UNIVERSITY OF FLORIDA
Florida Cooperative Extension Service

Fact Sheet HS-164
June 1993

Citrus Weed Management[1]

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INTRODUCTION

Florida's warm climate and relatively high rainfall is conducive to intensive pest, disease, and weed pressures. The environment is such that the rate of weed growth is very rapid, and croplands, including citrus groves, can revert to proverbial jungles over a short period of time if left unmanaged. Weed control accounts for about 20–25 percent of the total production costs, and weeds have been estimated to account for about 150 million dollars annually in lost revenues to the citrus industry. Such losses reflect the cost of weed control operations, including aquatic control, direct competitive effects and the reduced efficiency of production and harvesting operations. It is recognized that most of the current citrus acreage is under some form of integrated weed management program involving chemical and mechanical control methods.

There are various reasons for following good weed management practices in citrus groves. Weeds compete with trees, particularly young trees, for water, nutrients and light, with climbing vines easily covering larger trees if left uncontrolled. Good vegetative growth and the attainment of early productivity is partially attributed to the timely elimination of weed competition. Weed growth around tree trunks and canopy creates favorable conditions for the development of fungus diseases such as footrot and brown rot (on fruit). Rank weed growth killed during the winter can become a fire hazard during the dry spring months. Weeds reduce the efficacy of soil applied pesticides due to interception and also can interfere with the operation of low volume irrigation systems.

Soil and air temperatures are higher in groves with bare ground. Groves under nontillage chemical weed control programs have been shown to be 2°F to 4°F warmer during freezes than those under mechanical cultivation or sod culture.

A satisfactory weed control program involves an ongoing process of monitoring, and timely control measures involving chemical, mechanical, biological methods and occasional hand labor. Without a planned approach to weed management results will be inconsistent. Sources of weed infestation (seed or vegetative) identified and controlled prior to dissemination will greatly reduce the cost of weed control operations and other indirect losses. New species, if perceived as potential problems, should immediately be addressed in the weed control program. As many currently troublesome weed species spread from outside areas such as ditchbanks, fence rows and adjacent woodlands, these areas should also be closely monitored.

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1. This document is Fact Sheet HS-164, a series of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: June 1993.
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WEED CLASSIFICATION IN RELATION TO CONTROL MEASURES

From the standpoint of control, weeds can be classified in two ways. One classification is based on life cycle and the other on the subclass of the weed. On the basis of life cycle, weeds are grouped as annuals, biennials, and perennials. Most annual weeds reproduce from seed and complete their life cycle in one year or one season. Weeds germinating in the fall and producing seed the following spring or summer are called winter annuals. Biennials germinate and produce vegetative growth during the first season, produce seed after winter dormancy, and die during the second season. From a control standpoint, many biennials may be grouped with annuals since both have a determinate life span, are self-destructive, and propagate by seed. Control objectives include: (1) the control of growth of the above-ground portion of weeds, and (2) the prevention of seed production.

Perennial weeds live for 3 or more years. Most noxious perennials are complex and reproduce by seed and vegetatively by means of roots, stolons, and rhizomes. Control methods must, therefore, be designed to destroy the underground, vegetative organs. Many annual weeds are quite prolific seed producers, but seed production by perennial species ranges from essentially no viable seed to many thousand per plant. Some weed seeds lie dormant in the soil for many years before germination, thereby being always present for reinfestation under the right conditions.

Weeds are also sometimes classified by subclass into monocotyledons (grasses) and dicotyledons (broadleaf species). These classifications are useful where selective chemical control is based on morphological differences.

It has been estimated that of the more than 100 weed species that commonly occur in groves, only about 30 are considered very undesirable. Of these perhaps 20 are capable of or have become serious pests as evidenced by their undesirable growth behavior, competitive effects and cost of control. Some of these include Milkweed or Strangler Vine (*Morrenia odorata*), Balsamapple Vine (*Momordica charantia*), Morningglory (*Ipomea sp.*) (scarlet, pitted, cypress vine, sharp pod), Virginia Creeper (*Parthenocissus quinquefolia*), Briars (*Similax sp.*), Cat's Claw Vine (*Bignonia unguis-cati*), Narrow-Leaf Milkweed Vine or White Vine (*Sarcostemma clausum*), Love Vine or Woevine (*Cassytha filiformis*), Lantana (*Lantana camara*), Goatweed (*Scoparia dulcis*), Saltbush (*Baccharis halimifolia*), Teaweed (*Sida acuta*), Torpedograss (*Panicum repens*), Vaseygrass (*Paspalum urvillie*), Guineagrass (*Panicum maximum*), Peppervine (*Ampelopsis arborea*), Air Potato (*Dioscorea bulbifera*), and Wild Grape (*Vitis rotundifolia*).

METHODS OF WEED CONTROL

Mowing, tillage, and chemical weed control are the primary methods of weed control used widely in Florida citrus groves. Each method has its advantages and disadvantages. The choice of which method to use depends on grove location and planting system, the weed problem in the grove and to an increasing extent on the energy requirements and associated costs involved. Frequently, a combination of methods is the most appropriate.

Cultivation

Cultivation is no longer as widely used as a control method. Timing of cultivation of annual weed control is not as critical as with soil-active herbicides. Annual weeds are killed efficiently and economically by severing the stems from the roots while the weeds are young. Each crop of weeds must be killed in order to prevent competition with the trees and production of seeds. When seeds are produced, however, they are incorporated into the soil during the next cultivation where they remain viable for many years. Each cultivation also brings seeds to the soil surface where they can germinate. If environmental conditions are right, a new crop of weeds is produced. The sequence of cultivation followed by weed seed germination may continue indefinitely. The number of cultivations required should be determined by the number of flushes of weed emergence. Cultivation at proper time intervals can be used to ultimately kill deep-rooted perennial weeds by exhaustion of their underground food reserves. Stored food is consumed in the process of sending new shoots to the surface after each cultivation. Withdrawal of food reserves may continue for a week or more after new shoots emerge. When sufficient foliage has developed, food reserves are replenished by products of photosynthesis. Cultivation is most effective at the time of maximum net food depletion.

Control of many perennials in citrus groves is rarely achieved by cultivation. Thus, although infrequent cultivation provides temporary weed control, it spreads and invigorates perennial weeds by increasing the number of buried weed seeds and by widely distributing rhizome and stolon cuttings, tubers, and bulbs. The result of infrequent tillage is the establishment of solid stands of aggressive, resistant species such as guineagrass, bermudagrass, torpedograss, and nutsedge.

Constant cultivation results in the continual destruction of surface citrus feeder roots which normally grow in the undisturbed portion of the soil. For all practical purposes, the cultivated portion of the soil is of no use to the tree.

Mowing

Mowing is now more widely used in groves where cultivation is not recommended due to shallow root systems of trees on bedded flatwoods soils. It is appropriate where a cover crop is desired in bedded groves or on sloping terrain to prevent soil erosion. Mowing is easy to perform and presents a pleasing grove appearance, but has a high energy demand. Weeds can also be spread by seed and vegetatively during mowing operations.

While weed control by mowing is useful against tall-growing weed species, low-growing prostrate species are given an overwhelmingly competitive advantage. Mowed groves in many areas rapidly develop a solid stand of perennial grasses which becomes the stable vegetation, and the grove is thus converted to a sod culture. Even frequent mowing, however, will not sufficiently lessen water consumption by perennial grass, especially under drought conditions. Yield and growth of trees are reduced by sod culture in comparison with clean cultivation and chemical weed control. Mowing is practiced between the tree rows and away from the trees in combination with herbicide applications in the tree row over the root zone of trees.

Chemical Mowing

With the frequency of mechanical mowing required to maintain row middles under Florida conditions and its increasing cost, chemical mowing and wiping with low rates of glyphosate in low volume applications has become increasingly popular. Middles management, as the program is called, utilizes fewer mechanical mowings at a reduced cost and eventually results in the elimination of tall growing species and establishment of a more manageable sod of bermuda or bahia grasses. Advantages of established integrated mechanical/chemical middles management programs include lower costs, reduced weed competition with trees where root systems extend into row middles and good seedhead suppression leading to reduced weed proliferation through seed dissemination.

Chemical Weed Control

Chemical weed control is now widely accepted and used in the Florida citrus industry. The success of such a program is far more likely to be assured if particular attention is paid by the user to:

- the label information on the herbicide, regarding its properties, advantages, limitations, and precautions
- choosing the appropriate herbicides for the particular weed problem
- selecting the lowest rate of application within label recommendations that will be effective against the species on the soil type in question
- calibration of the equipment for the application rate required
- selection of a nozzle arrangement on the boom and boom height for uniform coverage of the surface to be sprayed
- the choice of application timing and frequency to ensure maximum effectiveness against target species.

It is important to understand the directions on the product label so that the chances of poor weed control results, tree damage, illegal residues in fruit, and soil accumulation will be minimized.

Herbicides may be classified as foliar- or soil-applied and may have systemic or contact activity. Systemic herbicides are those that are absorbed by either roots or above-ground plant parts and are translocated throughout the plant. Contact herbicides kill all plant parts actually sprayed with little if any translocation. For the control of well established perennial weeds, a postemergence herbicide with systemic activity may be used with a preemergence material. For herbicide recommendations refer to the current *Florida Citrus Pest Management Guide*: Weeds.

Herbicides and Rates of Application

The choice of herbicides and rates depends on:

- Label directions
- Scion variety
- Tree age
- Weed species
- Stage of weed growth
- Soil type (organic matter content) and the recognized potential for leaching.

Timing of Applications

Timing of applications is very important as soil-active herbicides are most active against germinating weed seedlings. As weeds become more mature and weed cover more dense, higher rates in combination with contact or systemic herbicides are required to achieve satisfactory control. Although some soil-active herbicides have postemergence contact activity also, it should be recognized that their preemergence residual activity is their greatest asset.

If a particular weed species such as balsamapple vine is the major problem, for example, an application should be timed to coincide with peak emergence of the vine seedlings. If applied too early, the herbicide concentration in the soil may have decreased below an effective level in the germination zone due to breakdown and/or leaching. Later applications when vines are already in tree canopies are also unsatisfactory. Lantana offers a second example of a species which proliferates due to poor application timing. In its early seedling stages, lantana is susceptible to some of the commonly used soil residual herbicides, however, larger seedlings are resistant. Milkweedvine offers another example, in that as the vines become established they become more tolerant to recommended rates of preemergence herbicides. Repeated applications must be used to eventually eliminate established plants.

Glyphosate is actually more effective when applied to perennial grasses at seedhead stage due to better translocation. Similarly, fall applications are more effective on woody perennial species vine and shrub, species such as Virginia Creeper and Lantana. However, as such weed species mature, dense growth and height make good spray coverage difficult to achieve.

Frequency of Application

Under Florida conditions, even two applications a year may not be enough for satisfactory weed control. This is particularly true in the southern locations where year-round growing conditions are more likely. Two applications or more a year are required, particularly at the onset of a chemical weed control program when difficult-to-control species including vines, shrubs, and perennial grasses are well established. As a satisfactory degree of weed control is established with time, residual herbicide rates may be reduced, particularly if two or more applications a year are made.

Where a continual tree-resetting program is in effect, as is currently the case in most Florida groves, it would be prudent to lower the rates and increase the frequency. More frequent, lower rates of application are less likely to injure the newly planted trees, particularly those on poorer soils. Although increased application frequencies result in greater equipment operation costs, this may be minimized by including split rates of herbicide in fluid and liquid fertilizer band applications. With the current emphasis on groundwater contamination, the trend toward more frequent application of lower rates of soil residual herbicides is appropriate.

Biological Control

Such control occurs to a limited extent naturally in Florida citrus groves. Keen observers in groves can frequently observe weeds under stress, perhaps showing foliar discoloration or distortion symptoms caused by one or more of these agents. The most commonly known biological control agent now is the fungal pathogen, *Phytophthora palmivora*, which was developed into the mycoherbicide, DeVine. This endogenous pathogen was originally found attacking the milkweed or strangler vine in groves.

The larvae of Noctuids including armyworms, cutworms, loopers, and others have been observed to effectively decimate stands of various grass species in groves. A number of leaf-mining beetles (Chrysomelidae) have been used successfully in Australia and Hawaii in controlling lantana, *Lantana camara*, and could be introduced into Florida. However, such introductions are frequently delayed or denied by various federal or state committees which must evaluate the risk-benefit picture. There has been some opposition to the introduction of biological control agents due to the fear that the introduced insects or pathogens will attack other plants once their primary food source has been consumed. Also, a weed of economic importance to one may be a desirable plant of value to others. In resolving such conflicts, the economic impact of the weed in croplands must be compared with the negative aspects indicated by those who oppose its control by such introductions.

Allelopathy in Citrus Weed Management

One area of innovative research is allelopathy and its application in agriculture. Allelopathy, the regulation of growth of one plant species by chemicals released by another, occurs widely in plant communities and is believed to regulate species density and distribution. Isolation and identification of natural compounds implicated in allelopathy have received considerable attention as it is possible that related compounds may be synthesized that can produce similar effects as pesticides. Several plant products have proven useful in control of insects, and the potential exists for the development of many other natural insecticides, herbicides and growth regulators.

Lantana, a rapidly growing perennial woody shrub, is an economic weed pest in Florida citrus groves. Its proliferation and spread are attributed to several factors including natural propagation, reduced use of manual weeding, tolerance to many currently used herbicides and little competition from other weed species. The interference with growth of plants growing in the vicinity of lantana (*Lantana camara* L.) has been attributed, at least in part, to the allelopathic effects of the weed. The absence of milkweedvine (*Morrenia odorata* Lindl.) infestations near lantana plants was observed.

Allelopathic effects of lantana residues (root, shoot), foliar leachates, and the soil (where lantana was grown) on milkweedvine seed germination and growth over a 30-day period were examined. Foliar leachates or the soil collected from the field where lantana had been growing had no effect on the final germination percentage or the seedling growth of milkweedvine. Incorporation of dried lantana shoot or root material into soil had no effect on the final percentage germination but caused significant reductions in milkweedvine growth over a 30 day test period. Roots were more inhibitory than shoots. Fifty percent of milkweedvine seedlings died within 15 days after germination at 1% (w/w) dried lantana root incorporation into the soil, and higher concentrations increased seedling death. Lantana roots incorporated into the soil produced foliar symptoms such as wilting and desiccation, whereas lantana shoots incorporated into the soil produced yellowing of the foliage of milkweedvine. Allelopathic activity of lantana residues was still strong even after decomposition of lantana residues for 4 weeks prior to the planting of milkweedvine seeds.

WEED CONTROL PROGRAMS

Weed control programs vary with location in the state depending on soil type, planting system and rooting depth. Programs for ridge growing conditions with deep, well drained sandy soil include herbicide applications in tree rows and mechanically cultivated or mowed row middles. Some chemical mowing is now practiced. Programs for flatwoods growing conditions involving shallow, inherently poorly drained soils which are disturbed in the process of bedding and ditching, also include herbicides in tree rows and mechanically or chemically mowed middles. No cultivation is used because of possible damage to shallow root systems. In both growing areas and planting systems supplemental weed control applications include herbicide injection through low volume irrigation systems and localized spot treatments for weeds escaping the standard strip applications.

THE INFLUENCE OF WEED CONTROL METHODS ON THE ENVIRONMENT

Weed control influences and is influenced by other grove practices. As the industry has converted from high volume overhead sprinkler irrigation to low volume systems, less of the grove floor surface is wetted thereby reducing weed growth in row middles and areas outside the emitter zones. In fact, during extended dry weather it now becomes difficult to establish cover crops in newly developed groves which in turn can affect wind erosion. The intensive usage of low volume irrigation has led to the more rapid leaching of herbicides in the emitter zones, resulting in earlier resumption of weed growth. Fertilizer applied through these systems also contributes to greater weed growth. To control such return growth more effectively and minimize leaching, lower rates of herbicides are being applied more frequently along with herbicide applications through irrigation systems and spot treatments with postemergence herbicides.

As planting densities increase, particularly in rows, the grove floor surface becomes shaded more rapidly by tree canopies thereby suppressing weed growth. Conversely, the high incidence of tree loss due to citrus blight, citrus tristeza virus, soil insects and nematodes and freezes, results in the reestablishment of weed growth as the grove floor surface becomes reexposed to sunlight.

ENVIRONMENTAL CONSIDERATIONS

Misapplication of herbicides can damage or kill desirable vegetation and citrus trees, ultimately causing undesirable environmental effects and possibly result in legal proceedings. To reduce the impact of herbicides on the environment outside the immediate target area efforts should be directed towards:

- minimizing application rates within recommended ranges for weed control
- avoiding the use of herbicides with high leaching potentials in areas with a history of groundwater contamination problems
- avoiding application close to desirable plants and trees susceptible to the particular herbicide(s)
- minimizing drift by not applying herbicides under windy conditions and by using low pressures and, if necessary, drift control additives
- better irrigation management to reduce leaching
- monitoring drainage outflows to determine levels of herbicides in water
- better erosion control to avoid movement of excessive amounts of surface-applied chemicals into ponds, lakes, and waterways
- better mixing and loading procedures and thorough on-site cleanup to avoid tree damage and contamination of adjacent water sources
- maintaining crop residue levels within the approved ranges by keeping application rates within recommended ranges and avoiding excessive herbicide spray contact with trees.

PROCEDURES FOR REDUCING HERBICIDE MOVEMENT IN SOIL

Ideally a herbicide, when applied to the soil, should reach its target in the plant root zone in sufficient concentration to control target weeds for a desired period of time, and then dissipate relatively rapidly with minimal negative environmental impact. Conventionally, many herbicides were applied at rates higher than those actually required for weed control under ideal conditions to offset losses that occur from their site of action in the plant root zone.

Alternatives available for reducing herbicide movement through the soil profile include the selection of less mobile herbicides with high adsorption capacity, low water solubility and a short persistence in the soil. More soluble products should be applied at lower rates at more frequent intervals along with good irrigation management. Newly developed herbicides are most likely to be effective at much lower rates and be relatively insoluble.

Adjuvants have been used extensively to modify the activity of herbicides on plant surfaces, however little information is available concerning their effects on the behavior of pesticides in soils. A recent approach by which certain adjuvants bind the herbicide molecules and then release them slowly over time holds considerable promise for minimizing herbicide losses through the soil profile. The release in a controlled manner not only may reduce groundwater contamination but may also enhance the efficacy of herbicides by retaining them in the weed germination zone.

Adjuvants can either be formulated with the herbicides or added to spray solutions just before application. A herbicide can either be chemically attracted to, or physically entrapped within another substance such as a polymer. The resulting complex contains the herbicide in a manner capable of being released upon hydration, hydrolysis, erosion, biodegradation, diffusion, osmosis, mechanical rupture or other means.

The effect of the polymer STAY-TEC on the efficacy of four herbicides (bromacil, diuron, norflurazon, simazine) was evaluated in greenhouse and field experiments. STAY-TEC, when added to herbicide solutions, increased the efficacy of bromacil, norflurazon, and simazine, which provided longer lasting weed control in the field than the herbicide applied without STAY-TEC. In greenhouse experiments, simazine applied with STAY-TEC provided less control of weeds than the herbicide applied alone in the first 6 weeks after application. Herbicidal activity was higher, however, in trays treated with simazine applied in combination with STAY-TEC than in trays treated with simazine alone 12 weeks after treatment. In laboratory experiments, STAY-TEC increased the adsorption and decreased the mobility of simazine, but it did not affect the adsorption or leaching of bromacil, norflurazon, or diuron in soil.

As seen from the greenhouse experiment, one problem with controlled-release formulations is that the amount of herbicide released from the herbicide-polymer complex initially is not sufficient to provide effective weed control. Therefore, the rates of the herbicides should be adjusted to provide concentrations high enough for weed control, but well below the tolerance level of the associated crop. Successful release of the herbicide from the herbicide-polymer complex in desired concentrations will depend upon several factors, such as rainfall, pH, soil type, etc. The polymers used as controlled-release agents should be biodegradable and should not alter the soil physical characteristics permanently.