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TWO WEED CONTROL SYSTEMS FOR FLORIDA CITRUS[1]

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Abstract. **Chemical (nontillage) and tillage weed management programs for citrus are compared in paired blocks at 2 locations in Florida over a 10-year period. Bromacil and diuron applied once or twice yearly provided chemical weed control, while tillage blocks were cultivated 3 to 6 times a year as required. No yield reduction resulted from long-term herbicide usage. Costs were initially much greater for the herbicide treatments, but became comparable to tillage costs particularly at an immature grove location. Energy usage was substantially greater for tillage than the herbicide operations. Changes in cost and energy inputs into the 2 weed control systems are attributed to increased prices of fuel, labor, equipment, maintenance and frequency of application. Other observations on tree condition, soil fertility, weed control, herbicide residues, and tree cold tolerance are discussed in relation to weed control methods.**

Florida's subtropical temperatures and 54 inches[4] average annual rainfall are conducive to rapid weed growth, which when left uncontrolled, results in citrus groves reverting to the 'proverbial' jungles. Traditionally, groves in Florida are excessively tilled primarily with such implements as choppers, discs, mechanical hoes, and hand hoes. Since the introduction of soil residual herbicides in the early 1960's, most of the young groves and an increasing acreage of older groves have come under various chemical weed control programs, with herbicides applied in strips of varying widths in the tree rows. Areas between rows are normally shallow tilled along the central Florida 'ridge' growing area where soils are sandy and well drained, or mowed in the east coast and southwest Florida areas where citrus is grown on raised beds. Here root systems are shallow and susceptible to damage from tillage equipment, and tillage programs would result in an unacceptable degree of soil erosion.

The trend toward widespread use of chemical weed control and away from mechanical methods is due to: 1) increased machinery and labor costs; 2) the need to minimize damage to tree trunks and surface feeder root systems; 3) the unsatisfactory length of acceptable control of vegetatively propagated perennial grasses and vines commonly spread by tillage operations; 4) repeated exposure of buried weed seed and their subsequent germination; 5) the greater confidence in the long-term safety of herbicides; and 6) research during the early 1960's which showed significantly better tree growth, earlier production and less physical damage to trees under herbicide programs than those under tillage programs (4).

The purpose of these studies was twofold: to determine the long-term influence of soil residual herbicides, specifically bromacil and diuron, on the growth and yield of citrus; and, secondly, to compare the performance of trees under total chemical weed control programs with standard tillage programs.

During 1968-69, commercial grove blocks for the research demonstrations were selected at Ona and Davenport, Florida. The Ona location consisted of a uniform 22-acre block of 8-year-old 'Valencia' oranges (*C. sinensis* (L.) Osbeck) on rough lemon (*Citrus jambhiri* Lush.) rootstock growing on a Myakka fine sand flatwoods soil with a permanent overhead irrigation system. The Davenport location was a 27-acre block of 27-year-old mixed orange cultivars on rough lemon rootstock on deep well-drained Astatula fine sand without permanent irrigation. The blocks were divided into two and the herbicide and tillage treatments initiated in 1969. Hyvar X (bromacil) and Karmex (diuron) at 2 and 4 lb./acre, respectively, were applied as tank mixes with a commercial herbicide machine consisting of tractor-mounted tank, pump and side-mounted boom with flat fan nozzles. After 1972, Krovar II (a commercially formulated product of the 2 ingredients at the above rates) was used as the herbicide treatment. The herbicide was applied over the entire grove floor (trunk to trunk). Normally 1 and occasionally 2 applications were made per year with spot applications as required. Over the past 5 years only one application per year has been necessary. Paraquat was added to the treatment during some early applications when dense weed cover was prevalent to enhance contact activity.

Mechanical tillage included discing, chopping, mechanical hoeing and occasional mowing. The frequency of tillage operations varied from 4 to 6 times per year; however, the frequency was less at the Davenport location. Hand labor was used periodically to remove vines from tree canopies, particularly in tilled blocks. Both locations received identical, routine commercial grove care during the study. The only variable was the use of chemical weed control and mechanical tillage treatments.

Cost figures include labor, depreciation, fuel and equipment maintenance for both methods of weed control. Herbicide treatments include the cost of materials.

Yields and fruit quality. At the Ona location the yield of the herbicide-treated block steadily increased compared with the tilled block. Over the 10-year-period 114 tons more fruit were produced in the former treatment (Fig. 1). The yield reduction in 1971 and 1972 was due to a severe freeze which resulted in considerable tree damage and fruit loss, particularly in the tilled block. Other freezes of less severity, including that during the 1976-77 season, caused greater damage in the tilled block. Some small differences have been observed in the solids per box in favor of the tilled block, but due to the large yield differences, total soluble solids per acre were greater in the herbicide block.

At the Davenport location, trees were considerably older at the initiation of the study, and yield responses were similar for both treatments (Fig. 2). Trees were not seriously affected by the 1971-72 freeze; however, an alternate bearing pattern was evident which may be partly due to periodic drought situations which occurred during fruit set and development and to the alternate bearing habit of the 'Pineapple' orange cultivar. Also, the grove was older and exhibited an increased natural tree mortality level in both treatments. Total soluble solids varied only slightly between treatments over the 10-year period with average annual yields of 2258 and 2268 lb./acre for the herbicide and tilled blocks, respectively.

Tree condition and mortality. While tree condition and

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[4]For metric conversions, see table in the front of this volume.

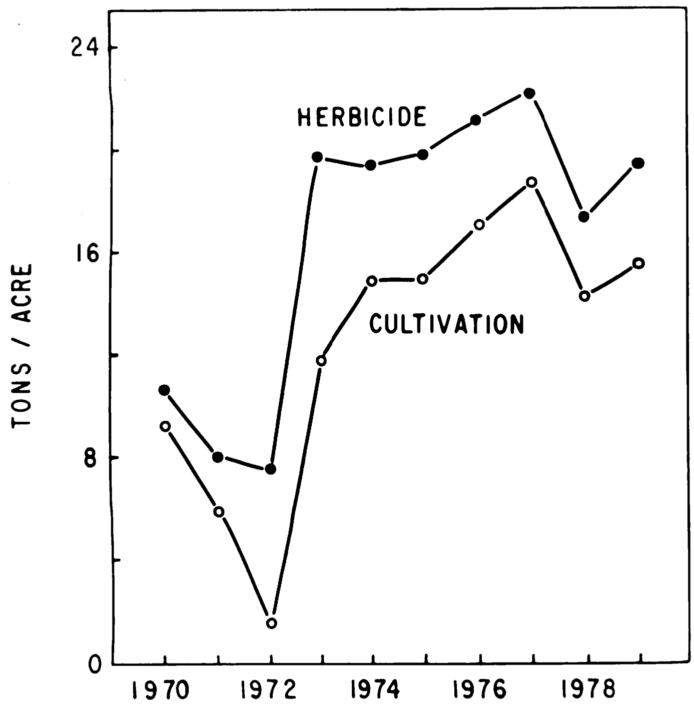

Fig. 1. Annual yields of 'Valencia' oranges in cultivation and chemical weed control blocks (Ona).

size were not influenced by treatments at Davenport, they were at the Ona location, particularly due to freeze damage which resulted in severe wood loss and canopy size reductions. The herbicide-treated block has been mechanically pruned (hedged) in a north-south direction as trees had begun to grow together between rows. This treatment was not required as early in the cultivated block as the canopy area had not developed as rapidly. Tree loss from the tilled block has been greater throughout the study.

Costs. With the increasing costs of machinery, its maintenance, fuel and labor, the frequency of tillage is becoming a major factor in the citrus production budget. At the Ona location (Fig. 3), the cost of chemical weed control

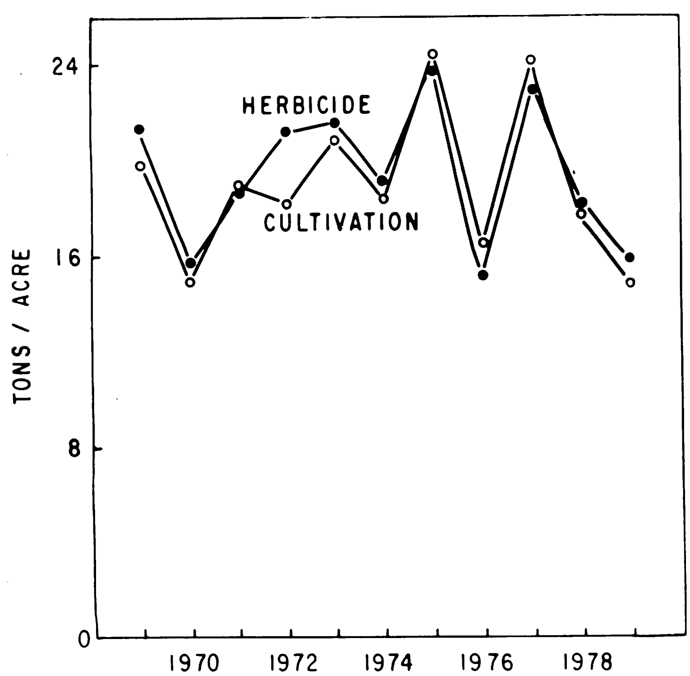

Fig. 2. Annual yields of mixed citrus in cultivation and chemical weed control blocks (Davenport).

has paralleled and actually dropped below that of tillage operations after its appreciably greater costs at the initiation of the study. The higher initial cost for herbicide control was related to the prolific weed growth with the smaller trees shading much less of the ground area, use of irrigation, and the year round warmer location contributing to the more prolific weed growth. The occasional annual increases in herbicide costs shown in Fig. 2 are due to the additional periodic spot treatments to control localized weed infestations.

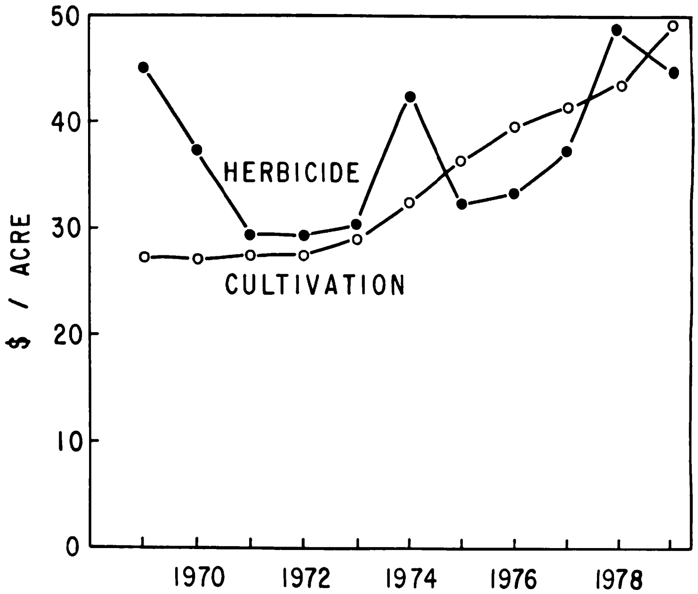

Fig. 3. Total annual cultivation and chemical weed control costs (Ona).

At Davenport (Fig. 4) the herbicide operation costs were greater than the tillage costs; however, the differences become less with time. At this location the frequency of tillage was less than at Ona due to the following: 1) the canopy shading effect of the larger trees, 2) the lack of supplemental irrigation, and 3) the more northern location with longer periods of colder winter temperatures.

Energy usage. A typical value for the amount of energy annually used in a mechanical weeding operation is 1.5 gal/acre of diesel fuel and for a typical herbicide spraying

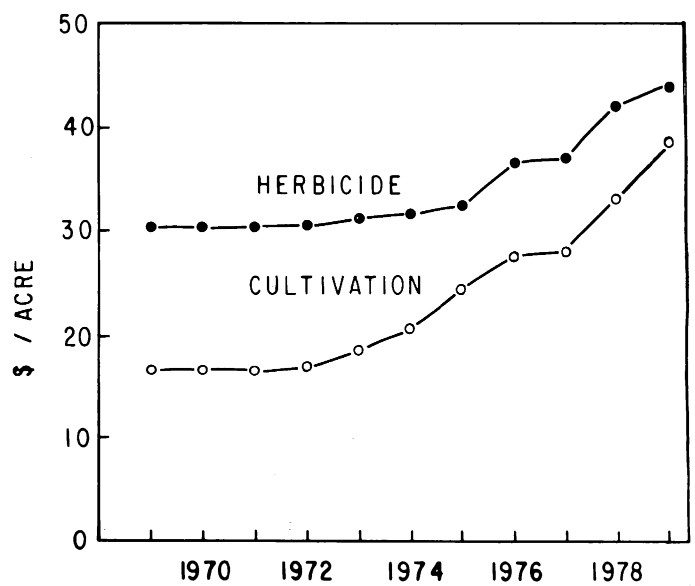

Fig. 4. Total annual cultivation and chemical weed control costs (Davenport).

operation 0.15 gal/acre (1). Figs. 5 and 6 show energy consumption costs per acre (based on gallons of diesel) at both locations for the chemical weed control and tillage operations. Tillage operations were performed at greater frequency than herbicide operations and also used greater horsepower tractors pulling heavier equipment. In computing energy usage for herbicide operations, the estimated energy used in the manufacture, packaging and transport of materials has been included and are expressed as gallons of diesel equivalent for the particular herbicide material used.

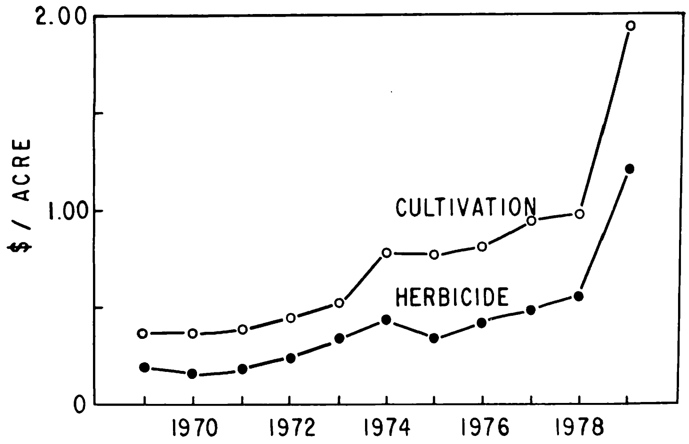

Fig. 5. Energy costs for cultivation and chemical weed control (Ona).

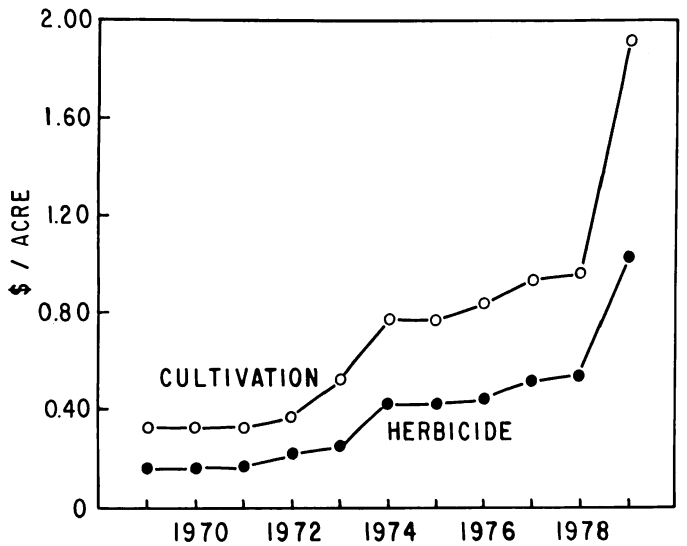

Fig. 6. Energy costs for cultivation and chemical weed control (Davenport).

Clearly the energy consumption by equipment is considerably less for the chemical weed control operations due to the reduced frequency of equipment usage, the lower tractor HP requirements, and consequent lower diesel consumption.

Weed control observations. A wide spectrum of broadleaf weeds, grasses and climbing vines were effectively controlled at the Davenport location. Four to 5 tillage treatments were required for each herbicide application to provide comparable weed control. The herbicide treatments controlled the vines under the tree canopies more effectively than tillage, since equipment could not get close enough to the trunks without causing trunk and surface lateral root damage.

At Ona, the reduction in weed populations under the herbicide program was very striking, with limited regrowth now occurring during the year between applications. Counts of annual vines under and in tree canopies showed 85% of the trees were infested in the tilled block compared to less than 1% infested in the herbicide block. Considerable hand labor was also used in the tilled block to detach those vines from canopies which had escaped the tillage equipment or regenerated following cultivation. In the herbicide-treated block, perennial grasses and vines have not been vegetatively propagated and spread as under the tillage program. Buried weed seeds have not been uncovered and allowed to germinate. It is expected that the herbicide application rates can be reduced in the future with perhaps only spot applications being necessary. Under the tillage program at Ona, weed regrowth, especially the perennial grasses, was rapid and vigorous.

Root densities. At the Ona location, root samples were taken with an auger at the 0-6 and 6-12 inch depths at 2 locations around the drip circle of 12 trees in each treatment block. There were twice as many roots in the 0-6 inch samples from trees in the herbicide block than those in the tilled block. These differences did not appear in samples taken at the 6-12 inch depths. This considerably reduced root density in the tilled block reflects root loss due to their destruction by repeated mechanical tillage of the surface soil layers. The rooting depths of trees in this soil type were shallow as indicated by the fact that in the tilled block the 6 to 12 inch sample contained only 20% of the roots found in the surface 0-6 inch sample.

Soil and leaf analysis. Soil samples were collected at both blocks from the 0-6 and 6-12 inch depths and analyzed for organic matter, pH, CaO, P_2O_5 and Cu (3). Organic matter content was twice as high in the tilled as in the herbicide blocks reflecting the greater weed cover over the period which has been incorporated into the soil. No consistent differences showed up in the levels of CaO, P_2O_5 and Cu between treatments in the surface 0-6 inch sampling zones at either location. However, some differences appeared between sampling depths. There was a greater movement of CaO and P_2O_5 into the lower profile in the tilled blocks, and the pH levels were also higher at the lower sampling depths due to distribution of the limestone applications into the soil through mechanical tillage.

Leaf analyses data for the major elements, N, P, K, and Ca, showed slightly higher N and Ca values in the tilled block; however, these values were within the sufficiency range in both treatment blocks (4).

Herbicide residues. Analyses of soil samples for the herbicides bromacil and diuron from treatment blocks at both locations showed low levels at various soil depths to 24 inches. Continuous applications at recommended rates have resulted in maximum levels of bromacil and diuron of 3.9 percent and 13.1 percent, respectively, of the total soil application during 8 years. No phytotoxicity symptoms have appeared in the trees in the herbicide blocks over the 10-year period indicating no accumulations of toxic levels in the soil (5).

Cold tolerance. Work in Texas has shown that some measure of cold protection can be obtained by maintaining grove soils undisturbed (nontilled) and weed free with herbicides. During freezes on nights with radiation cooling from 1957-1963, minimum air temperatures averaged 3.2°F higher at the 12-inch level over chemical weed control no-tillage plots than over mowed sod plots and 1.8°F higher than over clean cultivation plots. Clean cultivation averaged 1.4° warmer than sod. Yields also showed considerable differences after the freezes. Such differences were not recorded under windy conditions (2).

At the Ona block during the 1969-70 and 1970-71 winters, temperatures were recorded during 17 days. The average minimum temperature in the mechanically tilled block was 29.4°F and in the herbicide-treated block 30.1°F. The severe freezes of 1970 and 1971 resulted in striking differences in tree damage. Foliage kill was 27 percent less in the herbicide block than in the tilled block. This reduced freeze injury was related to larger tree size, greater vigor, soil condition prior to the freeze, and slightly higher soil temperatures. Two years after the freezes the canopy area of trees in the herbicide block was nearly twice that of those in the tilled block. The herbicide block produced 83 lb./acre of solids more than the tilled block the first year after the freeze and 256 lb./acre solids more the second year.

Periodic freezes since, although not as severe, have continued to contribute partially to tree size and yield differences between blocks.

Before chemical nontillage weed control programs can be recommended under certain Florida citrus grove conditions, we must determine: 1) the moderating effects of weeds on the microenvironment and their possible role in determining the diversity and stability on insect populations and disease organisms in their ecosystem, 2) the degree to which the beneficial contributions of weeds *to pest problems* in citrus crop management systems compensate for their considerable competitive and other undesirable effects, and 3) the influence of declining organic matter levels on tree growth, mineral nutrition and microbial populations.

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RESULTS OF CITRUS FERTIGATION STUDIES[1]

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Abstract. **Fertilization of citrus through low volume and sprinkler irrigation systems was examined. No difference in the mineral contents of leaves, fruit quality and fruit production was found between dry fertilization applied in the conventional manner and liquid fertilization through permanent overhead sprinkler systems. Comparisons of liquid fertilization through low volume irrigation systems and dry fertilization revealed results ranging from no difference to substantial differences. Absorption of nutrients by the trees from fertigation through low volume irrigation systems was influenced by the extent of ground coverage. The feasibility of fertigation in citrus with certain precautions concerning these operations is discussed.**

Recent advances in agrotechnology make it possible to apply fertilizer materials through the irrigation systems, a practice referred to as fertigation (1, 2, 4, 5, 6). This practice has several advantages including: 1) savings in cost of fertilizer application and labor; 2) fertilizer elements are already in solution and become available to plant roots more quickly than dry materials placed on soil surface; and 3) the high flexibility in irrigation timing makes it easier to schedule fertilization. Possible disadvantages to fertigation are: 1) poor results with improperly designed irrigation systems which will not give satisfactory coverage of fertilizer materials. This is especially true with drip and other low volume irrigation systems where only a portion of ground is irrigated; and 2) inability to always use the least expensive materials in fertigation. This paper reports findings of fertigation experiments conducted with both low volume irrigation and permanent overhead sprinkler irrigation systems.

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Materials and Methods

The low volume fertigation study was conducted in a bearing 'Valencia' orange block planted in 1963 at the Davenport grove of AREC, Lake Alfred. The experiment which involved both timing and methods of application had 12 treatments arranged in a 3 x 4 factorial design with dry fertilizer applied twice a year and liquid fertilizers 3 and 10 times a year. Application methods included drip irrigation with 2 and 4 drippers per tree and under tree sprays with 1 and 2 jets per tree. Each treatment was replicated 4 times in randomized 6 tree plots making a total of 48 plots in the experiment. There were no guard trees between plots. A venturi suction device was used to incorporate the fertilizers. The irrigation operating pressure was maintained at 25 psi which discharged 16.5 gal from the dripper per hour.

Fertigation through sprinkler irrigation systems was conducted in 3 groves in Lake, Hillsborough and Highland counties. These groves varied from 10 to 25 acres and all have permanent overhead irrigation systems discharging water at .12 to .15 inches per hour between 60 to 80 psi operating pressure. In each grove one-half of the block was fertilized with conventional dry fertilizer and the other half fertilized through the irrigation systems. The fertigation cycle usually required 6 to 8 hr with 1 hr to wet the trees, 1 hr to inject the fertilizer, and 4 to 6 hr to rinse the fertilizer from the tree foliage. The quantities and formulations of the dry fertilizer used in different groves varied with cooperator's preferences. It was not always possible to match the liquid and the dry fertilizers with the same formulation, but the trees were fertilized with the same quantities of plant nutrients in both the liquid and dry fertilizers.

Experimental blocks are described in Table 1. Leaf and