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Weed Control in Subtropical Conditions in Florida Citrus[1]

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The management of weeds in Florida's citrus groves has been a focus of discussion and study dating back over 100 years when mechanical or hand removal were the only control options.

It was not until 1956 that controlled experiments were conducted in commercial citrus acreage using herbicides for the control of annuals and perennial grasses (Burt & McCown, 1959). These studies were the beginning of preemergence weed control that allowed the citrus growers to efficiently and economically control the vegetation around the trees, shifting from mechanical and hand hoeing to chemical weed control. While limited grower trials were begun in 1962, it was not until 1964 that extensive grower use of herbicides began (Ryan, 1969).

The first extensive commercial use of herbicides was in 1964 (Ryan, 1969). In experiments conducted in the 1960s, researchers began to report that young trees treated with diuron or simazine starting one year after planting had greater tree growth than trees that were mechanically hoed (Ryan, 1965; Ryan & Kretchman, 1968). Treatments with better weed control also resulted in larger trees and subsequent greater yield (Ryan, 1969), beginning both successful and economical weed control. By 1975, at least one publication was discussing herbicide use and listing the benefits of chemical weed control; the authors did mention that this area was rapidly changing due to material development and changing techniques (Ziegler & Wolfe, 1975). Mention was also made of plant bugs and grasshoppers feeding and reproducing on cover crops and the problems these pests caused the citrus when cover crops were removed during the fall cultivation.

Today, due to the scarce supply of labor and its cost, the citrus industry relies very heavily on the use of herbicides. Herbicides can provide weed control not only under the tree canopy but within the row middle, depending on the selected material and its placement and rate.

The combination of preventive, chemical, biological (Burnett et al., 1973), mechanical, and, to a lesser extent, hand labor methods is used today to provide effective and economical weed management in Florida citrus groves.

Weed Control Programs

Today, citrus is one of the most important agricultural crops in the Florida economy, comprising 850,000 acres (Florida Agricultural Statistics Service, 1998) with an on-tree value of $1.1 billion for the

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1995-96 crop year (Florida Agricultural Statistics Service, 1996). Local television news reports in August 1997 estimate the economic value of Florida citrus to the state's economy at $8 billion with over 144,000 people employed in the industry.

Control of weeds has always been a major economic cost in citrus production because Florida's very favorable climate allows for weed germination and year-round growth. Weeds compete with citrus trees for nutrients, light, water, space and harbor insects and rodents that attack citrus trees. Additionally, weeds can increase fire hazards within groves, increase cold damage from radiation freezes, increase the incidence of *Phytophthora* foot rot, impede harvesting of citrus crops, interfere with low volume irrigation systems, and intercept soil-applied chemicals, thereby reducing their effectiveness. Weeds also affect harvesting operations, water distribution patterns from irrigation systems emitters, disease control, and environmental conditions within the grove. Desirable vegetation species in the row middle, however, can minimize soil erosion from both wind and water and provide nutrients and organic matter to the soil. Thus, the objective of today's citrus weed management program is not the elimination of all weed species from the grove floor but rather to suppress the undesirable effects of weed populations to a level that economic losses do not exceed the cost of weed management programs.

Weeds are classified based upon grouping species together whose similarities are greater than their differences. Category classifications can include broadleaf, grasses, and sedges. Broadleaf (dicotyledons) have broad leaves with net-like veins, display branching growth habit and generally reproduce by seeds. Grasses (monocotyledons) have narrow, strap-shaped leaves and rounded stems, are generally perennial, and reproduce by seeds and/or rhizomes or underground stems. Sedges are similar to grasses but have triangular stems. Sedges may reproduce by seeds, rhizomes or tubers.

Dicotyledon and monocotyledon weeds can be further classified as annuals, biennials, or perennials. Annuals complete their life cycle in one growing season. Annuals may be further classified as either summer annuals, which complete their growth in the spring to fall, or winter annuals, which complete their life cycle from fall to spring or early summer. Biennials require two growing seasons to complete their life cycle, forming rosettes in the first season of growth, then flowering, producing seeds, and dying in the second season. Perennials live for 2 or more years, sometimes living indefinitely. Perennial weeds are especially difficult to control with contact herbicides due to the underground storage organs that many species contain.

Cost of Weed Control

The use of chemical weed control has increased dramatically due to labor costs, equipment costs, product costs and availability, the shift to more narrowly spaced tree rows, and installation of low volume irrigation systems that prohibit the operation of mowing or tillage equipment under the tree canopy area. Weed control for the crop year 1995-96 accounted for 24.4% of the annual total specified production costs or $837.70 per acre in Central Florida citrus (Muraro & Oswalt, 1996). Cost for the other citrus regions within the state will vary slightly from the Central Florida production region. Using the Central Florida region cost data and assuming that 90% of the state's citrus has some type of chemical weed control under the tree, the total cost of herbicide materials and application equals $97.7 million per year. In addition to the cost of managing weeds under the tree, management of vegetation and/or weeds in the row middle is $48.6 million, bringing the total annual weed management costs to Florida's citrus industry to $146.3 million.

Over the past 20 plus years, the University of Florida has issued annual reports listing the estimated annual per-acre costs and returns for a mature Valencia grove producing fruit for the processed market. From these, selected reports at five-year intervals were chosen to provide the following estimates of the cost of weed management programs and are converted to cost per acre for under tree and row middles: $31.25 in 1976-77 (Muraro & Abbitt, 1977), $46.44 in 1980-81 (Muraro, 1981), $91.93 in 1985-86 (Muraro, 1986), $153.44 in 1990-91 (Muraro et al., 1991), and $204.75 in 1995-96 (Muraro & Oswalt, 1996). Thus, the weed control cost, as a percentage of the total specified cost, has increased

from 9% in 1976-77 to 24.4% in 1995-96 with the total annual cost of production increasing from $346.19 to $837.70 per acre, respectively (Table 1).

Benefits from Herbicides

Regardless of the cost of labor, herbicide use provides benefits from both an economic and a grove floor management standpoint. By using herbicides, the need for hand labor is minimized and in some cases can be almost eliminated. The application of preemergence soil-applied herbicides can prevent seed germination, thus eliminating early weed growth and competition with the citrus tree and improving efficiency of nutritional and pesticide application. Equipment costs and operational costs are generally reduced compared to those for mechanical, tillage, or mowing operations. Movement within the grove is improved for cultural and harvesting operations. Proper herbicide applications can minimize injury to citrus tree trunks and roots compared to mechanical hoeing, tillage, or cultivation operations. Injured tree trunks and roots are more susceptible to attack and injury by soil-borne pest and diseases (Jordan et al., 1992). Properly timed herbicide applications can reduce the number of seeds in the soil (seed bank) that are available for germination. The combination of herbicides and noncompetitive cover crops can reduce soil erosion compared to tillage operations, which is especially important in the bedded grove systems.

Tree Response to Herbicides

Herbicides that are properly selected and applied for specific tree age, scion, and soil type will not significantly injure otherwise healthy citrus trees. Herbicide damage to foliage and fruit has also been noted when herbicides were applied under windy conditions or use of improper equipment allowed the materials to contact areas other than the weeds or soil.

Positive tree responses have also been noted in groves that were properly treated with herbicides compared with those that were not treated or those that were cultivated. The canopy volume and tree trunks are larger in herbicide-treated groves, which will allow for increased production of citrus fruits (Jordan et al., 1992). This increase in size is due to the reduced competition of weeds for light, water, space, and nutrients along with the reduced injury to the tree from cultivation damage to the roots or tree trunk from hand or mechanical hoeing (Jordan, 1978; Singh & Tucker, 1984). The extent of the above competitions will vary with each grove and in some cases even within a given grove due to soil type and weed pressure.

Weed Control Programs

Preventive programs are most frequently overlooked as a method of weed control that should be incorporated into today's citrus production practices. Preventive programs entail the use of such practices as sanitation, spot spraying, or hand labor to prevent the source of weed infestation (seed and/or vegetative) from widespread dissemination throughout a given area. By removing the undesirable weed species prior to seed development, dissemination by wind or mechanical transport on equipment can be effectively delayed. Some examples of difficult-to-control species for which preventive weed control methods are beneficial are milkweed vine (*Morrenia odorata)*, guineagrass (*Panicum maximum)*, balsamapple (*Momordica charanta*), goatweed (*Scoparia dulcis*), and cogongrass (*Imperta cylindrica*). While preventive practices may not completely stop the spread of weeds, these practices may slow the spread of undesirable weed species, thereby reducing the cost of current programs.

Weed control programs will vary from location to location within the state and can even vary within a given site based upon specific conditions such as soil type, variety, method of herbicide application, and the presence of specific weed species. Herbicides used in citrus groves are generally divided into two groups: (1) soil-applied preemergence herbicides that should be applied before weed seed germination and (2) foliar-applied postemergence herbicides that are applied after the germination of the weed seed. The postemergence herbicides can be further divided into systemic or contact. Systemic herbicides are translocated within the target plant (Singh & Tan, 1992), killing the foliage and root system of the contacted weed. Contact herbicides kill only the plant parts made wet by the spray surface. Selective herbicides kill some plants without significantly

injuring other plants. Nonselective herbicides kill all plants present if applied at the correct time and rate. Each chosen method of weed control and herbicide selected have its own advantages and disadvantages. The most frequently chosen methods of weed control are chemical weed control and mowing with the use of tillage or cultivation, which is becoming less common in most areas of the state due to the damage that tillage causes to the fibrous roots, which are very close to the soil surface (Tucker et al., 1980). The use of low volume irrigation systems prohibits cultivation in more than one direction. Most groves that use low volume irrigation will use some type of chemical weed control program to keep the area under the tree nearly weed free for most of the year because weeds can affect the distribution pattern of most low volume under-tree irrigation emitters and can intercept soil-applied pesticides.

In addition to under-tree herbicide application, the use of chemical mowing is increasing each year as the cost of mechanical mowing increases due to rising equipment and maintenance costs. Chemical mowing consists of using sub lethal rates of systemic herbicide to suppress the growth and/or regrowth for up to 45-90 days of grasses and broadleaf weeds that grow in the row middle.

Herbicides are generally applied two or three times per year, and the total annual amount of herbicide materials will be nearly the same regardless of the application frequency. For preemergence materials, applications should be properly timed so that the maximum amount of herbicide is in the upper soil profile (0 to 2 inches) slightly before peak weed emergence. Materials applied too early will not have enough herbicide concentration to provide adequate weed control due to herbicide losses caused by leaching or degradation on the soil surface or within the soil profile. Some growers will alternate between products in an effort to choose those that will provide the greatest weed control for the given site and weed species present. Once adequate weed control has been achieved, the grower may consider reducing the frequency of application or reducing the rate of the material applied. The areas between the trees in the row middle are mechanically mowed or mowed chemically, except in some areas of the state that are very sandy. Those well drained, sandy sites may use some tillage instead of mechanical mowing (Tucker et al., 1980). However, tillage usage has been decreasing in recent years.

The selection of a herbicide and its rate will vary depending upon the (1) weed species present, (2) growth stage of the weed species, (3) soil type, (4) cost of herbicide material(s), (5) scion variety, and (6) tree age. Generally speaking, young groves will require greater attention to material selection and rate because the areas around the tree are more sun exposed and have greater weed pressure than do larger trees, which have greater shaded areas with lower weed pressure. Young trees generally will not tolerate herbicide rates as high as a mature tree. An exception to the lower weed pressure for mature trees is where vines are present. Vines can germinate in shaded areas and grow into the tree canopy, creating a host of problems for the tree and fruit harvesting operations.

Herbicide band width varies with the diameter of the tree canopy. Herbicides can be applied alone in water or, in some cases, mixed with suspension fertilizers (depending on herbicide compatibility) to combine the two operations into a single pass through the grove, thereby reducing the application cost. In groves with a well-designed irrigation system that has back-flow prevention devices meeting the approval of the Florida Department of Agricultural and Consumer Services regulations, some herbicide material(s) can be mixed with the irrigation water and applied via the irrigation system. This is referred to as chemigation or herbigation, if the materials have herbicidal properties only. If chemicals are injected into the irrigation system, all efforts should be taken to make sure the system is fully operational and to apply an equal amount of water with the herbicide per unit area. Growers should note that all materials cannot be applied in this manner, and they should fully read the chemical label and follow the directions printed on the label in their possession.

Weed Monitoring

Before herbicide application, growers should survey the grove and determine the stage of growth and type of weeds for that given location. Many products do not provide control of emerged species, thus requiring the application of more than one product to provide both preemergence and postemergence protection.

Very few herbicide materials will control grasses (annual and perennial), broadleaf weeds, and vines, thus requiring the application of more than one product to provide broad spectrum control. Rotation of soil-applied herbicides should also be considered to prevent the buildup of resistant annual and perennial weeds. The resistant species may not be evident initially; however, if the same herbicide and cultural program is maintained, over time their populations may build up until they infest the entire grove and become the dominant weed species (Jordan et al., 1992).

Mechanical mowing is generally more expensive than tillage due to the cost of equipment, equipment maintenance, and energy requirements. Mechanical mowing can also throw seeds under the tree canopy, increasing weed pressure in that area. However, groves are rarely cultivated if they are located in flatwoods with soils that are inherently poorly drained and if the trees are planted on raised middles or beds (Spyke et al., 1977).

Major Preemergence Herbicides Used in Florida

Bromacil

Bromacil (Hyvar X 80WP) was introduced for noncrop use in 1963 for control of annual and perennial grass weeds (Ryan, 1966) and is currently registered for the preemergence control of annual and perennial grasses and annual broadleaf weeds. Bromacil does have limited postemergence activity which is enhanced by the addition of a surfactant to the spray mixture. Beginning in 1994 the product label prohibits bromacil from being applied on vulnerable, deep, sandy ridge-type soils, thus limiting its use to the flatwood citrus production region of the state of Florida. The product is currently applied preemergence with limited postemergence activity up to 4.8 pounds active ingredient per acre (lb ai/A) per year for weed control in Florida citrus. Current use rates are shown in Table 2.

Over the years the product rate per acre has decreased due to better weed management practices and the concern for bromacil being found in the groundwater. Groundwater contamination is currently a major factor in the use of bromacil in many locations in the state that have vulnerable soils (Power, 1996).

Diuron

Diuron (Direx 80WP, Karmex 80WP) (along with simazine) was one of the first two herbicides registered for use in Florida citrus (Ryan, 1969) and was recommended in a University of Florida publication by 1962 (Kretchman & McCown, 1962). Early registration was for control of annual weeds, while today's registration is for the control of annual broadleaf weeds and annual grasses. By 1988 the rates were 1.6-3.2 lb ai/A with a maximum annual rate of 6.4 lb ai/A and have remained at this rate to the present time and are shown in Table 2. Foliage contacted by diuron may develop a bleached or bronzed appearance.

Norflurazon

Norflurazon (Solicam 80DF) first appeared in University of Florida recommendations in 1985 at a rate of 3.2-4.0 lb ai/A with a maximum rate of 8 lb ai/A per year. Norflurazon should be applied prior to weed emergence and should be incorporated with rainfall or irrigation for best results. Norflurazon is recommended for the control of annual grasses and certain broadleaf weeds. The recommended rate per acre remained unchanged from 1985 until 1995 when it was reduced to 2.4-4.0 lb ai/A. Norflurazon can be injected through low volume under tree irrigation systems. Current recommendations are shown in Table 2.

Oryzalin

Oryzalin (Surflan 4AS) first appeared in University of Florida recommendations in 1993 at a rate of 2.0-4.0 lb ai/A with a maximum annual rate per acre of 6 lb ai/A. Oryzalin is recommended for the control of annual grasses and certain broadleaf weeds. Oryzalin will not control perennial grasses or weeds that have germinated prior to application. To obtain maximum control, oryzalin should be incorporated into the soil with 0.5 to 1.0 inch of rainfall or irrigation. Oryzalin can be injected into the low volume irrigation system, providing the system has adequate backflow prevention devices. Current rates are shown in Table 2.

Oxyfluorfen

Oxyfluorfen (Goal 1.6E) was first listed in 1989 in the Florida Citrus Spray Guide in the section on products registered for use on Florida citrus. This 1989 listing stated the product is for nonbearing use only and did not appear in the general section on weeds. As of 1998, the product listing status has not changed since it is still omitted from the weed treatment guide section.

The product label for oxyfluorfen currently states the product is for nonbearing citrus use, which means that the trees should not produce fruit for a period of 12 months after the last application. Current use rates, as stated on the label, is for a postemergence application of 0.5-2.0 lb ai/A or a preemergence application of 1.2 to 2.0 lb ai/A. The maximum use per acre is 4 lb ai/A during a 12-month period. Current use rates are listed in Table 2.

Simazine

Simazine (Simazine 90DF, Caliber 90WDG, Princep 4L) was one of the first two herbicides registered for use in Florida citrus (Ryan, 1969) and was recommended in a University of Florida publication in 1962 (Kretchman & McCown, 1962). Early registration of simazine was for the control of annual weeds while today's registration is for the control of broadleaf weeds, annual vines, and annual grasses. Simazine does not control perennial grasses or have contact activity. In 1998 the rates were 2.25-3.96 lb ai/A per application and 7.92 lb ai/A maximum annually with the lower rates for trees less than one year old. Current recommended rates are shown in Table 2.

Thiazopyr

Thiazopyr is a new compound that obtained registration for use in Florida citrus in May of 1997 and appears in the 2000 Florida Citrus Pest Management Guide. Thiazopyr is a preemergence herbicide for the control of annual grasses and broadleaf weeds in citrus crops. The product can be applied in a single application or in two or three separate applications. The recommended application rate is 0.5-0.75 lb ai/A. The maximum annual rate per acre is 1.0 lb ai/A. For maximum weed germination rainfall or irrigation is needed within 7 days of application to move the herbicide into the germinating zone of the weeds. Current rates are shown in Table 2.

Other Herbicides

Napropamide (Devrinol), pendimethalin (Prowl) and trifluralin (Treflan) still maintain labeling which permits the product to be applied to citrus, but widespread use of these products does not occur in Florida citrus.

Postemergence Herbicides

Paraquat

Paraquat appeared in the University of Florida publications from 1969-1987 and was changed to paraquat dichloride with the trade name Gramoxone in 1986-1997 until the present for the postemergence burn down of all weeds. From 1986 until 1987 both paraquat and paraquat dichloride were recommended for use in Florida citrus. The rate was 0.5-1.0 lb ai/A in 1969 and was slightly adjusted in 1994 to 0.6-0.94 lb ai/A. Paraquat dichloride is still currently recommended in University of Florida publications. Current recommendations are listed in Table 3.

Glyphosate

Glyphosate is marketed under the trade name Roundup. It first appeared in the University of Florida recommendations in 1979 as a nonselective, systemic herbicide that is actively translocated from the leaf and stem tissue to the roots or rhizomes of the weed. Glyphosate is registered for postemergence use for total or partial control of most weed species. Glyphosate does not have any soil activity for preemergence weed control. The 1979 rates were 1.5-3.7 lb ai/A with an annual maximum of 7.9 lb ai/A. Recommendations cautioned growers not to apply to trees which were less than two years of age and to avoid green bark, tree foliage and fruit. Glyphosate's application rate was 20-100 gallons of water per acre. By 1984 the application rates were reduced slightly to 0.75-3.0 lb ai/A with a lower rate of 0.75-1.5 lb ai/A in 5-22 gallons per acre for the control of annual broadleaf weeds and grasses. The rates were adjusted slightly in 1985 to 1.0-4.0 lb ai/A. Chemical mowing recommendations first appeared in University of Florida publication in 1992. Glyphosate currently appears in the University of Florida recommendations and is the most popular postemergence herbicide currently used in Florida citrus production.

Sulfosate

Sulfosate (Touchdown 6L) is for the control of annual weeds and is applied at rates of 0.98-2.0 lb ai/A for annual weeds with higher rates of 2.0-4.0 lb/A for perennial weeds. Water volumes of 30-50 GPA will maximize activity. Activity of sulfosate will be reduced if pH of spray water exceeds 7. The maximum annual rate is 4.0 lb ai/A.

When using either glyphosate, sulfosate or paraquat dichloride all possible efforts should be taken to assure that the herbicide does not contact citrus fruit, foliage and/or green bark as damage can result to the contacted tissue.

Fluazifop-p-butyl

Fluazifop-p-butyl is marketed under the trade name Fusilade. It was first recommended in 1987 for use in nonbearing citrus for the postemergence control of annual and perennial grasses. The 1987 rate for fluazifop-p-butyl was 0.25-0.37 lb ai/A with the rates increasing to 0.37-0.5 lb ai/A in 1989. In 1996 with the introduction of the 2E formulation the rates were reduced to the 1987 rates of 0.25-0.37 lb ai/A. Fluazifop-p-butyl currently remains in the University of Florida recommendations and can only be used in nonbearing citrus sites.

Sethoxydim

Sethoxydim was first marketed under the trade name Poast Plus and first listed in University of Florida publications in 1993. The trade name was changed to Torpedo in 1994. The recommended rate of 0.37-0.47 lb ai/A has remained constant since it was first recommended in 1993 for the postemergence control of annual and perennial grasses and does not control broadleaf weeds. Sethoxydim remains in current University of Florida recommendations. Sethoxydim can be used in both nonbearing and bearing citrus groves.

Phytophthora palmivora

Phytophthora palmivora is the only commercially produced biological micro-herbicide registered for use in Florida citrus. It is marketed under the trade name DeVine. *Phytophthora palmivora* is used for the control of milkweed vines and was first recommended in University of Florida publications in 1987 (Knapp et al., 1987). The material is applied from June through September at one pint per acre to moist soil. One pint contains 3.2×10^8 live chlamydospores. The product should be kept refrigerated prior to use. *Phytophthora palmivora* did not appear in University of Florida publications in 1994 and 1995 but was listed in 1996-2000.

Herbicide Application

Changes in herbicide application technology have occurred in recent years with the development of sophisticated equipment which allows for the selective delivery of multiple herbicide products to specific grove floor sites. In a single application, tree rows and row middles may be treated with soil residual and postemergence products at various rates and combination with selectivity for tree age, soil type and vegetation species. Well maintained accurately calibrated equipment with good filtration and

agitations systems capable of uniform distribution of prescribed spray volumes and droplet size is essential for efficacious, cost-effective vegetation management. Worn nozzle tips result in increased spray delivery rates and distortion of distribution patterns and should be checked regularly. Improved herbicide boom design to reduce tree skirt contact, spray drift and interference of heavy weed cover with nozzle output will reduce tree damage and fruit drop while improving control of target vegetation. Tree skirt pruning and timing of postemergence application will also reduce boom and spray contact with low hanging limbs and fruit.

The use of low rate technology has been pioneered in Florida by Monsanto which involves using low volumes per treated area. Generally 20 to 50 GPA are used with lower volumes 10 to 25 GPA for chemical mowing application to row middles.

Effect on Grove Environment

Weeds will influence the grove environment by affecting both soil and air temperature and providing organic matter to the soil as the weeds decay. When the grove floor is covered with vegetation, it will insulate the soil, keeping it cooler in the summer and warmer in the winter. However, during the winter, groves that have a thick mat of vegetation may have an air temperature some 1-2 ^{o}C cooler than a grove without a thick mat of vegetation (Krezdorn & Martsolf, 1984; Singh & Tucker, 1984) on calm nights when radiation cooling is high, thereby increasing the chances of freeze damage to the citrus tree on marginal freeze events. Warmer grove temperatures have also been noted in Texas in groves that are weed free vs. those that are sodded (Leydon, 1969). Groves with a thick mat of vegetation during the dry months have an increased chance of damage by fire if the vegetation is ignited. A positive effect of grove floor vegetation is that, as the material decomposes, it will add organic matter to the soil surface, which will increase the soil's ability to hold water and nutrients for future plant use. Additionally, some leguminous species, such as perennial peanuts, actually provide nutrients to the soil via nitrogen fixation (Neff, 1997). In groves that are extremely wet due to temporary flooding, the existing vegetation can aid in the removal of excess water via transpiration, thereby reducing potential water damage to citrus trees.

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Table 1. Estimated cost for herbicide program and total specified cost of production per acre for a Valencia grove producing fruit for the processed market in central Florida area.

Production Year	Annual Weed Management Costs	Annual Specified Production Costs	Weed Control as a Percent of Total Specified Costs
1976-77	$ 31.25	$346.19	9.0
1980-81	$ 46.44	$539.53	8.6
1985-86	$ 91.93	$618.08	14.9
1990-91	$153.44	$892.16	17.2
1995-96	$204.75	$873.70	24.4

Table 2. Herbicides used in Florida citrus in 2000.

Common Name (Trade Name)	Tree Age	Treatment Rate Pounds Active Ingredient Per Acre (lb ai/A)	Maximum Annual Rate Per Treated Acre
Bromacil			
(Hyvar X 80WP)	< 1 year	1.6-3.2 lb ai/A	4.8 lb ai/A in flatwoods, prohibited on ridge
	1-3 years	1.6-2.4 lb ai/A	4.8 lb ai/A in flatwoods, prohibited on ridge
	> 4 years	1.6-3.2 lb ai/A	4.8 lb ai/A in flatwoods, prohibited on ridge
Diuron			
(Direx 80WP) (Karmex 80WP)	< 1 year	1.6 lb ai/A	6.4 lb ai/A on ridge soils, no mention of flatwoods
	> 1 year	1.6-3.2 lb ai/A	6.4 lb ai/A on ridge soils, no mention of flatwoods
Norflurazon			
(Solicam 80DF)	all	2.4-4.0 lb ai/A	8 lb ai/A
Oryzalin			
(Surflan 4AS)	all	2.0-4.0 lb ai/A	6.0 lb ai/A
Oxyfluorfen			
(Goal 1.6E)	nonbearing only	0.5-2.0 lb ai/A	4.0 lb ai/A
Simazine			
(Simazine 90DF) (Caliber 90WDG) (Princep 4L)	< 1 year	2.25 lb ai/A	3.6 lb ai/A
	> 1 year	2.25-3.96 lb ai/A	7.92 lb ai/A

Table 2. Herbicides used in Florida citrus in 2000.

Common Name (Trade Name)	Tree Age	Treatment Rate Pounds Active Ingredient Per Acre (lb ai/A)	Maximum Annual Rate Per Treated Acre
Thiazopyr			
(Mandate 2E)	all	0.5-0.75 lb ai/A	1.0 lb ai/A
(Futch et al., 1998)			

Table 3. Postemergence herbicide use rate in 2000.

Product	Recommended Application Rate Pounds Active Ingredient Per Acre (lb ai/A)	Maximum Annual Rate per Treated Acre
glyphosate (Roundup Ultra 4L)	under tree 1.0-2.0 lb ai/A for annual weeds 2.0-5.0 lb ai/A for perennial weeds middles management (chemical mowing) 0.25-5.0 lb ai/A for bahiagrass 0.5-0.75 lb ai/A for bermudagrass	10.5 lb/A
sulfosate (Touchdown 6L)	under tree 1.0-2.0 lb ai/A for annual weeds 2.0-4.0 lb ai/A for perennial weeds	4.0 lb/A
paraquat dichloride (Gramoxone Extra 2.5L)	0.62-0.94 lb ai/A	
sethoxydim (control grasses only) (Poast Plus 1.0EC)	0.28-0.47 lb ai/A	1.87 lb/A
fluazifop-P-butyl (Fusilade DX 2E) (control grasses only) NONBEARING ONLY	0.25-0.37 lb ai/A	
(Futch, et al., 1998)		