product and all of the properties listed in the foregoing specifications. An alternative to listing properties would be a statement that the oil in the product meets the specifications for FC 435-66 or FC 412-66.

Adoption of these specifications will exclude those oils of low refinement that we have found capable of causing excessive leaf drop, fruit drop and fruit blemish. It will exclude those oils of too high and too wide boiling range which we have found capable of retarding fruit color and delaying fruit maturity. It will exclude those oils with limited insecticidal action which give poor control. Although much of the gallonage applied in 1966 meets the FC specifications, oils with the disadvantages cited are still being widely used on Florida citrus.

The recommended oils are not expected to cost the grower more on the average, and overall probably will cost him less. For example, if an oil of low insecticidal efficiency has been used in the past, it is possible to obtain control with 1.0% oil where 1.3% was required before. This could save as much as $1.05 per acre or permit a price differential of about 10 cents per gallon for oil. Where unsuitable oils have been used, it is possible for fruit solids to be increased by 0.25 pound per box which at 40 cents per pound is 10 cents. For a 6 box tree and 70 trees to the acre this is a saving of $42.00 per acre, which would justify a higher price for the 10 gallons of proper oil substituted. Use of the recommended oils will minimize delay in development of fruit color and sugar content which will favor early harvest dates and high packout.

Actually, the recommended oils will be inexpensive pesticides. In many cases they will cost no more per gallon than the unsuitable oil previously used. They probably will cost a few cents per gallon more than the cheap oils of low refinement now offered.

We believe the upgrading of citrus spray oils will lead to better pest control and less tree and crop damage with this widely favored pesticide, and thereby benefit the entire Florida citrus industry at little if any increase in cost.

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EVALUATION OF SUBSTITUTED URACIL HERBICIDES FOR USE IN CITRUS

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Abstract

Isocil (5-bromo-3-isopropyl-6-methyluracil) applied on Lakeland fine sand at 6.4 lb/A and bromacil (5-bromo-3-*sec* butyl-6-methyluracil) at 3.2 and 6.4 lb/A produced symptoms of mild toxicity in orange trees. Fair control of torpedograss (*Panicum repens* L.) and mild symptoms in trees resulted from 4 applications of bromacil on Pomello sand at 3 lb/A with 5- to 7-month intervals. Control of torpedograss was excellent, but toxicity symptoms were moderately severe after 3 applications at 6 lb/A.

Terbacil (5-chloro-3-*tert.* butyl-6-methyluracil) (formerly herbicide 732) and herbicide 733 (5-bromo-3-*tert.* butyl-6-methyluracil) controlled Bermudagrass (*Cynodon dactylon* (L.) Pers.) and annual weeds on Lakeland fine sand with only slight tree toxicity symptoms after 3 applications of 5 lb/A at 6-month intervals. A total of 6 or 9 lb/A of terbacil gave better control of annual weeds at the end of the season if applied in 2 or 3 sprays during a 4-month period rather than in a single spring application. Control of torpedograss on Felda soil was fair to good from terbacil or herbicide 733 in 3 applications at 4 lb/A with 4-month intervals. Treatments of 2 applications at 4 or 6 lb/A were less satisfactory. Control was better with 2 applications at 8 lb/A, but slight toxicity symptoms occurred in some trees.

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Introduction

The discovery of a new group of herbicides, the substituted uracils, was first reported in 1962 (1). The first of these to be released for experimental use was isocil. Evaluation of this material for use in citrus was initiated in 1962, and results of trials during 1962 and 1963 indicated it was promising for eradication of torpedograss from unplanted land (2). A second material, bromacil, was found to have a somewhat wider spectrum of herbicidal activity, and it was introduced commercially for non-crop use in place of isocil in 1963. Bromacil was shown to be as effective as isocil in killing torpedograss, and after a number of experiments to determine suitable rates and timing of applications (3, 4), bromacil was suggested for use in eradicating patches of torpedograss from citrus planting sites or unplanted land adjacent to citrus groves (5).

Two additional substituted uracil herbicides made available for tests in 1964 were terbacil and herbicide 733. These 2 have been evaluated along with bromacil for grass and broadleaf weed control in citrus groves. The purpose of this paper is to present results from these evaluations and also to present data on tolerance of citrus trees to the substituted uracils.

Experimental Procedure

Preliminary evaluation of citrus tree tolerance to isocil and bromacil was made in 1962 on Lakeland fine sand at Lake Alfred. Three rates of each material were replicated twice. A 2-year-old 'Valencia' orange tree on 'Cleopatra' mandarin rootstock was in 1 replication of each treatment, and a 3-year-old 'Valencia' on rough lemon rootstock was in the other replication. The trees were examined at monthly intervals for evidence of herbicide toxicity and rated on a 0 to 10 scale, on which 0 indicates no visible symptoms of toxicity and 10 would indicate a dead tree.

An experiment to further evaluate tree tolerance and to determine the effectiveness of repeated applications of bromacil for control of torpedograss was initiated in March 1963 in a grove at the northern edge of Hardee County. The 6-year-old 'Valencia' orange trees on rough lemon rootstock had been injured by the 1957-58 and 1962 freezes. The soil in the grove is Pomello sand. Rates and dates of application are listed in Table 2. Treatments were replicated 4 times.

Starting in April 1964, terbacil and *herbicide* 733 were applied in duplicate at 2 rates, and bromacil at 1 rate, around 1-year-old 'Valencia' orange trees on rough lemon rootstock at Lake Alfred. Plots were observed periodically for control of Bermudagrass and annual weeds, and the trees were observed for symptoms of herbicidal toxicity.

In 1965, another series of treatments with terbacil was applied in 3 replications to plots around 2- to 6-year-old 'Valencia' orange trees on rough lemon rootstocks at Lake Alfred. A total of 6 or 9 lb/A was applied as a single treatment in April or was divided into 2 or 3 applications during a 4-month period. Herbicide 733, bromacil, and diuron were included for comparison. A surfactant[2] was added at 1/2% V/V in all applications. Observations were made on control of Bermudagrass and annual weeds.

An experiment was initiated in September 1965 to obtain information on control of torpedograss in a grove with terbacil and herbicide 733 and to determine whether tree growth would be affected by chemical control of torpedograss as compared with conventional control with a mechanical hoe. The experiment is located northwest of Ft. Pierce in a grove of 3-year-old 'Valencia' orange trees on sour orange rootstocks planted on 2-row beds on Felda soil. Treated plots were 8 feet wide and 25 feet long in the row, with 1 measured tree in the middle of each plot and a buffer tree at each junction of 2 adjoining plots. Treatment rates and number of applications are listed in Table 5.

The treatments were arranged in a randomized block design, with 3 replications in 1 row, and 3 replications in another row on a different bed. Cultivated check plots were not randomized with the herbicide treatments. The second row in each of the 2 beds was hoed mechanically, and trees in these 2 rows were measured for comparison with the herbicide treated trees. Trees were also measured in a cultivated row in a third bed to determine tree variability. Growth is expressed as increase in trunk circumference, measured 3 inches above the bud union at the start of the experiment and after 1 year.

The herbicides used in these studies were commercially formulated 80% wettable powders, applied in water at 70 gallons per acre. Rates

[2]Surfactant WK (dodecyl ether of polyethylene glycol).

of application are given in terms of pounds of active ingredient per sprayed acre (lb/A). Plot size was 12 by 12 feet except in the torpedograss control experiment at Ft. Pierce.

Results and Discussion

Mild symptoms of herbicide toxicity appeared on the orange tree leaves within a month after application of isocil and bromacil at Lake Alfred in 1962 (Table 1). Toxicity from the substituted uracils is expressed in citrus leaves as a loss of green color from the veins, not only from the main veins, but also from many small ones, resulting in a fine, yellow network throughout the leaves.

With the occurrence of toxcity symptoms after application of such relatively low rates of these 2 materials, there did not appear to be much prospect for their use in groves in Florida, and attention was focused primarily on their potential for eradicating certain grasses such as torpedograss prior to planting or in areas adjacent to groves. However, because of the effectiveness of high rates of bromacil against torpedograss, trials were made in citrus in Hardee County to determine whether this grass could be controlled without tree injury by making repeated applications of bromacil at low rates. Some symptoms of toxicity were anticipated on the basis of the results at Lake Alfred.

Partial control was obtained with bromacil at 3 lb/A applied 4 times at 5- to 8-month intervals over a 2-year period (Table 2). Symptoms of mild toxicity were apparent on the trees at times but later diminished or disappeared. At 6 lb/A, the torpedograss control was excellent but toxicity symptoms on the trees were much more severe. However, no leaf abscission was observed, and the symptoms gradually diminished in intensity, with re-greening of the veins. At rates higher than 6 lb/A, a single application resulted in moderate toxicity within about 2 months and, as at the lower rates, symptoms did not persist for very many months. The Pomello sand on which this experiment was conducted is lower in organic matter than many citrus soils. However, soils of similar types are encountered in portions of many plantings in flatwoods and coastal areas, and there is a possibility of tree injury from use of bromacil on such soils.

Applications of terbacil and herbicide 733 did not result in toxicity symptoms on 1-year-old 'Valencia' orange trees on Lakeland fine sand

Table 1. Tolerance of 'Valencia' orange trees to isocil and bromacil on Lakeland fine sand, 1962.

		Rating of toxicity symptoms (0-10)[1]		
	Rate	Months after application		
Herbicide	(lb/A)	1	2	3
Isocil	1.6	0.3	0.1	0.3
	3.2	0	0	0
	6.4	0.5	0.5	0.8
Bromacil	1.6	0	0	0
	3.2	0.4	1.0	0.1
	6.4	0.5	1.0	1.0

[1]Rated on a 0-10 scale. 0 = no symptoms; 10 = dead tree.

Table 2. Control of torpedograss and occurrence of toxicity symptoms in 6-year-old 'Valencia' orange trees from repeated applications of bromacil on Pomello sand, 1963-64.

Rate of bromacil lb/A	Dates of application	Torpedograss control[1] 12-20-63	Torpedograss control[1] 9-18-64	Torpedograss control[1] 6-13-65	Toxicity symptoms[2] 1963 12-20	Toxicity symptoms[2] 1964 7-30	Toxicity symptoms[2] 1964 9-18	Toxicity symptoms[2] 1964 11-25
3	3-22-63, 9-17-63 5-19-64, 10-19-64	5.3	6.4	7.9	0.4	1.0	0.4	0
6	3-22-63, 9-17-63 5-19-64	8.5	9.2	8.9	0.9	3.1	1.6	1.1
7.5	5-19-64	-	6.6	5.0	-	1.4	0.6	0
9	5-19-64	-	6.5	3.9	-	1.7	0.5	0.4

[1]Plots were rated for torpedograss control on a 0-10 scale. 0 = no effect; 10 = no grass visible.

[2]Trees were rated for toxicity symptoms on a 0-10 scale. 0 = no symptoms; 10 = death of the tree.

Table 3. Control of annual weeds and occurrence of toxicity symptoms in 1-year-old 'Valencia' orange trees from repeated applications of 3 substituted uracils on Lakeland fine sand, 1964-65.

Herbicide	Rate (lb/A)	Control of annual weeds (0-10), months after initial application: 2	4	6	8	15	Toxicity symptoms (0-10), months after initial application: 2	6	15
Bromacil	5 + 5 + 5	10.0	9.7	6.3	10.0	10.0	2.0	0	3.3
Terbacil	5 + 5 + 5	10.0	7.8	5.3	9.9	9.6	0	0	0.5
Terbacil	10 + 5 + 10	10.0	9.6	7.5	9.9	9.9	0	0	1.3
Herbicide 733	5 + 5 + 5	10.0	8.9	6.0	10.0	9.8	0	0	0.5
Herbicide 733	10 + 5 + 10	10.0	9.7	5.5	10.0	9.5	0	0	2.8

Dates of application: 4-8-64, 10-15-64, and 3-28-65.

until the second year, after a total of 15 lb/A had been applied, and symptoms were much less severe than from bromacil (Table 3).

Control of annual weeds was good from all 3 materials for 4 months but was less satisfactory by the end of 6 months (Table 3). Predominant annual weeds in the plots at that time were sandspur (*Cenchrus* spp.), pigweed (*Amaranthus viridis* L.), Florida pusley (*Richardia scabra* L.), *Gisekia molluginoides* and spurges (*Euphorbia* spp.). The amount of Bermudagrass was too variable to make valid comparisons of control between treatments. However, all treatments showed relatively good control of this grass after the second application. The only annual weed present in the plots in the observation at 15 months was pigweed. The substituted uracils are notably ineffective aginst *Amaranthus* species.

A single spring application of terbacil in 1965 resulted in better control of Bermudagrass early in the season than where the same total amount was divided into 2 or 3 applications over a 4-month period, but by the end of the season, control was as good or better from the split applications (Table 4). The same effect is apparent in the data for control of annual weeds. This may be partially due to the contact action of the substituted uracils, resulting in some "burndown" of weeds present at the time of application, and partially due to loss of activity late in the season from leaching or breakdown of the chemicals. Symptoms of mild toxicity were apparent in September on the trees treated with bromacil, and slight symptoms occurred on 1 of the trees treated with herbicide 733.

In the experiment to control torpedograss at Ft. Pierce, a total of at least 12 lb/A of terbacil or herbicide 733 applied within a year was necessary for satisfactory control (Table 5). With the exception of the treatment of 2 appli-

Table 4. Control of Bermudagrass and annual weeds with 3 substituted uracils and diuron on Lakeland fine sand, 1965.

			Control (0-10)			
	Rate	Dates of	Bermudagrass		Annual weeds	
Herbicide	(lb/A)	application	8-12	11-18	8-12	11-18
Terbacil	6	4-20	8.4 d	7.3 b	9.7 a	6.9 a
Terbacil	9	4-20	7.7 cd	7.5 b	9.6 a	8.2 a
Terbacil	2 + 2 + 2	4-20,6-9,8-12	6.9 bcd	8.5 b	8.8 a	9.7 b
Terbacil	3 + 3 + 3	4-20,6-9,8-12	5.9 bc	9.2 b	9.7 a	10.0 b
Terbacil	4.5 + 4.5	4-20,8-12	4.6 b	8.3 b	8.9 a	9.8 b
Herbicide 733	4.5 + 4.5	4-20,8-12	6.1 bcd	8.9 b	9.5 a	10.0 b
Bromacil	2 + 2 + 2	4-20,6-9,8-12	7.0 cd	9.6 b	9.8 a	10.0 b
Diuron	3.2 + 3.2	4-20,8-12	0.4 a	4.0 a	8.1 a	10.0 b

Values followed by the same letter or letters are not statistically different from each other at the 5% level of significance.

Table 5. Control of torpedograss with terbacil and herbicide 733, and effects on growth of 3-year-old 'Valencia' orange trees on Felda fine sand at Ft. Pierce, 1965-66.

Herbicide	Rate (lb/A)	Number of appli-cations[1]	Interval (months)	Torpedograss control (0-10)[2] Months after initial application 8	11	12	Increase in trunk circumference[2,3] (cm)
Terbacil	4	3	4	2.1 a	7.3 c	7.1 d	6.3 b
Terbacil	4	2	6	5.3 c	2.7 a	2.6 ab	6.3 b
Terbacil	6	2	6	6.4 cd	4.8 b	3.5 abc	6.3 b
Terbacil	8	2	6	7.5 d	7.8 c	7.1 d	6.7 b
733	4	3	4	2.1 a	6.9 bc	5.6 cd	6.5 b
733	4	2	6	3.8 b	1.4 a	1.4 a	6.4 b
733	6	2	6	6.4 cd	5.6 bc	4.1 bc	6.1 b
Check	-	-	-	-	-	-	4.5 a

[1]Initial applications 9-1-65.

[2]Values followed by the same letter or letters are not statistically different from each other at the 1% level of significance.

[3]Increase in trunk circumference from October 1965 to September 1966.

cations at 8 lb/A, the best plots at the end of 1 year were those on which a total of 12 lb/A had been applied in 3 applications at 4 lb/A rather than 2 at 6 lb/A.

There were no significant differences between herbicide treatments in respect to tree growth during the year, but growth was greater in all treatments than in the cultivated check rows. The mean increases in trunk circumference for all measured trees in the 3 check rows were 4.0, 4.7, and 4.2 cm. compared with 6.6 and 6.2 cm. mean increase for measured trees in the herbicide treated rows.

Symptoms of slight toxicity were observed in May on 3 trees of the treatment with 2 applications of terbacil at 8 lb/A. This was approximately 2 months after the second application. No symptoms were found in September.

Results with terbacil and herbicide 733 have been very similar in respect to control of perennial grass and annual weeds and also to tree tolerance. Recently, emphasis has centered on evaluation of terbacil because the manufacturer plans to register this material in preference to herbicide 733 for crop use. The data reported herein indicate that terbacil can safely be used in some citrus groves for control of perennial grasses and annual weeds. However, until it is registered by the USDA for use in citrus, its application should be confined to further experimental trials under a variety of soil and weed conditions to determine its range of usefulness.

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EFFECTS OF PHOSPHATE FERTILIZER ON YIELD AND QUALITY OF 'VALENCIA' ORANGES

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Phosphorus rate experiments were established in 1958 in two 25-year-old 'Valencia' groves on Lakeland fine sand which had not received phosphate for at least 5 years. Ordinary superphosphate was applied at rates of 0 or 120 pounds P_2O_5 per acre per year. In 1961, additional plots were added that received 0 or 360 pounds P_2O_5 per acre per year.

During the period from 1961 through 1965, yields in one grove were significantly increased by added phosphate in 3 of the 5 years, with an average increase for the period of .83 boxes per tree per year. In the second grove, yields were increased by treatment only once, in 1961. Internal fruit quality was generally lowered in both groves by the added phosphate: the contents of soluble solid and acid were decreased and the ratio of Brix-to-acid was increased.

The phosphate treatments increased the average phosphorus content of the leaves by a small but significant amount in both groves. Leaf calcium was also increased even though the groves received regular dolomite applications.

At the conclusion of the study, in 1966, the level of phosphorus in the surface soil in the no-phosphate plots was identical in both groves, 88 pounds phosphorus per acre. However, the soil in the more responsive grove contained less phosphorus in the subsurface horizons than did the other soil, both initially and at the conclusion of the study.

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INTRODUCTION AND LITERATURE REVIEW

The response of citrus to phosphate fertilization has been studied in Florida by a number of investigators. In most cases, the responses reported were generally unfavorable and were attributed, therefore, to excessive phosphate applications rather than to the correction of phosphorus deficiency (3, 5, 6, 8, 9, 10, 11).

Citrus yield responses to phosphate applications have been reported only twice in Florida. In one study, an experiment on Davie mucky fine sand, increased yields of 'Lue Gim Gong' oranges due to phosphate treatments were accompanied by a lowering of the soluble solids and acid contents of the fruit and by a reduction in the numbers of cull and dropped fruit (13). However, the role of phosphorus in the experiment was confounded by the limited availability of copper. In a second study, after 4 years of phosphate applications, Spencer found increased yields of 'Valencia' oranges in 2 different experiments located on Lakeland fine sand (12). Except for yields, no other responses were detected.

The 2 phosphorus experiments that were started by Spencer in 1958 were continued by the author through 1965 to obtain additional information on the effects of phosphorus on the fruit yield and quality of 'Valencia' oranges and on the mineral composition of the leaves.