CIR 1260

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Florida Crop/Pest Management Profiles: Peanuts[1]

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Production Facts

- In 2006, Florida ranked 4th nationally in peanut production with a crop value of approximately $52 million (1).
- The southeast is the largest peanut production region in the U.S., with Florida producing approximately 9 percent of the total national crop in 2006 (1).
- A total of 130,000 acres of peanut were planted during the 2006 production season in Florida. Of this acreage, approximately 120,000 acres were harvested, with an average yield of approximately 2,500 pounds per acre. The remaining 10,000 acres planted to peanuts were either harvested as green nuts, cut for hay, used as pasture, or abandoned. A total of 300 million pounds of peanuts were produced in 2006. Approximately 110,000 acres of peanut were planted in Florida in 2007 (1,2).
- Pest management makes up a large portion of the variable production costs for peanut. Estimated total crop production costs for 2006 were approximately $825 per acre, based on a 2,500 pound per acre yield in the southeastern United States, which equates to a unit cost of 33 cents per pound. About one-third of the total operating costs are invested in pesticides and spraying/scouting. This contrasts greatly with the 2006 price per unit which was a little over 17 cents a pound (1,3).

Production Regions

Peanut is adapted to all portions of Florida, except south Florida. The vast majority of peanuts are produced in the panhandle and north-central regions of the state. Jackson, Santa Rosa, Levy, Okaloosa, Marion, and Calhoun counties account for approximately two-thirds of the state's peanut production (4).

Production Practices

Peanut, also called goober, pindar, groundnut and earthnut, is a legume, a member of the pea family. It is a perennial herb, which is actually grown as an annual for production. Seeds are planted in the spring,

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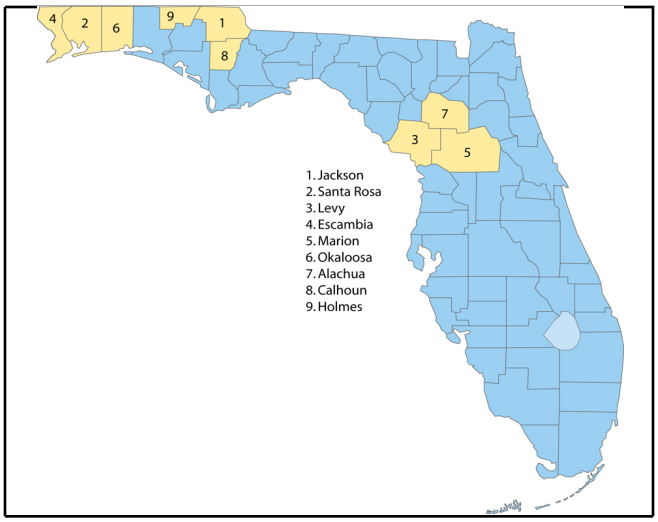

Major Peanut Production Regions in Florida.

beginning about mid-May. Seeds are planted 2-4 inches apart, 2-3 inches deep, in rows 24-36 inches apart, depending on the variety to be planted. Twin rows, where two rows about seven inches apart replace a single row, are widely used. The crop is seeded at rates from 100 to 120 pounds per acre. Approximately 10 days after planting, the crop emerges (cracking), the first flowers then appear 30-45 days after planting, with the first pegs starting to form and enter the soil a few days after bloom. Around 60-70 days after planting, the crop will reach full canopy closure. The plant continues to flower and peg depending on the environment and pod fill continues throughout the season. The maturing date varies depending on peanut type and cultivation but ranges between 120 to 170 days after planting. Commercial peanut harvest is done mechanically, with the harvest date determined by balancing weight gains and losses between mature and immature pods. Peanut is occasionally planted later in the planting-window season, because of the lack of rainfall during some spring seasons. Late planted peanut crops typically require more pesticides to generate typical yields (3,5).

In Florida, peanut production has changed dramatically in the last 5 to 10 years due to the disease tomato spotted wilt virus (TSWV). Many factors affect the severity of this disease, including: history and location, cultivar, planting date, plant population, insecticide use, row pattern, tillage, and herbicide use. Planting date and cultivar are generally the most important of these. Until the mid-90's Florunner was the most common registered cultivar used. However, with large losses to TSWV, many growers switched to the cultivar Georgia Green, which was resistant to the virus. The adoption of this cultivar has been wide over the past 10 years, with GA Green planted on 75 percent of the acres in 2005 and 58 percent of the acres in 2006. Some of the other varieties with TSWV resistance also have some white mold resistance and are therefore being adopted (3).

At harvest, producers dig the crop by inverting the plants vines on top of the soil, where it cures for about three days before combining. After combining the pod, they are dried mechanically before being inspected, graded, and sold. Because of its underground development, peanut production requires special harvesting equipment that is not used for any other crop. Average state yields generally fluctuate between 2,300-3,000 pounds per acre, with a potential harvest of up to 5,000 pounds per acre on selected fields (6).

Peanut is grown in soil that has a target pH of approximately 6.0. Nitrogen fertilizers are not necessary because the crop is a legume and therefore capable of fixing nitrogen within its root nodules. However, many growers apply a small amount of nitrogen to stimulate early growth of the peanut plants. Depending on the soil fertility of the growing site, 40-100 pounds per acre each of phosphorous and potassium fertilizer are applied annually. If peanut is grown for seed or if they are Virginia type, or if the soil tests indicate a need, gypsum is applied broadcast at early flowering to compensate for any calcium deficiencies. The rate of dry gypsum, when applied in a band over the row, is 400 pounds per acre, and 800 pounds per acre for Virginia types. Boron is applied at 0.75 pounds per acre in the fertilizer or 0.5 pounds of boron per acre as a foliar spray, usually with the first fungicide application (7).

Before the crop is purchased from the grower, it must be graded according to industry standards and inspected by licensed government personnel from USDA/Federal State Inspection service for *Aspergillus* mold (aflatoxin). Two species of *Aspergillus* are capable of colonizing many important grain crops including peanut. In fact, peanut is one of the three crops with the highest potential for invasion

by *Aspergillus* species, the other crops being corn and cottonseed. Peanut seed can be colonized by *Aspergillus* while in the ground in the seedling stage, before digging, during curing and drying in windrows, and in storage. Damage to the pericarp of the peanut induced by insects, drought, hail, frost, or mechanical harvest favors *Aspergillus* invasion. Insect damage can exacerbate the aflatoxin problem, so precise insect and disease management is imperative. Each wagon load of peanut is inspected and these will be condemned to the oil market if even one kernel in the grade sample is found to contain the *Aspergillus* mold as determined by visual inspection. Inspections for aflatoxin are conducted during the shelling process (8).

Worker Activities Peanut cultivation in Florida is managed by machinery operators exclusively (planters, inverters, combines). There are no worker activities during planting, growth or harvest.

Insect/Mite Management

Insect pests of peanuts are quite widespread across the production area and include: thrips, armyworms, cutworms, loopers, corn earworm, lesser cornstalk borer, wireworms, white grubs, leafhoppers, spider mites, aphids, rednecked peanut worm, whiteflies, three-cornered alfalfa hopper, velvetbean caterpillar, and whitefringed beetle larvae. Insect problems vary during the growing season and from one season to the next because of varying factors such as the weather and cultural practices (9).

Weekly scouting of each individual peanut field is recommended for insect pests. Inspections consist of thoroughly checking the vines from the bud to the root system, including both upper and lower leaf surfaces. Research has defined economic management treatment thresholds for certain insect pests, to identify the amount of damage a peanut plant can withstand without a yield loss. For armyworms, corn earworms or other foliage-feeding worm pests:

- Early season: 3-4/foot of row before plants meet in the middle. Then 4-5/foot of row after the plants reach in the middle.

- Late season: 5-6/row-foot once peanuts have completely covered the middles (9).

For cutworms, defoliation appears to be the best measure of damage levels. When approximately 20 percent defoliation is reached, some sort of management treatment is probably necessary. For peg and pod feeders such as lesser cornstalk borer and corn rootworm, treatment is necessary when the caterpillars or rootworms are found infesting 10 percent of the plants before pegging and 15 percent after pegging (9).

Insect/Mite Pests

Aphids. Aphids are soft-bodied, sucking insects about 1/8 of an inch long. They are not generally a problem on peanut but in large numbers can cause considerable damage by their reduction of plant vigor.

Corn Earworm. The corn earworm is a general feeder found on peanut and other crops such as corn, cotton, soybean, tobacco and tomato. They can develop into large infestations. These caterpillars vary in color from light green to pink to nearly black but are generally lighter on the undersurface of their body. When disturbed, they will curl their bodies up very tight. Small corn earworms are easier to control than the larger ones so it is important to check fields thoroughly and regularly.

Cutworms. Cutworms are stout and dark colored. During the day they stay just below the soil surface, under trash or in soil cracks. Most damage is done at night when they climb the plants and feed on the foliage; however, they also will cut plants off at the soil surface. The cutworms also will feed on exposed peanut that has been dug. Care needs to be taken in inspection of cutworm populations just before harvest since as soon as the vines are plowed, the worms will leave the drying foliage and begin feeding on the pods.

Armyworms. The stripes and coloration of the fall armyworm are highly variable; however, they can generally be identified by a white inverted Y mark in front of the head. Beet armyworm can be identified by a black spot on each side of the body just behind the head. The adult moth lays eggs in a fuzzy cluster and when they hatch the caterpillars move and feed together. Often large numbers congregate and move along together feeding on foliage; consequently, they are called armyworms. They often attack the vines

early in the season and feed on developing buds. This type feeding gives a ragged appearance when the leaves grow out.

Leafhoppers. Leafhoppers are small green or brownish wedge-shaped insects sometimes called sharpshooters. They have piercing-sucking mouthparts and damage peanuts by sucking sap from the leaves and buds causing leaf tips to turn yellowish-white or fringes of the leaf to turn brown (called hopper burn).

Lesser Cornstalk Borer. The lesser cornstalk borer is small and slender with alternating green and brown bands on its body. It lives in a silken tube just below the soil surface and bores into and tunnels up the stem. Lesser cornstalk borers frequently attack seedlings emerging from the ground or shortly thereafter. It is an erratic pest with outbreaks and plant damage usually occurring during dry periods on sandy soils. The worm also can be a severe problem from pegging time until harvest. Damage can be reduced significantly by keeping the land free of weeds and grass for several weeks before planting. In order to inspect for the lesser cornstalk borer, it is necessary to carefully dig the peanut plant with a trowel, small shovel or other instrument. The delicate sand-like silk webbing tubes are often left in the soil if the plant is pulled up or not carefully removed. If the above precautions are not observed, the grower will often overlook this pest. Earlier planting may help prevent late season losses.

Rednecked Peanut Worm. The rednecked peanut worm is a small, white-colored larvae with a brown head and a red band just behind the head, hence its name. They are 3/8 to 1/2 inch in length and feed in the buds of the plant. They do not occur often but can be difficult to control.

Corn Rootworm. The southern corn rootworm damages peanuts by feeding on the pegs and pods in the soil. These pests tend to be a problem more often in damp weather and on heavier type soils, however, it can occur in sandy soils. The adults of the corn rootworm beetle are greenish-yellow in color, about 1/4 to 3/8 of an inch long and have 12 irregular black spots on their backs. The damage to peanuts, however, is caused by the whitish-clear tender looking larvae about 3/8 inch long. The larvae appears two headed since both head and rear ends have a brown-like spot resembling the head of a worm. Management of this pest also can be quite frustrating because of it feeds underground. Once it is detected, it is virtually impossible to use any type of rescue treatment effectively. Therefore, producers generally rely upon preventive applications of granular formulations of insecticides just before egg hatch.

Spider Mites. Spider mites, about 1/60 of an inch long, are not insects but closely related organisms that damage peanuts by sucking fluid from the leaves causing them to turn yellow and die. They are not a common problem but may appear from time to time and can cause severe damage. Mites are particularly troublesome in dry weather and populations generally initiate around fences, trees, field margins or other obstacles in the field. They prefer healthy and vigorous plants to feed upon. Problems with spider mites can be enhanced when certain foliar pesticides are used.

Whiteflies. The silverleaf whitefly adult is approximately 0.8mm (1/32") long. It inhabits and feeds on the undersurfaces of leaves by penetrating the tissue and removing plant sap with its piercing-sucking mouthparts. The insects white color is attributed to the secretion of wax on its body and wings. The adults fold their wings over their bodies when at rest or while feeding. The females deposit their eggs on the underside of leaves where they are usually clustered in groups. The number of eggs laid by females ranges from approximately 50 to 400, with an average of about 160. The immature stages are thin and flat, elliptical in shape, and greenish-yellow in color. In most infestations, all stages of the life cycle are present. At the end of the nymphal cycle, it enters the pupal stage. The pupa has two conspicuous red eyes and the body is raised or convex in shape. It is yellow in color and about 0.7mm (1/35") long. The nymphal stages are sedentary, with the exception of the crawler, which after hatching moves a very short distance. Once a feeding site is selected the nymphs do not move. The nymphs may become so numerous that they almost cover the entire undersurface area. As the life cycle progresses from stage to stage, molting occurs and the cast skins (particularly from the pupae) remain on

the leaves. These structures are empty, silver in color, and resemble small fish scales on the leaves. Adults congregate, feed, and mate on the undersurfaces of the leaves of the host plants. They appear to be more active during the sunny daylight periods, and do not fly as readily during early morning, late evening, or night hours. This whitefly currently is known to attack over 500 species of plants representing 74 plant families and there is also a biotype that is resistant to many old and new insecticides. Feeding damage by both the nymphs and adults results in the accumulation of honeydew on the leaves, with subsequent growth of sooty black as well as other molds. The plants may have slow or abnormal growth. Other forms of damage include the removal of plant sap, vine, leaf, and plant breakdown, chlorotic spots, yellowing, leaf shedding and abnormalities of pod structure. It is believed that the pest injects enzymes into the host plant while feeding, affecting the normal physiological processes. The pest is also known to vector virus diseases to a large number of crops.

Three-Cornered Alfalfa Hopper. The three-cornered alfalfa hopper is related to the leafhopper. It is green in color, approximately 1/4 inch in length and stands about 1/4 inch high, being wedge-shaped and broad shouldered. It has rather prominent protruding eyes located low on its head. It pierces the tissues and sucks out plant juices. Its feeding causes the stem to scab over and take on a girdled appearance (which completely encircles the stem). The insect feeds deep in the plant foliage. The nymphs are similar in appearance to the adults but have spiny bodies and usually are more damaging than the adults.

Thrips. Thrips are about 1/16 of an inch long. The adults are dark and winged and the nymphs are wingless and yellow in color. They feed by rasping the young leaves of the bud and sucking out plant fluid. This results in scarred, deformed or possum-eared leaves. Thrips also are the vector for TSWV. Thrips infestations and damage are difficult to predict. Because the potential for thrips infestations cannot be predicted preplant and because thrips could be more easily and more reliably managed with at-planting insecticide treatments compared to curative treatments, significant acreage is treated annually for which monetary benefit is not immediately apparent. A significant factor in the widespread use of at-planting treatments for thrips management is the potential for thrips to interact with other stresses and reduce yields. Concerns about increased incidence of TSWV has resulted in increased use of at-planting treatments for thrips management.

Velvetbean Caterpillar. Velvetbean caterpillars attack foliage, strip plants of leaves, and destroy the terminal buds. They tend to be most numerous late in the season just prior to harvest. Velvetbean caterpillars are green to black in color and usually have stripes running the length of the body. The caterpillars can grow to two inches in length and are very active when disturbed. The adult moths are light brown and have a diagonal dark line across their wings from the front wing tip inward toward the body.

White Grubs. White grubs are the larvae of May or June beetles. They have a thick, white C shaped body with a brown head and three pairs of legs. They live in the soil and feed on underground plant parts. Grubs are most often a problem following sod crops.

Whitefringed Beetle. The whitefringed beetle is dark gray in color and about 1/2 inch long and has a white fringe or band along the outer edges of the body. They feed on the outer margins of leaves. The larvae or grubs cause the principal damage by feeding on roots or other underground parts. The grubs are yellowish-white in color and are about 1/2 inch long. They generally require eleven months for development into adults, but under some conditions may require up to two years or more. Whitefringed beetles normally overwinter as eggs or larvae. They usually produce one generation a year and spend all but about three months of their life in the soil.

Non-Chemical Management

A long crop rotation program is most productive for peanut cultivation; indeed, the best yields are achieved when the plant is grown in new fields. The current recommendation is a four-year sod based rotation which includes bahiagrass for two years, followed by one year of peanut, and one year of cotton. Cotton is widely accepted in crop rotation with peanuts, because each crop is resistant to the

species of root-knot nematode that attacks the other. This rotation aids in reducing nematode and soil-borne disease problems, whitefringed beetle damage, and permits better management of many weeds. In reality, however, primarily because of needed returns and land availability, rotation practices generally follow the two years peanuts - one year bahiagrass - two years peanuts scenario. Other non-chemical insect/mite management tactics include such things as modifying irrigation practices to manage pests (5,10).

Chemical Management

Effective insect management depends on a combination of cultural and chemical practices. Insecticide products commonly used on peanut include phorate, chlorpyrifos, aldicarb, methomyl, esfenvalerate, cyhalothrin, and carbaryl (11,12). The use of systemic insecticides helps to eliminate the need for additional foliar insecticide sprays, unless pests such as worms or mites become a problem late in the season. Systemic insecticides are applied in furrow at the time of planting. Granular formulations are applied with a special row-type granular applicator that can be calibrated to deliver proper rates. Other insecticides/miticides registered for use on peanut in Florida in 2007 were: acephate, azadirachtin, cyfluthrin, diflubenzuron, disulfoton, fenpropathrin, indoxacarb, propargite, pyrethrins +/- rotenone, spinosad, sulfur, and zeta-cypermethrin.

PHORATE. Phorate is a restricted-use organophosphate insecticide commonly used to manage thrips and leafhoppers, but it also exhibits population reduction properties on other early season peanut pests such as corn rootworms or wireworms if it is applied at pegging. It also tends to reduce the incidence of tomato spotted wilt virus by controlling the thrips vector. Forty-two percent of the Florida peanut crop was treated with phorate in 2002 and 2004 (11,12). The price of phorate is approximately $12 per pound of active ingredient, and the approximate cost of a maximum labeled application (1.2 lb ai/A) is $14 (13,14). It is only applied once per season. The restricted entry interval (REI) is 48 hours and the pre-harvest interval (PHI) is 90 days.

During the years 2002 through 2004, Florida peanut growers have applied phorate at an average rate of one pound of active ingredient per acre, totaling between 32,000 and 61,000 pounds of active ingredient annually (11,12).

METHOMYL. Methomyl is a restricted-use carbamate insecticide peanut growers use in their broad spectrum insect pest management programs. It is used to manage corn earworm, leafhoppers, fall and beet armyworm, green cloverworm, velvetbean caterpillar, cabbage and soybean loopers, cutworms, and grasshoppers. Methomyl is only applied during years that require treatment, as pests such as armyworms are not a problem every year. When applied, growers report that methomyl has a residual effectiveness of approximately 3 days in the field (5). Thirty-one percent of the Florida peanut crop was treated with methomyl in 2002 and 2004 (11,12). The price of methomyl is approximately $8 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.9 lb ai/A) is $7 (13,15). It is only applied once per season. The REI is 48 hours and the PHI is 21 days.

During the years 2002 through 2004, Florida peanut growers have applied methomyl at an average rate ranging from 0.4 to 0.9 pound of active ingredient per acre, totaling between 25,000 and 47,000 pounds of active ingredient annually (11,12).

ESFENVALERATE. Esfenvalerate is a restricted-use pyrethroid insecticide peanut growers use in their broad spectrum insect pest management programs. It is used to manage corn earworm, leafhoppers, fall and beet armyworm, green cloverworm, velvetbean caterpillar, cabbage and soybean loopers, cutworms, and grasshoppers. Thirty-one percent of the Florida peanut crop was treated once or twice with esfenvalerate in 2002 and 2004 (11,12). The price of esfenvalerate is approximately $133 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.05 lb ai/A) is $7 (13,15). The REI is 12 hours and the PHI is 21 days.

During the years 2002 through 2004, Florida peanut growers have applied esfenvalerate at an average rate of 0.05 pound of active ingredient per

acre, totaling between 2,100 and 4,000 pounds of active ingredient annually (11,12).

CARBARYL. Carbaryl is occasionally used by peanut producers to manage insect pests such as thrips, leafhoppers, corn earworm, velvetbean caterpillar, alfalfa caterpillar, ants, bean leaf beetles, blister beetles, cucumber beetles, darkling ground beetles, field crickets, grasshoppers, green cloverworm, Mexican bean beetle, rednecked peanut worms, sowbugs, stinkbugs, alfalfa hoppers, webworms, and whitefringed beetles (14,15,16). Approximately ten percent of the Florida peanut crop was treated with carbaryl in 2002 and 2004 (11,12). The price of carbaryl is approximately $7 per pound of active ingredient, and the approximate cost of a maximum labeled application (2.0 lb ai/A) is $14 (13,16). The REI is 12 hours and the PHI is 14 days.

During the years 2002 through 2004, Florida peanut growers have applied carbaryl at an average rate ranging between 0.5 and 1.0 pound of active ingredient per acre, totaling between 7,600 and 13,000 pounds of active ingredient annually (11,12).

CHLORPYRIFOS. Chlorpyrifos is an organophosphate insecticide, used to manage cutworms, lesser cornstalk borer and corn rootworm larvae, and to suppress wireworms. Interestingly, the label also claims suppression of white mold in peanut as well, but interest in this aspect has waned since the introduction of newer fungicides such as tebuconazole. In 2002, chlorpyrifos was applied to approximately 75 percent of the peanut acreage in Florida (11). When used at planting, as is done the vast majority of the time when it is used, chlorpyrifos granules are applied in a 6 to 12 inch band over the row behind the planter shoe and in front of the press wheel, at a rate of approximately 10.0 pounds of formulated product per acre (1.5 lb ai/A). If chlorpyrifos is applied at planting, it will not be applied at pegging, even though the repeat application is often recommended, due to economic considerations. The emulsifiable concentrate formulation is generally not used because of the possible threat of foliar burn. The price of chlorpyrifos is approximately $10 per pound of active ingredient, and the cost of a typical application (1.5 lb ai/A) is $15 (13,17). Total use of chlorpyrifos in Florida peanut in 2002 was approximately 69,000 pounds. Chlorpyrifos has a REI of 24 hours and the PHI is 21 days (17).

ALDICARB. Aldicarb is a restricted-use granular formulated carbamate insecticide used to manage thrips and nematodes. In 2002, aldicarb was applied to approximately 40 percent of the peanut acreage in Florida (11). Typically, a single application takes place at planting for thrips management. When applied, the aldicarb granules are placed in the seed furrow at a rate of 7 to 14 pounds of formulated product per acre (1 to 2 lb ai/A) and immediately covered with soil. For nematode management, a Special Local Need 24(c) registration in Florida (FL-780023) in place since 1978 allows for aldicarb to be applied in split applications, one at the time of planting and an additional application at peg initiation. Under this registration, aldicarb is applied at a rate of 10 pounds of formulated material per acre for each application. When applied at planting, the aldicarb granules are placed in a 6 to 12 inch band and immediately worked into the soil to a depth of 2 to 4 inches. The seeds are then planted in the treated zone. When applied at peg initiation, the granules are applied in a band 12 to 18 inches wide on the row and immediately incorporated into the soil. Although expensive, aldicarb use is partially due to the fact that thrips management is often accomplished prophylactically because of the inability to predict which acres will be infested and what the potential damage is likely to be. Furthermore, it is a common opinion that thrips injury is often not damaging to peanut growth and yield, especially when environmental conditions are favorable, but when other early-season stresses occur simultaneously, thrips damage can reduce yield (3). The price of aldicarb is approximately $25 per pound of active ingredient, and the approximate cost of a typical application (1 lb ai/A) is $25 (13). Total use of aldicarb in Florida peanut in 2002 was approximately 31,000 pounds. Aldicarb has a REI of 48 hours and the PHI is 90 days.

LAMBDA-CYHALOTHRIN.
Lambda-cyhalothrin, a restricted-use synthetic pyrethroid insecticide, is used primarily to manage armyworms, corn earworm, velvetbean caterpillar, leafhoppers, bean leaf beetles, weevils, stink bugs,

thrips and grasshoppers, and to suppress populations of lesser cornstalk borers, mites and aphids. According to producers, lambda-cyhalothrin has 5 to 6 days of residual activity in the field (5). In 2002, cyhalothrin was applied to approximately 50 percent of the states total peanut acreage. The price of lambda-cyhalothrin is approximately $325 per pound of active ingredient, and the approximate cost of a typical application (0.03 lb ai/A) is $10 (13,18). Total use of lambda-cyhalothrin in Florida peanut in 2002 was approximately 1,900 pounds. It can be applied by either ground or air. Lambda-cyhalothrin has a REI of 24 hours and the PHI is 14 days (18).

Biological Management

Bacillus thuringiensis. B.t. is occasionally used, in a prophylactic manner, by Florida peanut growers to manage early instar lepidopteran larvae (worm) pests. However, if worms are larger and more mature, or if worm populations exceed threshold levels, then more non-selective materials are used. B.t. is applied to less than 10 percent of the peanut acreage an average of 2 times (5). B.t. is not applied to peanuts much because of its short residual activity. It also does not provide as broad control of insects as other materials.

Disease Management

Peanut diseases reduce yields and monetary returns by retarding desirable plant development or by diverting product utilization. Some diseases, such as leaf spot and rust are obvious in appearance while others, such as root rots and pod rots, often are unnoticed until dry weather occurs or until harvest time. Other peanut diseases, such as yellow mold which produces aflatoxin, are only detected in harvested peanuts. All peanut producers experience loss from one or more diseases that occur annually on their crop. Disease control strategies are an essential component of all peanut production programs. One or more diseases from several dozen pathogens of fungal or viral origin can be found in fields from planting time until harvest. Yield reductions associated with foliar maladies such as leaf spot and TSWV pose the greatest threat of all diseases to southeast-produced peanuts.

The magnitude of damage and resulting crop loss varies with the time of occurrence, disease distribution, environmental conditions and, more importantly, the cause of disease. Each of these factors will influence choices about what control strategies may be needed. It is understandable, then, that no one management measure will be totally effective in managing all peanut diseases. A series of coordinated control measures is necessary to do a proper job. Each step requires knowledge and experience (19).

Disease Pests

Seedling Blight. Seedling blight is caused by a variety of fungi including *Rhizoctonia solani, Macrophomina phaseolina, Rhizopus* sp., *Lasiodiplodia* sp., *Diplodia* sp., *Aspergillus flavus, A. niger,* and *Pythium* sp. Symptoms include pre-or postemergence death of the seedling accompanied by elongate sunken, brown, gray or black areas in young plant parts. The stem above the infected area is greater in diameter than the infected area. Roots become decayed. Seedlings are stunted and often die (19).

Root Rot. (*Rhizoctonia* sp., *Pythium* sp., *Cylindrocladium parasiticum, Sclerotium rolfsii*) Symptoms of root rot include sunken dark-brown areas in primary roots and a general browning of secondary roots. The lower stems develop dry, sunken, brown to black areas that later may girdle the entire stem near the soil line (19).

Crown Rot. (*Aspergillus niger, Lasiodiplodia* sp.) Plants infected with the crown rot fungus appear weak and may wilt. First signs of infection on seedlings are water-soaked tissues on the crown and roots. Management of soil insects is important as they can predispose plants to crown rot infection (19).

Aerial Blight and Limb Rot. (*Rhizoctonia solani*) Leaves infected with this fungus have irregularly-shaped, lobed, tan leaf spots. As the spots expand in size, a greasy zone may be seen on the outer edge of the spots. Entire leaves and petioles may be infected. The vines may have elongated tan spots up to three inches or more. Within these spots, growth bands may be visible. During periods with high humidity, a webbing of fungal growth (like

spider webs or webs from spider mites) can be seen on and between leaflets and leaves (19).

Southern Stem Rot (Southern Blight, White Mold). (*Sclerotium rolfsii*) Stems, pegs, roots, pods and nuts are susceptible to infection with white mold. The first sign of infection is a sudden wilting of a stem branch. The leaflets may become yellow and turn reddish-brown; other branches wilt later. White mycelial growth may be found in lower parts of the stem and in nearby organic debris on the soil. Later, somewhat spherical structures called sclerotia occur. They are first white and soft, then light brown to pink, then dark brown and hard. Pegs may have lesions with shedding of the tissue (19).

Peg and Pod Rots. Peg and Pod Rots are caused by a variety of fungi including *Rhizoctonia solani, Pythium* spp., *Sclerotium rolfsii, Cylindrocladium parasiticum,* and *Cercosporidium personatum*. Symptoms on pegs include the development of light to dark brown lesions sunken or superficial, varying in size from small specks to entire peg blemish. Symptoms on pods appear as brown to black lesions on immature or mature pods. Spots may be angular, rough, or sunken. Extreme cases result in total decay. Adequate levels of calcium in the pegging zone will suppress pod rots. Appropriate management of soil insects and nematodes is necessary for management of peg and pod rots, as these organisms can predispose the plant to infection (19).

Diplodia Collar and Stem Rot. (*Lasiodiplodia* sp.) This disease can appear similar to white mold, but the absence of mustard seed-sized sclerotia indicates the possibility of this disease. Collar rot is likely to appear within 50 to 60 days after planting, but can occur later. Usually, the entire plant wilts whereas white mold causes wilting on a more gradual basis. Laboratory diagnosis is essential unless the necrotic stem has pin point-sized, black, pimple structures (pycnidia) present. Black lesions can be present on the stems midway up the plant (19).

Leaf Scorch. (*Leptosphaerulina crassiasca*) Leaf scorch symptoms are usually found on tips of leaflets in a v shaped pattern. The first sign of this disease is yellowing and then death of the infected area. Necrotic areas surrounded by a yellow halo often with dark circular areas or concentric rings in the dead tissue can be seen. Stem lesions are black and may be over six inches long (19).

Peanut Rust. (*Puccinia arachidis*) The first symptoms of peanut rust appear as whitish-yellow green flecks on the leaflets. Within 48 hours, rust colored erumpent pustules (sori) emerge. Most pustules occur on the lower side of leaflets. Leaves yellow and then turn brown and finally fall off. Infected areas in the field are often first noticed because of yellowing plants in a limited area. Later, plants in these areas die and rust pustules are evident on petioles, stems, and pegs. Rust can be redistributed over the entire field if left unchecked, and infection causes the plants to be harvested early, which reduces yield. Crop rotation, destruction of volunteer peanuts, and fungicide sprays will reduce the impact of this disease (19).

Yellow Mold. (*Aspergillus flavus*, a source of aflatoxin) Currently, diagnosis of this disease is made at the buying point. Inspectors look for signs of the fungus from random samples. This disease is more common in dry seasons and on damaged peanuts (19). For more details, refer to the earlier discussion on aflatoxin.

Tomato Spotted Wilt. This virus was first discovered on peanut in Florida in 1986. Tomato spotted wilt is a thrips-vectored virus, causing white etching-like ringspots on leaflets. Stunting of plants occurs if the infection occurs early. Buds may die and turn brown, and plants may be abnormally yellow (19). As stated earlier, it has become the key driving pest in peanut production.

Peanut Leaf Spot. Each year, peanut producers in Florida contend with a foliar disease complex commonly referred to as peanut leaf spot. The fungus *Cercospora arachidicola* causes early leaf spot, and the fungus *Cercosporidium personatum* causes late leaf spot. Early leaf spot predominates during May, June, July and August, while late leaf spot predominates during the remainder of the season. Late leaf spot can predominate throughout the season. Leaflets, petioles, stems and pegs are infected. Symptoms include brown-black spots with or without rough margins, sometimes having a halo around the spot (frog-eye). Some chemical burns are similar in appearance to early leaf spot. Peanut leaf

spot causes premature defoliation of the peanut plants. Premature defoliation weakens the plant and so the plants must be harvested prematurely, which results in reduced yield. Yield losses may vary from near zero to as much as 90 percent (in research tests). On a statewide basis in Florida, annual yield losses attributed to peanut leaf spot vary from 5 to 40 percent (19).

Non-Chemical Management

Nonchemical tactics for foliar disease management are important, but when used alone they will not permit sustained peanut production in Florida (19). Commercial production would not be a consideration without the use of chemical control methods (5).

Crop Rotation. Whenever possible, an interval of three to four years between peanut crops on the same land is preferable. Shorter intervals increase the occurrence of most peanut diseases. A soybean-peanut rotation may not be an appropriate rotation, because soybean is highly susceptible to the white mold fungus (Southern stem rot). Considering all peanut diseases, it is best to rotate with grass crops (pastures), sorghum or corn, since many fungi causing diseases of grass crops do not cause diseases of peanuts and vice versa. Also, studies show that fungi that produce aflatoxin will be in higher populations with rotations including corn and peanuts.

Site Location. If possible, it is not advisable to locate a peanut field next to a field that had peanuts the previous year. Peanut leaf spot has been more severe along the edges of fields next to an old planting site. Fields of tomatoes and peanuts should be spaced as far from each other as possible to reduce the spread of tomato spotted wilt virus by thrips from crop to crop.

Deep Plowing and Land Preparation. When the soil is turned during land preparation, every effort is made to bury surface trash and stubble at least six inches deep, even if a grass crop precedes the peanut crop. This tactic is specifically aimed at reducing white mold and other soilborne diseases. It is also beneficial in reducing leaf spot when the interval between peanut crops is only one or two years. Planting peanuts in a no-till situation can have both good and bad results. Seedlings and young plants are highly susceptible to soilborne fungi. Poor stands can result when the producer uses a single disk opener for the seed furrow. Better stands result when a subsoiler with a single disk opener is used. The shank of the subsoiler clears away organic matter from the emergence zone, which suggests that pushing away some of the organic trash from the immediate planting zone can be beneficial. The practice of strip-till is just now beginning and will probably become more popular because of soil considerations and cost savings.

Lime and Fertilizer Relations with Peanuts. Peanuts are a high calcium-requiring crop. Calcium availability and placement are critical for improved quality and yields of peanuts. Deficiency of calcium predisposes the plant to peg and pod rots caused by fungi. Calcium deficiencies usually result from inadequate calcium in the pegging zone or competition from excess cations such as potassium, magnesium, or ammonium.

Weed Management. Less limb rot and other soilborne diseases occur where herbicides are used instead of cultivation for weed management. Cultivation frequently increases damage to plants and often results in soil and debris being deposited on the peanut plant. These conditions are ideal for development of white mold and other soilborne diseases. Caution must be used with herbicides as intensive use of certain ones will stress peanut plants. Cultivation with sweeps oriented in a flat position in row middles prior to root growth in that zone is not expected to increase disease. Leaf spot and rust will be more difficult to manage where weeds are present. Weeds interfere with spray deposition and allow leaf wetness periods to be extended. Spores from the fungal diseases produced near the weeds serve as an intense inoculum source, thereby offsetting desired control.

Nematode Management. Nematodes cause wounds in peanut roots, pegs, and pods. They create an entry for fungi. Pod rot and white mold can be suppressed by reducing damage from nematodes.

Use of High Quality Seed. Purchasing high germinating seed with high vigor reduces peanut diseases. Using high quality seed reduces seedling

diseases caused by fungi. Also, a thicker stand of peanuts is likely to have a lower incidence of tomato spotted wilt.

Resistant Varieties. Some peanut varieties have intermediate resistance to diseases. Where resistance to leaf spot exists, fewer applications of fungicides may be required. Marketability of resistant varieties remains a concern for certain shellers and processors, because they should be kept separate from other varieties for efficient shelling. Varieties are currently available with resistance to leaf spot, rust, white mold, tomato spotted wilt, and *Cylindrocladium* black rot.

Adjusting Planting Dates. Earlier planting reduces the impact of peanut leaf spot, provided a proper spray schedule is used. Peanuts planted in early- to mid-April in Florida may not have to be sprayed with fungicides until 60 days after planting, compared to 25-35 days after planting for peanuts planted during May to early June. Tomato spotted wilt virus is spread by thrips, and populations of thrips are somewhat lower during May. Therefore, planting early to reduce leaf spot may result in more tomato spotted wilt than if planting is done in May. Also, planting too early into cool soils may result in more seedling blight. Higher seeding rates need to be used for planting in April, to compensate for plants lost to seedling blight. Later plantings have resulted in higher levels of aflatoxin in association with more lesser corn stalk borers. Later plantings are likely to have less damage from *Cylindrocladium* black rot.

Avoiding Deep Planting. Planting excessively deep will offset benefits from seed treatment fungicides. The longer it takes for a seedling to emerge, the longer the entire plant is exposed to soil borne fungi. Recommended planting depths are two to three inches in light textured soils and 1.5 to two inches in heavy textured soils.

Minimizing Stress on the Roots. Excessive use of herbicides and excessive wetting and drying of soils can weaken the root system and reduce the rate of growth, thereby allowing detrital fungi to colonize root tissue and reduce plant vigor (19).

Chemical Management

Effective disease management depends on the use of a combination of cultural and chemical practices. Fungicides used as preplant seed treatments has grown immensely and now include fludioxonil, mefenoxam, azoxystrobin, trifloxystrobin, thiophanate, and fluoxastrobin in addition to the older materials such as PCNB, carboxin, captan and thiram. Most of these seed treatment active ingredients are available as foliar materials as well. Foliar fungicide products commonly used on Florida peanuts include sulfur, tebuconazole, propiconazole, chlorothalonil, trifloxystrobin, pyraclostrobin, and azoxystrobin. There is minor use of materials such as coppers, maneb, mancozeb, and thiophanate (11,12). Other fungicides registered for use in Florida peanut production as of 2007 include: boscalid, iprodione, fluazinam, prothioconazole, and phosphite.

CHLOROTHALONIL. Chlorothalonil is the fungicide peanut producers utilize the most in their chemical disease management activities. This compound is used to manage leaf spot, rust, web blotch, aerial blight, and limb rots. Nearly all acreage in Florida is treated annually at an average rate of approximately 1.1 pounds of active ingredient per acre. The number of applications per season can range from 4 to 8, depending on the environmental parameters affecting the crop (19). Eighty-seven percent of the Florida peanut crop was treated with chlorothalonil in 2004 (12). The price of chlorothalonil is approximately $8 per pound of active ingredient, and the approximate cost of a maximum labeled application (1.1 lb ai/A) is $9 (13,18). The REI is 12 hours and the PHI is 14 days.

During the years 2002 through 2004, Florida peanut growers have applied chlorothalonil to between 87 and 99 percent of the crop an average of 5 times. Total annual use has ranged between 378,000 and 704,000 pounds of active ingredient (11,12).

TEBUCONAZOLE. Tebuconazole is a sterol-inhibiting systemic fungicide used to manage leaf spot, rust, white mold, and *Cylindrocladium* black rot. This fungicide is especially effective for rust, leaf spot and white mold management, as this material provides good to excellent control of these diseases when applied beginning 45 days after

planting. Half of the Florida peanut crop was treated with tebuconazole in 2002 and 2004 (11,12). The price of tebuconazole is approximately $120 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.2 lb ai/A) is $24 (13,16). The REI is 12 hours and the PHI is 14 days.

During the years 2002 through 2004, Florida peanut growers have applied tebuconazole an average of 1.6 times. Total annual use has ranged between 10,000 and 18,000 pounds of active ingredient (11,12).

PROPICONAZOLE. Propiconazole is also a sterol-inhibiting fungicide, used primarily to manage leaf spot. Approximately one-third of the Florida peanut crop was treated with propiconazole in 2002 and 2004 (11,12). The price of tebuconazole is approximately $95 per pound of active ingredient, and the approximate cost of a maximum labeled application for leaf spot (0.11 lb ai/A) is $11 (13,18). The REI is 24 hours and the PHI is 14 days. When used at a rate of 0.22 lb ai/A for southern stem rot, the PHI is 21 days.

During the years 2002 through 2004, Florida peanut growers have applied propiconazole an average of 1.3 times. Total annual use has ranged between 2,000 and 4,000 pounds of active ingredient (11,12).

AZOXYSTROBIN. Azoxystrobin was the first of the strobilurin fungicides and two others (pyraclostrobin, trifloxystrobin) are now available in peanut. These are used to manage white mold, leaf spot, and rust. It is applied to approximately 20 percent of Floridas peanut acreage an average of 1-2 times (11). The price of azoxystrobin is approximately $110 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.3 lb ai/A) is $33 (13,18). The REI is 4 hours and the PHI is 14 days. Total annual use is approximately 5,000 pounds of active ingredient (11).

PYRACLOSTROBIN. Pyraclostrobin is another strobilurin fungicide used to manage white mold, leaf spot, and rust. It is applied to approximately 20 percent of Floridas peanut acreage an average of 2.3 times (12). The price of pyraclostrobin is approximately $100 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.24 lb ai/A) is $24 (13,20). The REI is 12 hours and the PHI is 14 days. Total annual use ranges from 6,000 to 11,000 pounds of active ingredient (11,12).

TRIFLOXYSTROBIN. Trifloxystrobin is the third strobilurin fungicide used to manage white mold, leaf spot, and rust. It is applied to approximately 20 percent of Floridas peanut acreage an average of 1.2 times (12). The price of trifloxystrobin is approximately $100 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.1 lb ai/A) is $10 (13,16). The REI is 24 hours and the PHI is 14 days. Total annual use ranges from 750 to 1,000 pounds of active ingredient (11,12).

SULFUR. Sulfur is a fungicide that is used in combination with other fungicides such as chlorothalonil. It is used primarily to aid in management of leaf spot and rust. Sulfur is not regarded as an adequate stand-alone treatment of peanut diseases. It is applied to approximately one-sixth of Floridas peanut acreage an average of 1.5 times, at a rate of approximately 1.5 pounds of active ingredient per acre (12). The price of sulfur is approximately $1 per pound of active ingredient, and the approximate cost of a maximum labeled application (6.4 lb ai/A) is $6 (13,15). The REI is 24 hours and there is no PHI. Total annual use ranges from 38,000 to 52,000 pounds of active ingredient (11,12). The use of sulfur also provides some nutritional value for the peanut plant.

Weed Management

Successful weed management in peanuts involves using good management practices in all phases of peanut production. Weeds compete with peanut plants for moisture, nutrients, and light, with the greatest competition usually occurring during the first six weeks after planting. Although late-season weeds may not be as competitive as early-season weeds, they interfere with harvesting operations and also with fungicide and insecticide applications. Additionally, many weed species serve as alternate hosts for certain peanut pests such as armyworms,

loopers and aphids, as well as plant pathogens and nematodes. Since weeds can also provide shelter and food for natural enemies of peanut insect pests, weed management strategies should adequately address the positive and negative role of weeds in and around the peanut field. The most important weed pests in Florida peanut production are yellow and purple nutsedge, bristly starbur, Florida beggarweed, Florida pusley, morningglory, pigweed, sicklepod, wild poinsettia, hairy indigo, crabgrass, goosegrass, johnsongrass, and Texas panicum (21).

Weed Pests

NUTSEDGE . Yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*C. rotundus*) constitute the greatest weed problem in Florida peanuts. Both of these perennial sedges are found in disturbed habitats throughout Florida and the Southeast United States. Yellow nutsedge may produce some seed but reproduces primarily by rhizomes and tubers. The first plant develops rhizomes, which end in bulbs or tubers that produce new plants. Tuber production is favored by low nitrogen levels and high temperatures (80 to 91F). It 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 it 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). The plant also reproduces by seed to a limited degree. Although purple nutsedge is also 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. It is also able to survive extremely high temperatures.

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 six feet, creating a very competitive interaction with peanut plants.

GRASSES. Grass weeds, such as crabgrass (*Digitaria* sp.), goosegrass (*Eleusine indica*), Texas panicum (*Panicum texanum*), and johnsongrass (*Sorghum halepense*) can also be a problem for peanut growers in Florida. Crabgrass, a summer annual, roots at the nodes and reproduces by seed, flowering from June to October. Goosegrass, also a summer annual that flowers from July to October, is similar in appearance to crabgrass but grows in tufts and does not root at the nodes.

BRISLY STARBUR (*Acanthospermum hispidum*). Bristly Starbur is an upright annual with dichotomous (Y-shaped) branching. The Y-shaped form of branching gives the plant one of its common names, Slingshot Weed. The stems are densely covered with hairs. These hairs can be stiff and bristly or soft and flexible. The leaves have no stalk (sessile) and are opposite each other on the stem. They are oval to triangular-ovate in shape with a base that narrows rapidly to the stem. The margins of the leaves can have irregular teeth or they may be entire and smooth. Like the stems, the leaves are hairy. The hairs are on both the upper and lower surfaces and on the margins. The lower leaf surface is also dotted with glands. The flowers are typical of the aster or daisy family. Each head has 5-9 ray flowers.

FLORIDA PUSLEY. *Richardia scabra* is an erect to prostrate, loosely branched annual. The stems are hairy, up to 0.8 m long and do not usually root at the nodes. The leaves are oppositely arranged, ovate to elliptic-lanceolate shaped, up to 6.5 cm long and 2.5 cm wide. The leaves may be almost smooth, except for the margins, to rough on both leaf surfaces, and predominantly rough on principle veins. The leaf apex may be rounded to pointed. The leaf base is tapered with petioles ranging from very short to about 5 mm long. The opposite leaves are connected by a sheath with several ascending, hair-like appendages from 2-5 mm in length.

MORNINGGLORY (*Ipomoea* sp.). These vining plants not only grow throughout and over the peanut canopies, but can also create problems during harvesting. Morningglory often has heart-shaped leaves, but may also have fine bladed leaves, such as cypressvine morningglory. The plants usually have colorful flowers and are often established along fence lines.

SICKLEPOD (*Senna obtusifolia*). Sicklepod is an annual with erect, nearly hairless stems. The leaves are compound with 3-10 leaflets and a

conspicuous gland about 2 mm long between, or just above, the lowest pair of leaflets. The terminal pair of leaflets is frequently larger than the lower pairs of leaflets. The leaflets are photosensitive (the leaflets fold upward by flexible petioles at night or on cloudy days). The seed pods produced by the plant are from four to six inches long and curved like a sickle. The plant is also a legume, like peanut, so herbicides that are selective for peanut often fail to control this weed as well.

Non-Chemical Management

Crop Rotation. Crop rotations are an important part of the peanut weed control program, as mentioned earlier. Certain broadleaf weeds, which are not easily controlled in peanuts, may be controlled by herbicides that can be used in a preceding crop such as corn. Other benefits of crop rotations may include reduction in insect, disease, and nematode problems.

Cultivation. Cultivation can be utilized if effective weed control is not achieved with herbicides. However, if weeds have been controlled with herbicides, there is generally little benefit from cultivation. If cultivation is needed, throwing soil on the peanut vines must be avoided. Soil thrown on the vines may result in increased incidence of stem rot (white mold) and limb rot (21).

Chemical Management

Herbicides are the most effective method for controlling weeds in peanuts. Before purchasing a herbicide, the weed spectrum should be analyzed, since many herbicides are most effective on only certain weeds. The most effective weed control and highest peanut yields have generally been obtained using a herbicide program consisting of a preplant incorporated treatment, followed by a cracking stage treatment, followed by a postemergence treatment. The cracking stage treatment (that time when the soil cracks due to the emerging peanut seedling), if properly timed, is generally the most critical application in the peanut weed control program. Maximum effectiveness will be achieved if application is timed to the emergence of the weeds. It needs to be noted that peanuts under stress from cold weather, thrips injury, etc., may be subject to more injury from improperly timed cracking stage applications (21).

Florida peanut growers use preemergent herbicides such as ethalfluralin, imazethapyr, pendimethalin, and s-metolachlor, while compounds such as imazapic, 2,4-D/2,4-DB, paraquat, acifluorfen, and bentazon are used at cracking. Some (s-metolachlor, imazethapyr) may be used at either time and sometimes both. Postemergent herbicides include chlorimuron, clethodim, and sethoxydim. Other herbicides registered for use in Florida peanuts in 2007 include: glyphosate, diclosulam, dimethenamid, flumioxazin, lactofen, and trifluralin.

PENDIMETHALIN. Pendimethalin is an herbicide that is applied preplant incorporated in peanuts. It is used primarily for the management of weeds such as Florida pusley, pigweed, hairy indigo, crabgrass, goosegrass, johnsongrass, and Texas panicum. It is applied to approximately 50 percent of Floridas peanut acreage at a rate of 0.8 lb ai/A (12). The price of pendimethalin is approximately $8 per pound of active ingredient, and the approximate cost of a maximum labeled application (1.0 lb ai/A) is $8 (21,22). The REI is 24 hours and there is no stated PHI. Pendimethalin can be applied up to 60 days before planting, but it must be incorporated within 7 days of application.

During the years 2002 through 2004, Florida peanut growers have applied pendimethalin to between 49 and 50 percent of the crop an average of 1 time. Total annual use has ranged between 38,000 and 58,000 pounds of active ingredient (11,12).

ETHALFLURALIN. Ethalfluralin is also applied preplant incorporated in peanuts. It is used primarily for the management of weeds such as Florida pusley, pigweed, hairy indigo, crabgrass, goosegrass, johnsongrass, and Texas panicum. It is applied to approximately 50 percent of Floridas peanut acreage an average of 1 time, at a rate of approximately 0.75 lb ai/A (11). The price of ethalfluralin is approximately $10 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.94 lb ai/A) is $9 (21,22). The REI is 24 hours and there is no stated PHI. Ethalfluralin is mechanically incorporated into the soil as soon as possible after application and, to

prevent loss of herbicidal activity, is not delayed more than 48 hours after application. Total annual use in 2002 was 26,000 pounds of active ingredient (11).

S-METOLACHLOR. Metolachlor is used at the planting or cracking stage primarily for pigweed, crabgrass, goosegrass, Florida beggarweed, and Florida pusley management. It is applied to approximately 30 percent of Floridas peanut acreage. The price of s-metolachlor is approximately $15 per pound of active ingredient, and the approximate cost of a maximum labeled application (1.3 lb ai/A) is $20 (21,22). The REI is 24 hours and the PHI is 90 days. From 2002 to 2004, total annual use has ranged between 27,000 and 51,000 pounds of active ingredient (11,12).

PARAQUAT. Paraquat is used at the cracking stage for non-selective weed control. Although paraquat used to be applied to 100 percent of Floridas peanut acreage, the number of farmers using it has decreased. In 2002, approximately 80 percent used paraquat at cracking and it is estimated that this value is closer to 50 percent currently. It is used one time, at a rate of approximately 0.13 pounds of active ingredient per acre per season (11,21). At a price of $20 per pound of active ingredient, the approximate cost of a maximum labeled application (0.25 lb ai/A) is $5 (18,22). The REI is 12 hours and there is no stated PHI. Total annual use is approximately 8,000 pounds of active ingredient (11).

IMAZETHAPYR. Imazethapyr is used at planting primarily for nutsedge, wild poinsettia, pigweed, morningglory, cocklebur and bristly starbur management. Imazethapyr is one of the most effective herbicides for management of wild poinsettia, wild radish, and pigweeds (21). In 2004, it was applied to approximately 40 percent of Floridas peanut acreage at a rate of 0.06 lb ai/A (12). The price of imazethapyr is approximately $230 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.063 lb ai/A) is $15 (21,22). The REI is 4 hours and there is no stated PHI.

During the years 2002 through 2004, Florida peanut growers have applied imazethapyr to between 5 and 43 percent of the crop an average of 1 time. Total annual use has ranged between 250 and 4,000 pounds of active ingredient (11,12).

IMAZAPIC. Imazapic is a post-emergence weed management herbicide used in peanut production. It is used primarily in the management of nutsedge, but it also suppresses weeds such as brisly starbur, cocklebur, Florida pusley, morningglory, pigweed, sicklepod, hairy indigo, crabgrass, goosegrass, johnsongrass, and Texas panicum. In 2002 and 2004, it was applied once to 47 percent of Floridas peanut acreage (11,12). The price of imazapic is approximately $280 per pound of active ingredient, and the approximate cost of a maximum labeled application (0.063 lb ai/A) is $18 (21,22). The REI is 12 hours and the PHI is 90 days. Total annual use is approximately 1,000 pounds of active ingredient (11,12).

GLYPHOSATE. Glyphosate has become another widely used herbicide for non-selective clean up at planting. In 2002 and 2004, it was applied once to 44 percent of Floridas peanut acreage (11,12). The price of glyphosate is approximately $10 per pound of active ingredient, and the approximate cost of an average labeled application (0.63 lb ai/A) is $6 (12,22). The REI is 4 hours and there is no stated PHI for peanut. Total annual use ranges from 28,000 to 54,000 pounds of active ingredient (11,12).

2,4-DICHLOROPHENOXY BUTRYIC ACID (2,4-DB). 2,4-DB is a postemergent herbicide used primarily for broadleaf weed management. 2-4-DB is one of the better treatments for the management of sicklepod. It is applied to roughly half of Floridas peanut acreage one or two times at a rate of approximately 0.25 pounds of active ingredient per acre per season (12,21). The price of 2,4-DB is approximately $12 per pound of active ingredient, and the approximate cost of an average labeled application (0.25 lb ai/A) is $3 (21,22). The REI is 48 hours and the PHI for peanut is 30 days. Total annual use ranges from 18,000 to 44,000 pounds of active ingredient (11,12).

BENTAZON. Bentazon is an at cracking applied herbicide used primarily for management of weeds such as nutsedge, bristly starbur, cocklebur, pigweed and morningglory. Bentazon, included as a tank mix with paraquat, will reduce damage to the

peanut plant from the cracking time herbicide application. Its use has declined in tandem with paraquat. In 2004, bentazon was applied to 31 percent of Floridas peanut acreage an average of 1.5 times, at a rate of approximately 0.5 pound of active ingredient per acre (12). The price of bentazon is approximately $20 per pound of active ingredient, and the approximate cost of an average labeled application (0.5 lb ai/A) is $10 (21,22). The REI is 48 hours and there is no stated PHI for peanut. Total annual use ranges from 18,000 to 33,000 pounds of active ingredient (11,12).

CHLORIMURON. Chlorimuron is a postemergent herbicide typically used in peanuts to manage larger weeds (up to 10 inches) late in the season. It is used primarily in the management of Florida beggarweed, but it also is used in the suppression of hairy indigo, Florida pusley, morningglory, pigweed and sicklepod. In 2004, chlorimuron was applied to 20 percent of Floridas peanut acreage an average of 1.1 time, at a rate of approximately 0.01 pound of active ingredient per acre (12). Chlorimuron cannot be applied until 60 days after the youngest peanut plants have emerged. The price of chlorimuron is approximately $700 per pound of active ingredient, and the approximate cost of a recommended maximum labeled application (0.008 lb ai/A) is $6 (21,22). The REI is 12 hours and the PHI for peanut is 45 days. Total annual use is under 500 pounds of active ingredient (11,12).

CLETHODIM. Clethodim is a postemergent herbicide used primarily for crabgrass, goosegrass, johnsongrass and Texas panicum management. In 2004, clethodim was applied to 24 percent of Floridas peanut acreage an average of 1.4 times, at a rate of approximately 0.14 pound of active ingredient per acre (12). The price of clethodim is approximately $100 per pound of active ingredient, and the approximate cost of a recommended maximum labeled application (0.25 lb ai/A) is $25 (21,22). The REI is 24 hours and the PHI for peanut is 40 days. Total annual use ranges from 3,000 to 7,000 pounds of active ingredient (11,12).

SETHOXYDIM. Sethoxydim is also a postemergent herbicide used primarily for crabgrass, goosegrass, johnsongrass and Texas panicum management. In 2004, sethoxydim was applied to 10 percent of Floridas peanut acreage an average of one time, at a rate of 0.12 pound of active ingredient per acre (12). The price of sethoxydim is $48 per pound of active ingredient, and the approximate cost of a recommended maximum labeled application (0.47 lb ai/A) is $23 (21,22). The REI is 12 hours and the PHI for peanut is 40 days. Total annual use ranges from 2,000 to 3,000 pounds of active ingredient (11,12).

ACIFLUORFEN. Acifluorfen is an at-cracking/postemergent herbicide used primarily for management of Florida pusley, hairy indigo, Florida beggarweed, cocklebur and pigweed. In 2004, acifluorfen was applied to 25 percent of Floridas peanut acreage an average of one time, at a rate of 0.38 pound of active ingredient per acre (12). The price of acifluorfen is $35 per pound of active ingredient, and the approximate cost of a recommended maximum labeled application (0.38 lb ai/A) is $13 (21,22). The REI is 48 hours and the PHI for peanut is 75 days. Total annual use ranges from 4,000 to 14,000 pounds of active ingredient (11,12).

Nematode Management

Plant-parasitic nematodes are microscopic roundworms found in soil. General symptoms of nematode damage 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 (23).

Nematode Pests

Peanut Root-Knot Nematode. The peanut root-knot nematode (*Meloidogyne arenaria*) is the most serious nematode pest of peanut in Florida. It attacks peanut roots, pegs and pods throughout the season, stunting plants and reducing yields. Increased pod rot often is associated with root-knot nematode galls. Infestations of peanut by root-knot nematode can increase the severity of white mold and other soil-borne diseases. Controlling this nematode in sandy soils often increases yields by more than 1,000 pounds per acre. Juvenile root-knot nematodes are found throughout the year, and along with eggs constitute the major survival stage. Juveniles can

then infect the plant soon after planting. Soon after blooming and initiation of pod set (45 days post planting), root-knot juveniles may infect pegs and pods. Early infection may result in a weakened peg so that pods are lost in the soil or fall off during harvesting. Shells of pods that set may become heavily infected and extensively galled late in the season, resulting in drastic yield losses. Peanut plants are especially vulnerable to nematode infection late in the season, thus making it one of the most challenging crops for practicing nematode management techniques (23).

Lesion Nematode. All life stages of the lesion nematode except the egg and males are infective. The nematode may penetrate anywhere on peanut plants roots, pegs or pods. Lesion nematodes (*Pratylenchus brachyurus*) can suppress yield by several hundred pounds per acre by injuring pegs so severely that pods break off from the plants when they are turned up at harvest. The lesions these nematodes cause also can increase pod rot (5).

Ring Nematode. Ring nematodes (*Criconemella* spp.) are sometimes associated with reduced peanut yields. This nematode feeds on the outside of roots by thrusting its long stylet into the root tissue.

Non-Chemical Management

Nematode Monitoring and Field Choice. Peanut should be planted only in fields with the best yield potential. Fields with unusually high risks of nematode or other pest and disease problems should be avoided. To determine the suitability of each field for planting peanut, the producer should know which nematodes are present and their severity. Nematode infestations should be mapped based on symptoms seen on susceptible crops and laboratory assay of nematode samples. Both are required to have the best information regarding nematodes present and their distribution.

Field Mapping. The best information about distribution of nematode populations comes from records from previous seasons. A field map based on direct observations in the field provides far better information about nematode distribution than one based on a few nematode samples. Root-knot nematodes are readily monitored by observing root-knot galling of peanut roots/pods and lesions caused by lesion nematodes near the end of the growing season. Root-knot nematodes cause galls on many plants that make it easy to map their incidence in the field. However, to be sure that a population can damage peanut, galls must be seen on peanut. Identification of the peanut root-knot nematode species is relatively easy in the laboratory, but host race 1 of the peanut root-knot nematode (infects peanut) is not separated easily from host race 2 (does not infect peanut); they look identical under the microscope. Race separation depends on their ability to infect peanut plants. Lesion nematodes cause dry, brown lesions on roots, pegs and pods of peanut. Pod lesions caused by pathogenic fungi usually are larger and not as discrete as those caused by lesion nematodes.

Sample Analysis. Identifying the nematodes associated with a problem in a field and their relative numbers depends on analysis of soil and root samples by a nematology laboratory. Samples of soil and roots are best taken in the autumn or early winter, shortly before or after harvest of crops. Samples taken later, up to 1 month before planting, can help identify the kinds of nematodes present, but are less useful for detecting problematic levels of nematodes or predicting damage (23).

Economic Damage Threshold Determination. University experiments have been conducted to determine the relationship between yield of peanut and preplant peanut root-knot nematode densities. In three tests, 1-5 nematodes per pint of soil resulted in 10 percent pod losses, and thresholds for plant damage were 0-1 nematode per pint of soil. The latter is at the limit of detection. Since the tolerance limit of peanut to the peanut root-knot nematode in most seasons is quite close to the limits of detection, it is critical to sample whenever chances of detection are greatest. The final population density (nematode numbers) at or near harvest of the previous crop provides the best opportunity to detect peanut nematodes (23).

Crop Rotation. Peanut should follow poor hosts of peanut root-knot nematode, such as winter small grains (avoid wheat because it is a very good host for the peanut root-knot nematode) or pasture grasses.

Peanuts following crops such as tobacco or vegetables should be avoided. Field corn is only fair for reducing root-knot nematode populations but is better than continuous peanut. Grain sorghum appears to suppress root-knot nematode population densities 2-4 times better than corn. Cotton fits well in rotation with peanut, since the peanut root-knot nematode does not live on cotton, and the root-knot nematode that infects cotton does not live on peanut. Several years of bahiagrass have long been recognized as one of the best rotations to precede peanut. However, control of weeds in a bahiagrass planting is essential. Hairy indigo, alyceclover, and morningglory are a few common weeds that are good hosts for peanut root-knot nematode. Long rotations of three or more years out of peanut and other favorable hosts are better than one- or two-year rotations. Rotation should not be expected to reduce a root-knot nematode population abruptly because:

- Some of a nematode population will survive the winter without a host;

- Most crop plants can support at least a little nematode reproduction; and,

- Most fields have some weeds that support nematode reproduction.

Crop rotation is a far better tool to help keep relatively low populations from getting too high, or to gradually reduce high populations over several years. Unfortunately, rotations are of little value for reducing lesion nematode numbers, because the nematode lives well on many different crops, including most grass family crops, soybean, most vegetables, and cotton.

Fallowing. Fallow (leaving a field unplanted to reduce pests through lack of host plants on which to live) is often tried as an alternative to planting and maintaining an unprofitable rotation crop. Theoretically, it should reduce nematodes and other pests or pathogens that must feed on living plants. However, fallowing has several limitations as a nematode management practice. First, it is rare that a fallow field is truly lacking plants on which nematodes can live; volunteer plants from previous crops and weeds usually appear in the field. Thus, factors that reduce the effectiveness of rotation also can apply to fallow. If the field is kept practically free of potential host plants by some combination of chemicals and cultivation, the cost is likely to approach the cost of nematode control by chemical means, and there are likely to be serious losses of soil organic matter and perhaps heavy erosion because of wind storms or heavy rains during prolonged fallow periods.

Crop Destruction. After harvest, destroy roots of the preceding crop as promptly as possible, to interrupt reproduction of nematodes and other pests that could otherwise continue to reproduce on the old plants and any weeds that are present. Shredding crop residues, as by disking, also initiates decay of plant roots so that nematodes in them will be exposed to natural control agents in the soil and to nematicides.

Winter Cover Crops. A small grain cover crop can help prevent growth of weeds that are hosts of peanut nematodes and will help protect the soil from erosion during the winter. However, small grains planted while the soil is warm enough (above 65 ^{o} F) for root-knot nematodes to infect new roots may support some nematode reproduction before temperatures drop in winter. Rye, triticale, most varieties of wheat, and barley can support root-knot nematodes; many varieties of oats support less or none. Root-knot nematodes may not increase their numbers in some of these grains, but overwinter decline of the population may be less than desired.

Tillage. Turn the land deeply at least four weeks before fumigation or before final land preparation. This buries surface litter, reducing some fungus diseases, and encourages decay of live plant roots (such as those of a winter cover crop and weeds) that could protect nematodes from their natural enemies or nematicides.

Chemical Management

Nematicides and other soil applied insecticides should be rotated in fields that are to be planted in succeeding crop years. Repeated applications of some soil applied nematicide-insecticides has led to the build up of bacteria and other microbes that rapidly degrade them. Other than aldicarb, very little nematicide is used in Florida peanut production. Use

of 1,3-dichloropropene and metam were reported by one percent of growers in 2002 (11).

Key Conctacts

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