immediately after treatment) days 14, 21 and 42. Storage was at 21°C with subsequent transfer to −8°C until residue analyses. At 21 days after treatment approximately two and one quarter tons of each treatment was transported to A.R.E.C. Lake Alfred and subjected to the pilot plant feed mill where various fractions were prepared and stored for additional residue analyses.

Analysis was performed on peel and pulp separately, as well as the following processed products: washed peel, washed pulp, chopped peel, dried peel, peel oil, press liquor, fruit juice, emulsion water, peel frit, finisher pulp, prewater rinse, after-water rinse, dried pulp and molasses. Residues were determined by gas chromatography following a hydrolytic extraction and derivatization to the 2-butoxyethyl ester (3).

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