IMPACT STUDY

VIRGINIA
COOPERATIVE
EXTENSION
SERVICE

THE IMPACTS OF INTEGRATED PEST MANAGEMENT (IPM) ON VIRGINIA SOYBEANS

THE IMPACTS OF INTEGRATED PEST MANAGEMENT (IPM) ON VIRGINIA SOYBEANS

Robert M. McPherson
Associate Professor of Entomology
Virginia Tech

Richard F. Kazmierczak, Jr.
Extension Research Associate
Virginia Tech

Edwin G. Rajotte
Assistant Professor of Entomology
Pennsylvania State University

William A. Allen
Program Leader
Agriculture and Natural Resources
Virginia Tech

With specialized input from:

David E. Babineau, Plant Pathology
E. Scott Hagood, Weed Science
Patrick M. Phipps, Nematology and Plant Pathology
F. William Ravlin, Information Management and Entomology
Virginia Tech

Table of Contents

List of Tables

List of Illustrations

Acknowledgements

This state impact study about soybean IPM could not have been accomplished without the cooperative efforts of many individuals. The authors express sincere gratitude to Drs. Bill Ravlin, Dave Babineau, Pat Phipps, and Scott Hagood for their specific subject matter inputs. In addition, the technical assistance of Mrs. Terry Moss and Mrs. Stephanie Willoughby, and the secretarial assistance of Mrs. Beth Floyd and Mrs. Diane Bolling are greatly appreciated. The statewide random telephone survey was successfully accomplished through the guidance and direction of Mr. Clarence Dunkerly, Statistician in Charge, and Mr. Homer Rowley, Assistant Statistician, of the Virginia Crop Reporting Service. Computer programming and data analysis of the survey results was provided by Dr. Tom McAnge and his staff. A special thanks is also extended to Mr. James Cranor for his technical editing of this report, and to the members of the Evaluation Resource Group, the Economic Resource Group, and the Administrative Resource Group for their advice and support. The leadership and planning of Dr. Shirley Gerken, Evaluation Specialist, in directing this project to its completion is also greatly appreciated.

Finally, grateful acknowledgement is also extended to the many Virginia Cooperative Extension Service agents and growers who have supported and actively promoted the IPM concepts and philosophy throughout the Commonwealth. For, truly, without their participation and support, the Virginia soybean IPM program would never have accomplished its widespread adoption and implementation.

Executive Summary

IPM is a systematic approach to crop protection which uses all available pest control techniques and methods to maintain pest populations below economically damaging levels. The Virginia soybean IPM program integrates regular field monitoring, economic threshold levels, cultural control techniques, parasite releases, and pesticides into a pest management program that minimizes pest-related crop injury while maximizing the net economic returns.

The state evaluation of Extension's Soybean Integrated Pest Management (IPM) program was conducted over the three-year period of 1983 to 1986. It involved the inputs of many individuals associated with Virginia Tech, the Virginia Crop Reporting Service, the Virginia Department of Agriculture and Consumer Services, and the private sector.

Background

Virginia's involvement in soybean IPM began in the early 1970's with a pilot insect pest management program. By 1978, a formalized farmer-financed program was being implemented in four counties in the eastern region. Soybean IPM underwent a rapid and widespread expansion during the early 1980's. By 1983, there were fifteen counties with over 15,000 acres in farmer financed IPM programs. A computerized system was developed in 1984 to store the weekly pest infestation reports and to generate local, regional, and statewide pest summaries. Federal Extension IPM allocations supported most of the Virginia soybean IPM program development and implementation. Some University funding for soybean IPM also was available in the late 1970's. Funding for specific soybean IPM research and demonstration projects has been received annually since 1979 from such groups as the Virginia Soybean Board, the Virginia Agricultural Council, and various agricultural industries.

Study Objectives and Methods

The objectives of this soybean IPM evaluation were to measure the agricultural, social, and economic impacts on clientele groups; to determine social and economic characteristics of program participants; and to identify the scope and nature of resources used. These resources included management practices adopted, program delivery methods used, the role of the private sector, and linkages between the private sector and the University, and between research and extension.

The state soybean IPM impact study was designed to obtain information directly from randomly chosen Extension clientele. The 269 survey participants (2.7 percent of the state's total producers) were interviewed by telephone by survey specialists employed by the Virginia Crop Reporting Service. The information gathered from the clientele survey included a background profile (education, ethnic identification, gender, age, farm size, farm experience), behavior profile (use of field scouts, various control practices, information sources, and personnel), attitude profile (use of IPM concepts, Extension media, scout training), opinion profile (perceived reasons for using IPM), and economic profile (cost/benefit of using IPM practices).

Major Study Findings

Findings of the soybean IPM clientele survey included:

- Non-users were older and had more farming experience than did high users.

- High users had more college education than did low users and non-users.
- High, low, and non-users were similar with regard to race, gender, acres owned, and percent of family income derived from the farm.
- In general, growers preferred Extension literature, field demonstrations, and group meetings for obtaining IPM information.
- Over 63 percent of the respondents reported scouting their soybeans for pests.
- The most important benefits from IPM were perceived to be increased farm profits, increased crop yield and profits, protection of public health, increased knowledge of pest control, and reduction of environmental damage.
- High users reported higher yields and higher prices per bushel than did low and non-users. As a result, high users experienced greater net returns.

Implications

There are many implications for Extension that arise from the data generated in this study. Extension should serve the clientele's current needs by expanding support for reportedly preferred written material, field demonstrations, and production meetings. Future needs should be addressed through the expansion of computerized management networks and telecommunications. Because dealers and sales personnel were utilized regularly by many growers as IPM information sources, it is imperative that these individuals be thoroughly trained in existing and new IPM technology. Although over 63 percent of the soybean acreage was being scouted routinely for pests, large acreages were not being monitored. These non-participating farmers need to be educated on the benefits of pest scouting. The fact that gross revenues and profits tended to be higher for users that for non-users should be used by Extension to promote economic analyses of IPM as a mechanism of demonstrating the increased efficiency and profitability attributable to IPM practices. Extension should facilitate the formation of interdisciplinary teams to address the many economic, pathologic, entomologic, agronomic, and agricultural engineering problems that remain.

Introduction

Integrated Pest Management (IPM) is a systematic approach to crop protection that utilizes interelated topical information as the basis for sound pest management decisions. More specifically, it is a system that utilizes all suitable pest control techniques and methods to keep insects, nematodes, diseases, and weeds below economically injurious levels. Each pest control technique must be environmentally sound and compatible with production and user objectives. Because IPM is information-intense, it not only requires timely assessment of on-farm situations, but also stresses the acquisition of information from off-site. Off-site information often takes the form of educational programs which teach about new monitoring techniques and pest management actions. It can also consist of timely updates about the status of factors important to making pest management decisions.

IPM programs are based on the concept of monitoring pest population levels, crop stage of development, crop prices, and other factors pertinent to making rational pest management decisions. Once a critical threshold has been reached, the type of action necessary can be considered. Pesticides, biological control agents, cultural practices, resistant host plants, trapping techniques, and genetic modification of pests may be used separately or in some combination to reduce the impact of pests on a crop or urban situation.

Prior to the implementation of IPM programs, pest control strategies for Virginia soybeans relied almost exclusively on the use of pesticides sprayed on a calendar basis. There were no economic thresholds or other treatment decision guidelines, and farmers were not monitoring pest populations in their fields. Criteria used to trigger the application of pesticides included response to predetermined calendar date, reaction to treatment initiatives by neighbors who were spraying, and/or response to aerial applicator discounts to farmers who arranged for treatments early in the year. At the time when IPM programs were being implemented, most farmers were highly skeptical, some even hostile, to the new theory and practices, even though Allen and Roberts (1974) reported that nearly 90 percent of the total insecticide sprays used on Virginia soybeans were premature and often unneeded. The advent of concerns for environment, the energy crisis, the development of pest resistance, and a desire to reduce costs all served to make the calendar spray approach to pest management undesirable and led to the development of the formal Virginia Soybean IPM program.

Soybean Production in Virginia

World demand for soybean products has risen substantially since the mid-1970's, primarily due to a need for protein and carbohydrate. As a result, soybean acreage in the United States and Virginia increased dramatically during this time. According to annual Virginia Agricultural Statistics, harvested soybean acreage increased 83.4 percent from 1976 to 1984 (Table 1 on page 5). The total 1984 farm value for soybeans harvested in Virginia exceeded $129 million, which placed soybeans as the state's second largest income-producing row-crop, tobacco being the largest (Va. Crop Reporting Service 1985).

Table 1. Crop production statistics for soybeans produced in Virginia, 1976 to 1984.[1]

Year Produced	Acreage Harvested	Yield (bu/acre)	Production (bushels)	Percent double cropped	Percent planted in ESSEX
1976	398,000	20.5	11,500,000	56	32.6
1977	440,000	19.0	8,360,000	No data	37.5
1978	475,000	28.0	13,300,000	No data	43.2
1979	536,000	28.5	15,276,000	32	49.3
1980	610,000	15.0	9,150,000	37	46.6
1981	635,000	26.5	16,828,000	50	54.6
1982	665,000	29.0	19,285,000	54	62.3
1983	610,000	16.0	9,760,000	46	60.2
1984	730,000	29.5	21,535,000	52	61.2

[1] From annual *Virginia Agricultural Statistics*, (Virginia Crop Reporting Service, 1977-83).

Although Virginia's available acreage for soybean production is somewhat limited by extensive forested areas, Virginia producers have increased productivity by using diverse land-cropping systems. For example, 52 percent of Virginia's 1984 soybean acreage was double-cropped after the harvest of winter wheat or barley (Table 1). Most of this double-cropped acreage was planted in small-grain crop stubble, using minimum- or no-tillage systems. This practice of double-cropping soybeans and small grains not only increases the productivity of the land, but it also reduces the expenses associated with plowing and discing and contributes to conserving soil moisture and reducing soil erosion.

Most of Virginia's soybean crop is produced in the eastern, southeastern, and central regions of the state. While average farm size in the state is 169 acres, farm size in these regions is slightly higher (Va. Crops and Livestock, August 18, 1983). On most farms where soybeans are grown, the crop is rotated with corn and small grains; consequently, only a portion of the farm is planted in soybeans in a given year. In much of the southeastern region, peanuts are the primary crop, and soybeans are planted less frequently in the rotation. Table 2 summarizes the 1984 production statistics of soybeans produced in each Virginia region.

Table 2. Soybean acreage, yield, and production by region in Virginia, 1984.[1]

Region of State	Acreage Harvested	Yield (bu/acre)	Production (bushels)	Percent Planted in ESSEX
Central	98,000	30.0	2,936,000	63.1
Eastern	295,800	28.0	8,265,000	76.0
Southeastern	262,000	31.5	8,240,000	51.6
Southern	50,000	27.5	1,370,000	42.7
Other	24,200	29.9	724,000	23.7

[1] From annual *Virginia Agricultural Statistics*, (Virginia Crop Reporting Service, Sept. 1985).

Because annual precipitation in the soybean growing regions varies from 40 to 50 inches, only a few thousand acres of cropland are irrigated annually, and most of this acreage is in corn production. However, the temporal and spatial distribution of precipitation has not always been optimal for soybeans. The average yield for soybeans has therefore varied greatly, with a record yield produced during the wet season of 1984 (29.5 bu/acre), compared to lows of 15.0 bu/acre in 1980 and 16.0 bu/acre in 1983 during hot/dry growing seasons. This variability has prompted agronomists and agricultural engineers to begin research on improving irrigation management of agronomic crops in Virginia.

Other climatic conditions are also important to the success of soybean production, and the geographical location of Virginia's soybean acreage makes the state ideally suited for many soybean cultivars. However, the release of the Virginia Agricultural Experiment Station variety *Essex* in 1973 (Smith et al. 1976), has resulted in a rapid and widespread adoption of this cultivar throughout the state (Table 1 on page 5). *Essex* is a high-yielding cultivar that is well adapted to Virginia growing conditions, both as a full-season crop and as a crop planted late in the season after small-grain harvest. In 1984, four cultivars (*Essex, York, Forrest,* and *Bay*) made up over 79 percent of the total acreage planted. *Essex* has proved superior in yield to the other cultivars, although it is highly susceptible to the insect, disease, and nematode problems encountered in Virginia. Thus, it often requires pesticide applications to prevent economically damaging pest losses.

The Virginia Soybean Pest Complex

Soybean losses and associated costs attributable to diseases, insects, nematodes, and weeds are estimated to be in excess of $20 million annually (Va. Crop Reporting Service 1978, McPherson 1983a). The major current pests of soybeans in Virginia include:

- morning glory,
- jimsonweed,
- cocklebur,
- pigweed,
- Johnsongrass,
- corn earworm,
- stink bugs,
- two-spotted spider mites,
- Anthracnose,
- pod and stem blight,
- purple seed stain,
- lance nematode,
- lesion nematode,
- root-knot nematode, and
- cyst nematode.

Numerous minor pests also can cause crop losses in isolated areas. Martin and McPherson (1980) reported that 37 different weed species were commonly detected in Virginia soybean fields. The most common of the minor weed pests included:

- barnyard grass,
- crabgrass,
- fall panicum,
- foxtail,
- nutsedge,
- lambsquarter ,
- common ragweed,
- smartweed, and
- velvetleaf.

Stromberg *et al.* (1984) listed *Pythuim spp.*, *Phytophthora spp.*, and *Rhizoctonia solani* as minor disease pests of soybeans. McPherson *et al.* (1981) reported that minor insect pests include:

- Mexican bean beetle,
- green cloverworm,
- bean leaf beetles,
- cucumber beetles,
- soybean stem borer,
- soybean looper,
- beet armyworm,
- fall armyworm,
- Japanese beetle, and
- blister beetle.

Although these pests cause crop losses in both full-season and late-planted soybeans, each cropping system requires specific control strategies. Full-season soybeans have a greater likelihood of attack by Mexican bean beetles, stink bugs, and bean leaf beetles. Weed detection and correct use of post-emergence herbicides are extremely important to conventionally planted full-season beans in early spring, with weed management and control being essential during the first few weeks after emergence. Weed control strategies for soybeans that are no-till and double-cropped after small grain are somewhat different than those used in the full-season system, and current research indicates that nematode and disease management practices should be different for each cropping system. Cropping practices can also affect insect pest management. For example, soybeans planted after the harvest of wheat or barley are more susceptible to corn earworm.

Along with affecting the type of cultivars used, weather conditions and geographic location also influence the incidence of weeds, diseases, nematodes, and insects. Hot/dry periods prevent the effective use of herbicides and actually increase the likelihood of damage from corn earworm, spider mites, and nematodes. Cool/damp conditions favor the buildup of Mexican bean beetles, fungal and bacterial diseases, and weeds, and can increase injury from soil applied herbicides. Cool/damp conditions can also prohibit the timely application of post-emergence herbicides. However, there are some positive benefits related to Virginia's northeastern geographic location, as it is unsuitable for successful overwintering of many economically important pest species (velvetbean caterpillar, soybean looper, and fall armyworm). Although they do migrate northward each year, infestation usually occurs late in the season and these pests are seldom threats to Virginia's soybean crop. Most of the major soybean disease problems that occur in the southwest are likewise of little importance in Virginia, due primarily to geographic location.

Pre-IPM Pest Control

Prior to the widespread adoption of IPM programs which began in 1978, the Virginia Cooperative Extension Service was providing pest management information through a series of updated chemical control guidelines, some limited presentations at grower meetings, and periodic newsletters and news releases. There was only one Extension Entomologist responsible for nearly all of the chemical control recommendations in all the crop and livestock programs. As a result, the Extension Agent was often called into the field and asked to provide an immediate decision on whether the soybeans should be sprayed to control a particular pest. Because no formal educational information was available on sampling techniques, and there were no economic thresholds or other treatment decision guidelines, the agent depended on his "best judgement" to determine whether or not to treat. The criteria used to trigger the application of insecticides by producers who did not contact their Extension agent often included a predetermined calendar date, reaction to applications by neighbors, or responses to the aerial applicator who gave discounts for treatments early in the year. These inadequate treatment procedures resulted in nearly 90 percent of the soybean insecticide sprays being premature or unneeded (Allen and Roberts 1974). Although information on total pesticide use was very limited before the mid-1970's, estimated yearly insect-related soybean losses in Virginia were $3.057 million in 1969. In addition, even though pesticides were relatively ineffective, their application cost soybean producers approximately $3.00 per acre (estimated total of $525,000 statewide). Thus, it became apparent that an extensive program on insect management was needed in the state to educate the producers, Extension agents, and other agribusiness leaders about the concepts and philosophy of IPM techniques (Allen and Roberts 1974).

Virginia's Soybean IPM Program

Virginia's soybean IPM program was developed in 2 distinct stages: 1) an initial pilot study, and 2) full-scale implementation. Preliminary investigations in 1972-73 on the economic feasibility of scouting Virginia soybeans for insects showed that scouting could be a highly beneficial, cost-effective practice (Allen and Roberts 1974). Economic models also indicated that farmers could realize substantial net savings for each dollar invested in a scouting program (Allen and Roberts 1974).

Program Funding

Resources allocated for soybean IPM program development in Virginia are summarized in Table 3 on page 9. The majority of IPM funds have been derived from USDA-ES formula funding for IPM. In addition, the Virginia Tech Extension Division contributed $6,000 annually through fiscal year 1982. Most of these funds were spent for graduate research assistants working on corn and alfalfa, and for travel and supplies. Over $100,000 was also raised by farmers who participated in the farmer-financed scouting program to pay for insect scouting services.

In addition to Extension funding for soybean IPM, the soybean Extension Entomologist obtained funding for several research projects. These research projects, funding agencies, and amounts were:

1. "Soybean Insect and Weed IPM Research," Virginia Soybean Commission, 1979, $3,900;
2. "Trap Crops for Control of Soybean Pests," Virginia Soybean Commission, 1980-1981, $5,900;
3. "Economically and Environmentally Sound Systems of Insect Pest Management for Soybean and Small Grain," CSRS HATCH, 1981-1984, $15,300;
4. "The Effects of Pesticide Combinations on Target and Nontarget Pest Species in Soybean," Virginia Soybean Commission, 1981-1982, $8,000;
5. "Tactics for Management of Soybean Pest Complexes," Southern Regional Research Project S-157, 1982-1984;
6. "Corn Earworm Prediction and Control in Virginia," Virginia Soybean Commission, 1982-1984, $18,200;
7. "Management of Insect Pest Complexes in Soybean," Virginia Soybean Commission, 1983-1984, $10,500; and
8. "The Effect of Pyrethroid Insecticides on the Bionomics of the Two-Spotted Spider Mite Infesting Soybeans," Virginia Agricultural Foundation, 1984-1985, $11,650.

The funds from these research projects were used almost exclusively to pay for the technical support and scientific equipment needed to conduct the studies and to assist with Extension related travel and supplies. Additional funds of over $30,000 were obtained through chemical company grant-in-aid support to offset the costs associated with insecticide evaluations.

Program Objectives

With the pilot phase of the soybean IPM program successfully completed, two IPM Extension Specialists were hired in 1978 to begin the implementation phase of the program. The long-range goals of the IPM program were to:

1. Improve the pest management skills of Extension agents, farmers, and other agri-business personnel while economically protecting crops and maintaining yields, thus increasing farm profitability and reducing production risks.

2. Reduce badly timed and unnecessary pesticide applications while stressing the need for pesticides when economically damaging populations of pests are

Table 3. Resource expenditures for IPM in Virginia: Values are thousands of dollars allocated.

Fiscal year	Federal 3(d) funds for IPM	Federal 3(d) funds for soybean IPM	State funds for soybean IPM	State staff involvement (FTE)	Farmer and VA.Soybean Board
1979	75.0	37.5	6.0	0.75	2.6
1980	95.0	47.5	6.0	1.25	10.5
1981	115.0	57.5	6.0	0.90	14.6
1982	117.0	58.5	6.0	1.10	23.6
1983	117.0	58.5	0	1.50	32.9
1984	117.0	58.5	0	1.50	33.7
1985	117.0	58.5	0	1.25	31.5

present, thus reducing environmental hazzards and protecting non-target organisms.

3: Develop interdisciplinary multi-crop programs involving leadership roles for University faculty in Weed Science, Plant Pathology, Entomology, Agronomy and Agricultural Economics as well as personnel from the Virginia Department of Agriculture and Consumer Services.

4. Introduce new IPM technology into soybean, grain, and forage production in Virginia.

The specific program objectives that led to the successful Virginia soybean program were:

1. Survey producers prior to the initiation of an IPM program to establish baseline data on pest management problems, practices, and costs.
2. Develop scientifically reliable and economically feasible methods to sample and monitor pest infestations in all soybean cropping systems.
3. Determine the maximum number of damaging pests that can be tolerated in soybeans before pest control practices are needed.
4. Introduce genetic, cultural, and biological pest control practices into crop production.
5. Integrate management tactics that reduce risks and improve profitability of crop production.
6. Develop educational literature and programs necessary to change the attitudes and practices of farmers, extension agents, and agri-business leaders to adopt IPM technology.
7. Monitor the changes in pest management practices of farmers.
8. Provide an impact assessment for soybean IPM.
9. Make public the findings of the program.

Development of Soybean IPM

Although a complex process with numerous stages, the development of the soybean IPM program can be examined by looking at three major components: the identification of economic thresholds, the development of field monitoring techniques, and the use of biological, genetic, and cultural controls.

Indentifying Thresholds

Economic thresholds can be defined as those levels of pest population beyond which economic damage will occur to the crop. Thus, the challenge is to identify those critical levels and respond with control treatments when they are exceeded. However, these critical levels, and the appropriate control treatments, will vary for different types of pests.

Insects

The economic injury levels and economic threshold levels for many soybean pests have been extensively studied, with economic threshold studies having been conducted on soybean insect pests in Virginia annually since 1978 (Deighan *et al.* 1983, Ferguson *et al.* 1983). Thresholds were established for corn earworms (McAlister and Krober 1958, Thomas *et al.* 1974a, McPherson and Hynson 1983), Mexican bean beetles (Todd *et al.* 1972, Todd and Morgan 1972, McAvoy and Smith 1979), Stink bugs (Thomas *et al.* 1974b, Yeargan 1977, McPherson *et al.* 1979a), and spider mites (Baker and Connell 1961, Cannon 1965, McPherson 1984). The current Virginia threshold levels for the various insect species are reported by McPherson *et al.* (1981). In addition, long-term studies on insect pest complexes were initiated in 1982. Results from these pest studies will be incorporated into the IPM program as soon as they are validated.

Nematodes

Crop damage and economic injury levels for soybean nematodes were established in Virginia through considerable field plot research. This field research was conducted yearly by four plant pathologists and/or nematologists. Threshold levels were based on nematode populations extracted from soil collected in autumn immediately after harvest. This predictive assay allows recommendation to be formulated for the soybean crop to be planted the following spring. Because of changing cropping practices, conservation tillage, and double-cropping systems, much additional work is needed to modify recommendations for these new agronomic practices. Results from these studies will be used to strengthen the predictive nematode assay service as a guide for decision-making on the farm.

Diseases

The use of foliar fungicides for control of soybean diseases is not currently recommended in Virginia because yield response to foliar fungicides does not usually compensate for the cost of treatments. This recommendation is based on a compromise point system (a predictive scale for the use of foliar fungicides) and can be found in the annual "Proceedings of the Southern Soybean Disease Workers (SSDW)." The compromise point system assigns a weighted value to variety, cropping history, planting date, disease presence, field disease history, moisture, and whether or not the grower is planting for seed production. Under local Virginia conditions, the total number of points assigned to a field rarely exceeds the threshold level at which fungicide application is recommended. However, fungicide applications are often recommended to certified seed producers to help increase seed quality.

Weeds

Numerous studies on economic threshold levels for various soybean weed pests and weed pest combinations have been completed in recent years (Burnside 1972, Marra and Carlson 1983, Sherman *et al.* 1983, Higgins *et al.* 1984). Virginia research has focused on selective broadleaf and grass herbicides. Cost-benefit analyses of the various herbicide combinations are being conducted to determine which combinations are the most economical. The availability of effective post-emergence broadleaf and grass herbicides, and the ability to mix these products when necessary, should greatly expand the significance of weed scouting and the use of weed economic thresholds.

Field Monitoring Techniques

Although many procedures for controlling pests were developed as a result of the Virginia Soybean IPM Program, scouting is the major IPM option available to soybean growers. Scouting is the process of observationally determining pest identity and population levels. Primarily an information gathering activity, scouting is considered the cornerstone of the Virginia soybean IPM program. Trained individuals sample the crop to determine the type and quantity of pests present, crop growth stage, and environmental conditions. Although the sampling and diagnostic methods used by scouts vary, all techniques are based on statistical principles and require scouts to sample a high percentage of the soybean crop at frequent intervals (usually weekly). Scouting to gather accurate information is labor-intensive and demands a certain level of financial commitment on the part of the grower. However, scouting can yield accurate information concerning the seriousness of pest problems in an area. The active scouting of soybean fields is most often done by one of four groups of people:

1. Extension agents
2. Pesticide dealers and salesmen
3. A person or firm hired by the grower
4. The grower himself, a family member, or farm employee.

The objectivity and accuracy of the information provided to a grower by a scout can vary depending on the amount of training the scout has received and the professionalism with which they conduct the scout has conducted the scouting activities. The actual mechanics of monitoring will also vary with the particular type of pest being scrutinized.

Insects

Extensive research has been conducted on monitoring techniques for key insect pests of soybeans and these results are incorporated in the present IPM program. The first soybean monitoring practice developed was a field scouting technique that utilized a modified version of the ground cloth method described by Boyer and Dumas (1963). A form for recording sampling data was also prepared for use by field scouts, growers, and Extension agents (Allen 1974). This form was extensively revised (McPherson *et al.* 1982a) to facilitate data entry in the computerized management system.

Although the ground cloth method initially worked well, the expansion of no-till soybean farming (planting the beans into the stubble of recently harvested small grain), plus the initiation of drill-planting soybeans in narrow rows (10″ or less apart), resulted in a need for a different sampling technique. Thus, an alternative method was developed (1979-81) in which both the standard ground cloth plus a 15-inch-diameter sweep net was used. Statistical correlations were derived for the sweep-net method in all soybean cropping systems (e.g., conventional, drill-planted, and no-till systems (Deighan *et al.* 1985)), and a new sampling record form was prepared for those using sweep nets (McPherson & Allen 1980, revised 1982, 1984). The sweep-net technique has become widely used by scouts, farmers, and agents.

A corn earworm prediction technique, involving the monitoring of field corn in late July to estimate the number of ears infested with corn earworm larvae, was introduced in 1976. This monitoring allowed predictions to be made as to how severe this pest will be in soybeans in late August and September. These predictions were then sent to Extension agents via a newsletter.

The soybean insect scouting program has undergone a rapid and widespread adoption in Virginia. The farmer-financed program grew from a program in 4 counties with 1750 acres to 15 counties, 91 farmers, 15,128 acres, and 36 scouts in 1983. In addition to the farmer-financed scouting, an extensive series of county/area grower meetings and scout training sessions have been held to train growers and their family members (and farm hands) to scout their own fields for insects, weeds, nematodes, and diseases. Many pesticide dealers and pesticide industry representatives have also been trained to effectively monitor soybeans for these pests.

Nematodes

The nematode assay laboratory was developed in 1970 to determine the magnitude and species composition of nematode infestations in Virginia's cropland. Sampling techniques and forms were prepared (Phipps 1978, Elliott *et al.* 1983), and an extensive educational program was developed to increase farmer's awareness of the potential damage caused by these destructive pests. Nematode management practices actually implemented included: periodic nematode sampling of soils, nematode predictive assay, nematode diagnostic assay, crop rotation, varietal selection, and nematicides when needed.

Disease

An integral component of the field scout's duties is to identify abnormal soybean plants at each site in a field where insects are counted. Field monitoring enables the plant pathologist to be alerted to potential disease problems. Plant disease clinics for the identification of soybean disorders are in operation at Virginia Tech, at the Tidewater Research and Continuing Education Center, and at the Eastern Virginia Research Station. These centers concentrate on quick, accurate diagnoses that are provided to field scouts, Extension agents, and agribusiness personnel who submit samples. Education in disease detection and identification is incorporated into scout training sessions conducted yearly in eastern Virginia.

Weeds

The weed sampling and identification program in Virginia requires a detailed training session for growers and Extension agents due to the vast number of weed species infesting the crop. Historically, however, the need for wide-spread implementation of this type of training and associated scouting programs was minimal because only soil-applied, pre-emergence herbicides were available, and these were universally applied as "insurance" treatments. Recently, however, registration of selective post-emergence broadleaf herbicides such as acifluorfen and bentazon, as well as the selective post-emergence grass herbicides sethoxydim and fluazifop-butyl, has enabled producers to respond to the specific infestation of weeds observed in their fields.

Research is now underway to determine the competitive abilities of weeds in mixed infestations. This data, coupled with existing data on weed operations in soybeans, will allow comprehensive training of agents and growers on proper herbicide selection and decision-making based on density and species composition of the weed infestation. This type of IPM effort in weed control represents a significant advance over that which could be extended when only pre-emergence treatments were available.

Biologic, Genetic, and Cultural Controls

In past years, one of the major pest problems in soybeans was the damage done by the Mexican bean beetle. One avenue of research into preventing damage by this pest was the use of natural biologic controls.

Efforts to biologically mitigate the effects of the Mexican bean beetle centered on the use of natural enemies. Initial studies with one such enemy, the parasitic wasp *Pediobius foveolatus* (Crawford), were conducted in Maryland (Stevens *et al.* 1975, Reichelderfer 1979). These early studies concentrated on parasite biology and dispersal, with the first parasite releases taking place in Virginia in 1975 (Schultz and Allen 1976). The first widescale releases were attempted in 1978 and covered 19 counties in the state. Parasites for these releases were reared by the Virginia Department of Agriculture. Widescale parasite releases continued from 1978 to 1983, with the USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine Unit supplying several hundred thousand parasites for the four "Northern Neck" counties of Westmoreland, Richmond, Northumberland, and Lancaster.

Protecting the indigenous parasites and predators is another IPM practice that is strongly promoted in Virginia. Several studies were conducted on the seasonal abundance of the natural enemies of soybean pests (McPherson *et al.* 1982b, 1982c, Ferguson *et al.* 1984a, 1984b). Harper *et al.* (1983) reviewed most of these studies, and suggested that the application of systemic insecticides at planting is recommended only in the early-planted fields grown in areas historically attacked by early-season pests. Restrained use of systemic insecticides, and the use of less detrimental pesticides in general, should help preserve the natural enemies of soybean pests.

Since widescale parasite releases were begun in 1978, the acreage treated for Mexican bean beetle control has not exceeded 5,000 acres statewide in any given year (Table 4 on page 13). This can be compared to treatments prior to the parasite release program, when over 50,000 acres were routinely sprayed for this pest (Allen, Virginia Insect Survey Reports, 1969-1977, unpublished). Because of the success of the parasite release program, other methods of controlling the Mexican bean beetle have not been widely used since the late 1970's. However, these alternative control measures, which include genetic and cultural practices, may become important in the future.

Table 4. Statewide summary of Mexican bean beetle insecticide treatments and parasite releases.

Year	Counties receiving parasites	Number of parasites released	Acres sprayed for Mexican bean beetles[2]
1978	19	51,300	4,800
1979	28	30,360	4,500
1980[1]	15	146,000	4,200
1981	19	270,000	3,490
1982	18	584,000	4,700
1983	23	574,000	100
1984	17	95,500	0

[1] 21 counties scheduled to receive parasites, but rearing problems prevented some releases.

[2] Determined from annual insecticide usage surveys sent to Extension agents in the soybean producing counties.

The cultivar *Shore* was introduced by the Virginia Tech Agricultural Experiment Station in 1976 specifically for production in Virginia and Southern Maryland (Smith *et al.* 1976). *Shore* expresses both non-preference and antibiosis mechanisms of resistance that reduce adult and larval Mexican bean beetle populations during the early growing season. Resistance, however, becomes less apparent later in the season. *Shore* will outyield most cultivars when insect damage is heavy, but *York*, *Essex*, and other cultivars will generally outyield *Shore* in the absence of heavy beetle infestations.

Because of the lower yield potential, very few acres of *Shore* are currently being grown in Virginia. However, the genetic material is available for host plant resistance should Mexican bean beetle populations once again become a widespread economic threat to the state's soybean crop. Additional soybean host plant resistance studies are being conducted throughout the southeastern United States (Gilman *et al.* 1982, Hatchett *et al.* 1976).

Several cultural control practices have also been incorporated into the soybean IPM program. During 1979-1981, extensive trap-crop[1] field demonstrations were conducted in two counties on nearly 1,000 acres of soybeans. These field tests demonstrated the effectiveness of controlling Mexican bean beetles, bean leaf beetles, and stink bugs by using trap crops (McPherson 1983b). A 1982 survey of growers revealed that 16 percent were using the trap cropping concept (Rajotte and Ravlin, unpublished data).

Planting date, and to a lesser degree, row spacing, also can significantly influence insect pest population densities. In both 1980 and 1983, years of heavy insect population pressure, fields planted around mid-June to early July had much heavier population densities of corn earworms than fields planted during May or early June. McPherson and Allen (1981) reported over 60 percent of late-planted fields in the insect scouting program required insecticide applications to control corn earworms. However, spider mite and Mexican bean beetle infestations were higher in the early-planted fields. McPherson (1983a) reported similar results in the 1983 scouting season. The effects of planting date and cropping system are summarized for 1980 and 1983 in Table 5 on page 14. Manipulating planting dates and row spacings to reduce the likelihood of economically damaging insect pest infestations is strongly promoted in the Virginia soybean IPM program.

---

[1] Trap crops are small fields of soybeans planted earlier than all other fields in the area to attract and concentrate pest insects. These fields can then be treated to control the insects before infestation of the majority of the crops, which is planted later (McPherson and Newsom 1984).

Table 5. **The effect of planting date and cropping system on soybean arthropod pest problems in eastern Virginia.**

Cropping System	Number fields	Number acres	Corn earworms	Spider mites	Others[1]
			1980 % acreage with pest problem		
Full season, conventional	36	621	5.6	13.9	8.3
Full season, drill-planted	13	303	7.7	23.1	7.7
Double-cropped, no-till	49	875	61.2	4.1	2.0
			1983 % acreage with pest problem		
Full season, conventional	49	1,195	18.4	10.2	0.8
Full season, drill-planted	10	241	20.0	0.0	0.0
Double-cropped, no-till	202	4,918	46.5	2.0	0.7

[1] Others included primarily Mexican bean beetles and stink bugs in 1981, and included stink bugs in 1983.

Program Implementation

The successful implementation of an Extension program is dependent not only on the accessibility of the information being delivered but also on the organizational structure and educational programs developed for communicating with clientele.

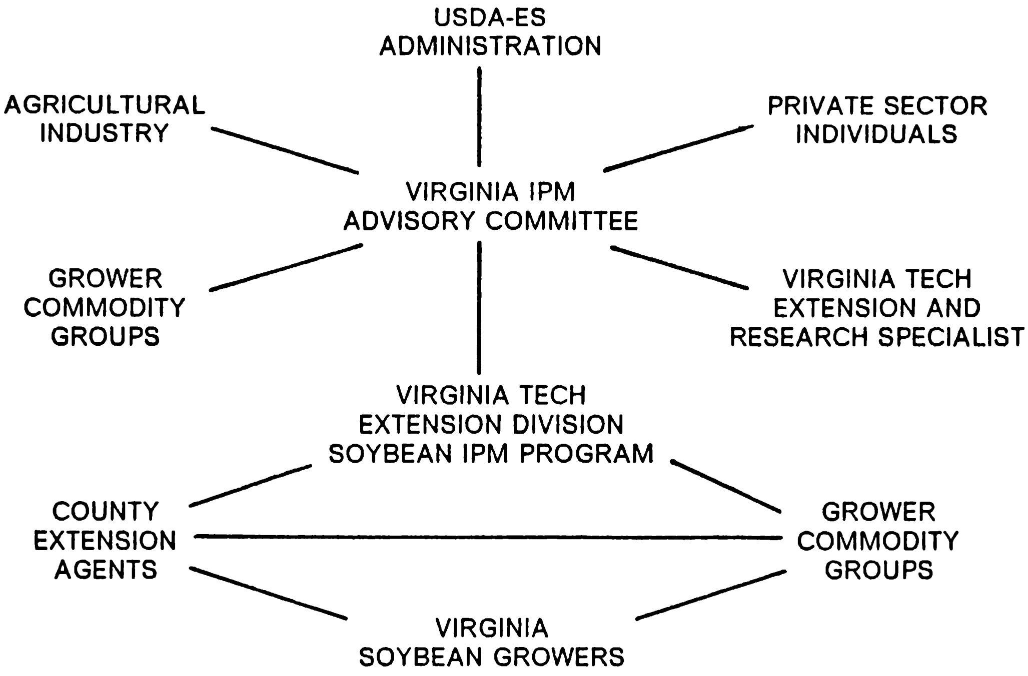
Organizational Structure

The formal organization and information linkages of Virginia's Soybean IPM program are detailed in Figure 1 on page 15. A state advisory committee was formed in 1978 to aid in program development, review, and planning. This committee was composed of state and federal Extension personnel, Virginia Tech research departments, grower commodity groups, agricultural industry representatives, and private sector individuals. The committee met regularly during the early implementation phase of the IPM program (1978-80) but has since met infrequently. In recent years the leadership of the state program has shifted to the Virginia Tech Extension Division. This group combines the talents and interests of Extension and research faculty to guide program development while utilizing and encouraging cooperative research between the IPM program and faculty in the disciplines of Entomology, Agronomy, and Plant Pathology. Research projects have also been conducted on a less frequent basis with faculty in Agricultural Economics.

Educational Programs

During 1978, the first year of IPM program implementation, a four-county farmer-financed insect scouting program was organized. This aspect of the program grew to include 15 counties by 1983, the year in which they were reorganized (Allen and McPherson 1982). Growers participating in this program organized a working group and hired a pest management field scout that was trained by the Extension Entomologist, Extension Plant Pathologist, and Extension Agent. The field scout was responsible for checking participating fields once a week for the duration of the program. After each field was sampled, the scout filled out a prepared information form and sent copies to the farmer, the Extension agent, the Extension specialist (for computerized information network), and the funding agency (i.e., local bank). These information forms only con-

Figure 1. Organization and information linkages of Virginia's Soybean IPM program.



---

tained data relevent to insect population estimates; fields scouts did not make recommendations on whether or not to spray. The treatment decision process was solely in the hands of the farmer, and growers who sampled their own fields were strongly encouraged to use the same field scout procedures, with sampling forms made available upon grower request.

County producer meetings were also utilized to inform the soybean farmers of IPM techniques and strategies. These sessions emphasized proper identification of pests, field scouting, and the use of economic thresholds. From 1978-85, a total of 115 county meetings were held on IPM topics. Many of these sessions were co-sponsored by various pesticide company representatives, who provided ground cloths for sampling insects, bulletins and brochures on insect identification, and refreshments or meals for participants. Over 3,650 farmers attended these meetings, which were organized by the area Extension agents and include presentations by the IPM specialists.

Insect scout training schools have also been a vital component of the IPM educational program. Each year a scouting school was held at the Eastern Virginia Research Station in which 20-40 field scouts and growers were trained to properly scout soybeans for pests. From one to six other training schools were held in northern, central, and southern Virginia each year. A total of 36 scout training schools, lasting about 4 hours each, have been held since 1978.

Between 1979 and 1985, a total of 87 soybean insect test demonstrations were conducted in eastern and southeastern Virginia. These demonstrations on producer's farms educated growers about IPM concepts and practices such as economic thresholds, trap crops, parasite releases, row spacing, and timing and rates of pesticide application. All these demonstrations were open to the public. In addition, many field research tests were conducted. Although these experiments were usually observed only by interested Extension agents and farm cooperators, the results were summarized in an annual Pest Management Test Demonstrations Report (McPherson *et al.* 1979a). Updated IPM information also was presented to producers who attended the field days at both the Eastern Virginia Research Station (Warsaw) and the Virginia Crop Improvement Association Research Farm (Mt. Holly). Twelve field days were held, usually with over 100 producers attending each.

Fourteen Virginia CES publications were prepared on soybean pest management from 1979-85. These publications were reviewed annually, revised when needed, and made available to all interested Extension agents, producers, and agribusiness leaders. Several were used in conjunction with the field scout training schools. In addition, control guides were revised annually for weeds (Hagood *et al.* 1984), insects (Smith *et al.* 1984) and diseases (Stromberg *et al.* 1984).

As a first step in computerizing the soybean IPM program, a small-scale computer-based information management system was developed by an interdisciplinary team and evaluated on a centralized IBM mainframe computer in 1981 (Ravlin and Allen 1984). The system, called the Pest Information Report Generation System (PIRGS), produced a series of six tables summarizing the events during the current and previous two weeks, and also facilitated data retrieval regarding individual farmers and fields. In addition to the production of regional field summaries, PIRGS provided a means of monitoring field scout activities in order to insure that all fields were visited on a weekly basis (i.e., personnel management). In the last phase of the program, the Spires Data Base Management System (DBMS) was incorporated into the system to make it more efficient. A broader spatial perspective was also gained through the centralization of multigrower, multicounty data sets, although the quantifiable benefits of this perspective have not been established. Models relating large-scale spatial and temporal interactions of crops and pests are now needed to improve the usefulness of this information (Stimac *et al.* 1980, Welch 1984).

Previously Documented Impacts

Through an extensive series of publications, news releases, county grower meetings, field scout training sessions, test demonstrations, and field days, soybean IPM is now being practiced on over 300,000 acres in Virginia. Economic crop losses due to insect damage have been nearly eliminated on IPM farms, although soybean losses throughout the state average over $538,000 annually (Table 6 on page 17). IPM control practices now being used include regular field scouting, economic thresholds, parasite releases, trap cropping and other cultural controls, insect and nematode predictions, and reduced pesticide application rates. While these practices have generally led to decreased insecticide usage statewide (8.9 percent reduction during 1980-82), IPM users have been known to use more pesticides than non-users in years of severe pest outbreaks. One example of this is 1983, when insecticide use by IPM users was 12.9 percent higher than overall county spray estimates (Table 6 on page 17). This increase was due primarily to the fact that IPM users sprayed many of their fields for spider mites, while non-users opted not to spray and, as a result, experienced large yield losses.

A summary of the insect crop loss assessments in IPM and non-IPM soybean test plots on replicated field experiments in eastern Virginia is given in Table 7 on page 18. In eighteen experiments, the yield increase attributed to IPM use was 4.5 bu/acre (29.6 bu/acre for IPM use versus 25.1 bu/acre traditional control practices). Assuming gross revenues of $6.00 per bushel and chemical control costs of $9.75 per acre, IPM users on average experienced a conservative net economic advantage of $18.25 per acre over non-users.

In addition to this evidence of the effectiveness of IPM in soybean production, there have been four formal impact studies of Extension's soybean IPM program in Virginia; a time-motion study of the economic feasibility of a cost-shared insect scouting service, a study of the willingness of farmers to participate in an Extension IPM program, a partial budget analysis coupled with a national agricultural sector impact analysis, and an assessment of the profit and risk associated with various IPM strategies.

Table 6. The cost of insect related crop losses and insecticide applications in Virginia soybeans.

Year	Acres[1] sprayed (1000)	Spray costs ($1000)	Crop loss[2] to insects ($1000)	Total losses ($1000)	% acres sprayed State[3] wide	IPM fields
1980	245.5	2,345	968.0	3.313	40.2	36.6
1981	295.0	2,729	403.0	3,132	46.5	27.1
1982	35.0	332	53.9	386	5.2	1.3
1983	246.1	2,330	730	3,060	30.8	43.7
1984	57.4	574	120	694	8.9	4.9

[1] Acres sprayed was determined from annual survey of county Extension agents.

[2] Acres not sprayed for insects, even though economic injury levels of pests were present, was determined from annual survey of county Extension agents. Crop losses (bu/acre) were determined from annual insect test evaluations. Value of crop ($/bu) was determined from *Virginia Agricultural Statistics.*

[3] Statewide acres includes both the acres being impacted by IPM and those not impacted by IPM.

Allen and Roberts (1974) examined the economic feasibility of a cost-shared insect scouting service for Virginia soybean farmers. They analyzed the time-motion components of scouting in a pilot IPM program and the resulting cost changes due to pesticide use in scouted and unscouted fields. They found that 87 to 90 percent of the sampled soybean acreage was treated prematurely and often needlessly, and that it cost less than $0.35 per acre to scout compared to an average pesticide treatment cost of approximately $4.00 per acre. This translated into a return on investment of over $3.00 per acre for every $1.00 invested.

The second impact study (Allen 1975) surveyed farmers in the soybean IPM program in four counties in eastern Virginia to determine why they were participating. Allen found that most farmers in the IPM program saved more than $5.00 per acre over nonusers, which resulted in an increased net return to management of more than $2.65 per acre over a 3-month period. This suggested that a major program objective, to help the farmers better time their insecticide treatments and thereby reduce production costs while maintaining yields, was being met. Allen also discovered that most farmers preferred to hire scouts instead of scouting themselves, and that the formal IPM program provided an organization through which this could be cooperatively accomplished.

Rajotte *et al.* (1985), in a third impact study, used partial budget analysis to compare the costs associated with several IPM strategies in both full-season and double-cropped soybeans. The IPM strategies examined were scouting, use of insecticide only in response to exceeding the economic threshold, and parasite releases. This study showed that there was a comparative savings, when measured as profit differences, in using IPM strategies rather than calendar pesticide applications. The authors then hypothetically extended this cost savings to all U.S. soybean acreage in order to demonstrate what could happen to crop and livestock production, resource allocation, and prices as a result of adoption of IPM technology.

Three scenarios were constructed by the authors and compared using a linear programming model. In the first scenario, all U.S. soybean acreage was assumed to be devoid of any IPM practices. In the second scenario, only Virginia farmers were assumed to use soybean IPM practices while the rest of U.S. soybean acreage still used traditional non-IPM practices. In the third scenario, all U.S. soybean acreage was assumed to use IPM practices. By maximizing the sum of producer plus consumer surpluses, the programming model projected price and quantity changes under each scenario.

The price and quantity levels in scenario 2 (IPM in Virginia only) were identical to those in scenario 1 (no IPM use). This suggested that while the Virginia growers received the same price for their crop as other farmers in the U.S., they benefited from the decreased costs associated with IPM use. However,

Table 7. Insect related crop loss assessments in IPM and non-IPM soybean test plots, eastern Virginia.

Year	Cropping System	Insect Pest[1]	Pop. peak[2] (develop. stage)	Yields (bu/acre)[3] IPM	Non-IPM
1979	F. season	MBB	9.8 per foot (R6)	35.0	30.0
1979	F. season	MBB	10.5 per foot (R6)	34.0	28.5
1979	F. season	MBB	12.6 per foot (R5)	42.3	35.1
1979	D. cropped	MBB	13.1 per foot (R6)	28.0	24.5
1980	F. season	SM	200+ per leaf (R6)	19.5	15.0
1980	D. cropped	CEW	2.0 per foot (R5)	9.8	5.6
1980	D. cropped	CEW	6.4 per foot (R5)	21.2	13.9
1981	F. season	BLB	at planting	53.7	51.1
1981	D. cropped	CEW	1.1 per foot (R5)	31.9	28.7
1982	F. season	BLB	2.4 per foot (R5)	32.3	30.9
1982	F. season	BLB	3.9 per foot (R5)	46.8	45.1
1982	D. cropped	CEW	1.1 per foot (R5)	43.4	38.6
1983	F. season	SM	200+ per leaf (R5)	16.2	6.1
1983	F. season	SM	600+ per leaf (R6)	11.0	4.3
1983	D. cropped	COMPLEX	several (R5)	18.0	13.3
1983	F. season	COMPLEX	several (R5)	28.3	20.8
1984	F. season	BLB	7.3 per foot (R4)	27.1	25.5
1984	F. season	SB	1.3 per foot (R5)	33.9	34.0

[1] MBB is Mexican bean beetle, SM is two-spotted spider mite, CEW is corn earworm, BLB is bean leaf beetle, SB is stink bug, and COMPLEX is a mixture of Mexican bean beetle, corn earworm, bean leaf beetle, and green cloverworm.

[2] Soybean developmental stages as described by Fehr and Caviness (1977).

[3] Side-by-side replicated tests where IPM indicates that insecticide controls were used when action thresholds were reached and non-IPM indicates that no insecticides were used even though action thresholds were reached.

when the savings from IPM use were extended to all U.S. soybean acreage, the acreage (and hence the production of soybeans) increased nationally and there was a corresponding decrease in price. Changes also occurred in other crops and livestock sectors.

The results of Rajotte *et al.* (19854) are typical of studies that examine the adoption of any new agricultural technology. When only a few farmers were using IPM, they were at an advantage by receiving the same price as non-users while experiencing lower costs. However, as lower-cost IPM practices were adopted by all soybean farmers, the return per unit cost savings disappeared.

In the fourth formal impact study, Greene *et al.* (1984b) explored the economic feasibility of various pest management strategies in terms of both expected net revenue and net revenue variability, or risk. After constructing representative production budgets for pest management strategies in the Northeast district, probability distributions of net revenue associated with alternative pest management strategies were compared using stochastic dominance criteria (Greene *et al.* 1984a). Results indicated that the IPM strategies for both full-season and double-cropped soybeans were preferred to conventional strategies in terms of both average net revenue and net revenue risk.

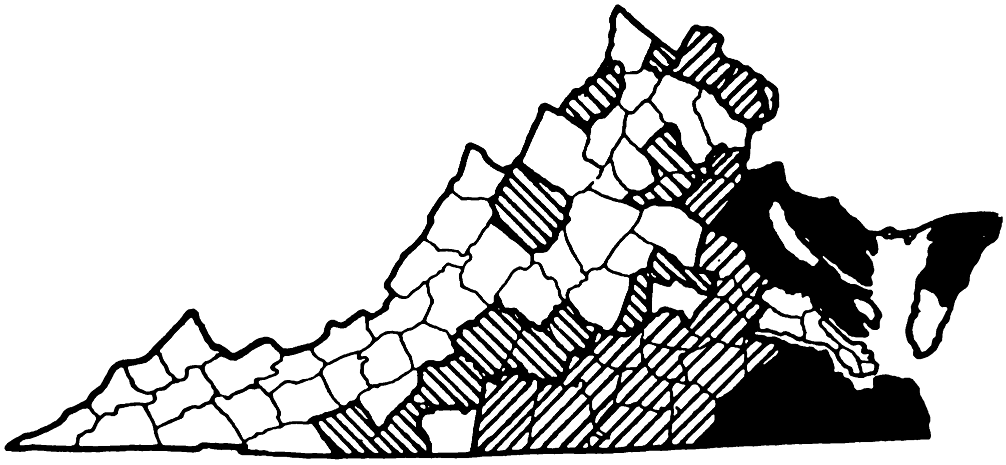
Grower Survey Methods

This section outlines the methods used to collect the data utilized in determining the impacts of the Virginia Soybean IPM Program.

Sampling Procedures and Statistics

The telephone survey was conducted utilizing the methods described by Dillman (1978) and Christenson (1975). A sampling frame of all farmers who grew soybeans in Virginia was obtained from the State Crop Reporting Service census records and represented the most current information on soybean growers in the state. The sampling frame consisted of approximately 10,000 growers located throughout the state. The counties with at least one sample response in the survey are shown in Figure 2.

Figure 2. Soybean growing counties sampled in Virginia.



■ Counties sampled in regions of the state having the most problems with insect outbreaks.

■ + ▨ Counties which together contain approximately 95 percent of the soybean acreage in the state.

Soybean farmers in Virginia were considered to belong to a homogeneous population since no obvious stratifying variables were noted. Thus, a sample list was drawn randomly from the sampling frame. The optimal sample size needed for a 5 percent precision of estimates with a 5 percent risk of Type I error was determined from published tables (Krijcie and Morgan 1970). A larger sample list was drawn to compensate for a small percentage of refusals and otherwise unreachable respondents.

Implementation

Prior to implementation, a pretest of the questionnaire was conducted as described by Dillman (1978). The purpose of the pretest was

- to ascertain whether respondents gave answers other than those pre-listed and to add additional answer categories as appropriate;
- to test the ease of administration of the survey instrument, the logic of the wording of the questions, the sequence of the questions, and to make refinements as necessary; and
- to estimate the amount of time necessary to interview each grower, and thus facilitate scheduling of the full-scale survey.

The Virginia Soybean IPM survey was administered using telephone interviews conducted by the Virginia Crop Reporting Service. Prior to commencement of the telephone interview for the clientele case studies, interviewers and supervisors assigned to the study received training by the Virginia Tech study team. In these training sessions, interviewing protocol was thoroughly reviewed, and interviewers were trained in-depth on the particulars of this survey and given an opportunity to conduct mock interviews (Dillman 1978).

Soybean growers in Virginia were interviewed during the period of February to March 1985. Regularly scheduled telephone interviews generally took place Monday through Thursday from 5 p.m. to 9 p.m., on Saturday from 9 a.m. to 5 p.m., and on Sunday from 12 p.m. to 9 p.m. Special arrangements were made to conduct interviews at other hours if needed or requested by respondents. In general, three call attempts were made to each sampled respondent in an effort to obtain a completed interview. Relevant sample statistics are given in Table 8.

Table 8. Comparison sample characteristics from the Virginia Soybean IPM survey: Compared to averages for the entire national study.

	Virginia	National
Sample Size		
-Total number	267	3258
-percentage of estimated total population	2.7	7.9
Response time		
-Mean (minutes)	21.2	26.3
-Standard error	0.4	0.9

All completed questionnaires were thoroughly edited by interview supervisors during the first week of interviewing, and rapid feedback on errors was provided to interviewers. In subsequent weeks, completed questionnaires were reviewed before being sent to the Virginia Tech study team. After entering into computer files, the data were examined for errors. Categorical answers were checked to determine if any responses fell outside permissible ranges. If this occurred, attempts were made to reconcile the problem using the original questionnaires. Continuous numerical answers were statistically analyzed for normality and extreme range errors. If extreme outliers were detected, they were deleted from mean calculations.

Administered as an approximately 30-minute telephone interview, the study questionnaire was designed to obtain the following information on Virginia soybean growers:

1. Current Practices
    - frequency, extent, cost, and executor of scouting
    - use of soybean specific IPM methodology
    - decision basis for use of pesticides

- frequency, extent, cost, and applier of pesticides by major category (i.e., herbicide, insecticide)
- acres planted, yield, and price received for commodity

2. Recognition and Attitudes towards IPM

    - when and from whom grower first learned of IPM
    - if IPM was not used, rated importance of reasons not used
    - opinions on the need and value of IPM educational programs
    - rated usefulness of IPM approaches

3. Knowledge Level and Information Sources

    - extent of contact with Extension
    - rated usefulness of print media, electronic media, and face-to-face contact in obtaining pest management information

4. Grower Demographic and Socioeconomic Characteristics

    - level of education
    - ethnic information
    - gender
    - age
    - years farming experience
    - acres owned
    - acres farmed
    - farm value
    - farm production value
    - percent of yearly income received from the farm

In considering the data presented in this report, it is important to remember that the information collected reflects the perceptions of the growers contacted and not necessarily a detailed examination of their business records.

Impact Indicators

To facilitate analysis of IPM program impacts on soybean growers, three levels of IPM usage were defined based on the practices the growers reported using. Three general types of practices were used to classify growers: scouting, passive monitoring, and specialized spraying. Scouting is the process of observationally determining pest identity and population levels. Passive monitoring devices include sticky traps and pheromone traps that are used to detect potential pest problems. Specialized spray methods are those which limit spraying only to pest infested areas and/or which reduce per acre pesticide application rates.

User levels were developed with the aid of the state IPM Coordinator and reflect the relative importance each IPM practice was given during implementation of the state program. The three categories employed in Virginia were termed Non-users, Low-users, and High-users.

Non-users were defined as those growers who did not scout their soybean acreage and did not use trap crops, nurse plots, narrow-row planting or nematode analysis. Low users were defined as those growers who scouted less than 50 percent of their soybean acreage using someone other than a pesticide dealer (i.e., hired scout, Extension agent, family member, or farm employee). or, if greater than 50 percent was scouted, it was done by a pesticide dealer. Low users also employed trap crops, nurse plots, narrow-row planting, and/or nematode analysis. High users were defined as those growers who scouted greater than 50 percent of their soybean acreage using someone other than a pesticide dealer (i.e., hired scout, Extension agent, family member, or farm employee). High users may also have employed trap crops, nurse plots, narrow-row plantings, and/or nematode analysis (Table 9 on page 22).

Table 9. Number of respondents in each user category.

	Level of IPM use		
	Non-user	Low-user	High-user
Number of respondents in user category	67	67	133
Percentage of all respondents	25.1	25.1	49.8

Constraints of Sampling Methods

Estimates of error need to be considered whenever analyzing and interpreting the results of survey data. When assessing the accuracy of a survey, it is useful to distinguish between two types of errors: sampling errors and non-sampling errors. The random sampling used in this survey allows the user of the statistics in this report to calculate sampling errors. The standard error of the sample (a measure of sampling error) for the Virginia Soybean IPM survey was 3.0 percent.

Non-sampling errors include the effects of refusals, unavailable or unreachable respondents, as well as unreliable or invalid information provided by respondents. Also included are the effects of coding or other processing errors. Unlike sampling errors, there is no simple or direct way of estimating the extent of non-sampling errors; however, biases which can arise from various aspects of survey operations were minimized through strict control for high quality and consistency of data collection and processing.

The survey statistics in this evaluation are also subject to the problems of non-response. Since virtually all survey efforts are limited by the resources that can be used tracking respondents, interviews are completed with only part of the sampled respondents. It is important to bear in mind, when reading this report, that there *may* be differences between respondents interviewed (upon which this report is based) and the remaining portion of the sample population who, for various reasons, were not interviewed.

Grower Survey Results

The following section details the demographic, socioeconomic, economic, and other effects of the soybean IPM program in Virginia.

General Demographic and Socioeconomic Characteristics of Clientele

The vast majority of growers responding were white, male, and over the age of 40 (Table 10 on page 24). Almost one-fourth of the growers had at least some college education, although only 8.1 percent had completed a degree program (Table 11 on page 25). Most were experienced farmers, with 93.7 percent having at least 10 years experience and more than one-half having over 30 years experience. Only 0.8 percent of the growers could be classified as relatively new to farming (less than 5 years experience).

The majority of soybean growers in the sample owned between 100 and 500 acres, although the average acres in soybeans was 77.3 (Table 12 on page 26). The difference between acreage owned and acreage planted in soybeans indicates that most soybean growers are also involved in other crop production. Overall, the amount of acreage farmed (not necessarily with soybeans) tended to be lower than ownership patterns, suggesting that the average soybean grower did not farm on rented land.

The estimated value of farms in the sample, as measured by the total value of the farm including land, buildings, and equipment, was concentrated in the $40,000 to $500,000 range, with the majority of farms worth between $100,000 and $500,000 (Table 13 on page 27). Only 4.1 percent of the farms were valued below $40,000 and just 11.4 percent were valued above $500,000. The approximate gross value of all farm products sold by the majority of soybean growers over the last three years was between $10,000 and $500,000, with half of the growers producing between $10,000 and $100,000 (Table 13 on page 27). However, over 27 percent of the growers reported sales less than $10,000, and 1.6 percent reported sales in excess of $500,000. In addition, over one-third of the growers reported receiving more than 75 percent of their income from the farm, although over 40 percent of the respondents indicated that their operations produced 25 percent or less of their yearly income (Table 13 on page 27).

Over one-third of the growers indicated they do not scout soybeans, with an additional 14 percent scouting less than 50 percent of their acreage (Table 14 on page 28). However, almost half of all growers indicated they scouted at least 75 percent of their acreage, and of those growers scouting, three-fourths had been doing it for at least 6 years. Only one respondent indicated that he/she had dropped scouting from their list of routine practices.

Although not as popular as scouting, growers employed a number of other pest control methods. Just under 40 percent of all growers used narrow-row planting, while soil sampling for nematodes was used by almost one-third (Table 14 on page 28). Nurse plots and trap crops were used by a very small number of respondents. These low responses to these cultural practices are probably due to several factors. First, nurse plots are used to enhance the buildup of parasites of the Mexican bean beetle. Interest in controlling this pest with parasites is down because Mexican bean beetle populations are much lower today than they were in the mid-1970's. Little or no acreage has been sprayed for this pest since 1980. Also, trap crops are useful only in the eastern counties, where stink bugs, bean leaf beetles, and Mexican bean beetles are a problem. This statewide survey questioned only a limited number of growers from counties where this IPM practice is promoted and used.

Table 10. Age, race, and sex distribution of respondents.

Demographic characteristic	Number responding	Percent of total responding
Age (years):		
< 30	8	3.1
30-39	25	9.7
40-49	57	22.0
50-59	64	24.7
> 60	105	40.5
	259	100.0
Race:		
White	212	82.5
Black	41	16.0
Hispanic	0	0.0
American Indian	1	0.4
Other	3	1.1
	257	100.0
Sex:		
Male	250	96.9
Female	8	3.1
	258	100.0

Note: Total sample size for this case study was 267. Cumulative counts (in this and all other tables) that are less than 267 are due to respondents not answering the relevant questions.

Table 11. Education and farming experience of respondents.

Social characteristic	Number responding	Percent of Total responding
Education:		
no high school	63	24.3
some high school	43	16.6
completed high school	90	34.8
some college	42	16.2
completed college	15	5.8
post-graduate work	6	2.3
	259	100.0
Farming Experience (years):		
0-5	2	0.8
6-10	14	5.5
11-20	48	18.8
21-30	45	17.6
> 30	147	57.3
	256	100.0

Table 12. **Acres owned, acres farmed, and acres of soybeans grown by respondents.**

Acreage characteristic	Number responding	Percent of Total responding
Acres owned:		
< 50	42	16.9
50-99	47	19.0
100-199	74	29.8
200-499	63	25.4
500-999	16	6.5
> 1000	6	2.4
	248	100.0
Acres farmed:		
< 50	65	25.5
50-99	51	20.0
100-199	45	17.7
200-499	64	25.1
500-999	21	8.2
> 1000	9	3.5
	255	100.0
Acres of Soybeans Grown:		
Mean	77.3	
Standard error	6.9	

Table 13. **Farm value, farm product value, and percent of income from the farm as reported by respondents.**

Enterprise characteristic	Number responding	Percent of Total responding
Farm Value[1] (in thousands):		
< 40	10	4.1
40-100	66	27.1
100-500	140	57.4
500-1,000	23	9.4
> 1,000	5	2.0
	244	100.0
Average Gross Value of All Farm Products over the last 3 years (in thousands):		
< 10	66	27.1
10-100	124	50.8
100-500	50	20.5
500-1,000	4	1.6
	244	100.0
Percent of Family Income From the Farm:		
0-10	58	23.4
11-25	43	17.3
26-75	50	20.2
76-100	97	39.1
	248	100.0

[1] Value as measured by the total value of the farm including land, buildings, and equipment.

Table 14. Years scouted, acres scouted, and pest management practices used by respondents.

IPM Practice	Number responding	Percent of Total responding
Years scouted:		
last 2	20	11.8
last 4	25	14.8
last 6	33	19.5
last 8	10	5.9
more than 8	81	48.0
	169	100.0
Acreage scouted:		
None	98	36.4
< 25%	20	7.4
25-50%	18	6.7
51-75%	12	4.5
76-100%	121	45.0
	269	100.0
Use these methods:		
narrow row planting	104	39.4
soil sampling for nematodes	82	30.8
nurse plots	9	3.4
trap crops	5	1.9

Demographic and Socioeconomic Characteristics by Level of IPM Utilization

When analyzed by level of IPM use, there were few differences between the growers in different user categories, although some exceptions did occur. While growers in all categories were concentrated in the over-40 age group, low-users were more than twice as likely and high-users were almost four times more likely to be under 40 years old than were non-users (Table 15 on page 30). The level of education among Virginia soybean growers was also higher for users of IPM technology (Table 16 on page 31), with high users more than twice as likely to have at least some college education and 4 times more likely to have completed a degree program than were non-users. While low and high-users had similar farming experience patterns, non-users were more likely than either to have had over 30 years experience (Table 16 on page 31).

Acreage owned did not vary significantly among user levels, although high-users had some of the largest farms (Table 17 on page 32). Acreage farmed once again closely followed ownership patterns, although non-users tended to farm fewer acres than they owned. Mean acreage devoted exclusively to soybeans was similar for non- and low-users (55.4 and 55.3 acres, respectively), while high-users planted almost twice as many acres in soybeans (99.5 acres). As was noted for the average grower, all user categories tended to farm more acreage than that planted exclusively in soybeans (Table 17 on page 32).

Most high and low-users had farms valued between $40,000 and $500,000, with the majority falling in the $100,000 to $500,000 range (Table 18 on page 33). Non-user farms, however, tended to be valued lower, with over 50 percent worth less than $100,000. The difference between user farm value was also reflected in the tendency of non-users to report a lower gross average product value than did either low or high-users. Percent of family income derived from the farm varied little among user groups, with the largest fraction of respondents reporting that between three-fourths and all of their income was derived from farm operations.

High-users were characterized by scouting more than 50 percent of their acreage, and by utilizing the scouting services of someone other than a pesticide dealer. The majority of high-users has reportedly scouted for more than eight years, while almost 50 percent of low and non-users started scouting within the last four years (Table 19 on page 34).

Of the non- and low-users who scout, all scouted less than 50 percent of their acreage or had a pesticide salesperson do the actual fieldwork. Non-users, by definition, used no other specific IPM method, but low-users employed various IPM practices besides scouting (especially narrow-row planting and soil sampling for nematodes) more often than did high-users (Table 19 on page 34).

Table 15. Age, race, and sex distribution of respondents by level of IPM use.

Demographic characteristic	Level of IPM use Non-user	 Low-user	 High-user
	----------------	(in percent)	--------------
Age (years):			
< 30	0.0	4.6	4.0
30-39	4.5	7.7	13.6
40-49	14.9	30.8	20.8
50-59	25.4	24.6	24.8
> 60	55.2	32.3	36.8
	100.0	100.0	100.0
Race:			
White	70.8	86.2	87.2
Black	27.7	10.8	12.0
Hispanic	0.0	0.0	0.0
American Indian	1.5	0.0	0.0
Other	0.0	3.0	0.8
	100.0	100.0	100.0
Sex:			
Male	97.0	97.0	97.6
Female	3.0	3.0	2.4
	100.0	100.0	100.0

Table 16. Education and farming experience of respondents by level of IPM use.

Social characteristic	Non-user	Low-user	High-user
	Level of IPM use		
	(in percent)		
Education:			
no high school	37.9	26.2	15.9
some high school	19.7	20.0	13.5
completed high school	30.3	29.2	39.7
some college	10.6	13.9	20.6
completed college	1.5	9.2	6.3
post-graduate work	0.0	1.5	4.0
	100.0	100.0	100.0
Farming Experience (years):			
0- 5	1.5	0.0	0.8
6-10	4.5	8.0	4.8
11-20	12.1	22.2	20.8
21-30	16.7	22.2	16.0
> 30	65.2	47.6	57.6
	100.0	100.0	100.0

Table 17. **Acres owned, acres farmed, and acres of soybeans grown by level of IPM use.**

Acreage characteristic	Level of IPM use Non-user	Low-user	High-user
	(in percent)		
Acres owned:			
< 50	16.1	16.4	17.1
50-99	25.8	18.0	16.3
100-199	29.0	32.8	28.5
200-499	25.8	29.5	23.6
500-999	3.3	3.3	9.8
> 1000	0.0	0.0	4.7
	100.0	100.0	100.0
Acres farmed:			
< 50	43.8	21.5	17.7
50-99	17.2	21.5	20.2
100-199	20.3	13.9	18.6
200-499	15.6	30.8	27.4
500-999	3.1	9.2	10.5
> 1000	0.0	3.1	5.6
	100.0	100.0	100.0
Acres of Soybeans Grown:			
Mean	55.4	55.3	99.5
Standard error	12.3	9.1	11.3

Table 18. Farm value, farm product value, and percent income from farm by level of IPM use.

	Level of IPM use		
Enterprise characteristic	Non-user	Low-user	High-user
	(in percent)		
Farm Value[1] (in thousands):			
< 40	6.8	3.2	3.3
40-100	47.5	24.2	18.8
100-500	37.3	62.9	63.9
500-1,000	8.4	8.1	10.7
> 1,000	0.0	1.6	3.3
	100.0	100.0	100.0
Average Gross Value of All Farm Products over the last 3 years (in thousands):			
< 10	42.4	27.0	19.8
10-100	44.1	50.8	54.2
100-500	13.5	20.6	24.2
500-1,000	0.0	1.6	2.4
	100.0	100.0	100.0
Percent of Family Income From the Farm:			
0-10	19.4	29.5	22.6
11-25	27.4	6.6	17.7
26-75	14.5	21.3	22.6
76-100	38.7	42.6	37.1
	100.0	100.0	100.0

[1] Value as measured by the total value of the farm including land, buildings, and equipment.

Table 19. Years scouted, acres scouted, and pest management practices used by level of IPM use.

Agricultural Practice	Non-user	Low-user	High-user
	Level of IPM use		
	(in percent)		
Years scouted:			
last 2	35.7	27.3	6.8
last 4	14.3	22.7	13.5
last 6	14.3	22.7	19.6
last 8	7.1	4.6	6.0
more than 8	28.6	22.7	54.1
	100.0	100.0	100.0
Acreage scouted:			
None	76.1	67.2	0.0
< 25%	16.4	13.4	0.0
25-50%	7.5	19.4	0.0
51-75%	0.0	0.0	9.0
76-100%	0.0	0.0	91.0
	100.0	100.0	100.0
Use these methods:			
narrow row planting	0.0	70.2	43.5
nematode sampling	0.0	46.3	38.4
nurse plots	0.0	4.6	1.5
trap crops	0.0	4.6	4.5

Economic Effects

Virginia soybean enterprise budgets for non-, low, and high-users, along with the budget for the average of all respondents, are given in Table 20 on page 36. They were constructed using information supplied by the state IPM coordinator and soybean specialists, and modified to reflect data collected in the survey. Description of the data collected by this survey and used in the budgets can be found in Table 21 on page 37.

A number of assumptions were made in developing the partial budgets for Virginia soybean growers. The most important of these include:

- Pest management practices may directly affect pest management costs and crop yield.
- Pest management practices may indirectly affect price received for the crop due to quality differences.
- Preharvest, non-pest management practices and their costs are fixed across all user groups.
- Land charges, insurance, capital cost, etc., are fixed across all user groups.

Thus, the following budget categories were allowed to vary dependent upon the results of the survey:

- Gross returns (price received times crop yield)
- Preharvest pest management costs (sum of pesticide costs, scouting costs, labor, equipment, and interest)
- Total Variable Costs (sum of preharvest non-pest management costs, preharvest pest management costs and harvest costs)
- Total Costs (sum of total variable costs and total fixed costs)
- Net Returns (gross returns - total preharvest costs - total harvest costs - fixed costs)

Soybean growers spent an average of $0.32 per acre for scouting service (including those who scouted their own fields and did not incur an out-of-the-pocket cost) (Table 20 on page 36). The pesticide cost for the average respondent was $22.92 per acre, while the average annual number of pesticide applications was 1.32. Production per acre for the average respondent was 28.5 bushels of soybeans, for which the average price received was $6.12 per bushel. Overall, pest management costs accounted for approximately 29 percent of pre-harvest variable costs and 18 percent of total costs. Soybean growers covered all variable and fixed costs, and received a positive return to management.

When examined by user level, differences were evident between the enterprise budgets for non-, low, and high-users. Because of the way IPM user levels were defined, non-users incurred the lowest scouting costs ($0.12 per acre). Low users, however, spent an average of $0.17 per acre and high-users spent an average of $0.50 per acre for scouting services. Low-users had the lowest number of pesticide applications per year (1.00 per acre), followed by non-users (1.12 times per acre) and high-users (1.55 times per acre). As is shown in Table 21 on page 37, this was primarily due to a larger number of herbicide applications by non- and high-users. The higher number of sprays reported by high-users was also reflected in pesticide costs, with low-users spending more than non-users ($15.92 and $15.15 per acre, respectively) and high-users spending the most ($18.63 per acre). High-users subsequently received higher yields (29.9 bushels per acre, compared to 26.6 for low-users and 27.4 for non-users) and higher returns than did other growers (Table 20 on page 36), which offset increased costs and resulted in increased profits. However, it is difficult to determine from this survey whether the increases were due strictly to the use of IPM. It may be that growers who use IPM technology are generally more skillful at managing their soybean acreage. Nonetheless, the resulting increase in gross revenue to high-users more than offset the increased pest management costs and produced greater net incomes.

The differences in Table 20 on page 36 could be due to several factors. It is clear that the pesticide costs per acre increased for high-users due to a larger number of treatments per acre and a higher percentage of the acres treated. However, the Virginia IPM program was heavily geared toward insect pest control. A large portion of the substantial pest control costs for high-users was due to greater weed control costs. As indicated

Table 20. Virginia soybean enterprise budget by level of IPM use.

			Average Grower			Non-User			Low user			High user	
	Unit	Price	Quantity	Value	Price	Quantity	Value	Price	Quantity	Value	Price	Quantity	Value
GROSS RECEIPTS	bu	6.12	28.5	174.42	5.99	27.4	164.13	5.99	26.6	159.33	6.24	29.9	186.58
VARIABLE COSTS													
Preharvest (Non-Pest Management)				51.64			51.64			51.64			51.64
Preharvest (Pest Management)													
Pesticides	acre	17.36	1.32	22.92	15.15	1.12	16.97	15.92	1.00	15.92	18.63	1.55	28.88
Pesticide application	acre	3.50	1.32	4.62	3.50	1.12	3.92	3.50	1.00	3.50	3.50	1.55	5.43
Scouting	acre	.50	.635	.32	.50	.24	.12	.50	.33	.17	.50	1.00	.50
Trap Crop	acre	.70	.02	.01	.70	0	0	.70	.05	.03	.70	.02	.01
Nurse Plot	acre	.25	.03	.01	.25	0	0	.25	.05	.01	.25	.05	.01
Total Pest Mngt.				27.88			21.01			19.63			34.83
Harvest				11.04			11.04			11.04			11.04
Interest on variable costs*	dollar	.12	45.28	5.43	.12	41.85	5.02	.12	41.16	4.94	.12	48.76	5.85
Total variable costs				95.99			88.71			87.25			103.36
FIXED COSTS													
Machinery and Equipment (Depr., Taxes, Ins., Int.)				31.73			31.73			31.73			31.73
Land Charge				25.00			25.00			25.00			25.00
Total Fixed Costs				56.73			56.73			56.73			56.73
TOTAL COSTS				152.72			145.44			143.98			160.09
Return to Management				21.70			18.69			15.35			26.49

*Note: Interest calculated on one-half of variable costs due to the typical 6-month debt carrying period.

in Table 21 on page 37, herbicide treatments far exceeded those of other pesticides. Finally, it is also possible that high-users were more risk-averse than non-users and thus utilized greater amounts of pesticides to minimize the probability of large losses due to pest problems.

Overall, the main distinguishing features between non-, low-, and high-users were:

- High users reported higher yields (29.9 bushels) than did low- (26.6 pounds) or non-users (27.4 pounds).
- High-users reported higher prices received for their crops ($6.24 per bushel) than did low- or non-users ($5.99 per bushel).

Table 21. Collected budget data of respondents.

		Level of IPM use		
	All survey respondents	Non-user	Low-user	High-user
Soybean yield (in bushels):				
mean	28.5	27.4	26.6	29.9
standard deviation	8.5	10.5	8.6	7.2
range	7-70	7-70	8-55	15-55
Soybean Price Received ($/bushel):				
mean	6.12	5.99	5.99	6.24
standard deviation	0.53	0.52	0.51	0.51
range	4.50-7.75	5-7	4.50-7.50	5-7.75
Number of Pesticide Applications (per acre per year):				
herbicide	1.08	0.97	0.88	1.21
insecticide	0.20	0.15	0.11	0.27
fungicide	0.01	0.00	0.00	0.01
nematicide	0.02	0.00	0.01	0.04
rodenticide	0.01	0.00	0.00	0.02
Total	1.32	1.12	1.00	1.55
Pesticide Costs ($/acre):				
mean	17.36	15.15	15.92	18.64
standard deviation	13.36	8.61	11.61	15.13
range	[1]0-99.99	0-30	0-50	3-99.99

[1] The maximum possible response of $99.99 was reported by one individual.

- Pesticide costs were lower for non-users ($15.15) than for low-users ($15.92), and lower for low-users than for high-users ($18.64).
- High-users sprayed a greater number of times (1.55) than did either low- (1.00) or non-users (1.12).
- High-users had slightly higher total pest management costs than did low- and non-users, due primarily to higher pesticide costs.
- High-users experienced greater returns to management than did non-users ($26.49 and $18.69 per acre, respectively), who in turn experienced greater returns than did low-users ($15.35 per acre).

Other Effects

At least fifty percent of all responding soybean growers in Virginia knew by name two major weed pests and one major insect pest of soybeans (Table 22) and reported them as causing problems on their farms. However, only between one-fifth and one-half of the growers reported having problems with Mexican bean beetles, stink bugs, lesion nematodes, and spider mites, all of which can be major soybean pests in Virginia. In addition, almost one-third of the growers incorrectly identified the fictitious spotted leaf worm as a pest, while approximately 8 percent reported problems with cedar rust, a disease not known to affect soybeans.

Table 22. Respondents name recognition of Virginia soybean pests.

Pest Species	Number responding	Percent of Total responding
Morning glory	217	84.8
Johnson grass	143	56.5
Corn earworm	128	50.4
Mexican bean beetle	110	43.5
Stink bugs	101	39.6
Spotted leaf worm	78	30.8
Lesion nematode	75	29.6
Spider mites	56	22.1
Cedar rust	20	7.9

Extension bulletins, handbooks, and manuals were considered by the majority of soybean growers (82.9 percent) to be most preferred or preferred sources of pest management information (Table 23 on page 39), while almost three-fourths of the respondents identified Extension agents as a major information source, even though 59.2 percent indicated that they sought advice from agents less than once a month (Table 24 on page 39). Extension newsletters, production meetings, and field demonstrations were also preferred sources of pest management information, but not considered as useful by the average grower as were neighboring farmers, newspapers, magazines, and dealers and salespersons (Table 23 on page 39). Scout training sessions and Extension short courses were reported as most preferred or preferred by only approximately one-quarter of the growers. Private consultants, telephone or telephone recordings, and the Extension computer network were preferred by less than 11 percent of the respondents.

Table 23. Respondent sources for obtaining pest management information.

Source of pest management information	Number responding	Percent of total responding
Extension bulletins, handbooks/manuals	208	82.9
Extension agents	186	74.1
Neighboring farmers	180	71.1
Newspapers or magazines	160	63.3
Dealers and salespersons	154	60.9
Extension newsletters	140	56.7
Field demonstrations	134	52.6
Extension production meetings	117	45.7
Scout training sessions	66	26.0
Extension radio programs	65	25.5
Short courses and workshops	49	19.2
Television	46	18.1
Private consultants	26	10.2
Telephone and Telephone recordings	17	6.8
Extension computer network	5	2.0

Note: On a rating scale of 1 to 4, with 1 being "least preferred" and 4 being "most preferred," the values above represent those respondents answering 3 or 4.

Table 24. Frequency of respondent contact with their Extension agent.

Contact with Extension agent	Number responding	Percent of total responding
Once per week	10	3.9
Twice per month	15	5.8
Once per month	52	20.2
< Once per month	152	59.2
Never	28	10.9
	257	100.0

Only 20.5 percent of the soybean growers indicated that they had heard of the term IPM (Table 25 on page 40). It is likely that many of the IPM users identified their IPM practices under some other name. Subsequent conversations with participating Extension agents revealed that many agents used alternate terminology such as pest management, insect pest management, weed management, or prescription farming when they were promoting IPM concepts and practices. This could have lead to some confusion among growers as to whether or not they ever heard of the term "Integrated Pest Management." Slightly over one-half (51 percent) of the soybean growers who recognized the term became aware of IPM through the Cooperative Extension Service. Another 21.5 percent learned of the program through newspapers and magazines, while 10.1 percent were introduced to it by farm supply dealers. The remaining growers found out about IPM through agricultural chemical salesmen, neighboring farmers, or other sources.

Table 25. Respondent name recognition of IPM and source of first contact with IPM.

	Number responding	Percent of total responding
Aware of IPM program	54	20.5
Where first heard of IPM:		
Cooperative Extension Service (including Extension agent, bulletins, handbooks, etc.)	76	51.0
Newspapers or magazines	32	21.5
Farm supply dealer	15	10.1
University personnel	2	1.2
Agrichemical salesperson	5	3.3
Neighboring farmer	8	5.4
Other	11	7.4
	149	100.0

When asked about what they considered important "selling points" of an IPM program, over 90 percent of all growers indicated that safe use of pesticides, increased crop yield and quality, reduced health hazards, and increased farm profits were highly valued (Table 26 on page 41). Increased knowledge of pests and pest control, the reduction of environmental damage, the use of less toxic and smaller quantities of pesticides, and increased peace of mind were also considered important.

When analyzed by user level, high-users reported by name a greater number of specific pests causing problems in their soybean fields when compared to either low-users or non-users (Table 27 on page 41). However, differences in problem pests between all three user categories was generally small and varied depending on the specific pest named. High-users identified the fictitious spotted leaf worm as a soybean pest a greater percentage of the time than did either low- or non-users. This could be explained by the fact that many insect pests have several common names, and the spotted leaf worm was misidentified as being another common name for one of the worm pests that growers encounter in their fields. The corn earworm, for example, is also commonly referred to as the soybean pod borer, the bollworm, and the tomato fruit worm.

The preferred pest management information source for all three user categories was the Cooperative Extension Service, with the largest fraction of all growers showing a preference for Extension handbooks and manuals (Table 28 on page 42). High-users, however, also greatly preferred face-to-face contact with Extension personnel, while low- and non-users equally preferred obtaining information from Extension agents or neighboring farmers. Overall, high-users tended to prefer some Extension programs (e.g. field demonstrations, scout training sessions) more than did either low- or non-users, while low- and non-users preferred radio and television as an information source much more than did high-users. In addition, only high-users reported accessing the Extension computer network, and they also used telephone information retrieval more often than did low- or non-users.

Table 26. Respondent perceptions of IPM "selling points."

IPM selling points	Number responding	Percent of total responding
Increases farm profits	138	95.8
Increases crop yield and quality	134	92.4
Reduces personal health hazard	132	92.3
Safe use of pesticides	132	91.7
Reduces family's health hazard	130	90.8
Protects public health	128	90.0
Better way of pest control	127	89.5
Increases knowledge of pest and control options	128	87.4
Promotes less toxic and smaller quantities of pesticides	126	86.9
Reduces environmental damage	119	86.2
Increases peace of mind	121	85.2

Note: On a rating scale of 1 to 4, with 1 being "not important" and 4 being "very important," the values above represent those respondents answering 3 or 4.

Table 27. Respondent name recognition of Virginia soybean pests by level of IPM use.

	Level of IPM use		
Pest Species	Non-user	Low-user	High-user
	(in percent)		
Morning glory	81.3	80.0	88.9
Johnson grass	54.0	53.9	59.2
Corn earworm	41.3	42.2	59.5
Mexican bean beetle	41.3	47.7	42.7
Stink bugs	27.0	43.9	43.2
Spotted leaf worm	28.6	16.9	39.2
Lesion nematode	12.7	26.6	37.9
Spider mites	12.7	21.5	26.6
Cedar rust	6.4	13.9	5.7

Table 28. Respondent sources of pest management information by level of IPM use.

Source of pest management information	Non-user	Low-user	High-user
	Level of IPM use		
	(in percent)		
Extension bulletins, handbooks, manuals, etc.	71.0	77.8	92.0
One-on-one with Extension personnel	67.2	60.3	84.9
Neighboring farmers	71.7	61.9	76.4
Newspapers or magazines	65.1	56.3	66.4
Dealers and salesmen	59.7	60.9	61.9
Newsletters	55.0	48.3	61.9
Field demonstrations	38.1	36.9	68.3
Production meetings	34.9	52.3	48.0
Scout training sessions	16.1	18.5	34.9
Radio	33.3	32.3	18.3
Short courses and workshops	23.8	21.5	15.9
Television	27.0	23.4	11.1
Private consultants	6.5	15.6	9.5
Telephone and telephone recordings	5.1	3.2	9.5
Computer network	0.0	0.0	3.9
Videotape	3.4	0.0	2.4

Note: On a rating scale of 1 to 4, with 1 being "least preferred" and 4 being "most preferred," the values above represent those respondents answering 3 or 4.

Contact with Extension agents varied among user levels, with some non-users (23.4 percent), low-users (15.2 percent), and high-users (2.4 percent) indicating they have never contacted their Extension agent (Table 29 on page 43). The majority of respondents in all three user categories had less than one meeting per month with their agent. Only 11 percent of non-users reported having at least one contact per month with their agent, compared to 28.8 percent for low-users and 40.2 percent for high-users.

Table 29. Frequency of respondent contact with their Extension agent by level of IPM use.

	Level of IPM use		
Contact with Extension agent	Non-user	Low-user	High-user
	(in percent)		
Once per week	0.0	1.5	7.1
Twice per month	1.6	4.5	8.7
Once per month	9.4	22.7	24.4
< Once per month	65.6	56.1	57.4
Never	23.4	15.2	2.4
	100.0	100.0	100.0

A number of soybean growers classified as IPM users indicated that they were not aware of the term Integrated Pest Management (77.3 percent and 75.4 percent for low-users and high-users, respectively) (Table 30). Of non-using soybean growers, 89.2 percent indicated they were not aware of the term. For those who did recognize the term IPM, by far the most common introduction was through the Extension service, (30.8, 45.6, and 55.4 percent for non-, low-, and high-users, respectively). Newspapers and magazines were also frequent sources of introduction to IPM, and were especially valuable to high-users (22.8 percent). Farm supply dealers were the source in at least 7 percent of all introductions to the program at each user level.

Table 30. Respondent name recognition of IPM and source of first contact with IPM by level of IPM use.

	Level of IPM use		
	Non-user	Low-user	High-user
	(in percent)		
Aware of IPM program	10.8	22.7	24.6
Where first heard of IPM:			
Cooperative Extension Service (including Extension agent, bulletins, handbooks, etc.)	30.8	45.6	55.4
Newspapers or magazines	23.1	17.1	22.8
Farm supply dealer	7.7	8.6	10.9
University personnel	0.0	2.9	0.9
Agrichemical salesperson	0.0	2.9	4.0
Neighboring farmer	0.0	14.3	3.0
Other	38.4	8.6	3.0
	100.0	100.0	100.0

Opinions on the relative importance of given IPM "selling points" varied between user categories, with both low- and high-users placing more importance on the reduction of personal and public health risk than did non-users (Table 31). Low- and high-users also listed reduced environmental damage as an important "selling point" twice as often as did non-users. The only points upon which non-users placed more importance than did high-users were IPM's potential for the safe use of pesticides and the possibility of increased farm profits. The latter "selling point", however, was perceived as important by the greatest fraction of responding growers in every user category.

Table 31. Respondent perceptions of IPM "selling points" by level of IPM use.

	Level of IPM use		
IPM "selling points"	Non-user	Low-user	High-user
	(in percent)		
Increases farm profits	100.0	91.4	97.0
Increases crop yield and quality	90.0	88.6	94.0
Reduces personal health hazard	80.0	91.2	93.9
Safe use of pesticides	100.0	82.9	93.9
Reduces family's health hazard	90.0	85.3	92.9
Protects public health	80.0	87.9	92.9
Better way of pest control	88.9	77.2	93.9
Increases knowledge of pest and control options	90.0	76.5	90.0
Promotes less toxic and small quantities of pesticides	90.0	77.1	90.0
Reduces environmental damage	44.4	84.4	90.7
Increases peace of mind	80.0	88.2	84.7

Note: On a rating scale of 1 to 4, with 1 being "not important" and 4 being "very important," the value above represent those respondents answering 3 or 4.

Major Trends Between Users and Non-users

The following subsection describes some major non-economic differences between users (defined as low- plus high-users) and non-users of IPM. Only information from which clear and consistent trends are evident is presented.

A greater percentage of non-users (55.2 percent) were over the age of 60 years than were users (35.3 percent), although this age group still encompassed the largest fraction of respondents at both user levels (Table 32). Only the IPM users (4.2 percent) had some individuals under 30 years of age. A larger fraction of IPM users (24.2 percent) were between the ages of 39 and 50 than were non-users (14.9 percent). The majority of both users and non-users (86.8 and 70.8 percent, respectively) were white (Table 32). More than twice the percentage of non-users (27.7 percent) as responding IPM users, however, were black (11.6 percent).

Farm value of $100,000 or less was reported by a greater percentage of non-users (54.2 percent) than users (23.9 percent) (Table 33 on page 46). Values of between $100,000 and $500,000, on the other hand, were reported by a larger fraction of users (63.6 percent) than non-users (37.3 percent). A small percentage of IPM users and non-users (9.8 and 8.5 percent, respectively) said that the total value of their farm was between $500,000 and $1.0 million, and only users (2.7 percent) reported farm value of more than $1.0 million.

Table 32. Age and race distribution of respondents by use or non-use of IPM.

Demographic characteristic	Level of IPM use Non-user	 IPM user
	-------- (in percent)	---------
Age (years):		
< 30	0.0	4.2
30-39	4.5	11.6
40-49	14.9	24.2
50-59	23.4	24.7
> 60	55.2	35.3
	100.0	100.0
Race:		
White	70.8	86.8
Black	27.7	11.6
American Indian	1.5	0.0
Other	0.0	1.6
	100.0	100.0

Table 33. Farm value and farm products value by use or non-use of IPM.

Enterprise characteristic	Level of IPM use Non-user	 IPM user
	-------- (in percent)	----------
Farm value[1] (in thousands):		
< 40	6.8	3.3
40-100	47.4	20.6
100-500	37.3	63.6
500-1000	8.5	9.8
> 1000	0.0	2.7
	100.0	100.0
Average gross value of all farm products over the last three years (in thousands):		
< 10	42.4	21.9
10-100	44.1	53.0
100-500	13.5	22.9
> 500	0.0	2.2
	100.0	100.0

[1] Value as measured by the total value of the farm including land, buildings and equipment.

The largest percentage of respondents surveyed (53 percent of users and 44.1 percent of non-users) reported their average annual gross value of all farm products over the last three years to be between $10,000 and $100,000 (Table 33). A larger fraction of non-users (42.4 percent) reported gross product value to be under $10,000 than did responding users (21.9 percent), while a greater percentage of users (22.9 percent) than non-users (13.5 percent) reported gross value between $100,000 and $500,000. Only individuals in the IPM user category (2.2 percent) reported gross product value at over $500,000.

Acreage farmed was greater for IPM users than for non-using growers, with 61 percent of the latter farming under 100 acres, compared to 39.7 percent of the former (Table 34 on page 47). A greater percentage of users than non-users (38.6 and 18.7 percent, respectively) farmed from 200 to 999 acres, with only IPM users farming in excess of 1,000 acres (4.8 percent).

Table 34. Number of acres farmed by use or non-use of IPM.

Acreage farmed	Level of IPM use Non-user	 IPM user
	-------- (in percent)	----------
1-49	43.8	19.1
50-99	17.2	20.6
100-119	20.3	16.9
200-499	15.6	28.6
500-999	3.1	10.0
1000-1999	0.0	3.2
> 2000	0.0	1.6
	100.0	100.0

Frequency of contact with Extension was greater for users than for non-users (Table 35). Only IPM users (5.2 percent) reported weekly contact, while a greater percentage of non-users than users (23.4 and 6.7 percent, respectively) never consulted their Extension agent. The majority of growers in both user categories (65.6 percent of non-users and 57 percent of users) said that they spoke to their agent less than once per month, but almost three times the percentage of users (31.1 percent) as non-users (11 percent) reported contact once or twice per month.

Table 35. Frequency of respondent contact with their Extension agent by use or non-use of IPM.

Contact with Extension agent	Level of IPM use Non-user	 IPM user
	-------- (in percent)	----------
Once per week	0.0	5.2
Twice per month	1.6	7.3
Once per month	9.4	23.8
< Once per month	65.6	57.0
Never	23.4	6.7
	100.0	100.0

Most users and non-users (87.2 and 71 percent, respectively) preferred to receive pest management information by reading Extension literature (Table 36 on page 48). A greater fraction of users (by a difference of 10.2 percent) favored one-on-one discussions with Extension than did non-users for obtaining this information. Users also preferred single-day production meetings or workshops, demonstration field days, and/or scout training sessions more than did non-users, who in turn preferred radio and television more than did users of IPM. All differences between growers in the two user categories exceeded 10 percent for each stated source of pest management information.

Table 36. Respondent sources of pest management information by use or non-use of IPM.

Source	Level of IPM use Non-user	 IPM user
	-------- (in percent)	----------
Extension bulletins, handbooks, manuals, etc.	71.0	87.2
Radio	33.4	23.0
Television	27.0	15.3
Single day production meetings or workshops	35.0	49.5
Demonstration field days	38.1	57.6
Scout training sessions	16.2	29.3
One-on-one with Extension personnel	67.2	77.4

Note: On a rating scale of 1 to 4, with 1 being "least preferred" and 4 being "most preferred," the values above represent those respondents answering 3 or 4.

First knowledge of IPM came from the Extension service for over half of IPM users (52.9 percent) and for 30.8 percent of non-users (Table 37). While both user groups were similar with regard to percentage learning of IPM from non-Extension print media or farm supply dealers, only users had first received their information from University personnel (1.5 percent), an agrichemical salesperson (3.7 percent), or a neighboring farmer (5.9 percent). The largest percentage of responding non-users (38.4 percent) first learned of IPM from sources other than those listed, as did a small percentage (4.4 percent) of IPM users.

Table 37. Source of first contact with IPM by use or non-use of IPM.

Source of Information	Level of IPM use Non-user	 IPM user
	-------- (in percent)	----------
Cooperative Extension Service	30.8	52.9
Newspapers and magazines	23.1	21.3
Farm supply dealer	7.7	10.3
University personnel	0.0	1.5
Agrichemical salesperson	0.0	3.7
Neighboring farmer	0.0	5.9
Other	38.4	4.4
	100.0	100.0

When classified by perceived IPM "selling points", a greater fraction of users rated each listed point as very important than did non-using growers (Table 38 on page 49). Virtually all users (96.9 percent) considered the protection of public health to be very important, compared to only 30 percent of non-users who rated this "selling point" highly. Reduction of family health hazards was regarded as a vital determinant in favor of IPM use by 75.2 percent of users and 60 percent of non-users, while increased crop yield and quality was very important to 71.1 percent of users and 40 percent of non-users. The reduction of environmental damage was a very important "selling point" to 53.5 percent of IPM users and 22.2 percent of non-users. A large difference could also be observed in respect to perceived importance of increased knowledge of pest control options, rated highly by 51.1 percent of users and 30 percent of non-users.

Table 38. Respondent perceptions of IPM "selling points" by use or non-use of IPM.

IPM "selling points"	Level of IPM use	
	Non-user	IPM user
	-------- (in percent) ----------	
Better way of pest control	33.3	47.8
Reduces personal health hazard	60.0	70.7
Reduces family's health hazard	60.0	75.2
Protects public health	30.0	96.9
Increases crop yield and quality	40.0	71.1
Increases farm profits	50.0	68.7
Reduces environmental damage	22.2	53.5
Increases knowledge of pest control options	30.0	51.1
Increases peace of mind	40.0	51.5

Note: On a rating scale of 1 to 4, with 1 being "not important" and 4 being "very important," the value above represent those respondents answering 3 or 4.

Summary of Study Findings

The following section summarizes the information obtained by the current study. It is organized into five parts: grower demographics, IPM program delivery, grower acceptance of IPM, grower economics under IPM, and pesticide use under IPM.

Grower Demographics

- A greater fraction of non-users (80.6 percent) were at least 50 years of age than were low-users (56.9 percent) or high-users (61.6 percent).
- A greater fraction of high-users (30.9 percent) had attended college, completed college, and/or done post-graduate work than had low-users (24.6 percent) or non-users (12.1 percent).
- A greater fraction of non-users (81.9 percent) had over 20 years farming experience than did low- (69.8 percent) or high-users (73.6 percent).
- A greater fraction of non-users (43.8 percent) farmed less than 50 acres than did low- (21.5 percent) or high-users (17.7 percent).
- The mean acreage of soybeans grown was greater for high-users (99.5 acres) than for low- (55.3 acres) or non-users (55.4 acres).
- A greater fraction of high (77.9 percent) and low-users (72.6 percent) estimated their farm value at over $100,000 than did non-users (45.7 percent).
- A greater fraction of high (26.6 percent) and low-users (22.2 percent) reported annual gross value of all farm products at $100,000 or more than did non-users (13.5 percent).
- High-, low- and non-users were similar with regard to race, gender, acres owned and percent of family income derived from the farm.

IPM Program Delivery

- A greater fraction of high- (24.6 percent) and low-users (22.7 percent) knew of the term Integrated Pest Management than did non-users (10.8 percent).
- The greatest fraction of high-, low-, and non-users (92, 77.8 and 71 percent, respectively) preferred Extension literature as a source of pest management information to any other source.
- Only high-users (3.9 percent) utilized Extension's computer network as a source of pest management information.
- A greater fraction of high users (68.3 percent) preferred field demonstrations as a source of pest management information than did low- (36.9 percent) or non-users (38.1 percent).
- A greater fraction of low-users (32.3 percent) and non-users (33.3 percent) preferred radio as a source of pest management information than did high-users (18.3 percent).

Grower Acceptance of IPM

- A majority of respondents (63.7 percent) reported scouting their soybean acreage, with 45.0 percent indicating they scouted greater than 75 percent of their acreage.
- Narrow-row planting was used by 39.4 percent of the respondents, while 30.8 percent reported soil sampling for nematodes.

- A greater fraction of high-users (54.1 percent) had scouted crops for more than 8 years than had low- (22.7 percent) or non-users (28.6 percent).
- Only high-users (100 percent) scouted more than half of their acreage.
- High-, low- and non-users were similar with regard to perceived importance of the following "selling points" of IPM: increased farm profits, increased crop yield and quality, protection of public health, and increased peace of mind.
- A greater fraction of high- and non-users (both 90 percent) considered increased knowledge of pest control options to be an important "selling point" of IPM than did low-users (76.5 percent).
- A greater fraction of high- and non-users (both 90 percent) considered the promotion of less toxic and smaller quantities of pesticides to be an important "selling point" of IPM than did low-users (77.1 percent).
- A greater fraction of high- (90.7 percent) and low-users (84.4 percent) considered reduction of environmental damage to be an important "selling point" of IPM than did non-users (44.4 percent).

Grower Economics Under IPM

- High-users reported higher yields (29.9 bushels) than did low- (26.6 bushels) and non-users (27.4 bushels).
- High-users reported higher prices received for their crop ($6.24 per bushel) than did low or non-users ($5.99 per bushel).
- Pesticide costs were lower for non-users ($15.15) than for low-users ($15.92) and high-users ($18.64).
- High-users sprayed a greater number of times (1.55) than did either low- (1.00) or non-users (1.12).
- High-users had slightly higher total pest management costs than did low- and non-users, due primarily to higher pesticide costs.
- High-users experienced greater returns to management than did non-users ($26.49 and $18.69 per acre, respectively), who in turn experienced greater returns than did low-users ($15.35 per acre).

Pesticide Use Under IPM

- High-users sprayed a greater number of times per year for weeds (1.21 times per acre) than did low- (0.88 times per acre) or non-users (0.97 times per acre).
- High-users sprayed a greater number of times per year for insects (0.27 times per acre) than did low- (0.11 times per acre) or non-users (0.15 times per acre).

Implications of Study Findings

The following section describes the study findings in terms of their implications for Extension's current operations, including factors associated with program inputs, delivery methods, and other programmatic issues. The implications of these findings for future IPM program development and delivery will be detailed as appropriate.

Program Status and Impacts

Virginia CES has been successful in introducing the concept of IPM to soybean growers, with a majority of respondents (63.7 percent) reportedly scouting at least some of their acreage. Little or no field scouting was being done prior to the initiation of this program. Of the producers that are now scouting, almost half (45 percent) reported scouting greater than 75 percent, and almost three-fourths have been using the practice for six years or longer. High-users, in general, have been involved in scouting for a longer period of time than have non-users. Other IPM techniques were generally utilized only by growers who also scouted. Narrow-row planting was practiced by 39 percent of respondents, and soil sampling for nematodes by 31 percent. Less than 4 percent planted nurse plots or trap crops as a method of pest control. Use of these methods would almost certainly increase if problems with Mexican bean beetles, stink bugs, or bean leaf beetles should rise to economic importance.

These data suggest that, of growers who do scout, most are heavily committed to the IPM program. Other IPM practices are most often used in conjunction with scouting, although less frequently. The fact that high-users have employed scouting for substantially longer periods of time than have either low or non-users suggests two points: that the amount of acreage scouted and commitment to scouting increases with time, possibly in response to improved crop yields; and that most respondents classified as high-users became involved in the program shortly after its inception. This implies that Extension may want to develop materials and programs that would lead non-using growers to gradually implement IPM practices. A program which educates farmers about various IPM techniques and their benefits and cost effectiveness and describes how they may be integrated into growing practices over a period of years could be perceived as reducing the risks associated with changing the nature of farm operations.

Examination of grower demographics reveals that high- and low-users were generally younger, better educated, and had less farming experience than did non-users. These two groups also reported higher farm values and higher gross production values than did non-using respondents. Non- and low-users farmed fewer acres overall, and fewer acres of soybeans in particular, than did growers classified as high-users. All three groups were similar with regard to race, gender, acres owned, and percent of family income derived from the farm. Thus, it would appear that IPM has found the greatest popularity among younger, wealthier, better educated growers -- those individuals traditionally willing to accept the risks of using new technologies (Rogers, 1983). Virginia CES has also been more successful at promoting IPM with those growers in the state who are most involved in soybean production, thereby impacting a large percentage of soybean acreage. While established program participants should not be neglected (their commitment will provide the basis from which future IPM programs can develop), the main implication for Extension is that future programs may need to target smaller soybean operations and/or an older, somewhat less educated clientele. IPM educational programs may need to be made more convincing to those farmers who have spent their lives utilizing traditional soybean pest management techniques.

The perceived benefits of IPM centered primarily around the economics of soybean production. Over 90 percent of all growers considered increased farm profits to be an important IPM "selling point", while over 88 percent believed that increased crop yield and quality constituted a persuasive point in favor of IPM use. High-users reported higher yields and prices received for their crops than did low- or non-users. This lead to higher returns per acre for high-users, even though pesticide (particularly herbicide) costs and costs associated with scouting were higher than for either low- or non-users. Because the major difference between user groups is the percentage of acreage scouted, and high-users -- who utilize scouting the most -- have better yields than do other growers, Extension may wish to stress that increased scouting may allow growers to realize higher yields and increased crop quality.

The collected economic data also indicates that herbicides were responsible for the largest portion of pesticide costs for all growers. In addition, because weeds are a major soybean pest affecting not only yield but also quality of and price received for the crop, increased monitoring of the fields by high-users apparently led to increased herbicide use. Insectide use, at which the Virginia IPM program was heavily geared, was low for all responding growers, although high-users tended to spray a greater percentage of their acreage.

When considering sources of pest management information, soybean pest complex knowledge and opinions on the critical reasons for using IPM, some important differences appeared between non-, low, and high-users. High-users tended to have better knowledge of the soybean pest complex than did either low or non-users, although they were also slightly more likely to misidentify (by name) an insect as a soybean pest. High-users clearly preferred to get their pest management information from Extension, especially during one-on-one contact with an agent. Non- and low-users also placed importance on Extension as an information source, but they found advice from neighboring farmers to be equally useful. Non- and low-users indicated preference for obtaining information from radio and television programs, whereas high-users generally did not prefer these sources of information transfer. This suggests that non- and low-users may not be as familiar with IPM methods mainly because of their normal information gathering activities. If a grower seldom collects and reads printed material, and is unlikely to contact knowledgeable professionals about potential problems, then he/she receives little exposure to IPM concepts, most of which are in printed or personal presentation form. The implication is that Extension may need to expand radio and television programming in order to educate those growers who normally use these electronic devices to gather information, while at the same time maintaining the availability of printed materials for those growers who prefer to research information on their own.

Future Program Development

The soybean IPM program has undergone a rapid and widespread adoption in Virginia since its implementation phase began in 1978. Extension agents have reported that nearly 50 percent of the total 610,000 acres was being impacted in 1983. However, about 80 percent of the state's soybean acreage is planted in counties susceptible to annual outbreaks of insect and nematode pests. Through continued educational efforts, it is anticipated that most of this acreage will be managed by IPM practices within the next five years. Current IPM techniques, however, will have only limited impacts on the relatively insect-free areas of the state.

One area where IPM can potentially impact all soybean acreage is in the control of weed pests. The entire soybean growing region of the state is infested annually with a variety of broadleaf and grass weed species. Weed IPM programs, as they are developed, will become integrated into existing programs.

People involvement has also rapidly increased in Virginia's soybean IPM program. Those actively participating include Extension agents and specialists, farmers, field scouts, Farm Bureau organizations, pesticide industry representatives, agricultural consultants, and other agri-business leaders. The thrust of program implementation will remain at the county level, where the Extension agents and producers maintain key leadership roles.

References

1. Allen, W. A. 1974. Survey report form No. 2-A, Soybeans. Va. Coop. Ext. Serv. Publ.

2. Allen, W. A. 1975. The 1975 results of four soybean insect pest management programs in Virginia. Experiment Results not for publication. 13 pp.

3. Allen, W.A., and R.M. McPherson. 1982. A manual for implementing an integrated pest management program for insects of soybean. Va. Coop. Ext. Serv. Publ. 444-016, 12 pp.

4. Allen, W. A. and J. E. Roberts. 1974. Economic feasibility of scouting soybean insects in late summer in Virginia. J. of Econ. Entomol., 67:644-647.

5. Baker, J.E., and W.A. Connell. 1961. Mites on soybeans in Delaware. J. Econ. Entomol. 54:1024-1026.

6. Boyer, W.P., and W.A. Dumas. 1963. Soybean insect survey as used in Arkansas. U.S. Dept. Agr. Coop. Econ. Insect Rpt. 13:91- 92.

7. Burnside, D.C. 1972. Tolerance of soybean cultivars to weed competition and herbicides. Weed Sci. 20:294-970.

8. Cannon, W.N., Jr. 1965. Populations of *Tetranychus atlanticus* Mcg. (Acarina:Tetranychicae) on soybean supplied with various levels of nitrogen, phosphorus, and potassium. Entomol. Exp. Appl. 8:153-161.

9. Christenson, J.A. 1975. A procedure for conducting mail surveys with the general public. J. Commun. Develop. Soc. 6:135-146.

10. Deighan, J., R.M. McPherson, and H.J. Ferguson. 1983. Bean leaf beetle and bean leaf beetle control in soybeans, 1982. Insect. and Acar. Tests 8:208-209.

11. Deighan, J., R.M. McPherson, and F.W. Ravlin. 1985. Comparison of sweep net and ground cloth sampling methods for estimating arthropod densities in different soybean cropping systems. J. Econ. Entomol. 78:208-212.

12. Dillman, D.A. 1978. Mail and telephone surveys: the total design method. John Wiley and Sons.

13. Elliott, A.P., D. Babineau, R. Wick, P. Phipps, K. Yoder, and D. Komm. 1983. Detection of nematode problems. Va. Coop. Ext. Serv. Publ. 450-031, 4 pp.

14. Fehr, W.R., and C.E. Caviness. 1977. Stages of soybean development. Iowa Coop. Ext. Serv. Spec. Rpt. 80, 12 pp.

15. Ferguson, H.J., J. Deighan, and R.M. McPherson. 1983. Mexican bean beetle and bean leaf beetle control in soybeans. Insect. and Acar. Tests 8:211.

16. Ferguson, H. J., R. M. McPherson, and W. A. Allen. 1984a. Effect of four soybean cropping systems on the abundance of foliage-inhabiting insect predators. Environ. Entomol. 13:1105-1112.

17. Ferguson, H. J., R. M. McPherson, and W. A. Allen. 1984b. Ground- and foliage- dwelling spiders in four soybean cropping systems. Environ. Entomol. 13:975-980.

18. Gilman, D. F., R. M. McPherson, L. D. Newsom, D. C. Herzog, and C. Williams. 1982. Resistance in soybeans to the southern green stink bug. Crop. Sci. 22:573-76.

19. Greene, C. R., R. A. Kramer, G. W. Norton, E. G. Rajotte, and R. M. McPherson. 1984a. An economic analysis of soybean integrated pest management. Am. J. Agri. Econ. 67:567-572.

20. Greene, C. R., E. G. Rajotte, G. W. Norton, R. A. Kramer, and R. M. McPherson. 1984b. A revenue and risk analysis of soybean pest management options in Virginia. J. Econ. Entomol. 78:10-18.

21. Hagood, E. S., O. E. Rud, and H. P. Wilson. 1984 (revised annually). Weed control in soybeans. Va. Coop. Ext. Serv. Publ. 456-003:10-32.

22. Hatchett, J. H., G. L. Beland, and E. E. Hartwig. 1976. Leaf-feeding resistance to bollworm and tobacco budworm in three soybean plant introductions. Crop Sci. 16:277-80.

23. Harper, J. D., R. M. McPherson, and M. Shepard. 1983. Geographical and seasonal occurrence of parasites, predators, and entomopathogens. *In* H. N. Pitre [ed.], Natural Enemies of Arthropod Pests in Soybean. So. Coop. Ser. Bull. 285.

24. Higgins, R.A., D.W. Staniforth, and L.P. Pedigo. 1984. Effects of weed density and defoliated or undefoliated soybeans (*Glycine max*) on velvetleaf (*Abutilon theophrasti*) development. Weed Sci. 32:511-520.

25. Krijcie, R.V. and D.W. Morgan. 1970. Determining sample size for research activities. Ed. Psych. Measure. 30:607-610.

26. Marra, M.C., and G.A. Carlson. 1983. An economic threshold model for weeds in soybeans (*Glycine max*). Weed Sci. 31:604-609.

27. Martin, J.R., and R.M. McPherson. 1980. Weed scouting in soybean fields in Virginia. Proc. South. Weed Sci. Soc. Ann. Mtg. 33:309.

28. McAlister, D.F., and C.A. Krober. 1958. Response of soybeans to leaf and pod removal. Agron. J. 50:674-667.

29. McAvoy, T.J., and J.C. Smith. 1979. Feeding and development rates of the Mexican bean beetle on soybeans. J. Econ. Entomol. 72:835-836.

30. McPherson, R. M. 1983a. Insects and mites take big bit out of 1983 Virginia soybean crop. S. E. Farm Press 10(47):6.

31. McPherson, R. M. 1983b. Soybean insect management guidelines number 8: Trap crops. Va. Coop. Ext. Serv. Publ. 444-048.

32. McPherson, R.M. 1984. Spider mite damage evaluations in soybeans. Va. Coop. Ext. Serv. Agron. Tips 6(2):3.

33. McPherson, R. M. and W. A. Allen. 1980 (revised 1982, 1984). Sweep net sampling in soybeans. Va. Coop. Ext. Serv. From 444-017.

34. McPherson, R. M. and W. A. Allen. 1981. Drought and insects: Bad news for beans. Agrichemical Age 25(4):16,18,42.

35. McPherson, R.M., and T.P. Hynson. 1983. Control of corn earworm and green cloverworm with aerial application on Sevin XLR, 1982. Insect. and Acar. Tests 8:216-217.

36. McPherson, R. M., and L. D. Newsom. 1984. Trap crops for control of stink bugs in soybeans. J. Georgia Ent. Soc. 19:470-480.

37. McPherson, R. M., W. A. Allen, and J. C. Smith. 1981. Soybean insect pest management for Virginia. Va. Coop. Ext. Serv. Publ. 444-040: 10 pp.

38. McPherson, R.M., D.E. Babineau, and W.A. Allen. 1982a (revised 1983). Ground cloth sampling for soybean insects. Va. Coop. Ext. Serv. Form 444-114.

39. McPherson, R.M., R.A. Clement, and J.R. Martin. 1979a (prepared annually). Pest management test demonstration report 1. Dept. of Entomology, Virginia Polytechnic Institute and State University.

40. McPherson, R. M., L. D. Newsom, and B. F. Farthing. 1979b. Evaluation of four stink bug species from three genera affecting soybean quality and yield in Louisiana. J. Econ. Entomol. 72:188-94.

41. McPherson, R.M., J.C. Smith, and W.A. Allen. 1982b. Incidence of arthropod predators in different soybean cropping systems. Environ. Entomol. 11:685-689.

42. McPherson, R.M., J.R. Pitts, L.D. Newsom, J.B. Chapin, and D.C. Herzog. 1982c. Incidence of tachinid parasitism of several stink bugs (Heteroptera:

Pentatomidae) species associated with soybean. J. Econ. Entomol. 75:78-86.

43. Phipps, P.M. 1978. An experimental nematode advisory program. Va. Coop. Ext. Serv. Tidewater Res. Cont. Ed. Ctr., Info. Series No. 36.

44. Rajotte, E.G., H.S. Baumes, Jr., R.M. McPherson, and W.A. Allen. 1985. Soybean integrated pest management: a demonstration of micro- and macroeconomic effects. *In* Bernat, G.A., G.W. Norton, E.G. Rajotte, C.R. Drake, and M.C. Holliman (eds.), *Interdisciplinary evaluation of pest management systems.* Bull. 85-5, VA Agric. Exp. Stat.

45. Ravlin, F. W., and W. A. Allen. 1984. A prototype agricultural data base management system for the state of Virginia. Final report. USDA, SEA, Extension Project 81-67.

46. Reichelderfer, K. H. 1979. Economic feasibility of a biological control technology using a parasitic wasp, *Pediobius foveolatus*, to manage Mexican bean beetle on soybeans. USDA Agricultural Economic Rpt. No. 430.

47. Rogers, E.M. 1983. Diffusion of innovations. Free Press.

48. Schultz, P. B. and W. A. Allen. 1976. Field evaluation of Mexican bean beetle suppression through use of *Pediobius foveolatus* in Virginia. Veg. Growers News 31(1)1,3.

49. Sherman, M.E., T. Lafayette, Jr., and R.E. Wilkinson. 1983. Sicklepod (*Cassia obtusifolia*) management in soybeans. Weed Sci. 31:622-627.

50. Smith, J. C., R. M. McPherson, and D. W. Sherrod. 1984 (revised annually). Control Soybean Insects. Va. Coop. Ext. Serv. Publ. 456-003.

51. Smith, T. J., H. M. Camper, Jr., J. C. Smith, and M. W. Alexander. 1976. The Shore Soybean. Virginia Polytechnic Institute and State University Res. Bull. 115.

52. Stevens, L. M., A. L. Steinhauer, and J. R. Coulson. 1975. Suppression of Mexican bean beetle on soybeans with annual inoculative releases of *Pediobius foveolatus*. Environ. Entomol. 4:947-52.

53. Stimac, J. L., J.W. Jones, J. W. Mishoe. 1980. Design of a distributed computer network for Florida agriculture. Agri. Comp. Bull. 1:15-28.

54. Stromberg, E. L., P. M. Phipps, D. E. Babineau, and A. P. Elliott. 1984 (revised annually). Diseases of Soybeans. Va. Coop. Ext. Serv. Publ. 456-003:7-9.

55. Thomas, G.D., C.M. Ignoffo, K.D. Biever, and D.B. Smith. 1974a. Influence of defoliation and depoding on yield on soybeans. J. Econ. Entomol. 67:683-685.

56. Thomas, G.D., C.M. Ignoffo, C.E. Morgan, and W.A. Dickerson. 1974b. Southern green stink bug: influence on yield and quality. J. Econ. Entomol. 67:501-503.

57. Todd, J.W., and L.W. Morgan. 1972. Effects of hand defoliation on yield and seed weight of soybeans. J. Econ. Entomol. 65:567- 570.

58. Todd, J.W., M.B. Parker, and T.P. Gaines. 1972. Populations of Mexican bean beetles in relation to leaf protein of nodulating and non-nodulating soybeans. J. Econ. Entomol. 65:729-731.

59. Virginia Crop Reporting Service. 1972-1985. Virginia agricultural statistics. Va. Dept. Agri. Cons. Serv. Bulls.

60. Welch, S. M. 1984. Developments in computer-based IPM extension delivery systems. Ann. Rev. Entomol. 359-81.

61. Yeargan, K.V. 1977. Effects of green stink bug damage in soybean and alfalfa fields. Environ. Entomol. 8:715-719.

**Virginia Cooperative Extension Service
Virginia Tech and Virginia State
Virginia's Land-grant Universities**

Publication 500-051
August 1987

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, and September 30, 1977, in cooperation with the U.S. Department of Agriculture. Mitchell R. Geasler, Director, Virginia Cooperative Extension Service, and Vice Provost for Extension, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061; Clinton V. Turner, Administrator, 1890 Extension Program, Virginia State University, Petersburg, Virginia 23803.