PI-171

UF UNIVERSITY of FLORIDA
IFAS Extension

Florida Crop/Pest Profile: Sugarcane[1]

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Sugarcane Production Facts

- In 2006, Florida ranked first nationally in value of sugar produced from sugarcane -- approximately $425 million. That amount was half of the total U.S. value of sugar from sugarcane that year. In general, the total amount of sugar produced from sugarcane in Florida is more than 20 percent of total sugar (from sugar beet and sugarcane) produced in the United States annually (1,2).
- The Southeast and Hawaii are the only areas in the United States where sugarcane is grown commercially. Approximately 400,000 acres of sugarcane are harvested annually in Florida, producing approximately 1.5 million tons of sugar annually (1,2). However, Florida's status as a sugarcane producer will likely change in coming years due to an agreement signed in June 2008, in which U.S. Sugar, the largest sugar producer in the United States and based in Clewiston, FL, will sell to the State of Florida, for the purpose of environmental remediation in the Everglades, 187,000 acres that has for decades been dedicated to sugarcane production.

Figure 1. A stand of sugarcane in Immokalee, FL, 2006. Credits: Josh Wickham, UF/IFAS

1. This document is PI-171, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date, October 2008. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
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- Meanwhile, sugarcane remains Florida's most valuable field crop, worth more economically than the combined value of all other field crops grown in Florida, including corn, soybean, tobacco, and peanuts. In terms of Floridas overall agricultural economy, sugarcane ranks third, behind the greenhouse/nursery industry, which is first in Florida, and the citrus industry, which is second in Florida.
- All Florida sugarcane is crushed at one of five mills in South Florida. Corporate growers comprise about two-thirds of the cane; the remainder are cooperative mills. The raw sugar travels by road, rail, or ship to refineries, or it is marketed in its raw state (2).

Regions of Sugarcane Production in Florida

Sugarcane, a tropical grass, is adapted to all portions of Florida. However, the commercial sugarcane industry is located in South Florida around the southern tip of Lake Okeechobee, especially in the Everglades Agricultural Area. The vast majority of sugarcane production in Florida (70 percent of the acreage and 75 percent of the tonnage) is produced in Palm Beach County. The remainder of commercial sugarcane production in Florida is in the adjacent counties of Hendry, Glades, and Martin (2). While most sugarcane is grown on muck soils -- which predominate near Lake Okeechobee -- approximately 20 percent of Florida's commercial sugarcane production is on sandy mineral soils (3).

Sugarcane Production Practices

Sugarcane is a multi-year crop and can be grown perennially in Florida. Sugarcane propagates vegetatively. Following harvest of the first crop -- the “plant cane,” the regrowth (“ratoon cane”) is harvested about once each year until plant condition deteriorates. Typically, an average of three annual crops will be harvested from a sugarcane field before the field is again replanted in seed cane, possibly following a fallow period.

When replanting takes place, generally from late August through January, portions of a mature sugarcane field are reserved to grow “seed cane.” This material, when harvested, is cut by laborers using a machete into stalk pieces approximately 1 foot in length. These pieces are planted every 2 - 4 years as dictated by plant condition.

The pieces of sugarcane are laid horizontally in the field in twin rows and covered with soil 3 - 8 inches deep**.** If harvest season is early enough in the year (before January), the field will likely be replanted to sugarcane (termed successive planting). If harvest is later, replanting may be delayed until the following season and the field may, in the interim, be planted in another crop, such as rice or sweet corn (termed regular or fallow planting). In 2005-06, 30 percent of the sugarcane crop in Florida was plant cane, and 70 percent was ratoon cane (2,4). During that same period, approximately one-third of the sugarcane was planted successively while the remainder was planted in the regular manner (2,4).

Sugarcane is harvested from late October through mid-April, and sugar yields are typically higher as the weather turns cooler. In order to complete the entire South Florida sugarcane harvest within the optimal time frame, some fields must be harvested before sugarcane plants have reached maximum yield potential. Consequently, considerable research has examined which cultivars should be harvested in early-, mid- or late-season.

The fields are burned to remove field trash, and then mechanically harvested cane is loaded onto trucks or rail cars to be transported to the mill.

Worker activities. The only part of sugarcane cultivation that requires field workers is planting, which is 95 percent conducted manually. Approximately 120,000 acres are typically planted a year, and a single worker may plant up to five acres of seed cane per day (4).

Insect/Mite Management in Florida Sugarcane Crops

As a tropical grass, sugarcane has evolved to resist many pests that are common in semi-tropical environments, but some pests still infest sugarcane. These pests include the following: sugarcane borer, white grubs, wireworms, yellow sugarcane aphid, and lesser cornstalk borer. (The lesser cornstalk borer is

more likely to infest sugarcane grown on sand.) Factors such as weather and cultural practices mean insect problems vary during the growing season and from one season to the next (5).

Types of Insects and Mites in Florida Sugarcane Crops

Sugarcane borer

The sugarcane borer, *Diatraea saccharalis*, is one of the most important above-ground pests of sugarcane in Florida. All varieties of sugarcane currently grown in Florida are susceptible to sugarcane-borer infestation, but different sugarcane varieties exhibit significant variation in damage and yield losses. Although this moth's principal host is sugarcane, many other grasses have been reported as alternative hosts. Significant damage results from the sugarcane borer larvae tunneling within the stalk; this damage includes loss of stalk weight (tonnage/acre) and sucrose yield. The borer's tunneling into the stalk also allows points of entry for secondary invaders. And if the tunneling is extensive, a condition called “dead heart” may occur, in which the terminal growing point of the plant dies. Weakened stalks are also more subject to breaking and lodging (5).

Regular scouting is the foundation of an Integrated Pest Management Program (IPM) for sugarcane-borer control. Scouting is necessary to estimate the pest-infestation level, as well as the naturally occurring beneficial borer parasites. A regular scouting program will also increase the chances of detecting other pests that may be damaging the crop (5). From March through November, sugarcane fields should be scouted every 2 or 3 weeks. One Florida sugarcane company scouts each 40-acre field in at least four locations. At each location, 5 stalks are randomly sampled from each of 5 stools spaced 10 feet apart (5 stalks/5 stools/location). It is best to detect borers before they tunnel into stalks so that, if necessary, control measures can be applied before any damage to stalks occurs. Characteristic signs that plants are infested are pinholes in leaves, tiny holes into midribs, holes into stalks, and frass (light-brown, fibrous waste material) at these holes. An infestation of borers cannot be positively identified until the sugarcane borers are actually observed. Scouts should examine leaves, the whorl, and behind leaf-sheaths, as well as splitting open stalks to detect borers tunneling inside stalks. Detecting two to three live larvae per 100 sampled stalks is generally thought to be enough to cause concern about economic damage (5).

One study of five commercial varieties showed that an average of one bored internode per stalk reduced sugar yield by an average of 5.6 pounds per ton of sugarcane. The range of loss was from 2.3 pounds per ton of sugarcane to 6.7 pounds per ton of sugarcane for the different varieties examined. Another investigation showed bored internodes produce 45 percent less sugar than undamaged internodes. Interestingly, certain regions of the Everglades Agricultural Area, where most of Florida's sugarcane is grown, seem to be considerably less prone to borer infestations. Environmental explanations are presumed, but definite reasons are not clear (6).

White grubs

White grubs found in Florida sugarcane fields are of the genera *Ligyrus*, *Cyclocephala*, *Phyllophaga*, and *Anomala*. Of these grub pests, the species *Ligyrus subtropicus* is the most abundant, causes by far the most damage to sugarcane, and, as a result, imposes the greatest economic loss for sugarcane growers. These pests tend to infest sugarcane in muck soils, damaging sugarcane by feeding on roots and underground stems. The first symptom of infestation is a yellowing (chlorosis) of the leaves, a condition usually followed by stunted growth, dense browning, lodging, plant uprooting, and, in heavily infested areas, death of the plant. Symptoms may appear as early as September.

Fields of plant cane usually have little or no grub infestation (5,7). Instead, damage from an *L. subtropicus* infestation is usually more severe in ratoon crops and most evident around the edges of a field, the area where the infestation usually begins. From there, the infestation slowly spreads in an irregular pattern throughout the field. Sugarcane fields infested with *L. subtropicus* may need to be replanted because ratoon regrowth and productivity can be severely reduced by this pest. Heavily infested areas may not be worth harvesting.

Growers use cultural control practices for sugarcane grubs. Discing infested fields, reducing the number of ratoon crops, and flooding are the most common methods of grub control in Florida. Discing kills many grubs and allows birds to kill many more.

Wireworms

Wireworms, the larval stage of click beetles, may cause severe damage to numerous crops in Florida, including sugarcane. At least 12 species of wireworms have been found in South Florida, but only the corn wireworm, *Melanotus communis*, is considered to cause significant economic damage to sugarcane. Traditionally, *M. communis* has been a more important pest of sugarcane grown on muck soil than sugarcane grown on sandy soil (5,8).

Generally, wireworms are a pest of newly planted sugarcane and only rarely a pest in ratoon sugarcane. During germination of sugarcane seed pieces, wireworms feed on the buds and root primordial. After germination, wireworms feed on shoots and roots. Most of the injury to young shoots is near the point where the shoots join the seed piece or stubble.

Wireworm injury can generally be identified as relatively large, ragged holes cut into seed pieces and buds or into young shoots. The death of buds or young shoots leads to stand reductions. Wireworm injury to sugarcane also facilitates the entrance of the fungus that causes sugarcane red rot disease (5,8).

Yellow sugarcane aphid

Yellow sugarcane aphid (YSA), *Sipha flava*, is a small, yellow aphid with short legs, antennae and mouth parts. This aphid's body is covered in short, stiff hairs. The pair of tubes (cornicles) that protrude from the top and end of the abdomen of most aphids are only slightly more than pore-like openings on YSA. This aphid takes 2 - 3 weeks to develop to the adult stage, at which point it can produce 3 - 5 nymphs per day for another 2 - 3 weeks. Winged forms of the aphid are produced under crowded conditions when plant quality is beginning to be significantly affected.

Natural enemies of YSA -- including rain, 10 species of ladybird beetles and several species of flower flies -- can greatly reduce YSA populations. However, reduction in the size of a YSA infestation by such means may not occur before the aphids have caused plant damage (5).

Yellow sugarcane aphids cause premature yellowing and death of sugarcane leaves. And when these aphids feed on very young plants, reduced growth and reduced tillering result. Longer, faster-growing leaves and internodes are some of the results of YSA feeding, but also thinner, lighter stalks with shorter node lengths and widths. Prolonged feeding by large populations of YSA can cause plant death.

When YSAs are removed, sugarcane leaf and node lengths approach sizes of uninfested plants, but node diameter remains lower on previously infested stalks. Sugarcane plants do not compensate for early-season YSA damage. As a result, such damage ultimately results in lighter stalks that contain less sugar (5).

Aphid numbers quickly build to numbers too numerous to count for sampling purposes. Leaf damage, however, is a good indicator of season-long effects on growth and yield. Leaves with <50% green tissue can be quickly counted and averaged over an area to compare long-term effects of YSA feeding with the relative size of the infestation. Resistance appears to be a viable control strategy since YSA shows a preference for certain cultivars (5).

Lesser cornstalk borer

The larva of the lesser cornstalk borer moth, *Elasmopalpus lignosellus*, is a slender, brown worm with creamy-white to bluish-green bands, 3/4” - 1" long when full grown. The lesser cornstalk borer larvae bore into young plants at or below the soil surface and usually cause a "dead-heart" similar to damage caused to sugarcane by the sugarcane borer or wireworms. When lesser cornstalk borers feed at or below the growing point, damage above the growing point appears as rows of holes in emerging leaves.

Larvae of the lesser cornstalk borer construct a tubular burrow in the soil, extending outward from

the cane plant. The burrow consists of soil particles, which the borer webs together with silk. The larva pupates in this burrow and transforms into a small moth. The presence of these silk tubes and/or a small, circular entrance hole distinguishes dead-hearts caused by lesser cornstalk borers from those caused by wireworms.

The life cycle of the lesser cornstalk borer ranges from 38 to 65 days. Generations overlap considerably with no sharp seasonal breaks in populations. However, infestations during late summer are uncommon. Most damage resulting from this pest occurs to young sugarcane plants during warm, dry periods. Ratoon cane usually recovers better from lesser cornstalk borer attack than does young plant cane. Although there are parasites of the lesser cornstalk borer, the protection this pest has from its silk tube may make parasites of the lesser cornstalk borer inefficient as biological control agents (9).

Cultural Management of Insects and Mites in Florida Sugarcane Crops

To manage sugarcane borer economically, use sugarcane varieties that exhibit resistance to infestation and damage. Varieties highly susceptible to the sugarcane borer are eliminated during the process of developing new varieties for commercial release. In addition to growing varieties that show at least moderate resistance to these pests, important cultural-control tactics also include destroying cane trash and stubble in infested fields and using seed pieces free of borer damage (6).

For white grubs, discing infested fields, reducing the number of ratoon crops, and flooding are effective methods of control. The best time to kill grubs by flooding is in August. At this time, water temperatures are warm, rainfall abundant, and feeding damage by the grubs is just starting (7).

For wireworms, flooding can be effective, but this method requires a minimum of six weeks of continuous flooding during the summer. Even longer flooding durations are needed during colder months. Flooding during late spring and summer will kill the wireworms and will also prevent egg-laying by the adult click beetles. Flooding fallow fields or growing rice as a rotation crop may eliminate the need to use a soil insecticide at sugarcane planting the following fall (8,10).

For yellow sugarcane aphids, several methods can assist sugarcane resistance to damage. These methods are variety-dependent and include tolerance and antibiotic effects on aphid development. Winged YSAs usually restrict their primary colonization to susceptible cultivars, including the following: 'CP 61-620', 'CP 72-1210', 'CP 72-2086', 'CP 80-1827' and 'CP 89-2143'.

Additionally, red imported fire ants, predatory earwigs and many species of ladybird beetles exert some control over these aphids. Heavy rains are also helpful in terms of dislodging aphids and washing these pests from the sugarcane plants (9).

Biological Management of Insects and Mites in Florida Sugarcane Crops

Alabagrus stigmatera and *Cotesia flavipes* are important wasp parasitoids of the sugarcane borer larvae in Florida. *A. stigmatera* is a large, solitary (one-per-host) parasite and active all year. *C. flavipes* is a small, gregarious (many-per-host) parasite and usually most active after July. *C. flavipes* is the most important parasitoid. *C. flavipes*, an endoparasite (parasite that grows within the host), injects eggs directly into the borer larvae.

Whenever sugarcane borer infestation approaches the economic-injury threshold, sugarcane borer larvae from the infested field should be dissected to determine the level of parasitism. If 50 percent or more of the sugarcane borer's larvae are parasitized, insecticides are not recommended. Insecticide applications may harm the parasite population without gaining additional control of the sugarcane borer.

Augmentative releases of *Cotesia* parasitoids have been highly effective for managing the sugarcane borer in sugarcane within Florida, Brazil and Costa Rica (6).

Chemical Management of Insects and Mites in Florida Sugarcane Crops

Soil insecticides are commonly used on half of the sugarcane acreage in Florida in any given year. Ethoprop and phorate are evenly used at about 1 lb ai/A to control wireworms when infestation levels are high. Approximately 2,000 acres of sugarcane in Florida are treated yearly with carbofuran at 0.5 lb ai/A to control lesser cornstalk borer when replanting in areas that harbor it. However, in 2008 the U.S. Environmental Protection Agency (EPA) announced plans to cancel registration for cabofuran. Other insecticides registered for sugarcane in 2008 in Florida were azadirachtin, B.t., carbaryl, cyfluthrin, cyhalothrin, esfenvalerate, and pyrethrins +/- rotenone, spinosad, and tebufenozide. Methoprene is available for control of fire ants.

Disease Management in Florida Sugarcane Crops

Among the many sugarcane diseases throughout the world, very few have affected Florida sugarcane historically. For example, until 2008, no fungicides were used on sugarcane in Florida, and varietal resistance to brown rust kept this disease under economic thresholds. However, orange rust was found in Florida in 2007. This disease will require growers of several cultivars, such as 'CP 880-1743' and 'CP 72-2086', to use fungicides to maintain economically acceptable yields.

Disease Pests in Florida Sugarcane Crops

Brown Rust

Since 1978, sugarcane production in Florida has been affected by brown rust (*Puccinia melanocephela*). This fungal pathogen is now found almost everywhere sugarcane is grown throughout the world. The spread of brown rust has had considerable economic impact. As a result, the practice of screening new cultivars for resistance has become an integral part of Florida sugarcane breeding programs. However, due to genetic variability within the pathogen population, resistance to brown rust has not been stable. For example, 'CP70-1133', an important variety grown for years without any sporulating pustules developing on it, would now be classified by plant pathologists as moderately susceptible. Other important commercial clones have also demonstrated increasing susceptibility to sugarcane rust over time (11).

Assessment of yield loss due to brown rust is difficult, but realistic estimates have been obtained. During 1988, rust was particularly severe on 'CP 78-1247' in Florida. A comparison of yields from 'CP 78-1247' that year with a variety of equal yield potential revealed yield losses due to brown rust were nearly 40 percent (averaged over 13 different locations in Florida where the varieties were grown side-by-side).

Another study of sugarcane-yield loss -- conducted by establishing a nearly disease-free check using a fungicide as a means for comparison -- demonstrated yield losses of 20-25 percent on a moderately susceptible sugarcane variety, 'CP 72-1210'. This variety dominated the Florida sugarcane industry during the late 1980s, occupying as much as 60 percent of Florida's sugarcane acreage. Based upon the acreage of 'CP 72-1210' during the 1987 rust epidemic, and using a conservative estimate of 20 percent yield loss, economic losses on 'CP 72-1210' during that season were estimated as surpassing $40 million (11).

Brown rust is mainly a disease of the leaf. The earliest symptoms are small, elongated, yellowish spots, visible on both the top and bottom leaf surfaces. The spots increase in length, turn brown to orange-brown or red-brown in color, and develop a slight, but definite chlorotic halo.

Lesions resulting from brown rust are seldom more than 1-3 mm in width. The lesions typically range from 2-10 mm in length, but occasionally reach 30 mm in length. The symptoms of brown-rust infection are usually most numerous toward the leaf tip, becoming less numerous toward the base. Pustules, which produce spores, usually develop on the lower leaf surface although certain sugarcane cultivars may develop pustules on the upper leaf surface when infected. Pustules may remain active over a considerable period of time, but spore production depends heavily upon climatic conditions.

Environmental factors most influential for rust development are leaf wetness and cool to moderate atmospheric temperatures. Several hours of free moisture on the leaf surface at a favorable temperature is necessary for successful spore germination, infection, and spread of the disease. While long dew periods and rainfall events both contribute to leaf wetness, rainfall events may not be as favorable for rust development. Heavy rains tend to remove spores from the atmosphere, and the spores are infective if they land on the soil, rather than on leaves. Increased soil moisture also favors rust infection by increasing humidity within the canopy and, thereby, lengthening the duration of leaf wetness.

In Florida, rust is most severe from February to May, when atmospheric temperatures are cool to moderate. Sugarcane plants are also most likely to range from 3 - 6 months in age during this season, and these plants are most susceptible to rust at that growth stage(11).

Eventually lesions on sugarcane leaves affected with brown rust will darken, and the surrounding leaf tissues will become necrotic. On a highly susceptible variety, considerable numbers of pustules may occur on a leaf, coalescing to form large, irregular necrotic areas. High rust severities may result in premature death of even young leaves. Severe rust infections can cause reductions in both stalk mass and stalk numbers, thereby reducing cane tonnage (11).

Orange Rust

Previously, orange rust was known as a minor disease of sugarcane in Asia and Australia. In 2007, however, the causal organism of orange rust (*Puccinia kuehnii*) was found in Florida sugarcane and also detected in sugarcane fields in Costa Rica, Guatemala and Nicaragua (12).

In the late summer of 2007, orange rust caused an estimated 10 percent loss on susceptible sugarcane varieties in Florida. In the late spring of 2008, more orange rust was observed on susceptible varieties of sugarcane in Florida, and the disease presented earlier in the season that year due to cool and dry weather conditions, ideal for early establishment (13).

It appears that plant cane is more susceptible to orange rust than is ratoon cane. Additionally, the biology of orange rust is similar to that of brown rust. However, varietal resistance to brown rust does not simultaneously confer resistance to orange rust. For example, the variety CP80-1743 has fairly high resistance to brown rust, but not to orange rust.

Sugarcane varieties most susceptible to orange rust ('CP80-1743' and 'CP72-2086') are planted widely in Florida. As much as a third of the overall acreage planted in sugarcane in Florida is planted with varieties that are susceptible to orange rust, including 'CP80-1743' and 'CP72-2086' (13). Researchers are currently determining whether orange rust is affecting 'CP89-2143' in two locations in Florida. This variety comprises about 20 percent of the acreage planted in sugarcane in Florida (13).

The designation, CP, in the cultivar name indicates a variety produced by the USDA's Canal Point breeding program in Palm Beach County, FL. The CP designation is followed in the cultivar name with the year the cultivar was named, typically 7 - 10 years prior to commercial release (14).

Non-Chemical Management of Disease Pests in Florida Sugarcane Crops

Planting resistant varieties of sugarcane is the best means of controlling orange rust. However, resistance has not been stable or durable on certain varieties, presumably because of rust variants. For this reason, it is highly recommended that growers diversify their varietal holdings. In this way, if a rust variant develops that is capable of infecting a particular variety, growers will not have a predominance of that variety.

Varietal diversification may also play an important role in holding down overall area-wide disease pressure, thereby reducing the natural-selection pressure for one particular rust variant. A general rule of plant propagation suggests that varietal diversification may assist in preserving the durability of host-plant resistance in currently resistant varieties (11).

Soil factors identified with high levels of rust infection on sugarcane include low soil pH and/or

high levels of P and K nutrients, so avoid growing susceptible varieties in areas with these soil conditions. Sugarcane grown in fields that have received recent applications of nutrient amendments is typically prone to rust. If possible, plant such fields with varieties that have durable rust resistance (11).

Chemical Management of Disease Pests in Florida Sugarcane Crops

Few effective disease-management tools are available for sugarcane. Propiconazole is available as a dip treatment for plant-cane pieces, and phosphorous-based fungicides are registered for foliar application. However, neither of these treatments is greatly effective for a leaf disease, such as rust, that attacks sugarcane 3 - 6 months after planting.

Because of the limited treatments available to control disease in sugarcane, the Florida Department of Agriculture and Consumer Services (FDACS) has declared a crisis exemption under Section 18 of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for the use of two fungicides (pyraclostrobin and metconazole). It is envisioned that the EPA will issue a 3-year quarantine exemption for this use (13).

As of mid-May 2008, approximately 10,000 acres of sugarcane in Florida had been sprayed with pyraclostrobin. The applications cost approximately $30/acre ($25/acre for the fungicide and $5/acre application cost independent of whether it is applied by ground or air).

Weed Management in Florida Sugarcane Fields

Weed control is most critical early in the season, prior to sugarcane-canopy closure over the row middles. Heavy weed infestations can add unnecessary expense to harvesting sugarcane. Additionally, a weed that is allowed to mature and produce seed will multiply weed-control problems for years to come. The most important weed pests in Florida sugarcane production are fall panicum, napiergrass, yellow and purple nutsedge, and pigweeds (15-17).

Weed Pests in Florida Sugarcane Fields

Nutsedge

Yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*C. rotundus*) are a constant pest of most crops in Florida. Both of these perennial sedges are found in disturbed habitats throughout Florida and the southeastern United States. Yellow nutsedge may produce some seed, but reproduces primarily by rhizomes and tubers. The first plant develops rhizomes, which end in tubers that produce new plants. Tuber production is favored by low nitrogen levels and high temperatures (80 - 91 F). Nutsedge is tolerant of high soil moisture, but is intolerant of shade.

Purple nutsedge is also able to reproduce from tubers when conditions are harsh, making this weed especially difficult to control. Unlike the rhizomes of yellow nutsedge, purple nutsedge rhizomes growing off the first plant produce new plants in a series (tuber-chains). To a limited degree purple nutsedge also reproduces by seed. Although purple nutsedge is intolerant of shade, it is able to survive a wide range of environmental conditions, growing well in nearly all soil types and over a range of soil moisture, soil pH, and elevation. Purple nutsedge is also able to survive extremely high temperatures (17).

Pigweed

Several species of pigweed are common weeds in Florida, including smooth pigweed (*Amaranthus hybridus*), spiny amaranth (*A. spinosus*) and livid amaranth (*A. lividus*). Pigweeds are summer annuals with taproots. These broadleaf plants reproduce by seed and can reach heights of 6 feet, creating a very competitive interaction with young sugarcane (17).

Fall panicum

Fall panicum (*Panicum dichotomiflorum*) is an annual that primarily emerges in spring and summer, but seed germination can occur almost year-round in Florida sugarcane fields. However, fall panicum tends to be sensitive to shading and is typically not found in sugarcane once canopy closure occurs. Fall panicum typically reaches a height of 1.5 - 4 feet, but has been reported to reach more than 6 feet in height. Growth

Figure 2. Sugarcane crops near Belle Glade, FL, being cleared of weeds, 2004. Credits: Thomas Wright, UF/IFAS

habit of this weed can range from erect to sprawling, and the plant can form large, loose tufts (15).

Napiergrass

Napiergrass (*Pennisetum purpureum*) is an enormous, weedy, cane-like grass commonly seen growing along canals and roadsides in the sugarcane-production areas of South Florida. Napiergrass, also known as elephantgrass, has been documented in almost 30 counties throughout Florida. Napiergrass is of African origin, but has been introduced to all tropical areas of the world because of its ability to quickly produce large amounts of biomass. Napiergrass is widely used as a forage crop in Central America, South America, and Africa. In the early twentieth century, napiergrass was introduced to South Florida and Texas as a forage crop, but napiergrass is no longer widely used for this purpose in Florida and has become a considerable weed problem.

Napiergrass is established throughout South Florida, especially along the banks of canals and ditches and in disturbed or cultivated areas. Napiergrass, which has no natural enemies in Florida, is considered to be one of the world's worst weeds. Napiergrass produces many small, viable seeds, which are easily dispersed. Napier grass also has a thick, aggressive rhizome structure. The Florida Exotic Pest Plant Council has identified napiergrass as an invasive species (16).

Non-chemical Management of Weed Pests in Florida Sugarcane Fields

Crop rotation

Crop-rotation patterns will affect weed management for a sugarcane crop. The need for weed management intensifies in successive planting operations due to cultivation, which contributes to germination of weed seeds. Traditionally, the fallow period between final ratoon harvest and planting of seed cane has effectively been used to manage

troublesome weed populations, primarily by mechanical cultivation. Flooding fallow fields also aids in weed control through the development of an anaerobic environment, in which weed-seed germination and seedling growth are impaired. In any given year in Florida, rice is grown as a rotational crop on approximately 10,000 acres that are otherwise planted in sugarcane. Additionally, herbicide treatment may be more effective after a flooded period (10,17).

Crop competition

Crop competition for sunlight is one of the most effective means of weed control. A good stand of sugarcane that emerges rapidly and uniformly and forms a complete canopy, shading the row middles early in the season, is effective in reducing weed competition. However, loss of sugarcane plants in ratoon crops due to rodent, insect, or harvest damage will create open spaces in the sugarcane canopy, under which weeds can proliferate. A concentrated effort to maintain maximum cane populations throughout all phases of production will benefit weed-control efforts (17).

Cultivation

Cultivation can be an economical means of suppressing weed growth. To assure that the sugarcane plants get the early advantage in the competition for sunlight, a height differential must be established between cane plants and weeds. Only when the cane plants are growing taller than competing weeds can mechanical cultivation be effective. However, cultivation when weeds are not present due to application of a herbicide or previous cultivation is not recommended. Cultivation when weeds are not present can encourage germination of additional weed seeds and remove the layer of herbicide present when soil-applied herbicides are used. In ratoon crops, mechanical cultivators must be able to cut through surface debris and thoroughly mix the soil (17).

Chemical Management of Weed Pests in Florida Sugarcane Fields

In Florida, as in commercial sugarcane production elsewhere in the world, herbicides are routinely used. The most commonly used materials include atrazine, 2,4-D, asulam, and ametryn. Herbicides used on less than 10 percent of the sugarcane acreage in Florida are metribuzin, halosulfuron, and pendimethalin (18,19). Other herbicides registered for use in Florida sugarcane as of 2008 are carfentrazone, dicamba, diuron +/- hexazinone, flumioxazin, glyphosate, paraquat, and trifloxysulfuron (17).

Atrazine

Atrazine is a restricted-use pesticide and the main herbicide used by sugarcane growers in Florida. Atrazine is applied to nearly all of the sugarcane grown in Florida as a preemergence treatment and sometimes as an early postemergent treatment. Atrazine controls most annual grass and broadleaf weeds. Atrazine is applied at a rate of 3 lb ai/A. The price of atrazine is approximately $3.50 per pound of active ingredient. The approximate cost of a maximum labeled application (4.0 lb ai/A) is $14 (20,21). A special local-needs registration allows up to 10 lb of ai/A per crop.

2,4-D

The herbicide 2,4-D is selective against broadleaf weeds when sprayed on the foliage and is routinely used for the management of spiny amaranth, ragweed, morning glory, and many other weeds. This herbicide is applied by ground or air to approximately three-quarters of Floridas sugarcane acreage at a rate of 1.9 lb ai/A (18,19). Higher rates of application are used for large or difficult-to-control weeds, such as alligatorweed. The price of 2,4-D is approximately $3 per pound of active ingredient, and the approximate cost of a maximum labeled application (2.0 lb ai/A) is $6 (17,20).

Ametryn

Ametryn is applied as a directional or semi-directional spray to annual grass and broadleaf-weed seedlings. Ametryn is especially

effective against alexandergrass and is applied to approximately 40 percent of Floridas sugarcane acreage. Ametryn is applied by ground or air at a rate of approximately 0.5 lb ai/A (19). The price of ametryn is approximately $7 per pound of active ingredient, and the approximate cost of a maximum labeled application (1.1 lb ai/A) is $8 (17,20).

Asulam

Asulam is a herbicide applied to foliage of immature seedling grasses. Application may be broadcast overall, directed, or semi-directed in sugarcane at least 14 inches tall. Asulam is applied only once per year. Asulam controls alexandergrass, broadleaf panicum, and other annual grasses, but response is slow. Asulam is applied by ground or air to approximately 20 percent of Floridas sugarcane acreage at a rate of approximately 1 lb ai/A (19). The price of asulam is approximately $12 per pound of active ingredient, and the approximate cost of a maximum labeled application (3.3 lb ai/A) is $40 (17,20).

Metribuzin

Metribuzin is applied by ground to a small number of sugarcane acres in Florida. Metribuzin controls most annual grass and broadleaf weeds, but is often mixed with atrazine or pendimethalin. Metribuzin is applied at the time of planting seed cane or ratooning (when the plant grows out of the stump), but prior to weed emergence. Metribuzin is applied at a rate of 0.8 lb ai/A (19). The price of metribuzin is approximately $23 per pound of active ingredient. The approximate cost of a maximum labeled application (1.9 lb ai/A) is $44 (17,20).

Pendimethalin

Pendimethalin is applied by ground or air to a small number of sugarcane acres in Florida. Pendimethalin controls most annual grass and some broadleaf weeds, but is often mixed with metribuzin. Pendimethalin is applied at the time of planting seed cane or ratooning, but prior to weed emergence. Pendimethalin can also be applied layby. Rainfall within seven days of application is needed to incorporate the herbicide into the soil, or effectiveness will be significantly decreased. Pendimethalin is applied at a rate of 3 lb ai/A (19). The price of pendimethalin is approximately $6 per pound of active ingredient. The approximate cost of a maximum labeled application (4 lb ai/A) is $24 (17,20).

Halosulfuron

Halosulfuron is applied by ground to a small number of sugarcane acres in Florida. Halosulfuron controls purple and yellow nutsedge, as well as some broadleaf weed species. Halosulfuron may be applied to any stage of sugarcane growth. Halosulfuron is applied at a rate of 0.05 lb ai/A (19). The price of halosulfuron is approximately $245 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.06 lb ai/A) is $15 (17,20).

Nematode Management in Florida Sugarcane Crops

Plant-parasitic nematodes are microscopic roundworms found in soil. Ectoparastic nematodes feed on sugarcane from the exterior of the root; endoparasitic nematodes enter the plant tissue to feed. General symptoms of nematode damage to sugarcane plants include stunting, premature wilting, leaf yellowing and related symptoms characteristic of nutrient deficiencies. Stunting and poor stand development tend to occur in patches throughout the field as a result of the irregular distribution of nematodes within the soil. Ratoon cane is generally most susceptible to damage from nematodes (22).

Most species of plant-parasitic nematodes favor sandy-soil conditions and are rarely a problem on muck soils. However, sugarcane grown in sandy areas has the potential for dramatic yield losses from nematodes (22).

Nematode Pests in Florida Sugarcane Crops

Sting nematode (*Belonolaimus longicaudatus*), an ectoparasite, is the most damaging nematode to sugarcane in Florida. Stubby-root (*Trichodorus* and *Paratrichodorus* spp.), ring (*Criconemoides* and related genera), and stunt (*Tylenchorhynchus* and *Quinisulcius*) nematodes are other ectoparasites that

may damage sugarcane and are common in Florida. Endoparasites that may damage sugarcane in Florida are lesion (*Pratylenchus zeae*), lance (*Hoplolaimus* spp.), and root-knot (*Meloidogyne* spp.) nematodes.

Non-chemical Management of Nematodes in Florida Sugarcane Crops

Crop rotation

Rotation with rice can reduce populations of plant-parasitic nematodes. Many of the nematodes that feed on sugarcane can also feed on rice under dry conditions. However, because rice is normally grown in standing water, most nematodes are killed by the flooded conditions (22).

Flooding

While flooding can be an effective nematode-management tactic for sugarcane, this practice is difficult on sandy soils, where nematodes are most prevalent. For best results, the area should be flooded for a 4-week period, then drained and left dry for 2 weeks, and then flooded again for 4 weeks (22).

Soil amendment

Filtercake or “mud” is the sediment left over following clarification of sugarcane juice. Filtercake amendment has been shown to reduce populations of plant-parasitic nematodes on sugarcane. Filtercake can be added as an amendment to sandy areas to reduce nematode damage.The addition of organic matter, including sugarcane filtercake, to sandy soil can also improve plant tolerance and make nematode damage less severe (22).

Chemical Management of Nematodes in Florida Sugarcane Crops

Even in sandy soils, where nematodes are most prevalent in sugarcane crops, nematicides are infrequently used. Ethoprop, in addition to managing wireworms, may provide nematicidal benefit when it is utilized. The fumigant 1,3-dichloropropene also provides temporary nematode abatement (22).

Vertebrate Management in Florida Sugarcane Fields

Several species of rat feed on sugarcane plants and can in some cases impose measurable economic loss. A special local-needs registration for the rodenticide diphacinone exists for sugarcane growers in Florida (21). The rodenticide, which in any year is used on less than one percent of the sugarcane acreage in Florida, is typically placed on ditch banks around seed cane (23).

Key Contact

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