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History of Row-Crop and Vegetable IPM Extension Programs in Florida[1]

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Background and History

From an agricultural standpoint, Florida has frequently been referred to as a natural greenhouse. Commercial food crops can be found growing somewhere in the state 12 months of the year. Numerous vegetables are grown over a wide area during all four seasons of the year. Citrus, avocados, mangos, pecans and other minor perennial fruits have been established over decades. The soil, turf and ornamental industry has grown rapidly to meet the needs of the state as well as national demands.

Florida has unique geography and climate. It is surrounded by the Atlantic Ocean on the east, and by the Gulf of Mexico on the west and along the southern coast of the panhandle portion of the state. The state has nearly 1,200 miles of general direct coastline, 2,276 miles of tidal shoreline, numerous miles of inlets, estuaries resulting in 8,426 miles of detailed shoreline, as well as other bodies of water. The temperatures are mild with few frost days even in the coldest areas and South-Central Florida seldom experiences temperatures below 32°F. The annual rainfall averages between 50-65 inches per year and can be unevenly spread over the year within the state (Morris, 1992). Due to these conditions, the entire state is capable of supporting agricultural commodities of one type or another. However, these factors also provide for a wide range of pest diseases, insects andother arthropods, nematodes and weeds, as well as slugs, snails, rodents and other mammals. These numerous species of pests may occur at high population levels, adding to the problems that the farmer encounters.

Insecticide Applications

More than any other time in history, the growers in Florida during the 1950s, 1960s, and early 1970s depended on pesticides to control their pest problems. This use is explained by a combination of variables and factors.

Availability of Pesticides

First, there was a wide range of insecticides, including chlorinated hydrocarbons, available. DDT, toxaphene, chlordane, endrin, aldrin and dieldrin

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were widely used on row crops as well as on fruits. During this period, a number of organophosphorus insecticides entered the market place. Parathion (ethyl), methyl parathion, diazinon, malathion, azinphosmethyl, dimethoate and other organophosphorus insecticides were widely used. These aforementioned materials were broad-spectrum in their activity for both foliage- and fruit- feeding insects, as well as soil-borne insects and arthropods. A grower could control a wide variety of target insects easily with the application of a single insecticide.

Low-Cost Pesticides

Second, during this period the cost of insecticides and applications was relatively low. Competition between basic producers, distributors and dealers of pesticides was keen and growers enjoyed a 'buyer's market.' At the same time, energy sources in the form of gasoline and diesel fuel were inexpensive, while competition was strong between manufacturers of tractors and spray application equipment. As a result, the relative cost of pesticides and their application was lower than during the mid-1970s when the experienced the energy crisis led to higher equipment and chemical costs.

No Economic Thresholds

Prior to the mid-1970s there were few, if any, economic thresholds available for insect pests found in the state. Consequently, each grower decided when to make insecticidal applications based on past experiences and the ability of the pest in question to feed, damage or destroy a crop. Many applications were based on fear of pest damage, not on knowledge concerning sampling and insect population assessment. Many growers used insecticides more on a preventative schedule than on need. Inspection of fields was basically to establish the presence or absence of insect pests. Presence, even at a low level, was enough to warrant a spray or series of spray applications. The general philosophy existed that "if there's one worm, there are bound to be more," or "one is one too many." Therefore, applications would be made whether needed or not.

High Disease Threat

The crop disease situation in Florida was another reason for numerous applications of insecticides. As previously indicated, the climate encouraged numerous pathogenic diseases of crops, particularly vegetables. The disease potential was, and continues to be, a threat and often required fungicide and bactericide applications on a regular preventative schedule (Agricultural Usage, 1991). Many growers added insecticides to the fungicide tanks as a preventative measure, since the cost wouldn't be that much greater. In the case of vegetable disease control and/or prevention, growers would spray on a calendar basis (e.g., for fresh market tomatoes approximately three applications per week). The addition of insecticides to the tank mix became routine, particularly with conservative growers.

High Production Cost

The high dollar value of the crops was another reason for what was termed 'insurance use' of insecticides. Florida was/is a state that produces a significant volume of the winter vegetables marketed in the U.S. (Florida Agricultural Statistics, 1991). These crops are planted sequentially over a large geographic area beginning in late July or early August, with the last plantings harvested by about June first (Tefertiller, 1983). Although insect problems may decline during the cooler winter months, plants are often exposed to high pest insect populations in the fall and spring months when the weather is a great deal warmer.

The overall cost of production of fresh market crops is very high (Smith and Taylor, 1991). Most growers indicated that they did not want to "take a chance" on potential pest problems that could jeopardize their high dollar investment. Therefore their decision to spray in most cases could be termed liberal. Even though a cost was involved in using insecticides, it was a small percentage of the overall costs incurred in delivering their product to the market on a schedule which would meet the dates of expected demands (Johnson, 1992; Smith and Taylor, 1991).

Demand for High Quality

Another significant reason for pesticide use that has always existed is the pressure on the farmer to produce fruits, and particularly vegetables, that are considered to be cosmetically high in quality. Consumers are reluctant to choose any products that have blemishes, holes, spots or other damage caused by insects or diseases. Therefore, the consumer has always exerted a subtle buying pressure by choosing to buy or select the 'picture perfect' fruit.

Certain crops are also subjected to marketing orders that allow only a small percentage of product damage or insect numbers per given sample. If these levels are exceeded, the entire lot is rejected. This restriction can result in a tremendous dollar loss to growers, which is another reason why the crops inquestion are often sprayed on a regular calendar-type schedule. This type of spray operation reduces the loss due to pest damage, and provides the consumers with the high quality and cosmetic appearance they demand.

Florida vegetables are sold primarily in the form of fresh fruit (e.g. tomatoes, peppers, squash, cucumbers, melons, snap beans, etc.) (Tefertiller, 1983). The grower's tolerance or threshold for insect damage is literally zero when the crop reaches the stage where fruit formation begins. During this vulnerable period, caterpillars and other insects that concentrate their feeding on fruiting structures can extensively damage a crop within 24-48 hours. Growers act conservatively at this time because their investments of money, time, and energy are at a maximum. Thus they are much more likely to use a precautionary insecticidal application against insect populations that occur during the fruiting period, than when the crop is in a vegetative state and the overall crop cost inputs are at a lower level. This problem is not as serious to growers whose fruits are used for juicing or canning purposes.

Materials and Usage

During the 1950s, 1960s and early 1970s, new insecticides were entering the market on a regular basis. Emphasis by both research and extension entomologists was on testing and on providing the grower with recommendations and training. Instruction on the identification of pests was provided along with recommendations for the best insecticides available to control these pests. Other work often involved developing proper spray tactics that would deliver the insecticides to the target, i.e., by varying pressure, nozzles, etc. Growers were primarily interested in what was new and what material provided the quickest and best pest control.

Although there was entomological work being carried out involving biology, behavior, life cycles, damage and expected outbreak, there was little known about specific Integrated Pest Management tactics. Economic thresholds and the effects of insecticides on beneficial insects and arthropods, as well as the use of insecticides that had the least impact on these populations, were relatively unknown. Growers sought compounds that would not only be quick intheir actions, but that would kill 100% of a pest population. When lower doses did not accomplish this task, they simply increased the amount until the goal was accomplished or they were satisfied with the results. *Bacillus thuringiensis* compounds began to appear on the market in the late 1960s. Although this material was known to be considerably less harmful to the user and non-target organisms, it was not readily accepted because of its high cost, short shelf life, and problems with formulations that resulted in poor physical mixing characteristics.

Loss and Costs of Insecticides

One of the first events that signaled the need for the development of IPM was the advent of the U.S. Environmental Protection Agency (EPA). Due to EPA regulations, DDT was removed from the marketplace. Ultimately aldrin, dieldrin, endrin and other chlorinated hydrocarbon insecticides were also removed. At this point in time, some of the newer organophosphorus insecticides and carbamates appeared on the market, but were priced relatively higher than the older existing compounds.

The sharp increase in the cost of insecticides caused growers to become more aware of spray costs and subsequently to consider accepting lower dosage rates. Growers began asking, "can I get the job done with less insecticide and/or applications?" At about the same time (late 1960s - early 1970s), pesticide resistance began to show up in certain pest insects.

Dipterous leafminer populations, for example, could not be controlled with the once efficient organophosphorus materials. The growers of tomatoes, lettuce, and especially celery were particularly hard hit. The industry tried all available materials but none seemed to control the leafminer. The same situation was true of many ornamental and cut-flower growers. The leafminer problem began about 1974 and continues to be a serious problem today.

During the period when chlorinated insecticides were widely used, lepidopterous insects were one of the primary problems and targets of many vegetable and field-crop growers. With the loss of the chlorinated materials, insect pests such as leafminers and aphids started to become more and more difficult to control. Fear that the celery industry wouldcollapse from leafminer attack caused the University of Florida research and extension personnel to begin work on a celery IPM program. Progress was made in the areas of scouting, population assessment, and identifying beneficial complexes (particularly parasitic wasps that attack leafminers).

Research attention was given to interaction between celery fields and surrounding weed and other non-crop plants that might play a role in parasite population levels. The same attention was given to the interaction of other vegetables and crops grown in close proximity to celery. Management tactics for controlling leafminers were started in the seedling beds and carried through until harvest. The celery growers were desperate and thus were willing to try management practices that had not been used in the past. Although several celery growers went out of business, the industry was able to survive. Some of the practices that emerged from this situation were:

- improved crop scouting and monitoring from the seedling stage until harvest
- acceptance of less than 100% control of celery pests in the field
- better timing of insecticidal applications
- acceptance of using lower dosages of available materials
- alternation of insecticides as much as possible in the spray program
- the minimization of use of insecticides that were injurious to the existing beneficial arthropods

One of the most successful tactics was the switching from organophosphates and carbamates to *Bacillus thuringiensis* (Bt) for control of caterpillars. The use of Bt through the season controlled pests without harming beneficial parasites, allowing the grower to market relatively clean celery. However, it was not until the EPA approved the use of cyramozine (Trigard), an insect growth regulator, that the problem with leafminers diminished.

Tomato growers also began to use the same tactics in dealing with the leafminer explosion of the 1970s and early 1980s. Leafminers are still a serious problem today. Control can be impossible on crop hosts where the use of cyramozine and/or abamectin is prohibited. The leafminer problem was found to be highly related to wild hosts. These includesurrounding weed environments, nearby commercial plantings of other crops, and the types and use patterns of insecticides applied in the area. There is a need for more research in order to better understand the complexity of problems involving leafminers and cropping systems.

The IPM Movement

The progression toward integrated pest management has been very complex and affected by a variety of factors both directly and indirectly related to agriculture (Johnson, 1992; Hoeller, 1978). The interaction of these factors has played and continues to play a significant role in the progress of IPM. The following information is pertinent to the movement and implementation of IPM in the state of Florida. The University of Florida research, teaching and extension programs have recognized these factors and have taken steps to address these issues in the implementation process.

The Environment

Although the word environment has existed for a long time, its prominence and meaning were perhaps best brought to the attention of the public by Rachel Carson's book Silent Spring. Since that time, the term environment has taken on new meaning and is a very strong issue that reaches to the depths of politics.

Since the late 1960s, the public has been developing a stronger concern for the environment and its protection. Many politically-oriented action groups and organizations have been formed since that time. The goals and purposes of these groups range from concern for a single species to wide-reaching protection and management of large land areas. This movement is becoming worldwide and is a strong force in the U.S. The protection of subjects of environmental concern certainly affects, and is strongly related to, agricultural production. Florida is a state where there is a complexity of crops grown, pests encountered, and a wide range of chemical control measures utilized in the struggle to maintain efficiency and profitability in the overall agricultural industry (Agricultural Chemical Usage, 1991). Since pests and their control are an important segment in the overall production of food, fiber and plants of an ornamental nature, the use of pesticides and theireffects on non-target organisms and the environment is a major public issue.

Forests in Florida

Florida has within its boundaries several national and state forests such as:

- Apalachicola National Forest - 557,000 acres located in the northwestern panhandle section of the state.
- Ocala National Forest - 366,000 acres located in the north central part of the state
- Osceola National Forest - 157,000 acres in the north part of the state
- Everglades National Park - 1,400,533 acres located at the extreme southern tip of the state

State forests include (Marth, 1990):

- Blackwater River (west) - 183,153 acres
- Withlacoochee (central) - 113,000 acres
- Pine Log (west) - 6,911 acres
- Cary (northeast) - 3,412 acres

There are approximately 30 additional state parks and 50 or more recreational areas and ornamental gardens that are within the Florida boundaries (Marth, 1990). These forests and recreational sites attract high numbers of visitors each year and are areas supporting constant recreational activities. The public demand is that the environmental integrity of these areas be maintained.

Water Everywhere

Florida has an area of 58,560 square miles of which 4,308 square miles are water. The state has recorded 7,712 lakes which are named and have a minimum of 10 acres in surface area. Lake Okeechobee is located in the center of south Florida and is 448,000 acres in size. It is the fourth largest natural lake in the U.S. and the second largest fresh water lake located entirely within a single state. Florida has 1,711 rivers and streams that serve as drainage for thousands of square miles and, along with numerous lakes, provide for fishing and recreation. The total length of all streams is approximately 10,550 miles (Morris, 1992).

The state also has large estuarine areas where fresh and salt water mix. Bays, lagoons and shallow waters provide an environment that is extremely rich in a wide range of flora and fauna. These warm and sub-tropical waters provide for an abundance of animal and plant life that cannot be found anywhere else in the U.S. The estuarine environment is not only highly productive, but it serves as a filter to clean the waters from waste, runoff and pollutants. Sea grasses growing below the tidal zone cover between 600,000 and 900,000 acres of submerged bottom. Mangroves are subtropical shrub-like trees that grow between tidal zones and cover over 500,00 acres. Salt marshes make up another 450,000 acres (Morris, 1992). The state government as well as the environmentalists are greatly concerned with protecting the state's estuaries, mangrove swamps and marsh lands from any additional damage, pollution or disruption. Florida also has one of the two existing marine sanctuaries in the United States. The Key Largo Coral

Reef Marine sanctuary was established in 1972 to safeguard the fragile coral life within its waters.

Animal Life

Almost 90% of Florida was covered with forests at one time. Very little if any of this virgin timber is left, with almost all of the current pine timber being second or third growth. About 50% of the state remained forested land in 1991. Florida's mixed vegetation of sub-tropical and temperate plants makes it somewhat unique. Nearly half of the species of trees native to the United States are found in Florida. Such diversity provides for a wide variety of animal life. Some of the mammals found include black bears, bobcats, coyote, mink, panthers, key and white tail deer, fox, opossum, raccoons, West Indian manatees and numerous species of bats. Major species of reptiles and snakes include alligators, crocodiles, and gopher tortoises. Five species of sea turtles can be found in coastal waters (leatherback, green, loggerhead, Kemps Ridley and Hawksbill) (Marth, 1990).

Numerous species of snakes, both venomous and non-venomous, are indigenous to the state. Birds of all sorts abound within Florida. Pelicans, cranes, eagles, egrets, hawks, herons, kites, ospreys, owls, quail, vultures, wild turkeys, wood storks, woodpeckers and numerous species of songbirds live in the varied habitats. The state also provides a refugefor many migratory birds such as geese, ducks and dove (Marth, 1990).

The rapid growth in population, tourism and industry in Florida within the last 50 years has created a strong concern about the welfare and survival of its animal life. Federal and state protection activities as well as environmental action groups have greatly increased their activities to protect these animals. Public awareness and interest in animals and their place in the environment has strengthened, particularly in the past 20 years. Currently there are 20 mammals, eight birds, three fish, six reptiles and four invertebrates on the endangered species lists. There are four mammals, 10 birds, three fish, and ten reptiles on the threatened species list, as well as six mammals, 18 birds, 10 fish, 13 amphibian/reptiles, and four invertebrates, on the Species of Special Concern list http:www.wildflorida.org/species.Endangered-Threatened-Special-Concern-2004.pdf

Water and Pollution

More than 7% of the area of Florida is water (Marth, 1990). Due to its geographic shape, no part of the state is more than 60 miles from saltwater. Thirty-five of its 67 counties have a border either on the Atlantic Ocean or the Gulf of Mexico.

Concern about water pollution is rapidly reaching into all levels of industry, recreation, tourism, and homeowner life. This subject also is tied closely to the environment. Agricultural pollutants in the form of pesticides and fertilizers are of particular concern. Measures are being taken to not only limit the surface runoff of pesticides and fertilizers, but to minimize the leaching of these materials through the soil. Because agriculture is a large and viable part of the economy of Florida, there is constant reassessment of its methods and how the chemicals used in the industry affect the water table, lakes and streams, estuaries, wetlands, bays and other aquatic environments (McCown and Gerber, 1973).

The Terrain

The state's highest point is only 345 feet above sea level. The landforms of the state are divided into four sections:

- The Northwest Plateau and Tallahassee Hills - this original flat upland is dissected by many streams.
- The Central Highlands - a mixture of flat land and hills in which are found many lakes and sinkholes. The four ridges bordering the area are ancient beach ridges.
- Coastal Lowlands - composed of low-lying flatwoods cover.
- Southern Lowlands - a swamp sink type flatland. Former beach ridges paralleling the coast are found many miles inland.

Florida soils are sandy in nature and overlay limestone with few exceptions. The water table is relatively shallow. Drainage in such soils is good.

Leaching occurs readily and plant nutrients and many chemicals are moved down through the soil profile quickly. Nutrients must be replaced frequently in order to supply needed and timely supply to crops. Excellent drainage, good soil aeration and tilth, coupled with the climate allows agriculture to be one of the state's most prosperous industries. There are eight basic soil types in Florida:

- Western Highland Ultisols - Level to sloping loamy and sandy soils that are well-drained. They are used primarily for field crops, pastures, and forestry.
- Western Highlands Untisols - Nearly level to sloping thick sands that are excessively drained. They are used for field crops, pasture, and forestry.
- Central Ridge Entisols - Nearly level to sloping thick sands used for field crops, watermelons, and citrus in the southern geographic regions.
- Central Ridge Alfisols and Ultisols - Gently sloping, well-drained sand with loamy subsoils underlain by phosphatic limestone. These soils are used for field crops, tobacco, vegetables, pasture, and citrus in southern regions.
- Flatwoods Spodosols - Nearly level and relatively poorly-drained sandy soils with a dark sandy, highly-compacted subsoil known as a hardpan layer. These are used primarily for pastures and forest products, but when managed properly vegetables ornamentals and citrus can be grown. These are the predominant soils in the state, but due to poor drainage they are less desirable for homesites.
- Soils of Organic Origin - Level, very poorly-drained organic soils underlain by marl or limestone. The soils are excellent for the production of sugarcane, vegetables, pasture and sod. They are located around and primarily south of Lake Okeechobee in the southern central part of the state. These soils are not desirable for homesites and urban development.
- Soils of Recent Limestone Origin - Level marl and sandy soils underlain by limestone. They are used for winter vegetables and subtropical fruits and citrus. They are found in the southernmost part of the state
- Miscellaneous Coastal - Beaches, tidal marshes and swamps. Used for recreation support of wildlife and water management (Marth, 1990).

Sinkholes

Sinkholes are relatively common in Florida and are classified into two types: solution and collapse sinkholes. Both occur as a result of natural erosion of the underlying bed of limestone. *Solution sinkholes* occur most frequently where overlying soil touches the limestone. As the limestone erodes the surface soil sinks, gradually forming a bowl-shaped depression. Water may fill in the sunken area. *Collapse sinkholes* are usually more violent and outstanding. They occur when an underground cavern can no longer support the weight of the soil above it and a hole opens suddenly.

Groundwater levels play a vital role in sinkhole development. Periods of prolonged drought result in low water levels in the supporting limestone and, due to the loss of buoyancy, water pressure and gravity will prompt a collapse. Also, sinkholes can occur because of active water movement and added pressure on weak joints and cracks brought about by heavy rains. Any area in Florida is capable of having sinkholes and excessive pumping of water during a drought adds to the occurrences. Each year, 300-400 new sinkholes are reported while an estimated 4,000 go unnoticed. Many are less than 20 feet wide and occur in isolated areas. The largest may reach a diameter of 300 feet and be 100 feet deep.

In recent years, there has been a great deal of concern about fertilizer and pesticide use in close proximity to sinkholes. Since the sinkholes often arethe lowest level in surrounding lands, they serve as a funnel for contaminated surface runoff and provide a more direct route of these materials into underground aquifers and streams.

Florida's water needs are provided primarily by groundwater reservoirs called *aquifers*. The state has six primary aquifers. Wells tapping into these aquifers can yield from several hundred up to 10,000 gallons per minute depending mainly on size, depth and location. Aquifers are recharged by rainfall and other forms of drainage. These water-holding reservoirs are subject to outside contamination as well as saltwater intrusion.

Water Management

Although studies reveal that Florida has more available groundwater than any other state, as its population mounts competition and concern over this resource increase. Many counties have already instituted water rationing when the measurable water table drops below certain levels. The demand for water is steadily increasing. Irrigation is the largest overall use of Florida's fresh water. It is used on citrus, field and vegetable crops, as well as for growing turf and many other plant uses. In 1980, Florida's water requirements to support human needs were increasing at very high rates. Concern and awareness of current and future water problems are also increasing (Marth, 1990).

The state water supplies are overseen by five water management districts that monitor growth trends, consumption, and conservation. These districts are powerful forces that set policy governing water use. Citizens are becoming very protective of rivers, lakes and wetlands. Their efforts have resulted in strenuous rules being set in place concerning the seepage or leaching of pesticides into ground water. Within the last several years some pesticides have been removed from the market or their use highly restricted as a result of their residues showing up in samples from wells. Other pesticides have had to add special warnings to their labels warning of potential leaching into groundwater (Johnson, 1992).

Wetlands

The concern for pollution and protection of water recharging systems extends to Florida's wetlands. Wetlands are ecosystems that are periodically inundated by fresh or salt-water. Such areas are known as swamps, bogs, marshes, cypress ponds, prairies, flood plains, river swamps, hammocks and other overflowed lands. These are crucial habitats for fish and wildlife, providing sources of food and breeding areas. They shelter and protect a number of known endangered species. Wetlands also play an important role in improving water quality by making nutrients available, filtering toxins, and protecting against erosion. They are also important in collecting flood runoff and in water storage.

It has been estimated that between 1850 and 1973, Florida lost 60% of its wetlands. During this period of time, many state laws favored and provided for drainage of land areas. This action created farm land, developments and roads, and generally tried to make the area 'productive.' Within the last 20 years there has been a considerable effort to change the drainage approaches used in the past. The state has provided strenuous laws that regulate wetlands and any damage, building, or polluting that may interfere with their natural beneficial functions (Marth & Marth, 1990; Morris, 1992).

Natural Springs

In addition to the lakes already mentioned, part of the overall water environment includes natural springs. The springs are a result of the underground aquifers and the pressure on the water contained within them. When deep fissures occur that run 100 or more feet below the ground surface, artisan springs are the result. High volumes of water are released at these natural openings. There are 320 known springs in Florida, found in 46 of the 67 counties. Twenty-seven of these springs are classified as first magnitude types because water flows from them at a rate of at least 100 cubic feet per second. Several first magnitude springs have an average flow rate of over 500 cubic feet of water per second. The combined water flow of the total springs in the state is approximately seven billion gallons per day. Springs also occur within many lakes and serve as a source of water needed to maintain normal levels. These lakes are known as 'spring fed' types. The springs, like other water sources, providefor recreation and are tourist attractions. There is constant effort to keep the springs pure and free of damage (Marth, 1990).

The efforts to protect Florida's water, both surface and sub-surface types, from numerous types of alteration, damage, and pollution have become well known in the last 20-25 years (McCown and Gerber, 1973). A trend to continue these actions and perhaps strengthen their protection is expected in the future. Evidence of water ecosystem protection can be found in the Florida Aquatic Preserve Act of 1975 (Marth, 1990; Morris, 1992).

Urbanization

By the time Florida attained statehood in 1845, the population was at 65,500. By 1900, it had reached 530,000. Florida's population reached 1,000,000 between 1920-1930. In 1987 Florida became the fourth most populous state, ranking only behind California, New York and Texas. Florida has gained 2,000,000 inhabitants since 1980. The current daily gain rate is estimated at approximately 900, with the 2000 Federal Census reporting a population of about 15,982,000. As of 1987, Florida had seven of the nation's ten fastest growing metropolitan areas. Florida has more people than Norway, Sweden, Switzerland or Austria and has about the same population as Cuba, Greece and Belgium. This growth has occurred primarily since 1950, when it ranked number 20 in the U.S. with a population of 2,771,000 (Morris, 1992).

Of all 67 Florida counties, only a small rural county in western Florida showed a loss (-1.1%) in population from 1980-1990. There were 15 counties, however, that increased over 50%, with the state as a whole increasing by 33.4% (Morris, 1992).

The population of Florida has shifted toward the southern part of the state since 1900. At the turn of the century, 66% of Florida's population was in the rural northern and western part of the state. Twenty-nine per cent was located in central Florida and 5% in south Florida. In 1930 the figures were north and west, 41.3%; central 41.3%, and south 17.4%. By 1950 the percentages were north and west 34.3, central 38.0 and south 27.7%. In 1980 the populationwas north and west 20%, central 43%, and south 37% (Morris, 1992).

The southern part of the state with its almost frost-free, warm, sub-tropical climate has been attractive to new residents, particularly since WWII. Also for many years Miami was a major center for winter tourists. Since Miami had both a deep water port and an international airport, it became a center for travel and business operations into the Caribbean Islands, and Central and South America. As a result of climate and location a significant percent of its population is of Spanish and Island (Caribbean) descent. Dade County (in which Miami is located) had a population of 1,437,094 in 1990, although less than 300 people occupied it in 1898 (Morris, 1992).

The growth in the central part of the state has been steady. It still contains the largest portion of the population of the state's three regions. Some of the reasons for this are central Florida's mild climate, numerous lakes and streams, many business centers, and a great deal of industry (including the large phosphate and citrus production operations). Tampa Bay and the warm beaches of the Gulf of Mexico have also been major influences. The central Florida area has good water drainage and does not contain a large percentage of low-lying swampy lands unfit for building (Marth, 1990).

Tourist attractions like Disney World, Epcot Center, Universal Studios, the Space Center, Busch Gardens and the beaches of Daytona contribute to growth in the central part of the state by creating jobs. The Tampa Bay area, with its deep water port, has been a busy shipping center for years. The central Florida area also has two large inter-national airports located at Orlando and Tampa (Marth, 1990). North Florida's population percentages as compared to the other areas of the state have dropped over the years, but populations have increased in the area. The area has a deep water port and large airport at Jacksonville. It contains the state capital at Tallahassee and another sea port at Pensacola, located at the extreme western border of the state. This section of the state has many small rural counties and towns. There are numerous forests and timber-related industries located throughout the region (Marth, 1990).

This area has five major state universities located within its boundaries and several large military installations. The northern part of the state was settled first, primarily for farm and timber activities. Counties in north Florida were formed during the 1820s, central Florida counties in the 1830-80s, and the southern counties from 1900-1925 (There were a few exceptions where seaports, transportation and agricultural centers were located) (Marth, 1990).

Florida has long been a state popular with retirees. Those 65 years and over constitute 17.8% of Florida's population - the largest proportion of any state. Three counties have a median age of more than 50 years. Florida's population also has the highest median age (36.3 years) of any other state. Nearly two-thirds of the state's new residents since 1955 came from the states of New York, New Jersey, Ohio, Illinois, Pennsylvania, Michigan and Georgia. The percentage of retirees moving to Florida is about double that of the overall state growth rate. The counties along the Gulf Coast are popular with retirees and have a much higher population density. Pinellas county, for example, has a population density of 2,759 persons per square mile. Some of the northwestern counties of Florida have less than 20 persons per square mile (Morris, 1992).

Florida is considered a popular state in which to reside because of its tax structure. It is one of the few states which does not have an income tax. There is also a $25,000 homestead exemption for homeowners. Sales tax is 6%, but does not include medicine, or food purchased for self-preparation. The state has no inheritance tax. Automobile license and tag fees are relatively cheap compared to most states (Morris, 1992).

Florida is a popular tourist state because of its many attractions, miles of sandy beaches, and warm winter climate. It depends on this industry for a large part of its income. In 1989, the Florida Department of Commerce reported that the state had 38,712,303 tourists. In 1991 it was estimated to be over 40 million. They enter the state equally via auto and air travel. The Department of Business Regulation reported a total of 28,534 licensed lodging establishments with over one million available rental units, and nearly 50,000 public food establishments with a seating capacity of nearly 3,000,000 patrons. Approximately 30% of Florida's employment is connected with the service industry (Morris, 1992).

Florida crops are grown along the coasts and in the warm winter regions of the state which are the areas most popular to tourists. In certain areas of highly populated south Florida, houses and tourist attractions often border winter vegetable fields and subtropical fruit and citrus groves. Palm Beach County, for example, is one of the top agricultural production areas of the U.S. There is increasing concern when farm operations and the use of chemicals must take place in close proximity to people (Johnson, 1992).

Field Labor

Since Florida's agriculture is composed of numerous vegetables, as well as a variety of citrus crops and sugar cane, there is a large demand for field labor. The high value of these crops requires a great deal of hand labor in the production as well as in the final harvesting stages. Much of the labor force is migratory or what is termed 'off-shore' labor. These people come from many different areas and often are poorly educated and unable to read English or to communicate effectively. There has been a great deal of public, government, and grower concern about their welfare and exposure to agricultural chemicals, particularly within the last two decades. Efforts have been made from many levels of the industry to protect farm labor from the residual effects of pesticides. Educational programs have been implemented along with more strenuous labeling of pesticides. Time required between spraying and reentry into the field and worker dress codes have become more specific, as have warnings such as the use of posted signs in treated fields involving certain designated pesticides. There have also been many new rules and regulations put in place in the last 20 years involving spillage, proper storage, and exposure of laborers to hazardous farm chemicals. Currently, new programs are being planned for improved and more intensive training of agricultural workers. The political concern over farm safety and the exposure of agricultural workers to pesticides and pesticidal residues has been a driving force in seeking better and safer methods with which to deal with this problem. This has led to a new appreciation, need, and understanding of the IPM concept (Johnson, 1992).

Costs and Liability

As indicated earlier in the text, grower costs have increased dramatically since the energy crisis of the early 1970s, and this includes the protection of crops against pests (Smith and Taylor, 1991). The costs of introduction of new pesticides to the market have increased considerably due to the increased testing required to meet the complexities of performance, health hazards, residue tolerances, effect on the environment, contamination potentials to water and other non-target areas, and other requirements of governmental agencies. The cost of pesticide application, including equipment and labor, has also increased dramatically at the same time. The growers are becoming more concerned about the recovery of costs and the positive economic benefits gained when they apply pesticides (Johnson, 1992; Pohronezny 1983).

The U.S. government passed laws in the late 1970s that require training, testing, and licensing of individuals (farmers or other commercial applicators) before they can purchase or apply pesticides designated as restricted. The restricted pesticides are those considered hazardous to the users or the environment, highly toxic, or otherwise dangerous. The Cooperative Extension Service was given the responsibility for creating educational literature and materials, teaching, and testing the clients to meet the demands of this program. The materials are comprehensive in nature and include pest identification, basic biology, safety, chemical and non-chemical control formulations, calibration, and a multitude of additional subject matter needed to accomplish the goal. Upon completion of training, the potential user has to pass a comprehensive examination prepared by the Extension Service that thoroughly covers the subject matter. The provision of training and development of materials for the project has been primarily the responsibility of university-based extension specialists. The distribution and delivery of training materials is carried out by strategically located county extension staff.

The Florida State Department of Agriculture is in charge of fees and issuing licenses. The state requires that a user must undergo additional training on a periodic basis to renew licenses. The Extension Service is responsible for providing newand updated training in the form of written and visual materials, as well as in service training lectures on approved or related subject matter. The state has approved a program for renewing restricted permits requiring the recipient to attend and receive a number of Continuing Educational Units (CEU) credits over a specific time period as an alternative to purchasing written materials, or the recipient can review and study visual packages and pass a written exam.

This program requires a great deal of time, study, and the expenditure of minimal funds in order to obtain the permits. A large portion of the training, whether the recipient chooses the CEU or the written literature method, places a strong emphasis on a wide variety of IPM concepts. These include tactics and schemes related to both chemical and non-chemical control of crop pests. The areas of training covered require the inputs by extension specialists from Agronomy, Horticulture, Entomology, Nematology, Plant Pathology, Soils, Agricultural Engineering and other related departments. This mandated program has played an important role in the awareness, need, and movement toward implementing IPM.

The liability of using agricultural chemicals has also played a significant role in the movement toward adopting many facets of the IPM process. These facets involve rules and regulations in which the user is responsible for correctly using pesticides. There are serious and significant fines (up to thousands of dollars) involved for use of any pesticide inconsistent with the label and its directions and instructions. There are also laws governing the responsibilities, liabilities and costs that are to be encountered in pesticidal spills, improper storage, improper transportation and misuse of pesticides. Intended use of certain pesticides must be pre-filed with the state and specific requirements met before they can be legally approved. An example of this is the application of Temik (aldicarb). The license holder is also liable and responsible for those agricultural workers that operate, apply, or deal with pesticides under their directions.

There are specific laws that deal with chemical trespass (i.e., pesticides that drift or move from the intended target onto either non-target sites or find their way onto property or areas outside the intended use). Lawsuits involving misuse, drift and chemical trespass have been numerous in the last 20 years and arebecoming more so. These suits and settlements can be very expensive.

Pesticidal liabilities may occur involving illegal residues. The premature reentry of agricultural workers into contaminated fields has caused serious problems and resulted in considerable fines and charges. The growers, of course, must use pesticides in such a manner as to ensure that pesticide residues on their crops do not exceed federally established allowable levels. Violation of these federally-mandated guidelines may result in the grower being prohibited from marketing the incorrectly treated crop or produce. The proximity of agricultural areas in Florida to densely populated urban, tourist, and business sites increases the likelihood of problems resulting from chemical trespass. Potential harm to the environment through water and other types of pollution results in greater grower caution and increased fear of liability.

The grower is also responsible and liable for the proper storage of pesticides once they are purchased. This liability applies not only to the proper use of, but also to the thorough cleaning and disposing of containers as prescribed by law.

The increasing liabilities required in the use of pesticides have also been a reason for the movement towards IPM. Growers are becoming highly concerned and are in constant need for training and updating in these various areas. The Extension Service has been and currently is a prime provider in keeping the grower aware of his responsibilities and liabilities through numerous communication methods which aid the user in preventing these costly mistakes (Johnson, 1992).

Tri-State Management Project: the Situation in 1974

Alabama, Florida, and Georgia represent one of the major agricultural food and fiber producing regions of the southeast and the entire south. A favorable conglomerate of climate, soil, and water augmented by innovative and resourceful growers has contributed to these states becoming one of the major producing areas of corn, peanuts, and soybeans in the southern United States.

The IPM program that was proposed for this area of the United States provided an excellent vehicle for introducing to the producers the true concept of pest management, and establishing scientifically sound pest suppression programs for control of insects, weeds, diseases, and nematodes. Adoption of these pest control practices by growers in these states, and subsequently throughout the mid-south, would have a significant impact on the agricultural economy of this important agricultural region. The overall strategy of the program would be a strong factor in preserving the intensive and profitable production of these crops in these three states.

Regional Project Objectives

The basic objective of this project was to provide the necessary education and demonstrate its implementation for effective and efficient management and control of insects, weeds, diseases, and nematodes in peanuts, corn, and soybeans in Alabama, Florida, and Georgia. The specific objectives were: (1) to provide producers of corn, peanuts, and soybeans with an accurate, effective, and unbiased field monitoring and advisory service to assist them in accurately interpreting pest problems and determining solutions, and (2) to incorporate the various tools of technology (pesticides, cultural practices, and biological agents) into a compatible system to assure optimum yields and profits with minimum impact on the environment.

Regional Project Organization

A regional pest management coordinating committee consisted of three representatives from each state. These representatives were the Extension Entomologist, Extension Plant Pathologist, and Extension Weed Science Specialist from each of the three participating states. Of these, a project leader was designated by the respective Extension Director. Dr. Charles Boone served as the project leader for Georgia; Dr. Freddie A. Johnson for Florida; and Dr. Roy J. Ledbetter, the project leader for Alabama. Dr. Ledbetter served as the Chairman of the Tri-State Coordinating Committee. The chairmanship rotated on an annual basis among the cooperating states. Dr. W.G. Eden, Chairman, Department of Entomology and Nematology, University of Florida, served as administrative advisor to the committee. The duties of this committee were to coordinate the planning, work,and educational efforts of the tri-state project and make recommendations necessary to its administration (Taylor et al., 1976).

Regional Project Evaluation

Evaluation and review of each state pest management program was conducted annually with each state project leader and state advisory committee. In addition, a regional project evaluation was conducted annually with the Regional Pest Management Coordinating Committee.

Results from these evaluations and review efforts along with research needs were clearly defined so that the program increased its effectiveness in aiding producers of these crops in Florida, Georgia, and Alabama. The regional effort gave Extension personnel the opportunity to cooperate in evaluating the educational programs conducted in teaching pest management concepts. he program provided the opportunity for making any desirable changes in overall projects emphasis and direction (Good, 1976).

Regional Project Funds

Special funds were needed to finance the project. Each state received a total of $25,000 per year for three years. These funds were renewed upon submission of an annual report by each state and the regional committee to the Extension Service/USDA. The evaluation provided for this project was submitted to the funding agency.

The Situation

Peanuts, soybeans, and corn were selected for the tri-state pest management project because of their value to the economy of these states. The acreage, yield, dollar value, and economic rank of these food crops to each of these states and to the proposed counties are shown in Table 1. These crops provided a major source of agricultural income to farmers in Alabama, Georgia, and Florida. Despite available technology, the losses from pests (insects, weeds, plant diseases, and nematodes) were significant. Table 1 summarizes specific pest losses for these crops in these states.

Pests

Peanut Pests*

Insects

Peanuts were attacked by many insect and mite species.These arthropods attacked and damaged the roots, seedlings, foliage, and pods. The most important arthropod pests of peanuts included the lesser cornstalk borer *Elasmopalpus lignosellus* (Zeller), leafhoppers Empoasca spp., white-fringed beetles *Graphonathus* spp., spider mites *Tetranychus* spp., and the granulate cutworm *Agrotis subterranea* (Fabricius). These pests damaged peanuts during the seedling, pegging, and nut-filling stage. Many defoliating insects attacked peanuts, including the corn earworm *Helicoverpa zea* (Boddie), velvetbean caterpillar *Anticarsia gemmatallis* (Hbner), soybean looper *Pseudoplusia includens* (Walker), cabbage looper *Trichoplusia ni* (Hbner), beet armyworm *Spodoptera exiqua* (Hbner), and the fall armyworm *Spodoptera frugiperda* (J.E. Smith). Various species of thrips *(Franklinella)* damaged young seedling peanuts, retarding growth and perhaps reducing yields.

*The taxonomic nomenclature of diseases, insects, weeds and nematodes occurring in the text was updated using the following references: (1) Alfieri, et. al. 1991; (4) Farr, et al. 1989; (36 Stoetzel, 1989; and (41) Truelone, 1977

The key insect pest of peanuts was the lesser cornstalk borer. This insect caused significant economic losses the last 4-5 years prior to 1974 and was implicated as being one of the factors in increasing the incidence of a peanut pathogen, *Aspergillus flavus.* Without regular weekly inspections, the lesser cornstalk borer could not be detected until it was too late to prevent heavy losses. Borer infestations could be detected and controlled by proper inspection and timing of insecticide applications. Farmers lacked sufficient knowledge concerning control and management concepts in order to make decisions on when to initiate control. Preventative applications of available insecticides resulted in excessive use, and thus increased environmental contamination and cost of production. However, many producers made preventative applications before damaging infestations were present, or did not initiate control measures until high infestations had developed that resulted in yield losses.

Growers made several applications of ethyl parathion at the rate of two pounds active ingredient per acre applied preventatively for control of the lesser cornstalk borer. This increased production costs and hazards to the applicator, animals, and others in the treated environs.

Growers would make applications of fungicides to control *Cercospora* leaf spot. They habituallyincluded an insecticide with each fungicide application to control various anticipated insect pests. Insecticides used most often were toxaphene and/or carbaryl. Multiple applications of those insecticides included with the fungicide application decimated the beneficial insect population and resulted in a buildup of certain pests such as spider mites, the beet armyworm, and perhaps the granulate cutworm. It was thought that 25-50% of the total amount of insecticides used on peanuts could be reduced if the treatments were made on the basis of need, as determined by an assessment of field populations, and if the applications were made utilizing proper application methods. To prevent economic losses and assure the proper timing of insecticides, threshold levels had to be established and levels of pest populations had to be determined before initiating a spray.

Diseases

Several diseases, primarily of fungal origin, often drastically reduced peanut yields. Leafspot diseases caused by *Cercospora arachidiocola* S. Hori and *C. personata* Ellis & Everh., southern blight *Sclerotium rolfsii* Sacco., root and pod rot *Rhizoctonia solani* Kuhn, *Rhizopus* seed and seedling rot (*Rhizopus* sp.), yellow pod *Aspergillus flavus* Link Fr., and brown rot *Aspergillus niger* Tiegh, were among the more commonly occurring peanut diseases. Other diseases which appeared less frequently included rust *Puccinia arachidis* Spreg., black pod rot *Pythium myriotylum* Drechs., and black rot *Cylindrocladium crotalariae* (C. A. Loos). Losses varied from 1-5% for most diseases. However, southern blight caused a minimum of 10% damage annually.

Nematodes

Several species of nematodes were reducing peanut yields. Known losses in individual grower fields had been as high as 1328 pounds in field demonstration tests. Samples processed by Nematode Analysis Laboratories indicated that 30-60% of peanuts surveyed needed treatment, depending on the area and the species, or mixtures of nematode species, found in the analysis. The more important species affecting peanuts were peanut root-knot nematode *Meloidogyne arenaria*, lesion nematode *Pratylenchus* spp. and sting nematode *Belonolaimus longicaudatus* (Rau). Losses varied by state but could exceed 10%.

Weeds

A wide variety of weed species created production problems and could cause large economic losses. Major weed species infesting peanuts in the tri-state pilot project area were: Florida beggarweed *Desmodium tortuosum* (SW) DC, sicklepod *Cassia obtusifolia* L., bristly starbur *Acanthospermum hispidium* DC, morningglories *Ipomoea* spp., cocklebur *Xanthium* spp., Florida pusley *Richardia scabra* L. wild watermelon *Citrullus vulgaris* L., pigweeds *Amaranthus* spp., yellow nutsedge *Cyperus esculentus* L., purple nutsedge *C. rotundus* L., Texas panicum *Panicum texanum* (Buckl.), goosegrass *Eleusine indica* (L. Gaertn.), and crabgrass *Digitaria* spp. Yield losses by state varied but could exceed 20%.

Soybean Pests

Insects

Soybeans were attacked by insects that fed on the seedlings, foliage, and pods. Insects that attacked the seedlings and stems included various species of cutworms, the three-cornered alfalfa looper, and the lesser cornstalk borer. The principal foliage feeding insects included the velvetbean caterpillar, fall armyworm, soybean looper, green cloverworm *Plathypena scabra* (Fabricius), corn earworm, beet armyworm, bean leaf beetle *Ceratoma trifurcata*

(Frster), and the Mexican bean beetle *Epilachna varivestis* (Mulsant). Pod-feeding insects included the 'podworm' (corn earworm), the southern green stink bug *Nezara veridula* (L.) and the green stink bug *Acroscternum hilare* (Say).

The podworm and stink bugs were the most important insects that attacked soybeans. The podworm was the key insect pest, attacking beans from pod set to pod maturity. Infestations were usually heavier following treatment for foliage-feeding insects prior to bloom. The podworm usually occurred in damaging levels from mid-August to mid-September. This was the generation after the insect had left corn, tomatoes, and other host crops. The small larva usually started feeding on leaves and blooms, and then bored into immature pods and destroyed several beans. Both the nymphs and adults of stink bugs sucked juices from young soybean pods, causing discoloration to the beans and subsequentreduction in grade. Heavy populations of stink bugs would occur in isolated parts of a soybean field. Unless fields were examined closely, such infestations went unnoticed and eventually required treating the entire field. If populations were monitored weekly, only small areas of the field were found to need insecticide treatment. The soybean plant could tolerate a foliage loss of at least 33% prior to pod set without adversely affecting the yield. When growers made two or more applications for control of these foliage-feeding insects, podworm infestations often ensued, requiring control. If fields were not monitored weekly for podworm infestations, these insects would often go unnoticed until they reached the 3rd instar and thus began to feed on pods. After reaching 4th and 5th instar, this insect became virtually uncontrollable by available insecticides. Research at the time indicated that for many of the foliage-feeding insects such as the velvetbean caterpillar and the fall armyworm, carbaryl could be used at minimal rates to control them. The minimal rate of carbaryl would not completely decimate the beneficial insect population. When the beneficial insect population had been decimated, the beet armyworm, usually a secondary pest, developed as a primary pest which was virtually uncontrollable with available insecticides. Acceptable threshold data were available for control of both the 'podworm' and stink bug. Sampling techniques were also available and if utilized by the grower could usually reduce the amount of insecticides applied up to 75% (Reese and Kempter, 1974; Taylor et al., 1976).

Diseases

Foliar, stem and pod rot, and seedling diseases were becoming increasingly important. Research was proving that topical fungicidal sprays increased yields. The more important diseases of soybeans were frogeye leafspot *Cercospora* sp., brown spot *Septoria glycinea* Hemmi, purple stain *Cercospora kikuchii* (Matsumoto & Tomoyasu), pod and stem blight *Diaporthe phaseolorum* var. *sojae* (Lehman & Wehmeyer) and var. *caulivora*, and seedling diseases *Rhizoctonia solani* Kyuhn. Losses from the diseases could exceed 10%.

Nematodes

Losses in beans were caused by root-knot nematode *Meloidogye* spp., soybean cyst nematode *Heterodera glycines* (Ichinohe), reniform nematode *Rotylenchulus reniformix* (Linford and Oliveira), sting nematode *Belonolaimus longicaudatus* (Rau), and spiral *Helicotylenchus* spp. Yield reductions and/or losses could exceed 15%.

Weeds

Many weed species contributed to soybean production problems of growers. Some of the more important ones were: Florida Beggarweed *D. tortuosum*, sicklepod *C. obtusifolia*, bristly starbur *A. hispidum*, yellow nutsedge *C. esculentus*, Texas panicum *P. texanum*, morningglories *Ipomoea* spp., cocklebur *Xanthium* spp., goosegrass *E. indica*, crabgrass *Digitaria* spp., pigweeds *Amaranthus* spp., and wild watermelon *C. vulgaris*. Losses varied but could exceed 15%.

Corn Pests

Insects

The most serious insect pests of corn in the tri-state producing area included billbug *Calendra* spp., sugarcane beetle *Euetheola humilis ruqiceps* (LeConte), corn earworm, corn leaf aphids *Rhopalosiphum* spp., cutworms *Feltia* spp., fall armyworm, southern corn rootworm *Diabrotica undecimpuntata howardi* (Barber), lesser cornstalk borer, southern cornstalk borer *Diatraea crambidoides* (Grote), southwestern corn borer *Diatraea grandiosella* (Dyar), European corn borer *Ostrinia nubilalis* (Hbner), and two species of leafhoppers. The latter two insects served as the vectors of corn stunt virus disease. This was a serious disease of corn and economic losses occurred in many corn producing areas.

One of the most important corn insects was the corn earworm, which sometimes caused severe damage in the whorls of corn and to the ear. Other insects such as the southwestern corn borer, the European corn borer, southern cornstalk borer, and fall armyworm fed in the whorls. Many times insecticide applications were made, usually by air, to control these insects. This method of control usually did notprovide effective suppression. Also, if these applications were not properly timed, populations of honey bees were destroyed, which was especially detrimental during the silking and pollination stage. Research results indicated that control of the corn earworm and other whorl-feeding insects was not usually economically justified in corn grown for grain.

The lesser cornstalk borer, white fringed beetle, and several species of cutworms attacked young seedling corn. These insects caused severe reductions in stands without the grower knowing of the infestations or how to monitor for these insects in order to properly time insecticide applications. The billbug and sugarcane beetle also caused significant stand losses to some fields each year. The southern corn rootworm caused damage to the root system of corn and losses were sometimes significant. Certain systemic insecticides provided effective control of the southern corn rootworm and the two species of leafhoppers that served as vectors of corn stunt virus disease. One leafhopper species was an indigenous vector and one was migratory. Research results indicated that the incidence of this disease could be maintained at a very low level by using one of the systemic insecticides at planting time. However, preventative treatments for leafhoppers in all fields resulted in increased production costs. Fields could be monitored during the growing season, disease symptoms observed, and treatment made in those fields the following year. Most applications of insecticides to corn were made without sufficient knowledge of insect biology, economic threshold, and proper methods of control.

Diseases

Leaf and stalk diseases caused minor, sporadic losses in corn. Southern corn leaf blight *Helminthosporium maydis* (Niskiado & Miykw), Race T, had caused severe losses nationwide. However, with a return to normal cytoplasms, this problem had been solved. Leaf, stalk, and ear diseases that caused problems in individual fields were northern corn leaf blight *Helminthosporium turcicum* Pass, common smut *Ustilago maydis* (DC) Corda, southern rust *Puccinia polysora* Underw., bacterial leaf blight *Pseudomonas alboprecipitans* Rosen, stalk and/or ear rots *Fusarium* spp., *Diplodia* spp. and *Macrophominia* spp., maize dwarf mosaic virus (MDMV) and corn stunt (CS).

Nematodes

The major nematodes causing losses in corn were sting nematode *Belonolaimus longicaudatus* (Rau), stubby root nematode *Paratrichodorus christiei* (Allen) Siddigi, lesion nematode *Pratylenchus* spp., and root-knot *Meloidogyne* spp. Losses exceeded 15% in some fields.

Weeds

The same weed species that infested peanuts and soybeans were also a problem in corn. These have been listed previously. Losses per crop and/or field varied from 10-25%.

Research

Research on control and management of insects, weeds, diseases, and nematodes on peanuts, corn, and soybean was conducted concurrently in all three states in this project. Several full-time research entomologists, plant pathologists, nematologists, and weed scientists were at that time engaged in research on pest management in soybeans, peanuts, and corn. Economic threshold levels were available for many key insects in these crops. Certain information was also available on beneficial insects and their role in controlling destructive insects, as well as the effects of insecticides on beneficial species.

Peanut disease research indicated that runner type peanuts could be assayed to determine percent infection of *Cercospora* leafspot. Adjustments and/or adaptations could be made for other foliar disease. Also, research had shown that moisture sensors (hygrothermographs) could be used to determine the optimal time to spray peanuts for prevention of leafspot infection. White mold disease losses could be estimated by counting the number of southern blight-infected plants (dead crowns) per 100 feet of row and correlating with yield potential.

Research on soybean diseases indicated that foliage, stem, and pod diseases were decreasing yields significantly and that topical foliar fungicide applications increased yields, seed quality, and/or germination. Research was available on samplingtechniques using trifoliate leaves and stems plus pods for monitoring and/or evaluating for disease of these parts of the soybean plant.

Peanut nematode control research was available that showed that lesion nematode populations increased when (PCNB) Terraclor was used to control southern blight. This would permit monitoring of peanut fields after seedling emergence for the presence of lesion nematodes. If lesion nematodes were present, nematicides could be used at this time. Growers' fields could also be monitored during the growing season for information on the necessary nematode treatment for the next crop to be grown in that field.

Limited research indicated that nematodes caused economic damage to corn. Sampling of fields, particularly problem areas, provided necessary information on infestations which should be treated.

Research in weed science had shown that by following a well-planned weed management program, including the proper use of herbicides, mechanical and cultural control methods, the major weed pests could be maintained below levels that would reduce crop yields. At the time, research was underway to determine growth habits and economic threshold levels of key weed pests. Research also indicated that repeated use of herbicides with selectivity for annual grasses and other weed species that predominated at one time on most fields resulted in shifts in weed populations to the more difficult-to-control perennial weeds.

Several commercial companies provided financial support for screening and evaluation of prospective selective pesticides. Research on a total pest management program for these crops had been supported by funds from ARS and CSRS (USDA). Grower organizations in all three states were active in research and promotion of these food crops and provided support to this program.

Extension programs in these states had extended research technology and changed grower production practices. Close coordination was maintained by the project leader with the appropriate research scientists. As new innovations became available, recommended procedures were integrated into project management (Taylor et al., 1976).

Grower Practices and Availabilities of IPM Approaches

Peanut producers usually made from three to six applications of insecticides per crop season. These insecticides included toxaphene, methomyl, carbaryl, chlordane, parathion, monocrotophos, trichlorfon, and ethyl parathion. Systemic insecticides such as disulfoton, phorate, carbofuran, and aldicarb were frequently used as preplant treatment for control of thrips. At the time, total insecticide costs ranged from $8 to $20 per acre. In an effective pest management program, it was thought that these costs could be reduced by 25 to 50% and possibly more in some instances.

Fungicides such as chlorothalonil, benomyl-maneb-oil, triphenyltin hydroxide and copper hydroxide were regularly applied to peanuts for the control of leafspot disease. The number of applications needed varied from four to ten depending on location, humidity, temperature, rotation, planting date, and harvesting date. Monitoring humidity to determine optimum infection periods enabled growers to apply fungicides as needed, and to possibly save one to three applications. During certain years unfavorable environmental conditions would lead to air applications rather than ground applications in order to control disease.

Proper monitoring of peanut fields using the vertical runner technique could aid in discovering tolerant and/or resistant strains of the causal fungus. This could make it possible to shift to more effective fungicides.

Southern blight infections could be identified by field monitoring. Control by cultural practices was not always sufficient in these fields; therefore, proper fungicidal treatment had to be advised.

Several fumigant and non-fumigant nematicides were available and being used on peanuts. Field sampling after seedling emergence permitted the grower to treat certain nematode infestations at mid-bloom to early pegging time with a non-fumigant nematicide. Routine sampling during the growingseason and/or at harvest time could assist the grower in planning and treating the following year's crop.

Every available type of pre- and post-emergence herbicide was being used on peanuts. Monitoring peanut fields enabled growers to use the proper combination of rotation (some herbicides could be used on corn and/or soybeans that could not be used on peanuts and vice-versa), peanut herbicides and cultural practices for maximum weed control. Monitoring of fields also could permit the proper timing of directed and over-the-top sprays of recommended herbicides.

Soybean producers made from three to five applications of insecticides per growing season for control of seedling, leaf, stem and pod feeding insects. Insecticides used included toxaphene, malathion, carbaryl, methyl parathion, methomyl, ethyl parathion, and chlordane. By monitoring the insect populations weekly, it was thought that these insecticides could be reduced to less than two applications per season on an average year. In many areas it might be possible to avoid the use of any insecticides, because most of the applications used for defoliating insects were usually not necessary and triggered subsequent problems which frequently required two or more applications for other insects.

Limited amounts of foliar fungicides (micronized sulfur, copper, benomyl, and mancozeb) were used on seed soybeans in 1974. Monitoring of soybeans could result in the timely application of recommended fungicides, resulting in better yields of soybeans. Often, two to four applications of a fungicide might be used depending on the variety and environmental conditions; however, monitoring could keep this to a minimum.

Nematicides such as dibromochloropropane (DBCP) and ethoprop were used to treat soybeans in 1974. Monitoring of soybean fields could enable growers to determine with almost 100% accuracy whether they must treat the next crop to be grown on that land. Monitoring weed populations enabled growers to utilize the various types of herbicides for maximum benefit. Proper herbicides could be recommended for rotational crops as well as for the present crop. Monitoring during the growing season also could help to recommend the proper herbicide atthe proper rate, especially in regard to cracking time, directed and over-the-top sprays.

Corn producers were usually making from one to two foliar and one preplant application of soil insecticide per growing season. By monitoring the insect population and delineating infestations of certain soil insects, these applications could be reduced to one or less per season.

Insecticides used on corn included heptachlor, carbaryl, parathion, toxaphene, EPN, carbofuran, disulfoton, phorate, fensulfothion, fonofos, and ethyl parathion. Monitoring corn fields would help locate disease and nematode problems, localized high pest populations, and subsequent needs for resistant varieties. From this information, rotation programs and nematicide treatments could be utilized. Monitoring weed populations in corn would enable full utilization of cultural practices, rotations, mechanical cultivation, and use of herbicides for maximum weed control. Proper timing with proper herbicides utilized as pre-, post-, directed, lay-by, and/or over-the-top applications could maximize their effectiveness (Taylor et al., 1976).

Peanut producers at the time of this study applied insecticides without assessing insect populations. This increased the number of applications and subsequent production costs as well as increasing the pesticide load to the environment. In a pilot cotton pest management program, producers had responded to new technology and insecticide applications had been greatly reduced (Reese and Kempter, 1974). More importantly, the program had developed an awareness of the role of beneficial insects in managing certain pest insect species. Producers had also improved the methodology of insecticide use and, subsequently, the insecticide pressure on key insect pests that could lead to resistance.

Monitoring peanuts for air, moisture, and temperature with hygrothermographs could help to better time the first application for leafspot diseases. This would make subsequent applications more effective and would also aid in proper timing for those applications. During most years, hygrothermographs plus monitoring with the vertical runner technique would reduce the number of fungicide applications. Monitoring for southern blight would assure the proper application of fungicides at the proper time.

Monitoring peanut fields for nematodes would assure the proper application of an effective nematicide at the proper time, i.e., preplant or in-season. At the beginning of a program the use of nematicides on certain fields might increase, however, total overall use could be reduced by treating only fields that indicated a need.

Monitoring and mapping fields for weed populations would result in better weed control in peanuts and in crops grown in rotation. Monitoring would especially dictate timing of cracking, directed, lay-by, and over-the-top sprays with a recommended herbicide (Reese and Kempter, 1974; Taylor et al., 1976).

Objectives of the Tri-State Management Project

- Conduct and evaluate a pest management program with selected growers in communities in Alabama, Georgia, and Florida. The goals of the program were to demonstrate the most effective techniques in managing insects, weeds, diseases, and nematodes. Pesticides and methods of application were based on the latest available technology which utilized naturally-occurring parasites, predators, and pathogens. The impact of this program would be expected to reduce production costs and the pesticide load in the environment.
- Reduce the amount and frequency of pesticides used. This would result in reducing health hazards to humans and wildlife, insecticide pollution, and producer's insecticide costs. Timing and placement of selective pesticides would be a vital part of this program.
- Report and provide information on the efficiency and cost-profit analysis of the pilot pest management program to the peanut, soybean, and corn producers of this study area. An intensive educational program based on program results would be initiated and expanded in each state. The potential for the full utilization of technology and techniques developed through this pilot effort would be immense. It would be transferred into an intensive educational programfor all peanut, soybean, and corn producers in the tri-state region. This could result in millions of dollars in savings in production costs and improve the efficiency and methodology of pest management.

Proposed Area for Project Activity

The area selected for this project was Houston County, Alabama; Decatur County, Georgia; and Jackson County, Florida. All three of these counties border each other and are divided by the Chatahoochee River. The counties were selected because of their pest problems, the opportunity for improvement in pest control usage and methodology, and the potential for expansion to all producers of these crops in other areas in each state. The number of growers selected in each state was from five to ten, encompassing a total of 2,000 to 3,000 acres. Each of these growers had planted acreage of all three crops. Farmers in these counties were receptive to utilization of innovative control measures and the application of new technology.

The project had national significance in that participating growers in all three states would be involved in a similar effort. The opportunity for improving methodology and increasing efficiency and education in the use of pesticides was available to the IPM team. The challenge was to reduce the adverse effects of pesticides to applicators and other entries in the treated environment without sacrificing food quantity or quality. The results were expected to be significant.

Methods and Procedures

A County Extension Agent (IPM) was employed in each county to direct the program. Pest management aides (scouts) were employed in each county to monitor pest populations in each field. These aides and the county extension agent for pest management were supervised by the staff of state extension specialists in entomology, plant pathology, nematology, and weed science. They also received guidance from the extension staff at the county level. The aides were college students; the extension agent for pest management was a professional holding a M.S. degree. The position was filled by a person with as much training as possible in the various agricultural areas that composed the overall IPM philosophy.

The composition of the County Pest Management Committee was structured to give an opportunity for all appropriate interested persons and agencies to become involved. The committee was composed of local farmers and businessmen and was used to nominate growers for participation. Growers were screened for their willingness to participate and support a long-range project. They also agreed to serve as whatever they were randomly chosen to be for the project - either an IPM or a conventional control grower. Criteria for nomination also included the grower's expected ability to adopt new technology, and the location of the farm within the county. Farm location was crucial because the committee felt that all sections of the county should have a demonstration farm and all basic soil types should be represented. A grower name pool representing the potential test areas was created. Once the nominating list was complete, the farmers within each test area were randomly chosen as an IPM participant or as a control grower. Growers agreeing to participate were added to the project until 10 growers (approximately 3,500 acres) were committed to the project for three years. In the random process, an equal number of growers agreed to farm and control pests in the conventional manner. These growers would not use the IPM scouts or other procedures and would keep the necessary records to serve as a control group comparison, or the purpose of assigned acreage to the scouts, the 10 participants were grouped according to location within the county and number of acres to be scouted. Totals were based upon the assumption that a scout could check 1,000 - 1,200 acres per week. The project leader and the state Pest Management Advisory Committee provided the necessary technical support and total leadership to the project. Scouts, the county IPM agent, and the other county extension personnel initially underwent a 3-day intensive regional training program provided by a combination of extension and research faculty from the three states (Taylor et al., 1976; Johnson and Linker, 1976).

Specific scout training was continued with 10-14 hours of classroom instruction covering identification of the major pests, sampling techniques, and how to properly scout a field. After the classroom instruction, the scouts were taken to commercial fields and given approximately two full days of in-field training, practicing scouting techniques and pest identification. During the season, additional update training wasgiven at scheduled bi-weekly meetings and in personal in-the-field sessions with the county IPM agent (Johnson and Linker, 1976, 1977; Johnson, 1978).

Test fields were monitored weekly, and a report submitted to the grower on the day the monitoring took place, including pest population data on insects, weeds, diseases, and nematodes. A copy of the report was submitted to the county IPM agent the same day. If any action seemed necessary, the county IPM agent contacted the grower, and a joint decision was made. In any situation the county IPM agent was not familiar with, the appropriate state extension specialist was contacted for advice. The scouts were not allowed to make any chemical or non-chemical control recommendations. This information delivery system gave the grower more accurate and precise data with which to make decisions about using chemical control, planning rotation programs of crops for the second and third year phase of the project, and managing weeds, plant diseases, and nematodes as well as soil insects.

The specific flow of information from the scout to the grower and county IPM agent was facilitated by the use of two forms; a field report card and a pest report form. Field reports were recorded on 5" x 8" index cards with entry slots for pest counts and observations for each sample taken. The data was then transferred to a triplicate 8 1/2" x 11" grower report card. The cards were filed for cross-referencing and as a check on the system. Scouts used one report card per individual field to record observations and counts from each sample site. Once all of a grower's fields had been checked, or at the end of the day, scouts would record the compiled sample data collected onto the grower report forms, which were left in a location convenient for the scout and grower. Field report cards were left at the local county extension office, or were collected from the scouts by the pest management agent. The process allowed the grower, the county office and the state project coordinator to have identical copies of the data. This system proved to be very helpful in scouting research carried out at a later date.

Grower report forms improved over the three years the project operated. The 1975 form was designed to facilitate keypunching of the information. However, this format was confusing to the grower. In 1976, the grower report form was redesigned to makeit easier for the growers to understand the data collected. Growers were given a report for each individual field every week during the growing season. By the time the growing season was completed, some growers had a large stack of report forms. This made it difficult to follow natural increases and decreases in pest numbers. The grower report form was further changed in 1977, so that an entire season's weekly summaries of individual fields could be entered on one form. The growers were provided notebooks so the season-long reports could be systematically filed. Cooperating growers quickly learned how to use the new forms, which solved the problem of how to present the information necessary for pest management decisions without confusing the grower with excessive paperwork. Space for nematode and fertilizer assay results was allocated on the new form so that by the time the growing season was complete, a field pest history had been developed which could then be used as part of the input into crop rotation and future planting strategy decisions.

The County Pest Management Committee included a chairman and a treasurer. The treasurer collected $1.50 per acre for peanuts and $.50 per acre for soybeans from the participating growers (there was no charge for corn). The grower contribution was used to pay part or most of the financial support for the three pest management scouts. A state Pest Management Technical Advisory committee involving extension and research personnel in entomology, weed science, plant pathology, and nematology provided the necessary overall planning, coordination, and key leadership for the project. The IPM project leader (extension entomologist in Florida) headed this committee.

An intensive educational program provided by the aforementioned committee was initiated to teach the growers the concepts of pest management. As the program progressed and results were obtained, the educational base was built and expanded upon to include information that would be useful to all growers in making similar changes and improvements in their methods of pest control.

It was anticipated that at the end of the second and perhaps the third year, growers would be paying full cost of the pest management aides, and at the end of three years, county extension staffs would assume theresponsibility of the costs of the extension agent for pest management.

Project personnel, particularly the pest management scouts and the extension IPM agent, were provided the additional necessary training relative to toxicity, safety and appropriate handling and management of pesticides used in the project. If contact with fields treated with pesticides justified routine monitoring of cholinesterase levels of the pest management personnel, the arrangements were made with local physicians and hospitals.

The county extension personnel maintained constant vigilance and surveillance on wildlife, fish, beneficial organisms, and the environment. Annual summaries provided information on the status of the project in the test area and other adjoining areas where the crops included in the program were grown commercially. Pest data collected weekly were also summarized and sent to all participating growers in the project area and to participating intra- and interstate agencies. Relevant data were stored for future computerization and retrieval.

Effectiveness of the program was determined by cost analysis of pest management expenditures deducted from yield values. Pest infestations were monitored weekly to determine the efficiency of the pesticides used in the pest management program. Grower acceptance was evaluated by a survey related to utilization of pest management practices and pesticide use. The economic impact of the project was determined by comparing records of participating IPM farms which used the new concepts and records of similar farms in each county that continued to farm using the older, established conventional methods. This comparison was made from the standpoint of insecticide usage, production yield, and optimization of net income. Progress of the pilot program was reviewed weekly by the County Pest Management Committee, and at least monthly by the State and Regional Tri-State Committees. At the end of the first growing season, the process was reviewed critically to plan for any revisions or modifications of the program that would be needed for the second year (1976). Participating peanut, soybean, and corn producers were invited to the county review meetings to participate in discussions on the progress and future project plans.

The funds for the Tri-State Project were used to develop a multi-crop, interdisciplinary pest management program that provided a complete program direction and emphasis on the concept of pest management, which at that point in time had not been developed anywhere in the country to its fullest extent (Johnson and Linker, 1976, 1976, 1978, 1979).

It was expected that this program could be carried forward and expanded by special IPM extension agents and the private sector upon completion of the pilot study. As previously indicated, grower organizations at the time had a tremendous interest in this program and could assume certain leadership roles in expansion of the program to other commercial peanut, soybean, and corn growing areas in each state. Overall direction and support of the total three-year project was provided in each state by a Pest Management Advisory Committee. The project leader and head of the Advisory Committee in each state was as follows: (1) Alabama (Auburn University) - Dr. Roy J. Ledbetter; (2) Florida (University of Florida) - Dr. Freddie A. Johnson; and (3) Georgia (University of Georgia) - Dr. Charles Boone. The composition of each state Pest Management Advisory Committee included the respective state's extension plant pathologist-nematologist, the extension entomologist, plant pathologist, nematologist, and weed specialist, or the appropriate commodity production specialists, a research entomologist, plant pathologist and weed scientist, a representative from the Department of Agriculture and Related Industries, the State Supervisor of APHIS/USDA, and representatives from appropriate grower organizations.

Once the program was organized, all appropriate agricultural interest groups in each county and the appropriate grower organizations in the county and state were invited to attend and participate in meetings in which the objectives and plans for the conduct of the program were reviewed. As the program progressed, timely news releases on a variety of IPM-related subjects were made through radio, television, and newspapers (Johnson and Linker, 1977).

Related Extension Activities

A Pest Management Association of growers was organized in each county. A chairman and treasurer of the grower organization were chosen by the growers. The treasurer collected the funds from the participating growers and was responsible for paying the pest management scouts. The Association was committed to furthering the IPM movement once the prototype project was complete.

An ARS-funded regional research project on integrated pest management and intensive cropping systems was being conducted in Georgia. Researchers were in the process of initiating a comprehensive research study in this subject area. This particular research involved monitoring pest composition and densities as well as pesticide residue in a total crop management system. Principles and practices developed by these researchers were utilized in the Tri-State Project (Johnson and Linker, 1976; Taylor et al., 1976).

Results and Effects of the Tri-State Project

Based on questionnaires, surveys and the opinions of participants, approximately 90-95% of the recommendations recorded by the extension specialists and IPM agents were followed by the cooperating growers. Each year, acceptance of the many tactics and strategies that composed the IPM program increased. The growers started bringing problems to the IPM agent, rather than him having to take the problems to the grower. One of the most rewarding occurrences was that farmers would bring in insects and other pests and ask, "How many more of these can I tolerate before I must spray?"; rather than asking the old question of "How much and what kind of pesticide do I need for this?" (Johnson and Linker, 1978a).

Before the Tri-State Project there were no cooperative programs operating in the area. As a result of the Tri-State Project, training sessions supported by the chemical and agricultural industry companies were held and were well attended. The training resulted in private companies hiring extension-trained IPM scouts and using them to service their customer-growers. The growers were well pleased with the service, and there was an increase in participants each year (Johnson and Linker, 1976).

The growers began to expect the systematic IPM approach and accepted recommendations based on factual field monitoring. They also came to respectthe timeliness of field monitoring and became quite disturbed if the scout assigned to them was not punctual. The participants seemed very pleased with the program and believed that their pesticide costs were lower than ever before while yields were just as good or better. The growers began asking for more service and information than could be provided at the time. As a result, they began to learn the intricacies of scouting and began to monitor their own crops. The University of Florida Plant Pathology Department developed and put into use a time-saving and more efficient method of evaluating *Cercospora* leafspot on peanuts. This technique made available a much-needed systematic method of evaluating the leafspot disease in relation to the projected final peanut yields.

The geographic area where the project took place also produced other crops. The groundwork established for IPM practices on corn, peanuts and soybeans provided acceptance for the practices on other crops as techniques were made available. The program also resulted in better interaction and cooperation between the Extension faculty and other commodity and support departments such as Agronomy, Soil Science, Agricultural Economics, etc. Cooperation and inputs from the research faculty were splendid. The Center for Environmental Programs became a much- needed cooperator and put both time and additional funds into the project. Local agricultural and business concerns offered help in many ways, while local banks and farm lending firms took a special interest in the overall program.

The IPM scouts were more extensively and thoroughly trained each successive year of the program. This was the result of better methods becoming available due to the experience, problems and demands of the previous year. Each year the data collecting and time saving field monitoring record systems were improved. As a result, data quality was not compromised and was far less confusing to the grower than the early systems. Before the pilot program ended, the IPM agent had taught the growers enough about IPM that they were able to make their own evaluations and to select the best available control approach for most of their pest problems. There was a great deal of effort put into field research demonstration plots for the growers. This effort was continued and expanded each year. The demonstrations included trap-cropping techniques, spray timing, and use and comparison of broad spectrum versus host specific pesticides.

During the pilot project, the participating growers added more of their individual acreage into the program. The number of cooperating growers (both IPM and conventional control groups) remained the same according to the original plans. In order to obtain comparative quantitative data to support the program, the original agreement with cooperators was kept intact without adding new growers and additional variables. However, it was very satisfying that there were many growers who demanded to join the program. As previously discussed, the pilot growers contributed funds for peanut and soybean acreage, but not for corn. In addition to the original grant from the Federal ES-USDA, the Florida Cooperative Extension Service and the Center for Environmental Programs also contributed direct and indirect funds to the project.

As the program progressed, more growers became interested and wanted to participate in IPM. A two-day IPM scouting school was held for growers and other interested parties for the purpose of providing the basic training for pest management scouts.

The program was well attended and the participating growers in the subsequent program did a commendable job in implementing the recommendations stemming from the pilot program. The participating growers in the additional program reported that their pesticide costs were a great deal below those experienced previously and that yields were better in most cases.

In the IPM program, extra educational efforts were made in using available pest-resistant plant varieties and up-to-date cultural techniques that would control certain pests. In addition, planting times (early and late) were scheduled to avoid expected peak populations of pests (particularly if the plant would be in a vulnerable stage at that time), and crop rotation programs for pest control that would fit the grower's land and resources were established. Chemical treatment was used only as a last resort.

Criteria for Pesticide Use

- The pest in question had been monitored by trained IPM scouts on a weekly basis, and pest thresholds were considered economically damaging by research data or professional opinion.

- The recommendations of the IPM agent were based on proper identification of the pest or pests concerned. In selecting a chemical, the agent would base his decisions on the chemical's potential impact on the environment, its ability to control the pest, and its capacity to provide long or short-term range control, depending on the particular need.

- Florida growers were made aware of the necessity of using the chemical and were encouraged to use only the minimal rate of the chemical. The grower was also encouraged to use the most up-to-date methods in applying the material, such as keeping application equipment in excellent shape, calibration of the equipment, use of appropriate nozzles, spray paraphernalia and proper nozzle arrangement, etc. Finally, the users were warned of needed safety precautions.

As the pilot project progressed, the growers became more experienced in using field data and adjusted to following the IPM approach. Decreased use of pesticides with better control obtained, lower application costs, and increased yields of quality equal to the control group helped growers save money (see Table 2 and Table 3). Net profits increased due to thereasons listed above, since direct savings had been realized by a reduction in total pesticides applied. Profits increased by increasing the quality of the crop. When pesticides were used within the IPM program, applications were scheduled so that maximum benefit was obtained. The IPM program served as a catalyst to make the growers more aware of intricacies in using and choosing a specific chemical for a particular job. This knowledge led to the growers being less likely to follow recommendations from improperly trained outside sources.

Less total chemicals were applied overall by the cooperating growers as compared to the conventional control group. When pesticides were applied, it became a practice to use the lowest possible rate of the most environmentally acceptable pesticide began to become a practice. Great strides were made in reducing the use of persistent chemicals like toxaphene.

Case Study: Toxaphene

When the Pilot IPM program began in 1975, one specific problem encountered was lack of planning for the use of toxaphene by peanut growers. The growers applied toxaphene on a habitual schedule. Investigations by IPM agents and other extension specialists revealed the following reasons for the excessive spraying of the compound:

- Toxaphene was used as a herbicide to control sicklepod (coffeeweed, *C. obtusifolia* L.). No specific dosages seemed to be followed or practiced by the growers. Often the attitude "if a little is good, a lot is better" prevailed.

- Aerial applicators recommended to the growers that toxaphene was a "good sticking agent" for fungicides that were often applied by air. Many growers were found to follow the advice of the aerial applicator over that of personnel trained in IPM and pesticide use.

- Some growers were under the impression that peanuts responded and grew better when toxaphene was used on the crop.

The toxaphene problem was dealt with by the IPM staff and other agricultural scientists. Progress was made in slowing the indiscriminate use of the material, until it was later taken off the agricultural market by the federal government (Johnson and Linker, 1976; Johnson 1992).

Expansion of IPM Programs

Field and plot demonstrations were utilized throughout the pilot program, testing the abilities of low to minimal insecticidal doses to control target pests. The applied work included demonstrating the use of new compounds and their effect on the beneficial arthropod complex as well as control obtained at less-than-lowest labeled rates. An expanded IPM program for peanuts and soybeans wasoffered during the last year of the pilot project to any grower willing to pay the salary and travel expenses of a scout. So many farmers responded to this offer that the demand for scouting services exceeded personnel available to handle the work load. It was necessary to reduce the acreage allotted to the expanded program in order to ensure that each additional grower received the kind and type of service required for the IPM process to work. A third additional IPM program was also offered to small farmers in the county who could not afford to pay for the services, but could benefit from IPM and improved pest control procedures. Funding for the program was supplied by the Comprehensive Employment and Training Act (CETA) federal grant. The addition of the two supplementary IPM programs to the pilot program significantly increased the number of participating growers and committed acreage.

Corn

Corn was originally included as a primary crop in the Tri-State project, but as the program progressed the growers and the IPM team felt that the program should be modified. Soybeans and peanuts needed to be and were scouted on a weekly basis during the season, however, it was decided that this schedule could not economically be justified for corn. It was recommended that monitoring of corn be concentrated at the following critical growth stages: (1) just after emergence; (2) at the early whorl stage, when the corn is 12-18 inches tall; and (3) during the silking and ear-filling stage. Otherwise, the basic tactics andstrategies previously discussed were applied. The following IPM tactics on corn were found to be the most effective:

- rotating crops, usually on a 2-4 year program

- developing thorough crop histories of pest appearance and damage

- previous-season weed mapping (for better planning of herbicide usage)

- previous-season nematode sampling (so that nematicides could be applied at planting)

- using pesticides at planting time, preferably those with both nematicidal and insecticidal activity

- using insecticides on an as-needed basis, pending pest threshold levels at strategic points in the growth cycle

- planting as early as possible

- using early-maturing varieties

- harvesting as soon as the moisture content permits

The last three strategies were practiced to avoid heavy whorl and foliage damage by fall armyworm and corn earworms. Harvesting grain as soon as possible reduced weevil and other mature kernel pests.

Wheat

Due to the low profits experienced in growing field corn and the development of wheat varieties adapted to Florida conditions, growers began utilizing wheat for grain and rotational cover crops as well as for grazing. Varieties were developed that had resistance to diseases such as rust and mildew, as well as the Hessian fly.

The entomology extension specialists have made available literature discussing biological information of pest insects; specific IPM control strategies, including updates on recommended resistant varieties; scouting techniques, procedures and recommended frequencies; and action thresholds for insect pests. Many of the IPM principles and strategies developed for corn, peanuts and soybeans are used for wheat. Most wheat growers are aware of these tools and are using them in their production practices.

Sorghum

Acreage of sorghum also increased due to the dry weather experienced in the late 1970s and 1980s andgrowers used the crop as a grain and silage substitute for the declining corn acreage.

The extension specialists responsible for the crop developed production training materials that encompassed insect biology and damage, strategies (such as rotation, planting times and other cultural control measures), comprehensive scouting measures, and action or economic thresholds.

IPM scouting schools held for agronomic crops were expanded to include sorghum. A strong effort was made at grower meetings and training workshops, as well as through other contact methods, to make available the many tactics used to control sorghum pests.

Tactics and Strategies

The following IPM tactics and strategies were taught and implemented in the original pilot program:

- Regular systematic scouting
- Cultural practices and their effects on pest populations
- Theory and use of economic thresholds or action levels of pests
- Evaluation of management decision on pest populations
- Awareness of beneficial insects
- Value and importance of record-keeping
- Value of crop history
- Effective crop rotation programs
- Advance weed mapping and nematode sampling for future crop sites
- Use of plant disease evaluation techniques
- Upgrading of scout training as new research is available
- Workable farmer self-evaluation techniques of field data for pesticide use decision-making
- Selection of pesticides which have complementary action
- Tailoring and selecting pesticide compounds and rates to best fit the needs of a particular situation
- Improvement of pesticide application methods
- Improvement of pesticide safety pertaining to workers, applicators and environment
- Understanding and use of pest-resistant varieties
- Promotion of the conservation of natural control agents and arthropods (Johnson and Linker, 1976, 1977, 1978b)

The Extension Service at all levels has continued to integrate these tactics and strategies to fit the original crops, as well as additional crops in which they are applicable. New IPM tactics have been added constantly as they developed. This information has been made available to the growers and interested parties through a variety of methods.

Information Delivery

From the beginning of the pilot project, there was a need and demand for a constant flow of information to the growers. The delivery of IPM information was enhanced by three methods. First, during the crop season a weekly local newspaper article discussed current pest problems and possible control strategies. The newspaper articles also contained photographs of the pests and pest damage. Second, a citizens'-band radio was installed in the vehicle of the local IPM agent. The radio allowed the agent to quickly and easily locate and respond to growers on their farm, so that consultations and decisions on urgent problems could be immediately addressed. Third, a business-band radio was also installed in the IPM agent's vehicle so that the local extension office personnel could stay in constant contact with the IPM agent, permitting him to respond to telephone calls placed to headquarters. These communication improvements allowed pressing problems to be addressed rapidly and more efficiently than ever before (Johnson and Linker, 1978b).

As a result of the original Tri-State Pilot Project, Florida augmented its overall IPM program in several ways. Annual scouting schools for corn, peanuts and soybeans were expanded into an additional geographic area. Cotton scouting and IPM services were added to the originally established crops. The primary purpose of the schools was to train scouts, however, they were well attended by growers, agricultural supply dealers, agri-business personnel and other parties that were interested in IPM concepts. These schools have been held consecutively for the last 31 years.

At the termination of the pilot project, Florida hired two full-time county IPM agents (in the field-crop agronomic area), each with a master's degree in the area of pest management. Their purpose was to continue the programs in the farm regions of the state which had the largest crop acreage, and to further implement and enhance the work started in the Tri-State Pilot Project. Further goals were to develop IPM programs in other cropping areas where opportunities were available. In 1979, Florida hired an extension IPM specialist at the PhD level in order to provide development, support, leadership and implementation of IPM programs on all field crops, and to provide close liaison and support to the county and regional IPM agents. This position also provided support to county and private consultant programs that were developing as a result of the Tri-State Project.

Written Information

Hard copy or written information in the form of circulars and more recently publications available on the internet have been made available to growers by the extension specialists. These publications contain information on how to monitor and sample the crop, drawings, descriptions and information on identifications of pest insects and economic thresholds. The literature also contains information on registered chemicals and rates for control. These are available for:

corn (http://edis.ifas.ufl.edu/IG060)

cotton (http://edis.ifas.ufl.edu/IG059)

peanuts (http://edis.ifas.ufl.edu/IG062)

sorghum (http://edis.ifas.ufl.edu/IG063)

soybeans (http://edis.ifas.ufl.edu/IG064)

tobacco (http://edis.ifas.ufl.edu/IG066)

wheat (http://edis.ifas.ufl.edu/IG067).

Extension specialists from other disciplines also publish similar literature concerning pests such as nematodes, plant diseases and weeds. These publications have been popular with the county extension staff, growers, pesticide dealers and other interested parties.

Multi-Media

Over the past 31 years, IPM information and application of numerous tactics and strategies has been included in oral presentations, in-service training sessions, workshops and grower and commodity-crop meetings. Scouting, sampling, pest identification, the role of beneficial arthropods and the use of economic thresholds have been stressed particularly and have become an important segment of the educational process. There have also been TV, radio and video tapes made available on these subjects. Extension specialists frequently write timely subject-mattertopics for crop and farm journals, newspapers and other periodicals. The IPM concepts usually appear, or are alluded to, in most of these articles.

Photograpy

From the beginning of the Tri-State project, it was strongly recognized that growers needed and demanded high quality color photographs of all types, including beneficial insects, arthropods, and other organisms; crop damage of roots, stems, foliage, flowers and fruiting structures; as well as harvesting, spray application and other forms of equipment. One of the goals of the project was to develop a catalog of 35 mm color slides covering these subjects on corn, peanuts, and soybeans. These slides proved to be very valuable in training scouts, growers and teaching students. The improvement and provision of new teaching slides (with the aid of a professional photographer) has been an important priority. The extension entomology division has generated many new high-quality slides and color plates, most of these slides can be used in the IPM teaching process. Color plates and slide sets of beneficial insects, arthropods and fungi have been particularly popular and in strong demand.

FAIRS

Beginning in 1979 and continuing to the early 1990's, the University of Florida College of Agriculture developed a computerized information system known as the Florida Agricultural Information Retrieval System (FAIRS). This computer project resulted in the development of comprehensive crop production databases for specific crops. The information included the available IPM tactics and strategies for use by extension, research and the private user. This project resulted in user-friendly databases and other pertinent information being made available to the county agent, with up-to-date computer equipment being provided to all of Florida's 67 counties. The computerized information was also accessible to the University of Florida research centers, as well as to students, all departments, libraries, and other interested parties. The FAIRS program utilized features such as presentations ofhigh-quality colored photographs of insects, diseases, treatments, etc., which can be viewed by the grower or extension agent at any location in the state. This mechanism provided the pathway for any new agricultural information, including IPM-related materials, to be made available statewide in a matter of minutes after the decision has been made to publish or release the knowledge. Consequently, an extension specialist or researcher could distribute a copy of new work, research data, or photographs, and it can be used by an infinite number of clients once it has been entered into the computer systems. Pest control information including IPM topics have been in constant demand.

The development and widespread use of the Internet allowed for the information assembled for FAIRS to be made available to a wider audience while still retaining the desirable characteristics of the FAIRS program. These included the ability to quickly and easily update, and the ability to display high-quality images of pests, pest damage and beneficial insects.

The Tomato IPM Program

A proposal to begin a pilot pest management project on tomatoes was submitted to the U.S.D.A. Extension Service in 1976. The project was subsequently funded for a period of three years and took place in Dade County, Florida. Dade County is located in the southeastern part of the peninsula and is one of the primary regions for production of winter vegetables in the United States. Because of favorable climate, technological development, adequate water and excellent growers, tomatoes represented a multi-million dollar income to the area.

Many pests, including diseases, insects, nematodes, and weeds constituted serious hazards to products and presented individually limiting factors to tomato production in the area. Although much information was available for control of specific pests, no comprehensive pest management system had been developed. There was a need for more efficient and effective pest control, while at same time the public urged a reduction in use of environmental pollutants through reduced use of pesticides (Busby, 1976; Good, 1976).

Objectives and Implementation

The objective of the pilot project was to provide a scientifically sound and educational demonstration of effective and efficient pest control for pests of tomatoes. Other, more specific objectives were to provide accurate unbiased field monitoring of pest intensities coupled with an advisory service to assist in the interpretation of observations, pest identification and problem solutions, and to incorporate into an effective pest management system the varied control techniques available. These included the use of pesticides, cultural practices, and biological control agents that would maximize production and profits, minimize the impact of pests, and reduce environmental pollution (Busby, 1976).

The program was carried out by an IPM Coordinator who was an Extension Specialist in Plant Pathlogy stationed in Dade County, and further additional members who were Extension Specialists in Entomology, Nematology, Plant Pathology and Vegetable Crops (weed control) with consultants in Economics, Soils and other disciplines as required. The responsibility of this Coordinating Committee was to plan and execute the necessary demonstrations of pest management in tomatoes and to formulate advice to growers and the pertinent involved University of Florida staff members.

Evaluations were made semi-annually to review the pest situation and to plan the best strategies for the subsequent crop. Tomatoes were grown from August until June, but were categorized as fall/winter and winter/spring crops. The IPM Coordinator, the Coordinating Committee and the administrative advisor (Plant Pathology Department Chairman) were the primary evaluators, with inputs from the research faculty, cooperating growers and other concerned or interested individuals. The objectives of the reviews were to increase the effectiveness of the IPM systemsemployed and to improve the educational value of the program to the growers (Busby, 1976).

Tomato Pests

Pests of tomatoes in the Dade County area were varied and abundant. The basic problems encountered are summarized below:

Diseases

Damp off - *Rhizoctonia solani* Kuehn

Fusararium wilt - *Fusarium oxysporum* f. *lycpersici* (Sacc.)

Verticillum wilt - *Verticillium albo atrum* Reinke and Berthier

Southern blight - *Sclerotium rolfsii* Sacc.

Schlrotinia stem blight - *Sclerotinia sclerotiorum* (Lib)deBary

Late blight - *Phytophthora infestans* (Mont.) blight

Bacterial spot - *Xanthomonas vesicatoria* (Dioge) Dye

Sorauer - *Alternaria solani*

Grey leaf spot - *Sytemphyllium solani*

Leaf mold - *Cladosporium fulvum* (Cooke) Cif.

Target spot - *Cornespora cassiicola* (Berk and M. A. Curtis)

Fruit rot type disease - *Phoma destructiva* plowr.

Fruit rot type disease - *Boterytis cinerea* Pers.

Fruit rot type disease - *Phytophtora parasitica* (Dastur)

Bacterial soft rot - *Erwinia Carotovara* (L. R. Jones)

Mosaic Virus - Potato Virus Y. (PVY)

Mottle Virus - Tobacco Etch Virus (TEV)

Mosaic Virus - Cucumber Mosaic Virus

Cucumber Mosaic Virus - Pseudo Curly Top Virus

Insects

Tomato pinworm - *Keiferia lycopersicella* (Walshingham)

Wireworms - *Melanotus* spp., *Conoderus* spp.

Field cricket - *Acheta* (= *Gryllus*) *asimilis* Fab.

Serpentine leafminer - *Liriomyza sativa* Blanchard Fab.

Cabbage looper - *Trichoplusia ni* (Hbner)

Fall armyworm - *Spodoptera frugiperda* (Smith)

Beet armyworm - *Spodoptera exigua* (Hubner)

Corn earworm - *Heliothis zea* (Boddie)

Southern armyworm - *Spodoptera eridania* (Cramer)

Green peach aphid - *Myzus persicae* (Sulzer)

Flea beetles - *Epitrix* spp.

Cucumber beetles - *Diabrotica* spp.

Thrips - *Frankliniella* spp.

Cutworm - numerous spp.

Spider mites - *Tetranychus* spp.

Squash bug - *Anasa tristus* (De Geer)

Brown stink bug - *Euschistus servus* (Say)

Southern green stink bug - *Nezara viridula* (Linnaeus)

Potato leafhopper - *Empoasca fabae* (Harris)

Leaf-footed plantbug - *Leptoglossus phyllopus* (L.)

Big-footed plantbug - *Acanthocephala femorata* (F.)

Nematodes

Root-knot - *Meloidogyne* spp.

Reniform - *Rotylenchulus* spp.

Stunt - *Tylenchorhnychus* spp.

Weeds

Smooth pigweed - *Amaranthus hybridus* L.

Common purslane - *Portulaca oleracea* L.

Goosegrass - *Eleusine indica* (L.) Gaertn.

Purple nutsedge - *Cyperus rotundus* L.

Black nightshade - *Solanum nigrum* L.

Spiny amarantha - *Amaranthus spinosus* L.

Mexican pricklepoppy - *Argemone mexicana* L.

Spiny sowthistle - *Sonchus oleraceus* L.

Slender amaranth - *Amaranthus virdis* L.

Annual sowthistle - *Senchus olwexwua* L.

Large crabgrass - *Digitaria sanguinlis* (L.) Axop.

Common lambsquarters - *Chenopodium album* L.

Bidens - *Bidena alba* (L.) DC.

Black medic - *Medicago lupulin* L.

Lantana - *Lantana camara* L.

Rosary pea - *Abrus precatorius* L.

Florida purslane - *Richardia scabra* L.

Common ragwood - *Ambrosia artemissifolia* L.

Other Pests

Rats - unknown species

Mice - unknown species

Slugs - unknown species

Snails - unknown species

Many parasitic and predaceous insects were found in conjunction with the tomato pests. A list of these beneficial arthropods is provided below.

Beneficial Arthropods

Parasitic Wasps - Hymenoptera: Braconidae

Ground Beetles - Coleoptera: Carabidae

Tiger Beetles - Coleoptera: Cicindellidae

Lady Beetles - Coleoptera: Coccinellidae

Earwigs - Dermaptera: Forficulidae

Assassin Bugs - Hemiptera: Reduviidae

Damsel Bugs - Hemiptera: Nabidae

Big-Eyed Bugs - Hemiptera: Lygaeidae (*Geocoris* spp.)

Tachinid Flies - Diptera: Tachinidae (including the feather-legged fly *Trichopoda* spp.)

Spiders - Aranea: Oxyopidae (including the green lynx spider *Peucetia viridans*) (Busby 1976).

Pesticide Use Patterns Prior to IPM

Preplant Stage

Tomato seeds in most cases were typically treated with a fungicide/insecticide which acted as a protectant at planting. Most growers applied an insecticide such as chlordane, which was mixed with planting fertilizer. Others used a chlorinated material as a band treatment in the row at planting time. Growers also broadcasted a material such as parathion granules prior to planting, and disked them into the soil to reduce soil insect populations.

Seedling Stage

As soon as the plants emerged, pesticidal spraying began. Most spraying was done with high volume, high pressure, tractor-drawn sprayers. Gallonage applied at the seedling stage ranged from 35-85 gallons per acre. Sprays were applied biweekly or at least once every 5-7 days (Johnson 1992, Pohronezny, et al. 1986). This procedure had been followed for years and was considered to be 'preventative.' Onevery important reason for the frequent sprays was that plant diseases could run rampant within a few hours under the warm, humid, sub-tropical environment where rain occurs frequently (often exceeding 100 inches per year in this specific locality). Sprays for numerous bacterial and fungal diseases were mandatory. Since the spray machine must be used to apply disease-combating materials anyway, the grower operated on the premise that it was only 'cheap insurance' to add other pesticide components to the tank. Before strenuous government (Environmental Protection Agency, Occupational Safety and Safe Act) regulations, the high cost of chemicals, and the quality of IPM strategies, the growers were accustomed to routinely adding low cost insecticides and fungicides as a preventative treatment. This attitude was prevalent since the average costs to the grower for producing an acre of tomatoes in Dade County in 1974 was $2,919.00 (Busby, 1976). In 1990-91, this cost was $8,322.92 (Smith and Taylor, 1991). The growers felt that the costs of pesticides were superficial or of minor concern when the total costs and risks of growing tomatoes were taken into consideration.

Mid-Plant Growth Stage

As the tomato plant continued to grow, spray applications averaged twice per week and spray gallonage increased to approximately 80-100 gallons per acre. The interval of time between sprays was shortened if pest populations persisted, began to build up, or if frequency of rainfall increased. Observations were made where tomatoes were sprayed 23 times in a 21-day rainy period. Most tomato growers had enough available spray equipment to cover every acre they grew in a 24-hour period or less. If necessary, ground sprays were supplemented with aerial applications.

Late Plant Growth and Fruiting Stage

Spraying continued as described until harvest was complete. Spray gallonage on mature tomatoes increased to approximately 100-165 gallons per acre. The tomatoes grown in Dade County were primarily sold for fresh market consumption. The left-overfruits were sold to the public as 'you pick them' operations, sold to canners, or sold to small road-side stand operations. Many were abandoned. Often there was no incentive for the farmer to practice sanitational pest control by plowing under residues since additional money could be made due to the above reasons. Farmers did not want to spend any more money or energy on a crop from which they could no longer gain any cash benefit, and therefore abandoned the field. Tomato farmers did not own their land and would farm in new or different fields each year. Therefore, pests left behind to multiply as a result of abandonment were often of little concern on an individual basis.

Total Sprays

In the time period of approximately 135 days that tomatoes were growing, the crop was sprayed from 20-40 times with an average being closer to 32-35 times (Johnson, 1992). In extreme cases, farmers may apply as many as 60 fungicide sprays on some winter crops (Pohronezny et al., 1986). It was difficult and impractical to determine what specific materials were used in the largest quantities in the area. Each grower's spray program was somewhat different. It was not unusual to find 5-17 different ingredients within a tank at a given spraying. This included insecticides, fungicides, bactericides, soluble macro- and micro-nutrients, wetting-sticking agents, or other adjuvants. Tomatoes normally had more than a single insect or disease pest at a given time when grown under the subtropical conditions. This made a combination of sprays necessary (Johnson, 1992). Pesticides most commonly used were:

- **Insecticides** - azinphosmethyl, carbaryl, dimethoate, endosulfan, mevinphos, methomyl, parathion, toxaphene, and *Bacillus thuringiensis*
- **Fungicides** - chlorothalonil, mancozeb and maneb
- **Bactericides** - copper, sulfate, copper hydroxide, and streptomycin
- **Fumigants** - methyl bromide plus chloropicrin (used for nematodes, soil diseases, insects and weeds)
- **Herbicides** - diphenamids and paraquat

Other rodenticides, molluscicides and various materials were also used. Best estimates indicated that each acre of tomatoes received between 18-20 pounds of insecticides, 1-6 pounds of herbicides, and 50+ pounds of fungicides.

Irrigation

Irrigation in Dade County was quite different from what most farmers were accustomed to. The soil was old coral-reef calcium deposit type in which the surface was shaved and crushed by heavy specialized equipment to a depth of 4-6 inches before it could be used for planting. In this loose rocks media, tomato seeds or transplants were planted and the crop grown on what agriculturists term 'modified hydroponics.' The permanent water table lay from 2-11 feet beneath the soil surface. A nine inch diameter hole was drilled to a depth of 25 feet through the solid calcium rock (this served as a natural well casing) and diesel or gasoline engine/ pumps were mounted on trucks that were driven and positioned over the well. An aluminum drop pipe was placed into the well and irrigation water could be applied from each well via a gun-type head to approximately 3-5 acres at a time at the rate of 1,100-1,400 gallons of water per minute. Water and its pollution became a major concern during the 1970s, and the local farmers and tomato growers were faced with new problems and liabilities.

Working with Farmers

In most instances, the Dade County tomato farmer was an aggressive businessman as well as a farmer. He was quick to change and adopt new ideas if and only if proof through research or well-presented demonstrations indicated that these programs would make him more money, save him money, make his endeavors safer or less onerous, or make his product more acceptable (Busby, 1976; Johnson, 1992).

The growers were aware of pesticides and their dangers, costs, and other drawbacks, however with growing winter vegetables being a gamble at best and with growers putting perhaps all their lives' savings at risk, they did not hesitate to apply pesticides even if there was only a remote chance that damage to their crop would take place if the pesticide was not applied.

At the beginning of the pilot program, it was felt that the tomato growers would take advantage of a well-planned IPM program and would use it to the point of becoming a practice if the program was meritorious. The past decade had seen them make major shifts from sandy soil to rock-soil farming, from open row to covered mulch plant beds, and from chlorinated hydrocarbon to organophosphorus and carbamate type insecticides. Furthermore, growers reduced fertilizer application from 4,000-6,000 pounds to 1,500-2,000 pounds per acre, went from one row single seeding equipment to 3-4 row automatic seeding and thinning equipment, and began the use of soil fumigants. These practices were considered to be extreme changes and were often called 'drastic' and 'hopeless' by the growers at the time of their early conception. However, these changes were accepted and had become established practices which were being used at the beginning of the IPM program (Busby, 1976).

The evidence at the time (1976) indicated that growers were willing to accept 'better ways' of producing their crops, even though the acceptance was not fast or easy to accomplish. It was felt that a well-planned, organized IPM project with proper goals and with support from Research and Extension professionals would be a worthwhile undertaking that would be accepted by the tomato industry. New approaches with the IPM program included:

- training of growers to select the proper pesticide needed for a specific job
- using specific pesticides at the minimum amount that would give effective and economical control
- promoting proper up-to-date methods of using pesticides so that maximum efficiency was realized with minimum pesticide and energy inputs
- using the most current methods available for crop inspection so that pesticides would be used as near to the optimum time that they were needed for the most efficient pest control
- training the growers to properly identify tomato pests in order to determine if control action was necessary

By integrating the five objectives, it was felt that significant reduction in double-spraying and wastage could be accomplished, while improper use, overuse, and other related errors could be eliminated. This would result in an overall reduction in the amount of pesticides added to the environment and decrease exposure of urban populations to chemicals.

Program Operation and Administration

The tomato IPM pilot program was operated and administered basically like the Tri-State Project in the way internal and external advisory committees were set up, scouts were trained, and growers were selected and educated. The program was monitored concerning benefits and cost impacts on the environment and community (Busby, 1976).

The majority of tomatoes were (and currently are) grown in the southeastern, Atlantic coast, central Gulf coast, south central, and northwestern areas of the state (Florida Agricultural Statistical Service, 1991). Dade county was selected as the site for the pilot project because it is the most southerly site in the state and has warm annual temperatures, allowing the county to be one of the few areas in the U.S. that can grow mid-winter tomatoes. In addition, Dade has severe pest problems of all types, and is located geographically where potential environmental problems are highly likely. Dade County is bordered on the east by the Atlantic Ocean, on the south by a combination of Florida Keys, Everglades National Park, and Florida Bay, on the west by the Everglades National Park and on the north by the Everglades and the metropolitan area of Ft. Lauderdale. The tomato farming area is located in the south and southwest portion of the county around the towns of Homestead, Florida City and Perrine. Approximately 17,000 acres are committed to tomatoes in this general area from August until June.

As discussed above, the tomato growing areas are in very close proximity to both national parks andlarge urban areas. Farm areas and dwelling areas are intermingled, and production takes place within close proximity to a large number of people, as fields often end where homes, schools, and shopping centers begin. This situation creates a great deal of uneasiness and concern among many people, both in and out of the state, and increases the demand for safe alternatives to traditional methods of pest control. Additionally, Dade County's low elevation (approximately 15 feet above sea level), combined with its numerous canals (built by the Army Corps of Engineers to drain low-lying landings into oceans and bays) creates the potential for pesticide runoff and leaching into the shallow water table. Questions were raised as to the type and extent of pollution that could be taking place and what its potential effects could be on Biscayne Bay, Florida Bay and other waters of the Atlantic and Gulf of Mexico.

The population growth of Dade County was one of the most rapid in the United States, going from a population of 298 in 1989 to 495,047 in 1950 to over 1,400,000 in 1975. Population density in Dade County in 1980 was third highest in the state with 791 persons per square mile. Also, Dade County, where Miami and Miami Beach are located, is a center for tourism. Tourists are highest in number at the time of the year (fall, winter, early spring) that farm pesticide use is at a maximum, and detrimental publicity involved in the use of pesticides could be harmful to many concerned groups.

Finally, a great deal of migratory labor is used in Dade County, particularly during harvest, so finding ways to minimize the dangers of field re-entry and pesticide use is of primary concern.

The Pilot IPM program was established to increase understanding and improve efficiency in the use of pesticides. It was a beginning effort, along with the promotion of existing programs and research, that would improve the overall pesticide use patterns in this complex farming-urban area (Good, 1976; Johnson and Linker, 1976). In turn, relationships and understanding between the various segments of society and agriculture would improve. The expected increase in the efficient use of pesticides certainly would notharm the existing plant and animal life, nor the quality of the land and water which were in such close proximity to farm operations. The IPM program was expected to play an important role in reducing possible dangers that existed between this close farming-urban environment.

Program Results

The program proved to be popular with the growers and the community. The second year a sub-pilot project was demanded and was started in the large tomato growing area of Ruskin-Palmetto-Bradenton, which is located on the west central coast of Florida near the Gulf of Mexico and the Tampa Bay area (Pohronezny, et al., 1986). The IPM program served to point out many research needs and gaps. Many of these needs were met as a result of this program, and much new information was generated. A comprehensive Tomato Scouting Manual with color-illustrated dichotomous keys for insects and diseases in Florida tomato fields was published as a result (Pohronezny, et al., 1983).

Due to the program, the Coordinator (IPM Specialist) job was made into a permanent position in the state to carry out and promote the use of IPM in tomatoes and other pertinent vegetable crops. This faculty member continues to do research related to IPM and to work with growers, peers, and county extension staff members through the various media means to continue and improve the IPM concept (Pohronezny, 1991). The success of the specific tomato IPM program will be further discussed under the Current Situation section.

The Scouting and Monitoring Situation

The role of the IPM scout is one of the most important segments of implementing an IPM program. If success is to be expected, scouting must be timely and reliable. The scout serves as a bridge between the knowledge obtained by research and the person who is the decision-maker (Reese and Kempter, 1974; Johnson and Linker, 1979; Sprenkel, 1991).

The scout generates the information that meets two very important needs in the IPM process. One is that proper identification of the pest must be made. This requires proper training, supervision and experience. Many mistakes in identification have resulted in multiple applications at high dosages of the wrong pesticides. Misidentification has also resulted in pesticides being used for physiological and/or nutritional disorders thought to be diseases, or to control beneficial arthropods thought to be harmful. These mistakes are expensive to the grower as well as to the environment.

The scout also performs the important duty of collecting the proper data, based on counts that indicate the economic threshold or action level. Improper scouting through oversights can cause a decision to be made too late, resulting in heavy crop loss. Dishonest or haphazard assessment of pest populations, or reporting them to have reached economic levels when truly they are below these levels, also causes needless dollars to be spent and unnecessary pressures to be placed on the environment.

The availability of well-trained, dedicated scouts may be the 'weak link' in the overall IPM process. Research can be generated to steadily improve the techniques in sampling and the establishment of functional thresholds, etc. Extension can improve training, and techniques and their application; however, all of these are of little value unless scouts with sufficient background and desire to assimilate training and carry out the work can be put into action.

Recruitment

In the programs where extension have been involved, recruitment is carried out by members of both the county and state staff. The University of Florida has provided a large number of scouts that were students in the College of Agriculture. The University of Florida in the past had a program where students needed an internship in order to obtain an IPM certificate (Strayer, 1991). Many students enrolled in this program, as well as various others, were used in the scouting programs.

Students other than those enrolled in agriculture also were recruited and developed into excellent scouts. These students came from numerous disciplines from engineering to language majors. In many cases, these non-agricultural students were from a locality where IPM scouts were needed and had a home or family close to the job, so relocation was not necessary. Junior or two-year colleges are located throughout the state. Since most of these students lived at home and commuted to college, they provided a local supply of trainable labor.

School teachers were also a labor pool that was recruited in order to fit certain scouting needs. Although both school teachers and college students generally developed into good scouts, their school vacation schedules often did not properly coincide with the time of year that crops were being grown and required scouting. In some cases, students that were interested in either upgrading their work experience or earning additional money withdrew from school for a term in order to complete the scouting season. As the IPM concepts became more popular with growers, students that had been scouts during their educational programs were hired by large growers, private consultants, or other agricultural businesses in order to use their expertise and to develop programs involving their particular IPM need. Members of farm families were also recruited and trained to become scouts on their own family operations.

Scouting is a job that requires a great deal of energy. Walking, bending and/or stooping, and other physical activity is required on most days on the job. A scout will walk approximately ten miles each day as they carry out their pest monitoring duties. Therefore, it was found that scouting was more appealing to younger than older people. Female scouts were observed to perform equally with male scouts. The ability to learn, be responsible, be conscientious and be dedicated outweighed having agricultural experience or being a student of agriculture. However, students involved in a program such as Entomology, Nematology, Plant Pathology, Agronomy, Horticulture and particularly those pursuing an IPM certificate were superior scouts (Johnson, 1978; Pohronezny, et al., 1983).

Scouts used by private consultants and other agricultural industries were sometimes recruited by the employers, but in many cases they were recruited by the Extension Service for their use. In most cases, the Extension Service provided the training for these individuals.

Training

The majority of IPM scouts were intensively trained by Extension Service personnel for approximately three days before a particular growing season started. Classes were scheduled so that the scouts would be entering the field immediately after the formal instruction was complete.

Formal training included a host of topics ranging from crop phenology to the random sampling process. Each extension specialist (entomology, plant pathology, nematology, weed science) provided training in pest biology, identification, habits, damage to the crop, specific sampling techniques, expected time of the pest appearance, environmental niches, plant parts to be infested or infected, and other pertinent information.

Scouts were also taught how to use identification keys containing photographs, drawings and other illustrations of both pests and the forms of damage they cause. Training in terminology involving crops and associated pests was also provided.

Scouts were trained in the various sampling techniques, ranging from how to enter the field to specific soil or leaf sampling. During the classroom sessions, the scouts were shown samples of live weed seedlings, active cases of diseases and nematodes (live and dead), and bottled or pinned insect specimens. These samples were prepared in advance of the training sessions by the respective extension specialists. Research workers also took part in the formal training sessions.

Each specialist provided literature that dealt with the specific pests that attack or would be encountered on the target crop. A scouting manual was provided to each scout. The manual contained all the necessaryinformation and publications from each of the pest disciplines, identification keys, color plates, glossaries, crop phenology, rating systems, record forms, supplementary publications, and other information that would be referred to on an as-needed basis.

Scouts were also trained in dealing with their clients, with personal relations emphasized. Other aspects of instruction included how to prepare precise and accurate identification and data reports, the importance of being non-biased in sampling and site selections, as well as the expectations involving conscientiousness and job responsibilities.

Scouts were also trained in job safety, which involves avoiding unnecessary contact with pesticides, field re-entry and knowledge of residues (especially of specific pesticides that would be used in the program), pesticide poisoning symptoms and antidotes, instruction on procedures in case of storms and lightning, accident avoidance relating to driving and travel dangers, and precautions for working where venomous snakes could be encountered.

Once formal classroom training had been completed, the scouts were taken to prepared fields where they had to demonstrate scouting methods, sampling techniques, and pest identifications. Scouts were given written tests covering the various subjects taught and were required to make a passing grade before officially beginning a job, unless they were working on their own farm. The scouts used in the Extension-related IPM programs did not make any pesticide recommendations and were purposely not trained in this decision-making process.

Follow-Up

The scouts were in constant contact with their supervisor, which was an IPM Coordinator or a specifically trained person employed by the Extension Service. Additional training was accomplished by daily contact or as often as the need arose. This was particularly necessary during the first few weeks with a beginning scout on the job. It was also necessary for the Coordinator to meet regularly with the scouts as a group for further in-field or classroom training. Theextension specialists representing the various disciplines also provided further in-field and supplementary training when it was needed.

Follow-up education was a key part in the overall scout training process and it was particularly important when working with first-year scouts. Scouts that were experienced often served as senior scouts and helped those who were 'rookies' and less knowledgeable. Private consultants that utilized the cooperative service served as supervisors for their scouts and provided them with further training.

The Need for IPM and the Current Situation

The need for IPM has become increasingly evident, particularly in the last 20-25 years. This publication has discussed many of the reasons for the increased interest in the IPM program. The following summarizes, in no particular order of importance or occurrence, the factors that have played a role in bringing out the IPM process:

- The establishment of the Environmental Protection Agency (EPA) by the federal government
- The increasing concern of the public about environmental issues, particularly the effects of pesticides on wildlife and endangered species
- The withdrawal from the market of chlorinated hydrocarbon chemicals and many other pesticides that were found to be harmful to man or to the environment
- The continued creation of federal and state agencies (such as the Federal Occupational Safety and Hazard Act (OSHA), the Florida State Department of Natural Resources (DNR), Department of Environmental Regulations (DER) and others) that deal with pesticide misuse, spills and other safety problems
- The federal act administered by the EPA that requires all users of restricted pesticides to be trained and licensed before they can purchase or apply these designated materials
- The continued increase in agricultural production costs including pesticides. These costs went up drastically in the late 1970s and early 1980s, due in part to petroleum increases and market shortages.
- The constant and increasing concern by the public and the federal and state departments of labor about the safety of farm labor. Much of the concern centers around contact with pesticide residues.
- The state of Florida's rapid population growth, where urbanization and development often bring dwellers and tourists in close proximity to agricultural operations and pesticide use
- The very strong concern about pollution of Florida waters (aquifers, lakes, rivers, streams, bays, estuaries and other bodies) by chemicals or by other means. The purity of these resources are depended upon for personal, recreational, and other valuable uses.
- Increased liability and costs to the farmer through chemical trespass lawsuits, non-target drifts of pesticides and other related problems
- the increase in the frequency of resistance of pests to classes of pesticides requiring growers to selevtively use pesticides and otherwise adopt Insecticide Resistance Managmenet (IRM) plans.
- The consumer's increased concern and awareness of pesticides and pesticide residues involving food products
- The added cost and the more comprehensive requirements and rules required of producers of pesticides in developing and bringing new as well as keeping old compounds on the market
- The availability of more research that deals with non-chemical control of pests, more efficient chemical control measures, and research leading to new strategies and tactics that support IPM
- Biocontrol measures became more popular, and the knowledge of the value of protecting the beneficial environmental organisms that provide natural pest control reached new audiences.
- Increasing problems involving resistance to pesticides by numerous pests were being encountered at an extremely high rate.
- Educational efforts and support of IPM were increased by the Universities at the research, teaching and extension levels.
- Communication methods with the farmer were improved, with more comprehensive literature concerning IPM being made available.

Current Status

There have been many positive actions that indicate that IPM is progressing, and that the growers and other personnel of the agricultural industry in Florida are becoming more aware of the importance of continuing to move the IPM program forward (Summerhill, 1987).

In the last 30 years, growers have made tremendous progress in understanding the need for crop monitoring through scouts (Johnson and Linker, 1978b; Pohronezny et al., 1986). They have realized that understanding the principles of IPM has led them to better understand soils, crop nutrition, water requirements, and other IPM-related strategies that are needed in total crop production.

The Florida Extension Entomology-Specialists in conjunction with a professional photographer have produced a series of high- quality color plates/fact sheets of many crop pests, as well as beneficial organisms with accompanying explanatory information. Over the past 15-20 years, specialists have made extra efforts to educate the growers and other extension personnel at the county level about the value of beneficial organisms (Schuster, 1991; Johnson, 1992; Pohronezny, 1992; Sprenkel, 1991). The information has primarily been presented in grower meetings, in-service training sessions, and printed literature. The growers are becoming more inquisitive about beneficials, population dynamics, feeding habits, behavior, sensitivity to variety of insecticides, and other biological information.

A movement has been underway for some time to educate growers about the constant use of a single insecticide and the role this action plays in the target pest's developing resistance to a given compound (Johnson and Liner, 1976; Hoeller, 1978). The resulting resistance to insecticides by dipterous leafminers, diamondback moths, and sweetpotato whiteflies has become disturbing to the growers of Florida. Efforts to have growers alternate the application of available insecticides, use lower dosages, improve spray techniques, and implement other IPM tactics have been more successful than in the past. The growers are becoming more aware of, and seeking use of "softer" compounds such as *Bacillus thuringiensis* and other materials for specific problem pests. This allows for more efficient or effective management of other target or secondary pest insects in their overall control program (Summerhill, 1987).

Thirty years ago, the general trend (or certainly the desire) seemed to be that 98-100% control of insects was expected from an insecticide and that the kill had to occur instantly. If an insecticide application did not perform satisfactorily and within expected time frames, growers would frequently reapply with a heavier dosage or try another material. Within the last 15-20 years, educational efforts have steadily improved this line of thought and growers are becoming resolved to the fact that it is not necessary in most cases to obtain this high level of control (Summerhill, 1987). They also are aware of the cost of materials (Franke, 1991) necessary to achieve these results, as well as the indirect cost this type of control action has on the environment and future production efforts. Patience and understanding in the realm of realistic time frames required for a control effort to reduce or control a target have also improved.

Growers are beginning to employ more border, band and spot treatments of insecticides than they did in the past. They have found that in many cases broadcast treatments are not necessary to prevent yield losses, and 'row' treatment of smaller target areas is acceptable as far as pest control is concerned. Of course, these actions are significantly cheaper. Othertactics such as seed treatment, additions of insecticides to transplant water, and concentrated efforts to maintain transplant beds free of pests before transfer to field plantings have been recommended by the extension service. A great deal less time, energy, money and pesticides are utilized when these low-cost preventative control actions have been carried out, rather than waiting for damaging field pest populations to develop.

Observations over the last 20 years indicate that many growers have developed a high level of respect for, and perhaps to some degree a fear of, highly toxic insecticides such as parathion, phosdrin and others. Many are reluctant to use these materials, while some refuse altogether. The growers as a group have improved in their ability to select control materials that are not only less toxic to themselves and their labor force, but that do not impact as heavily on the local environment. Several growers over the past 15 years have mentioned that they notice more wildlife, particularly quail, on their farms after they implemented recommended IPM programs.

It is felt that the Restricted Pesticide Certification Licensing program has played and still is playing a role in educating pesticide users, both private and commercial, about many useful tactics and strategies that are functions of the IPM philosophy. The Extension Service has been responsible for developing educational materials, teaching, and testing the participants of this program.

At the present time, growers and other pesticide applicators can renew their licenses by attending a series of presentations where they obtain Continuing Educational Units (CEU's). These CEU credit meetings have been extremely popular the last several years. Growers that have attended these sessions represent a wide variety of crops. These programs are taught by Extension Specialists and other related pesticide-knowledgeable personnel. The subject matter of these presentations includes many topics related to IPM such as rotation, use of resistant varieties, cultural control of pests, pest avoidance by timing of plantings, crop sanitation, proper use of pesticides, and other IPM pest control strategies.Insecticides and other pesticides as a rule are considered to be relatively expensive by present-day standards. Many of the cheaper materials have either been cancelled by regulatory agencies or removed voluntarily from the market due to the high cost of the re-registration process mandated by U.S. Federal Law. The added costs of using the limited available materials has led growers to become more aware of using precise timing of applications, and has improved accuracy of recommended dosages. Growers are paying a great deal more attention to the correct means of applying pesticides than in the past. Efforts to calibrate sprayers, maintain the application equipment, and make extra efforts in order to spray more efficiently as far as the pest target is concerned are becoming more popular.

Insecticide Use under IPM

The Extension Service has particularly promoted the following IPM steps for growers to follow when use of insecticides become necessary to control a pest:

- Make sure the proper identification of the target pest has been made.
- Determine that the economic or action threshold established for the pest in question is met so that the correct timing of the application is as near accurate as possible.
- Select the proper pesticide after considering factors such as control of primary pests, control of secondary pests (if they exist), likelihood of developing insecticide resistance, effects on beneficial organisms, the impact on the environment, water pollution (via runoff and/or leaching), and safety factors.
- Use the correct dosage that will accomplish the task (with an understanding that the use of sub-lethal amounts can call for reapplication, and overdosage can bring about resistance and other undesirable actions).
- Correctly apply the pesticide according to the label and adhere to sound principles involving calibration, recommended delivery speed, application pressures. Use the proper techniques and equipment to accomplish the task.

The first two steps must be accomplished by monitoring or scouting, while the last three must be a final decision by the grower. Hopefully, thesedecisions will be made only after he has used the training, literature, knowledge, and experience gained or made available through a variety of means.

More than ever before, growers are realizing the importance of sanitation measures and the role this tactic plays in the overall pest control program. This process is being used more and more, particularly when resistant insects are encountered such as sweetpotato whiteflies, leafminers, and diamondback moths. Growers have also become acutely aware that this method also reduces nematode populations and disease pressures.

Currently, growers are becoming aware of the value of crop history and of keeping better records of pest problems, population changes encountered, intensities, etc., thus they are better able to plan for and deal with expected situations in the future. In conjunction with keeping crop histories, the growers have responded to education and encouragement to map their fields for nematodes and weed species. This strategy has played an important role in proactive planning for selected and needed control measures in order to best utilize rotation programs. The mapping and information obtained from crop histories frequently allows growers to avoid potential problem areas or to apply preventative control measures in advance. These usually involve the use of less pesticide while at the same time providing more efficient control. The more sophisticated growers are practicing an increasingly wider range of IPM tactics and strategies in their production of crops. This often includes the hiring of IPM knowledgeable management personnel and the encouragement of their employees to attend training sessions in order to stay up-to-date on the latest recommendations that are generated by research. The growers also have become more cooperative in working closely with university extension and research staff members to jointly approach work associated with improving the IPM knowledge base.

IPM is being practiced in Florida at various levels and percentages for various crops. Currently, there areprograms and strong efforts ongoing in citrus and urban IPM (including turf, homeowners and golf courses). This publication has been devoted to row crops (agronomic and vegetable) IPM efforts, and does not address the other programs.

Specific IPM programs, as previously discussed, were first installed with agronomic crops. The activity and growth in the agronomic area has been steady. In 1991, it was reported that 14,570 acres of cotton were involved in IPM under private consultants and an additional 29,995 acres were influenced by the Extension Service. This constitutes almost 100% of the cotton grown within the state. In 1991, the state has approximately 55,000 acres of peanut allotment, of which 8,050 were practicing IPM under private consultants and additional 22,480 were influenced by the Extension Service. The soybean acreage in Florida has dropped over the past several years due to low prices. However, an estimated 40-45% of the acreage is scouted regularly and many other growers monitor their crops on at least a minimal basis. The soybean growers are aware of the IPM recommended pest thresholds and generally employ these when making a decision to apply insecticides. Due to the lower prices received in the last several years by growers of grain, sorghum and corn, there was only minimal specific acreage being scouted and practicing the full program. However, the growers of these crops have been made aware and are now incorporating specific IPM strategies in their production practices.

In 1991, the Extension Service trained 27 scouts and 89 producers in the agronomic crop area. The training was comprehensive and included scouting as well as instruction in the available and recommended IPM strategies and philosophies. The Extension Service currently employs a full-time PhD-level IPM state specialist to develop and implement agronomic-IPM programs. In 1991, the IPM multi-county staff included inputs of 1.5 FTE (full-time equivalents) and 3.2 FTE inputs from other county staff members. These aforementioned personnel all hold degrees at the master's level. An agronomic IPM advisory committee is active and is composed of eight members representing five different agencies and departments. As of 1991, there were 24 private consultants/ firmsthat were providing IPM services to agronomic crop growers (Sprenkel, 1991).

Vegetable growers were first exposed to organized IPM programs as a result of the Tomato IPM project in Dade county in 1976. In 1978, the program extended to include the central west coast growing area. This was also a major growing region composed of Hillsborough and Manatee counties. By 1979, this program had expanded to a third site which included the southwest Collier county growing area. The original pilot IPM program began with 365 acres dedicated to being scouted once per week and was funded by state and federal dollars. By 1983, the pilot program was scouting 4,700 acres of tomatoes twice weekly with extension-trained scouts funded entirely by the private sector. This involvement by the growers allowed the extension personnel the freedom to concentrate on developing IPM educational programs.

Other IPM Crops

The success of the Tomato IPM program created an interest in growers producing other crops similar in nature. As a result, University of Florida IFAS personnel also worked to develop an IPM program for snap beans (Pohronezny, 1991). They developed a sound research base including crop sampling techniques, and action thresholds for several key insect pests. Other IPM tactics such as plant spacing arrangements, variety selection, and a reduced pesticide residue program were included in the overall strategy.

Limited IPM programs, which primarily involved selection and use of pesticides on demand, were implemented on strawberries and peppers. Private scouting companies were the primary delivery agent for these two crops, as well as the performing agent for scouting services on sweet corn and cole crops. These crops did not have the needed comprehensive database to support the development of programs that were available for tomatoes and snap beans. The participating consulting scouting service businesses initiated their own trial and error efforts in developing workable sampling techniques as well as actionthresholds. Many of the specific techniques used for these crops were unknown to persons outside these firms and were considered to be trade secrets. Some of the protocols used have not been subject to scientific evaluation, and their effectiveness has been tested only by client satisfaction. The University of Florida Extension Service put forth concentrated efforts to make IPM support educational information available to growers, scouts and consultants while the research group continued to fill data gaps identified by extension personnel (Pohronezny et al., 1986; Pohronezny et al., 1989).

Vegetable Production

A study on the impact of educational programs in IPM on vegetables was made by the Florida Cooperative Extension Service from 1984 to 1986. Four crops (tomatoes, snap beans, strawberries, and bell peppers) were included in the study. Percentages of state-wide planted acreage scouted at that time were: tomatoes - 47%, snap beans - 34%, strawberries - 14%, and bell pepper - 36%. Based on the data in the study, it was concluded that participation in extension IPM programs had a substantial positive impact on production of these crops. Practices used in disease and insect management accounted for most of the changes exhibited by growers. Nematode and weed control practices have been less influenced by IPM programs. The study revealed that 62% of the growers reported that net returns (savings in pesticide costs minus scouting fees) were increased following the use of IPM strategies. Most of the economic benefits were due to fewer applications of pesticides. Overall, 83% of the growers reported their use of insecticides had decreased as a result of involvement in an IPM program. On the average, the amount of insecticide and miticide (lbs. a.i./acre) sprayed decreased 21.1%. Decreases ranged from 10% for snap beans to 50% for bell pepper. A majority of growers reported that fungicide use remained about the same after initiation of an IPM program, but about 29% reported a reduction of fungicide use averaging about 9% (lb. a.i./acre).

Growers did not list cost savings as the major benefit realized in IPM programs. Early and accurateidentification of pests was viewed as the major incentive for hiring scouts. Most growers surveyed were aware of the importance of insect predators and parasites. About 57% of the growers of both tomato and snap beans reported that they considered the status of leafminer parasites before making the decision whether or not to apply insecticides. Among the tomato growers, 39% were aware of the Florida Agricultural Information Retrieval System (FAIRS) which had available a tomato production database including known IPM tactics and strategies, and 82% indicated a desire to have access to FAIRS (Pohronezny et al., 1989).

Levels of Involvement

Personnel communications with the Extension Vegetable IPM Specialist and other related researchers and members of the vegetable industry estimated the following levels of IPM scouting program involvement (Pohronezny, 1991; Schuster, 1991; Stansley, 1991):

- The southwest tomato growing area (Naples and Immokallee) - 80%
- The northwest Florida area (Quincy) - 100%
- The central west coast area (Ruskin-Palmetto) - 35%
- The southeastern area (Homestead) - 20-25%
- The eastern Atlantic coast area information was unavailable.

Estimates were that 80-90% of all tomato growers in the state were practicing certain IPM strategies or some of the IPM tactics and concepts. It was also estimated that specific insecticide sprays used on tomatoes had been reduced by 50% of the amount applied in 1976 or at the beginning of the program. In 1992, about 50% of the bush bean growers were scouting their acreage and using IPM concepts. Celery growers scouted 60% of their acreage and followed the IPM scouting concepts. They chose to use in-house trained personnel rather than private consultants.

Various forms of IPM strategies are being used by sweet corn and pepper growers. The crops are being scouted primarily by private consultants. It wasreported that due to pepper scouting programs, insecticide applications to control the pepper weevil were better timed and had been reduced by one-third (Pohronezny, 1991; Summerhill, 1987).

Growers in the northern part of the state who produce potatoes for chipping purposes have been particularly concerned about insect and nematode pests since 1990 when aldicarb was removed from the market. These growers are beginning to experience increased costs in control of both nematodes and insects. Efforts were made by the extension service in the 1991 and the 1992 season to increase IPM education available to growers. This was done through meetings, literature, and one-on-one farm visits. Twice weekly scouting, the use of action level thresholds, use of minimum insecticidal dosages, alternation of chemical compounds, use of *Bacillus thuringiensis* and other 'safe' insecticides, and the identification of beneficial organisms was stressed. The chipping potato growers are now showing a willingness to be more dedicated and comprehensive in their crop monitoring, and in following basic action thresholds that had been brought to their attention due to their specific production needs and pesticide expenses encountered during the past two growing seasons (Johnson, 1992).

The table stock potato growers of south Florida have shown a strong interest in management of wireworm pests that have been a nemesis to their crops for many years. As a result of their support and University of Florida research efforts, IPM strategies have been put into use involving non-chemical control by managing off-season cover crops for potato land. The management programs appear successful and are popular with the potato industry (Jansson, 1991).

As a result of outbreaks of resistant dipterous leafminers experienced by potato growers in 1991, there has been approval of an emergency use of an Insect Growth Regulator IGR (cyramozine) for the control of this pest in all the potato growing state areas. However, a Leafminer Resistance Management Committee was formed to maintain the viability of the available leafminer insecticides. The committee is composed of University of Florida (IFAS) scientists,industry scientists and representatives, and growers. Collectively, they have been monitoring leafminer resistance in various populations, determining the genetics of resistance, supporting emergency exemptions, and recommending pesticide label changes which should reduce the opportunity of further resistance development. The committee also developed a series of IPM management guidelines which growers are urged to adhere to in order to delay the onset of leafminer resistance. The guidelines include scouting, use of action thresholds, crop sanitation, alternation of insecticides, and leafminer resistance monitoring (Botts, 1991).

Another significant indication of the forward movement and grower acceptance of IPM was indicated in the recently published record of economic production costs of vegetables published by the University of Florida Agricultural Economists.

The report is composed of grower costs for various vegetable crops. Scouting fees were included in the production costs of sweet corn, celery, eggplant, peppers, and tomatoes grown in all geographic areas of the state and for watermelons in the four production areas (Smith and Taylor, 1991).

Current Needs for the Improvement of IPM Programs

IPM practices in Florida have advanced slowly but consistently over the past 15 years. As discussed in this chapter, growers have moved positively towards crop monitoring (scouting), being aware of and valuing beneficial organisms, limiting pesticide usage, and using other tactics. However, these are only some of the necessary ingredients in an IPM program and do not in themselves constitute a thoroughly integrated program.

Many of the current pest control practices are slanted heavily towards either insect pests or plant diseases. Frequently, nematode and weed control strategies are treated independently. There are a few examples of a total program that encompasses working strategies for insects, weeds, diseases, and nematodes. There are also some crops where pests such as slugs, snails, rats, mice and other occasional mammalianpests should be addressed in order to be able to practice a total program.

Application of Research

IPM is driven by consistent and continued research and education. Growers are not always quick to employ every new technique that becomes available. Often they are skeptical from past experiences, and frequently add a new tactic to their production practices only after observing it as a successful operation over a period of time. When employing a new tactic or strategy, a grower may only do so with limited acreage and will incorporate it into their operation gradually.

It is important for institutions of higher learning and other agricultural agencies to develop the basic IPM tools if growers are expected to adopt IPM programs. Cooperation and interaction between research, extension, private consultants and the fertilizer and chemical industry representatives is also needed so that all segments of the industry are working towards a common goal. In most cases, the universities are expected to develop the IPM research and education for the state. Research is expensive and needs the cooperative support of all concerned facets from the grower level to the consumer.

Further Research

As previously discussed in this chapter, there are crops that have solid research to support IPM programs while others are limited and some have very little at all. Popular crops such as peanuts and soybeans have drawn the most research attention. There are numerous other crops for which lesser amounts of research and IPM tactics are available. Some growers of these crops extrapolate or use scouting techniques, thresholds, or approaches based on common sense, field experiences, or derived from those available for other related crops. There is also a need for new and improved information in order for IPM to continue to be practiced, and to expand to other crops. The following are such needed developments:

- Effective specific crop monitoring or scouting procedures. This should include insects, diseases, nematodes, and weeds.
- Establishment of economic thresholds or action levels for the major pests of a given crop.
- Information that would indicate the basic effects of certain pesticides on the various beneficial organisms.
- Ground-level research that would provide information on the use of pesticides in lowest possible amounts, optimum combinations, and best alternating patterns of different chemical families that would maximize the delay of the development of pest resistance to pesticides.
- Determination of vulnerable periods in pest life cycles so that chemical use would be more timely and efficient.
- Ecological and population dynamic interactions that occur between cropping systems, particularly those with a commonality of pests.

- Weed populations and crop interactions as they pertain to dynamics of insects, disease, and nematode populations and beneficial organisms.
- Better pest population prediction models, particularly insects, diseases, and nematodes.
- Improved application equipment and methods to improve the delivery of pesticides to the specific pest target.
- More host-specific pesticides, particularly insecticides.
- More understanding of the efficiency and manipulation of biological and natural control agents.
- Comprehensive Sanitation
- Improved mechanical barriers and pest repellent strategies.
- Increased efforts into post-harvest pest control measures, particularly of diseases.
- High-quality color photographs of the pest complexes and the subsequent damage to crops.
- Thorough IPM training programs, each geared toward the proper audience, i.e., agents, scouts, private consultants, dealers, farmers, etc., with sufficient well-prepared literature for the various clientele.
- IPM training packages for primary and secondary public/ private school use that would expose students to the basic definitions and long-range goals of IPM as it relates to food/fiber production.
- Risk-benefit studies for the various chemical and non-chemical pest control measures.
- Stronger efforts in developing crop cultivars that are resistant to multiple pests.
- Pest host plant preference and trap cropping programs.
- Improvement and introduction into cropping systems, comprehensive sanitation-type control programs.

Ultimately the consumer, particularly of fruits and vegetables, probably plays a more important role in the use of pesticides by the grower than the average lay person realizes. Most consumers demand and purchase only food products that are free of any blemish, insect or disease scarring or other wounds. Many of these fruits are taken out of the system by strict grading efforts at post-harvest packaging and shipping operations. It is well known that 'cull' fruits, even though nutritive, would never be accepted on the market. If there are too many off-grade and wasted fruits or vegetables, the message to the grower is to improve the grade or lose the market. Therefore, the grower generally has little choice but to increase the amount and/or number of applications of pesticides. The same situation holds true if the food purchasing consumer either complains to the retailer or refuses to purchase fruits or vegetables that do not meet theircosmetic standard. The refusal to buy is a message that is relayed back through the system of wholesalers, brokers, packers, and ultimately to the grower. Again, the message is to make sure that the product has no insect or disease-related abnormalities. The grower usually answers this problem with the use of more pesticides.

In order for IPM program to reach the efficient levels that are being sought, the consumer must be willing to play a part in the overall process. In order to accomplish this task, a comprehensive and in-depth educational program supported with quality research must be aimed at the general public (including school systems) as to the value of food that is not cosmetically perfect. This undertaking would probably be slow, and would probably encounter resistance as well as lack of interest. However, the author feels that this is an important step in the overall process of reducing the amount of pesticides applied to crops grown in Florida and in the nation.

IPM is a program that requires a wide range of inputs from a variety of sources. The program has improved in practice and quality over the past 15-20 years, but has many goals to attain in the years to come. Although the term IPM has become popular and is being used widely in the various forms of literature, at this point in time, it in no way should be assumed that we have working IPM tactics, strategies and programs for all crops. This point needs to be conveyed from the consumer level all the way up to the legislative and agricultural policy making levels.

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Table 1. Acreage, Dollar Value and Estimated Pest Losses to Corn, Peanuts and Soybeans in Alabama, Georgia and Florida - 1974

State	Crop	Acreage (State)	Dollar Value (State)	Tri-State Pest Losses			
				Insects	Weeds	Diseases	Nematodes
Alabama	Peanuts	201,000	86,334,000	6,906,720	8,800,000	32,000,000	8,633,000
	Soybeans	1,020,000	186,048,000	14,883,840	31,700,000	27,907,000	27,907,000
	Corn	650,000	106,145,000	8,491,600	17,600,000	15,922,000	15,922,000
Georgia	Peanuts	528,000	305,000,000	24,400,000	16,050,000	54,400,000	1,525,000
	Soybeans	1,000,000	190,000,000	30,400,000	11,709,000	Not Available	Not Available
	Corn	1,880,000	363,210,000	29,057,280	31,950,000	2,556,000	3,333,000
Florida	Peanuts	55,000	29,700,000	4,455,000	4,449,000	5,940,000	3,000,000
	Soybeans	279,000	58,381,000	8,757,150	8,793,000	8,757,150	8,575,150
	Corn	398,000	64,954,000	9,743,100	8,870,000	21,434,820	9,742,100

Table 2. Tri-State Pest Management Project - (Florida) Percent of Peanut Acreage Treated for Foliar Insects 1975 - 1977

Group**	Year	Number of Treatments								Yield lbs/a
		0	1	2	3	4	5	6	7+	
IPM	1975	46	19	18	17	0	0	0	0	3971
Control		0	22	48	18	12	0	0	0	3704
IPM	1976	35	36	22	7	0	0	0	0	3282
Control		21	13	56	10	0	0	0	0	3175
IPM	1977	24	38	12	1	0	0	9	16	3297
Control		0	17	23	18	0	28	0	14	2836

**It was felt that the comparison between the IPM and Control group was strong since each had an equal chance in being selected as an IPM test farm. In fact, two growers that had the number one and two highest peanut yields the previous year and had been former "star farmer" award growers were randomly selected as members of the Control group.

Table 3. Tri-State Pest Management Project - (Florida) Percent of Soybean Acreage Treated for Foliar Insects 1975 - 1977

Group**	Year	Number of Treatments							Yield lbs/a
		0	1	2	3	4	5	6	
IPM	1975	0	9	48	31	12	0	0	34
Control		0	0	15	39	11	20	15	28
IPM	1976	0	6	50	44	0	0	0	32
Control		0	28	35	32	2	3	0	27
IPM	1977	61	10	23	6	0	0	0	31
Control		37	10	12	9	28	4	0	27

**It was felt that the comparison between the IPM and Control group was strong since each had an equal chance in being selected as an IPM test farm. In fact, two growers that had the number one and two highest peanut yields the previous year and had been former "star farmer" award growers were randomly selected as members of the Control group.