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Adoption of Integrated Pest Management in U.S. Agriculture

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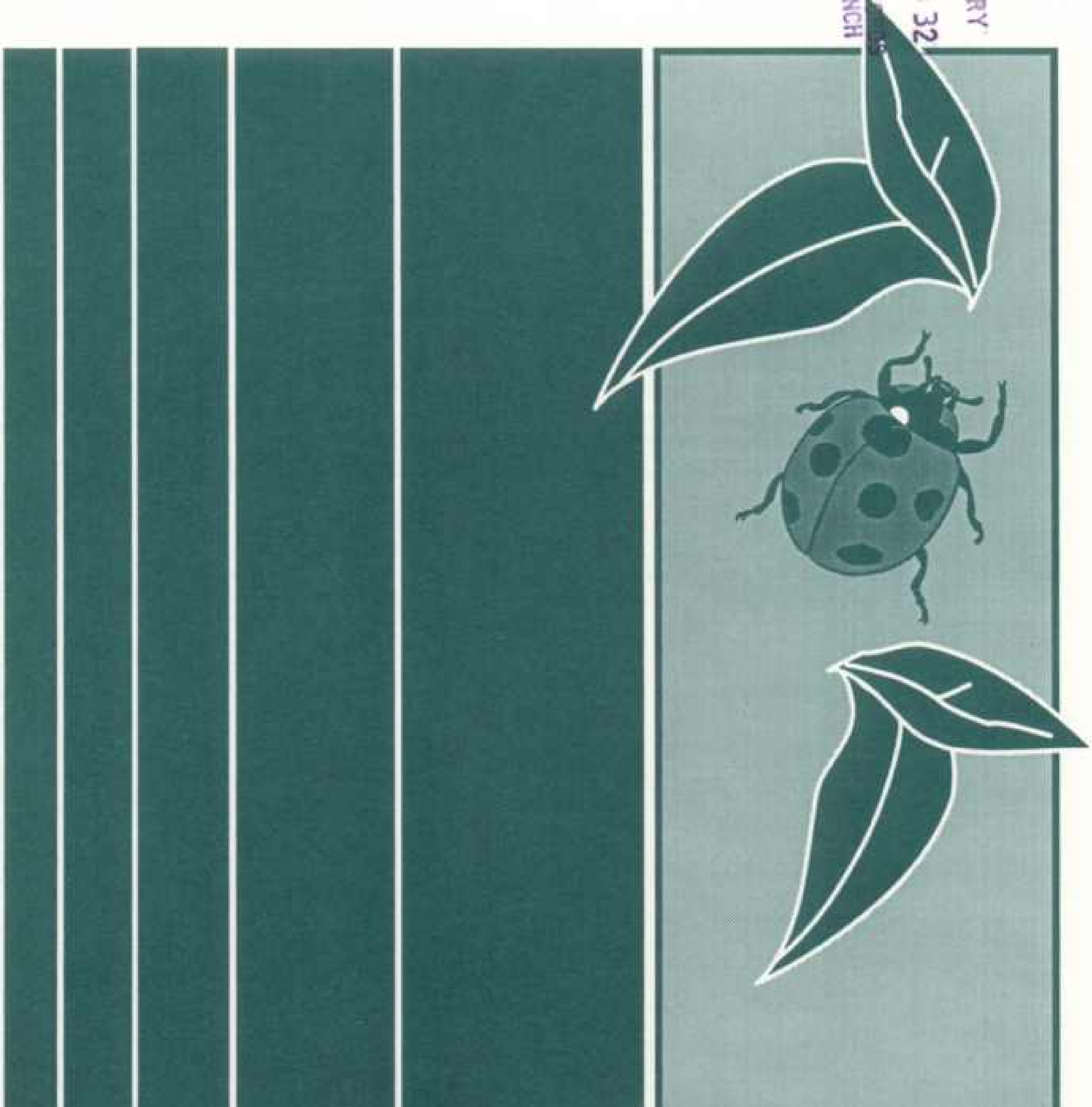

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Abstract

This report summarizes information on the extent of adoption of integrated pest management (IPM) techniques in the production of fruits, vegetables, and major field crops. Farmers are considered to be using IPM if, before making pesticide application decisions, they closely monitor pest populations (scouting) in order to determine when a population has reached an economically damaging threshold. Over half of the Nation's fruit, vegetable, and major field crop acres are now under some level of IPM, according to USDA survey data. A host of pest management practices are used, and their adoption rates vary by crop and State. The data suggest two strategies to increase adoption of IPM. One is to increase the availability of alternative practices through more research in crops and regions where few alternatives are used. A second is to encourage more farmers to adopt existing IPM technology.

Keywords: IPM, fruits, nuts, vegetables, field crops

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Contents

Summary

Integrated pest management (IPM), a strategy for reducing farm use of pesticides, is being applied on over half of the Nation's acreage of fruits and nuts, vegetables, and major field crops (corn, soybeans, and fall potatoes). This report documents, for the first time on a national level, IPM use among U.S. farmers, based on data collected from surveys conducted in 1991-93. The Clinton Administration has made IPM an important part of its pesticide legislative reform proposals. In testimony before the Congress in September 1993, the Administration committed to conducting the research and education efforts necessary to achieve the adoption of IPM on 75 percent of the Nation's crop acreage by the year 2000.

Earlier studies on IPM use were limited in that they looked only at certain crops or only in certain regions. Some of those studies did report a reduction in pesticide use among IPM users. The data in this report provide a baseline from which to evaluate IPM adoption, not a link between IPM and pesticide use.

Farmers were considered to be using IPM if, before making pesticide application decisions, they monitored pest populations (scouting) in order to determine when a pest population had reached an economically damaging threshold. Corn farmers who rotated crops to alleviate insect problems were also considered IPM users. Other commonly used IPM techniques include field sanitation in fruit production, mechanical cultivation and hand hoeing for weed management in vegetable production, and crop rotation in field crop production.

Survey responses show low adoption rates on some of the more sophisticated IPM techniques, such as release of beneficial organisms. Levels of adoption also vary widely among crops and regions. For example, IPM is more prevalent on grapes (54 percent of reported acres), oranges (64 percent), and almonds (54 percent). By comparison, pesticides are applied without economic thresholds (non-IPM) on 60-90 percent of berry, cherry, and peach acres. Inadequate knowledge of available IPM alternatives, too few crop consultants to deliver IPM services, and the higher managerial input necessary for IPM implementation are all impediments to adoption.

Adoption of Integrated Pest Management in U.S. Agriculture

Ann Vandeman, Jorge Fernandez-Cornejo,
Sharon Jans, and Biing-Hwan Lin

Introduction

This report summarizes information on the adoption of integrated pest management (IPM) techniques in the production of fruits, vegetables, and selected field crops in the United States. The data are compiled from grower surveys conducted in 1991, 1992, and 1993 by USDA under the Pesticide Data Program and the USDA Water Quality Program. They are the most comprehensive and up-to-date survey data available on IPM practices at the national level. For each of the crops included in this report, the survey data represent 70 percent or more of total U.S. acreage. (Potatoes are the only exception. The four States included in the survey represent 56 percent of total U.S. fall potato acreage.)

IPM has been adopted on 50 percent or more of the crop acreage in the fruits and nuts, vegetables, and field crops studied for at least one of the three major pest types: insects, diseases, and weeds. These results are the first part of a study of the impacts of IPM on U.S. agriculture. The information developed here will be used in a future report to estimate IPM's effects on pesticide use and net production returns. These estimates will be used to predict changes in total pesticide use and net farm income that can be expected from an expansion of IPM to 75 percent of all crop acreage.

What Is a Pest?

Whether introduced or naturally occurring, insects, diseases, and weeds or uncultivated plants all exist in the environment and in agricultural ecosystems. Not all such organisms are pests. A pest is defined by the damage it causes to crops, resulting in reductions in yield, crop quality, or both. Changes in the biological community can cause an organism's status to change from nonpest to pest. For example, tactics used to control one insect species may lead to the emergence of other species as pests if natural enemies are eliminated. Such secondary pest outbreaks of organisms not previously responsible for significant crop damage are one of the problems resulting from conventional chemical control (Allen and others, 1987).

What Is Pest Control?

In some instances, pest control refers to the complete elimination of an organism from the environment in which it is a problem. Although in reality few pests are totally eradicated, conventional approaches to pest control generally operate with this goal in mind. Integrated pest management (IPM) seeks to *suppress* pest populations to avoid economic losses. The presence of pests is tolerated at population densities below economically damaging levels (Allen and others, 1987).

Definitions of IPM

There are many definitions of IPM. However, monitoring, the use of economic thresholds, multiple management tactics, and the use of ecological information are common elements defining IPM.

The USDA's Agricultural Research Service uses the following definition of IPM:

- "IPM is a management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adapting cultural management, and using pesticides judiciously" (USDA Agricultural Research Service, 1993).

Zalom and others define IPM this way:

- "IPM is an ecologically-based pest control strategy which is part of the overall crop production system. 'Integrated' because all appropriate methods from multiple scientific disciplines are combined into a systematic approach for optimizing pest control... 'Management' implies acceptance of pests as inevitable components, at some population level of an agricultural system" (1992).

The National Research Council defines IPM as:

- "A pest control strategy based on the determination of an economic threshold that indicates when a pest population is approaching the level at which control measures are necessary to prevent a decline in net returns. In principle, IPM is an ecologically based strategy that relies on natural mortality factors...and seeks control tactics that disrupt these factors as little as possible" (1989).

The National Coalition on Integrated Pest Management uses the following definition:

- "Integrated pest management is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks" (1994).

Components of an IPM Program

Information is the most fundamental component of IPM for two reasons. First, an understanding of the agricultural ecosystem is essential to preventing pest problems and successfully implementing IPM. Second, IPM relies upon close monitoring of pest populations in order to determine when a population has reached an economically damaging threshold. Determining the threshold at which control tactics are applied against a particular pest "requires knowledge of pest biology and crop physiology as they relate to the environment, naturally occurring biological controls and the effects of possible control actions on other organisms in the environment" (Zalom and others, 1992).

Information plays a key role in two additional components of IPM. The first is implied in the use of the term "integrated." No single material or practice is relied upon where multiple tactics are available to manage a pest problem. Thus, although synthetic pesticides may be one of the treatments used, they will not be the only form of treatment. In particular, IPM attempts to use biological and cultural methods wherever possible. Increasing the availability of alternative pest management techniques based on existing ecological relationships is a principal objective of IPM research.

The second information component is implied by the term "management." Treatment decisions are based on economically derived decision rules. The decision rule, or economic threshold, indicates if and when a management strategy must be applied to avoid net economic losses. Economic thresholds are developed from research in which the physical damage caused by the pest at a known level of infestation, the revenue losses from that damage, and the costs of treatment are all taken into account. Scouting, defined as the regular, systematic sampling for pests (and beneficials) in the field in order to estimate population levels, is the primary method of monitoring pest populations to determine if an economic threshold is reached. Computer models based on weather conditions and other factors are also used to predict the onset and severity of a pest outbreak. Populations of beneficial organisms as well as pests are monitored. IPM thus combines naturally occurring forms of control, which take advantage of ecological relationships in the agricultural ecosystem, with economically derived rules for the application of pesticides.

Nonchemical methods used in IPM programs include:

- Biological controls: natural enemies, often called "beneficials," which include parasites, predators, and insect pathogens; semiochemicals, including pheromones and feeding attractants; and biopesticides.

- Cultural controls: cultivation, mulching, field sanitation, and crop rotation.

- Strategic controls: planting location, planting date, and timing of harvest.

- Host plant resistance: insect- and disease-resistant plant varieties and root stock.

Many of these methods prevent pest problems by denying pests food, shelter, or other life necessities. Some methods are also employed in monitoring. In fact, the principal use of pheromones is to attract target pests to traps used in monitoring.

Chemical controls are also part of IPM, but the use of pesticides in IPM differs from that under conventional pest control. Where possible, IPM relies on pesticides that target specific pests, can be used at lower rates, and are less toxic to beneficial organisms (Allen and others, 1987). New application methods are being developed that employ biological materials such as pheromones and feeding attractants to lure the target pest to the pesticide. Application rates, timing, and frequency are chosen to minimize effects on beneficials, and pesticides that substitute for each other are interchanged to slow the development of pest resistance to pesticides.

Development of IPM Programs

The development of IPM programs begins with basic research into pest biology, ecology, and taxonomy in the context of local cropping systems. This research lays the foundation for the development and integration of management techniques that make up an IPM strategy. The evolution of the IPM concept originated with such basic research in the 1950's (Stern and others, 1959).

Federally funded IPM research and extension began in the early 1970's with the "Huffaker Project" (Allen and others, 1987). IPM research focused first on cotton, soybeans, alfalfa, citrus fruit, pome fruit (apple, pear, etc.), and stone fruit (peach, plum, cherry, etc.). Additional IPM projects included tobacco in North Carolina, and celery, snap beans, and strawberries in Florida (Allen and others, 1987; Pohronezny and others, 1989). Research and extension have also produced programs in turf, ornamental, and forest IPM.

The USDA Extension Service simultaneously began delivering IPM programs to producers and conducting training programs to expand the capacity of the private sector to deliver IPM services (National Research Council, 1989). As the demand for IPM consulting services has grown since the mid-1970's, commercial consultants working with the Extension Service have developed IPM programs in more crops. In Florida for example, these include sweet corn, cole crops (broccoli, cauliflower, etc.), and peppers.

IPM Goals and Policy

IPM programs have been introduced to the agricultural community as a more profitable and efficient approach to pest management than conventional chemical methods. In many cases, IPM has resulted in reduced pesticide use (Norton and Mullen, 1984). With public attention increasingly focused on the environmental and health problems associated with pesticide use, IPM has been looked upon as a vehicle to reduce reliance on pesticides. The Clinton Administration has made IPM an important part of its pesticide legislative reform proposals. In testimony before the Congress in September 1993, the Administration committed to conducting the research and education efforts necessary to achieve the adoption of IPM on 75 percent of the Nation's crop acreage by the year 2000 (Browner and others, 1993). The data presented in this report provide a baseline from which to evaluate progress toward increasing IPM adoption.

Measuring the Use of an "IPM Approach"

The growing conditions that influence pest populations are location-specific. Factors such as temperature, humidity, and length of season all affect the type and severity of pest problems. Just as pests are crop- and location- specific, IPM programs are specific to the crop and region for which they are designed. An effective biological control in one area may fail in another area under different climatic conditions or where different crop varieties are grown. This crop and regional uniqueness greatly complicates the task of measuring IPM adoption at the national level.

To overcome this difficulty, we chose to employ two concepts in the definitions of IPM--an economically derived decision rule and multiple tactics for pest management--to arrive at a general definition of an "IPM approach." This general definition provides a good indicator of the level of acceptance of IPM across crops and regions, and is consistent with the various definitions of IPM outlined earlier.

Acreage is divided first according to whether farmers reported both scouting and applying economic thresholds to make pesticide treatment decisions. Where these methods are used, the acres are classified as under IPM. For corn, the largest crop analyzed in this report, an alternative criterion is employed. Crop rotation effectively prevents major insect problems in corn. Therefore, corn acres under rotation and not treated with insecticides are also classified as under IPM.

Our definition further divides IPM acres according to the number of additional tactics employed in pest management.[1] This allows us to give greater weight to the use of multiple tactics, while still including IPM approaches where multiple tactics may be unavailable or inappropriate. Our method is similar to that used in the 1987 national evaluation of

[1] The set of additional practices considered in the definition of an IPM approach varies by crop type. See the crop sections that follow for complete lists of practices.

Extension IPM programs (Napit and others, 1988). We identified three levels of IPM: acres on which no additional pest management practices were used (low-level IPM); acres using one or two additional practices (medium-level IPM); and acres using three or more additional practices (high-level IPM).

Some farmers use no pesticides at all. They include farmers whose crops are not susceptible to significant pest damage. For example, corns and soybeans are rarely treated for disease (NASS, 1994). They also include farmers who have adopted organic and other pest management strategies involving nonchemical methods quite different from those most commonly used by the conventional grower. Because the survey data do not distinguish between reasons for not applying pesticides, we chose to report all acreage where no pesticides are applied as a separate category.

Table 1--Target crops and survey coverage, fruits and nuts, 1991

Crop	Planted acres in survey States	Percent of U.S. acres
	Acres	
Nuts:		
Almonds	380,000	99
Hazelnuts	28,300	100
Pistachios	52,900	100
English walnuts	181,000	100
Fruit:		
Apples	381,000	82
Apricots	17,300	92
Avocados	82,300	100
Blackberries	4,000	*
Blueberries	22,450	*
Dates	5,200	100
Figs	15800	99
Grapefruit	128,700	97
Grapes	729,750	99
Kiwifruit	720,099	
Lemons	61,600	99
Limes	6,200	100
Nectarines	25,900	98
Olives	29,700	100
Oranges (except temples)	612,800	100
Peaches	143,000	79
Pears	68,500	95
Plums and prunes	131,000	100
Pomegranates	3,100	*
Raspberries	10,700	*
Sweet cherries	47,300	99
Tangelos	14,250	100
Tangerines	13,950	70
Tart cherries	39,400	79
Temple oranges (Florida)	7,700	100
Total	3,251,000	

* No U.S. acreage estimate available for 1991.

Source: *Agricultural Chemical Usage: 1991 Fruits and Nuts Summary*, June 1992.

Overview

The remainder of this report includes a section summarizing the data sources, followed by three sections corresponding to the three surveys. The information obtained from each IPM survey varies because each survey's questions were tailored to specific cropping systems and pest problems. In addition, some differences in the data reported from the 1991 Fruit and Nut Survey and the 1992 Vegetable Chemical Use Survey reflect question changes made to improve data quality.

For example, the 1991 fruit survey collected data only on professional scouting, that is, scouting conducted by a commercial service or other professionally trained personnel using formal sampling methods recommended by Extension IPM programs. The scouting methods used by many farmers are less sophisticated than those used by professional scouts. However, a previous study found that farmers perceived their pest monitoring as scouting, and felt that it was an important part of their pest management activities (Pohronezny and others, 1989). Many chemical dealers also conduct field scouting that may or may not involve recommended sampling methods. For this reason, the 1992 survey collected information on all scouting by source of scouting service, whether performed by commercial services, chemical dealers, or farmers themselves.

Data on pheromone use also underwent change. With the exception of a few products, pheromones are used exclusively for monitoring. However, in the 1991 fruit survey, pheromone use for monitoring and for control are combined in a single question. As a result, the fruit data overestimate pheromone use for control purposes. The uses were separated in the 1992 vegetable survey, and only control uses in vegetable crops are included in this report.

Data on IPM Adoption

USDA began collecting information on agricultural pest management techniques along with chemical use data (including fertilizers and pesticides) in 1990 under the Pesticide Data Program (PDP) and Water Quality Program. These programs were initiated in response to public concerns over the environmental and health risks associated with the use of agricultural chemicals. Data collection under these programs is designed to improve both the quantity and reliability of pesticide use and residue data. By providing better information, the programs assist government agencies in dealing with issues of food safety and water quality arising from the use of agricultural chemicals.

Chemical use and cropping practices surveys are conducted annually in field crops and semiannually in fruit, nut, and vegetable crops under these programs. The surveys are a cooperative effort involving the USDA's National Agricultural Statistics Service, the USDA's Economic Research Service, and the U.S. Environmental Protection Agency. The survey questions are developed in consultation with these agencies, other USDA agencies (Agricultural Research Service and Extension Service), commodity

Table 2--Target crops by State, fruits and nuts, 1991

Crop	AZ	CA	FL	GA	MI	NY	NC	OR	PA	SC	TX	VA	WA
Nuts:													
Almonds		X											
English walnuts		X											
Hazelnuts								X					
Pistachios		X											
Fruit:													
Apples	X	X		X	X	X	X	X	X	X		X	X
Apricots		X											
Avocados		X	X										
Blueberries				X	X		X	X					
Blackberries								X					
Dates		X											
Figs		X											
Grapefruit	X	X	X										
Grapes	X	X			X	X		X	X		X		X
Kiwifruit		X											
Lemons	X	X											
Limes			X										
Nectarines		X											
Olives		X											
Oranges[1]	X	X	X										
Peaches		X		X	X	X	X		X	X	X	X	X
Pears		X				X		X					X
Plums and prunes		X			X			X					X
Pomegranates		X											
Raspberries					X			X					X
Sweet cherries		X			X			X					X
Tangelos	X	X	X										
Tangerines	X	X	X										
Tart cherries					X	X		X	X				
Temple oranges[2]			X										

[1] Except temples.

[2] Florida.

Source: *Agricultural Chemical Usage: 1991 Fruits and Nuts Summary*, June 1992

Table 3–Target crops and survey coverage, vegetables, 1992

Crop	Planted acres in survey States	Percent of U.S. acres
	Acres	
Asparagus	89,310	98
Broccoli	118,600	100
Cabbage	69,300	88
Carrots	100,300	93
Celery	34,020	99
Cucumber	116,100	71
Green peas	329,400	92
Lettuce	259,200	97
Melons	326,300	80
Onions	113,600	77
Peppers	61,800	89
Snap beans	224,230	78
Spinach	27,500	78
Strawberries	46,300	93
Sweet corn	640,400	85
Tomato	357,400	87
Total[1]	2,913,800	

[1] Including cauliflower, eggplant, and lima beans.

Source: *Agricultural Chemical Usage: Vegetable 1992 Summary*, June 1993.

Table 5–Target crops and survey coverage: corn, soybean, and fall potatoes, 1993[1]

Crop	Planted acres in survey States	Percent of U.S. acres (CPS only)[2]	Percent of U.S. acres (CPS with IPM)[3]
	1,000 acres		
Corn	65,690	90	78
Soybeans	53,470	84	72
Fall potatoes	1,118	94	56

[1] CPS in 1993 also included other crops: winter wheat (84% of U.S. acreage), durum wheat (89%), and upland cotton (77%). IPM questions were not collected for these crops.

[2] Cropping Practices Survey (CPS), 1993.

[3] Selected States.

Source: *Agricultural Chemical Usage: 1993 Field Crops Summary*, March 1994.

Table 4–Target crops by State, vegetables, 1992[1]

Crop	AZ	CA	FL	GA	IL	MI	MN	NJ	NY	NC	OR	TX	WA	WI
Asparagus		X				X		X			X		X	
Broccoli	X	X									X	X		
Cabbage		X	X	X		X		X	X	X		X		X
Carrots	X	X	X			X		X	X		X	X	X	X
Celery		X	X			X			X			X		
Cucumber		X	X	X		X		X	X	X	X	X	X	X
Green peas		X			X	X	X	X	X		X		X	X
Lettuce	X	X	X			X		X	X			X		
Melons	X	X	X	X		X				X		X		
Onions	X	X		X		X			X		X	X	X	X
Peppers		X	X			X		X		X		X		
Snap beans		X	X	X	X	X		X	X	X	X		X	X
Spinach		X						X	X			X		
Strawberries		X	X			X		X	X	X	X		X	X
Sweet corn		X	X	X	X	X	X	X	X	X	X	X	X	X
Tomato		X	X	X		X		X	X	X		X		

[1] Three surveyed crops (cauliflower, eggplant, and lima beans) were excluded in this report (except in the totals) due to an insufficient number of answers on IPM questions.

Source: *Agricultural Chemical Usage: Vegetable 1992 Summary*, June 1993.

Table 6–Survey coverage: Corn, soybean, and fall potatoes, 1993[1]

State	Corn	Soybeans	Fall potatoes
Arkansas		X	
Idaho			X
Illinois	X	X	
Indiana	X	X	
Iowa	X	X	
Maine			X
Michigan	X		
Minnesota	X	X	
Missouri	X	X	
Nebraska	X	X	
Ohio	X	X	
Oregon			X
South Dakota	X		
Washington			X
Wisconsin	X		

[1] Survey States and crops in which IPM data were collected. The 1993 survey also included other crops: winter wheat (84% of US acreage), durum wheat (89%), and upland cotton (77%). IPM data were not collected for these crops.

Source: *Agricultural Chemical Usage: 1993 Field Crops Summary*, March 1994

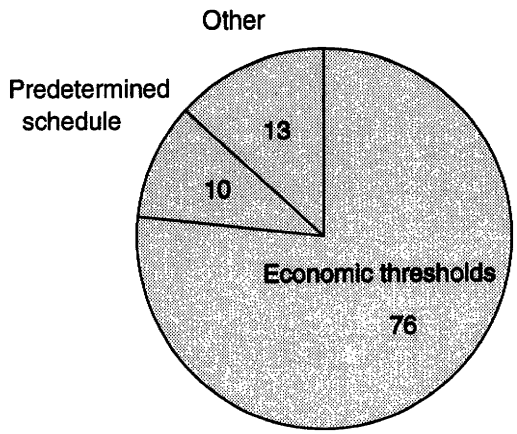
groups, crop scientists, and extension specialists. The surveys provide statistically reliable data on chemical use and production practices representing a majority of the acreage of 6 major field crops, 30 fruit and nut crops, and 20 vegetable crops grown in the United States (tables 1, 3, and 5). Economic and IPM-related questions are included for a subset of crops and farms sampled.

Estimates of IPM adoption are derived from growers' responses to a number of production practice questions in the surveys. Each farmer was asked to report on the use of pest scouting, and on their decision criteria for pesticide application. In addition, farmers were asked about practices commonly considered to be IPM techniques, such as use of beneficials, resistant varieties, crop rotations, and alternate planting dates.

Data are compiled from three surveys: the 1991 Fruit and Nut Chemical Use Survey, the 1992 Vegetable Chemical Use Survey, and the 1993 Cropping Practices Survey. These surveys provide the only current national estimates on pesticide use and IPM practices. Complete lists of the crops and States surveyed are included in tables 2, 4, and 6. The data are collected from randomly selected producers in personal interviews by trained enumerators.

Figure 1

Pesticide application decisions, fruits and nuts (percent of scouted acres)



Fruits and Nuts

Data on fruit and nut IPM were obtained from the 1991 Fruit and Nut Chemical Use Survey, conducted between October and December 1992. The survey targeted 30 commodities and covered 13 States, accounting for most of the U.S. acreage in fruit crops (tables 1-2).[2]

Vegetables

Data on vegetable IPM were obtained from the 1992 Vegetable Chemical Use Survey and its Economic Follow-On, conducted between October 1992 and April 1993. The survey targeted 20 commodities and covered 14 States, accounting for most of the U.S. acreage in vegetables (tables 3-4).[3]

Field Crops

Data on field crop IPM came from the 1993 Cropping Practices Surveys (CPS), conducted annually between June and December (the data collection period varies by crop). CPS began collecting detailed data on chemical use and production practices for selected field crops and States under the Water Quality

[2] Pecans are excluded from this report because acreage is not estimated at the national level.

[3] In this report, some commodities have been aggregated and three (cauliflower, eggplant, and lima beans) have been excluded (except in the totals) because of an insufficient number of answers on IPM-related questions.

Program in 1990. The 1993 surveys covered both pesticide use and IPM information for corn, soybean, and fall potato production in selected States (tables 5, 6).

Fruits and Nuts

Scouting

Table 7 shows the percentage of fruit and nut acreage professionally scouted, by crop, in the 13 surveyed States. Professional scouts include independent crop consultants, onfarm entomologists, and other trained professionals providing scouting services.

Professional scouting is practiced on 50 percent or more of the acreage in most major fruit and nut crops, including apples (54 percent), grapes (68 percent), oranges (75 percent), grapefruit (83 percent), almonds (64 percent), and walnuts (65 percent). Professional scouting for insects is most common, followed by scouting for diseases and scouting for weeds.

Use of Economic Thresholds

To use economic thresholds correctly, growers must monitor fields for pests. Therefore, we report the grower's most important pesticide application decision factor only for scouted acreage. On most, though not all, scouted acreage, fruit growers rely on economic thresholds to make pesticide application decisions (table 8, fig. 1).

The use of economic thresholds in conjunction with pest monitoring distinguishes IPM users from non-IPM users. Thus, although 54 percent of apple acreage is professionally scouted, fulfilling the monitoring criteria for IPM, only 43 percent of apple acreage meets both the monitoring and threshold criteria for IPM. Equivalent figures for other major fruit and nut crops are 68 percent and 54 percent for grapes, 75 percent and 64 percent for oranges, 83 percent and 62 percent for grapefruit, 64 percent and 54 percent for almonds, and 65 percent and 43 percent for walnuts.

Pest Management Practices

IPM also involves the use of cultural, strategic, and biological forms of pest management (table 9, fig. 2). Some practices, such as field sanitation (removing debris from the orchard or vineyard that may harbor insects or disease organisms), are widely adopted (73 percent of apple acreage, 64 percent of grape acreage, 66 percent of sweet cherry acreage). Other methods, such as use of beneficials, are not as widely used (24

Table 7--Use of scouting, fruits and nuts, 1991

Crop	Any scouting	Scouting for insects	Scouting for diseases	Scouting for weeds
	Percent of acres			
Nuts:				
Almonds	64	64	61	59
English walnuts	65	65	60	51
Hazelnuts	25	25	9	6
Pistachios	95	95	83	74
Fruit:				
Apples	54	54	53	45
Apricots	61	61	51	32
Avocados	47	47	43	34
Blackberries	9	9	9	9
Blueberries	46	45	41	16
Dates	1	0	0	1
Figs	49	19	19	49
Grapefruit	83	83	70	67
Grapes	68	68	63	58
Kiwifruit	41	41	39	30
Lemons	78	78	65	50
Limes	44	43	43	38
Nectarines	87	87	84	86
Olives	70	70	70	51
Oranges (except temples)	75	75	70	61
Peaches	47	47	45	41
Pears	59	59	56	51
Plums and prunes	75	75	69	66
Pomegranates	33	33	33	32
Raspberries	32	30	31	24
Sweet cherries	46	45	43	38
Tangelos	61	61	58	48
Tangerines	76	76	62	58
Tart cherries	53	53	50	38
Temple oranges (Florida)	72	72	72	70
All fruits and nuts	65	65	61	54

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey.

Table 8--Pesticide application decision criteria for scouted acreage, fruits and nuts, 1991

Crop	Predetermined schedule	Economic thresholds	Contract requirements[1]	Other
	Percent of acres			
Nuts:				
Almonds	12	84	0	3
English walnuts	5	66	0	29
Hazelnuts	19	74	0	7
Pistachios	7	90	0	4
Fruit: [2]				
Apples	10	78	0	12
Apricots	11	78	5	6
Avocados	9	70	0	21
Blackberries	22	78	0	0
Blueberries	34	49	2	6
Figs	0	74	0	26
Grapefruit	20	75	1	4
Grapes	9	0	12	12
Kiwifruit	5	90	0	5
Lemons	2	74	0	24
Nectarines	2	89	0	9
Olives	1	99	0	1
Oranges (except temples)	11	84	0	5
Peaches	23	57	1	19
Pears	2	64	1	34
Plums and prunes	5	47	0	48
Raspberries	24	54	0	22
Sweet cherries	11	75	0	13
Tangelos	12	79	0	9
Tangerines	6	90	0	4
Tart cherries	19	93	0	1
Temple oranges (Florida)	6	93	0	1
All fruits and nuts	10	76	0	13

[1] Where pest management decisions are controlled by the processor, produce company, or other buyer with whom the producer has a contract for the commodity.

[2] Insufficient data for reporting dates, limes, and pomegranates.

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey.

percent of apple acreage, 18 percent of grape acreage, 16 percent of sweet cherry acreage). The reported levels of pheromone use are high relative to the small number of registered uses of pheromones for pest control. Pheromone use in nectarines, apples, pears, and nut crops appears particularly high, primarily because farmers reported pheromones used for monitoring as well as for control.

The number of additional pest management practices used on a given crop indicates the grower's reliance on multiple biological and cultural pest management methods, a key ingredient of IPM. In all crops, more than half of the acreage is treated with at least one such practice (table 10). In several fruit and nut crops, including almonds, apples, grapes, nectarines, olives, and pears, more than half of crop acreage is treated with three or more practices.

Measuring the Use of an "IPM Approach"

High-level IPM use (professional scouting, economic thresholds, and three or more additional practices) varies from 10 percent or less in a few crops (blackberries, lemons, temple oranges) to around 50 percent in nectarines and olives (table 11, fig. 3). High IPM use is more prevalent in crops where well-developed IPM programs exist, such as apples (27 percent), grapes (37 percent), oranges (26 percent), and almonds (32 percent). No pesticides are applied on 20 percent or more of some fruit and nut crop acres, including kiwifruit, figs, avocados, apricots, and walnuts. Pesticides are applied without economic thresholds on 60-90 percent of berry, cherry, and peach acreage.

Figure 2
Pest management practices, fruits and nuts, 1991

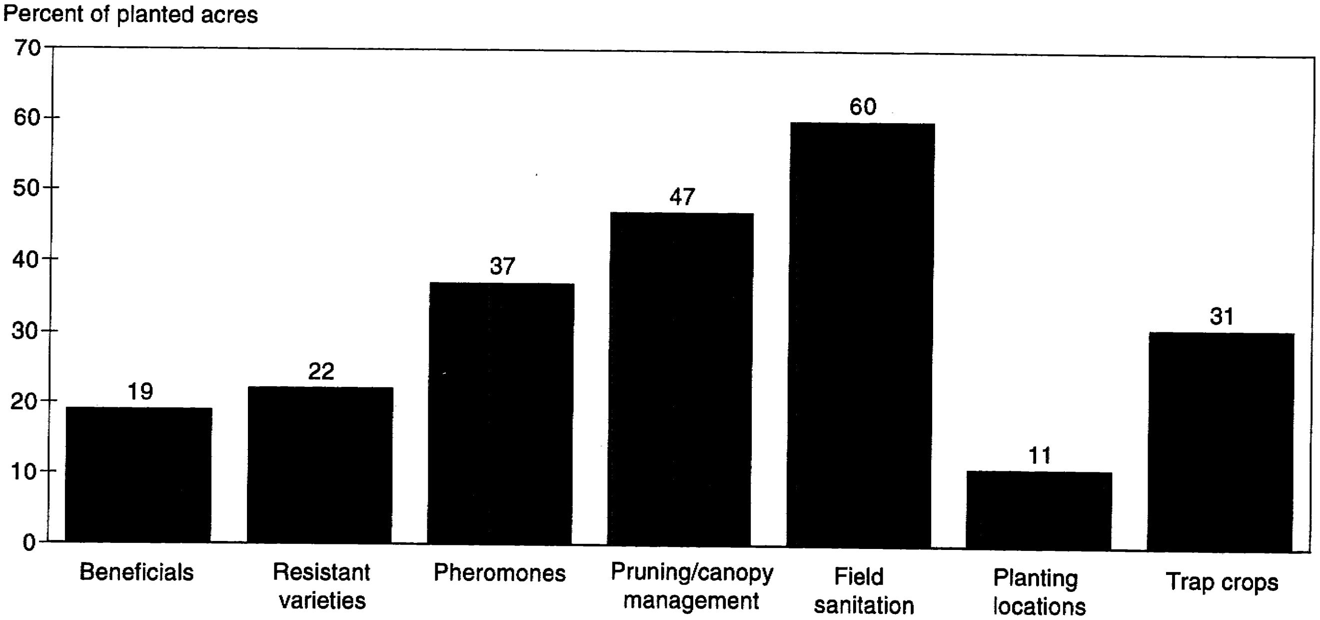


Figure 3
Fruits and nuts under an IPM approach (percent of planted acres), 1991

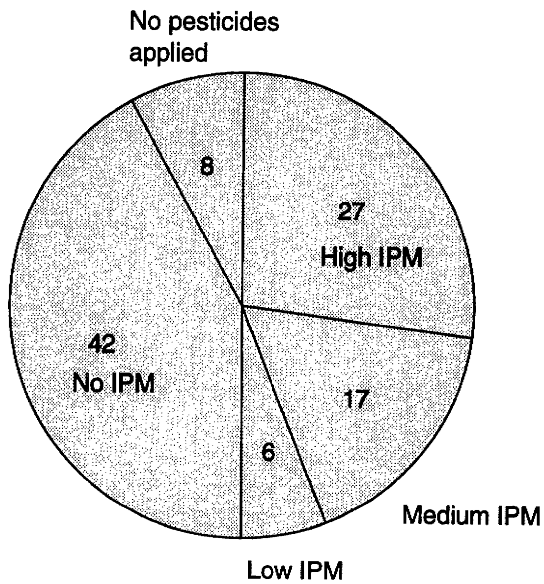


Table 9--Pest management practices, fruits and nuts, 1991

Crop	Beneficials	Resistant varieties	Pheromones	Pruning/ canopy management	Field sanitation	Planting locations	Water management practices	Trap crops[1]
	Percent of acres							
Nuts:								
Almonds	14	16	62	40	82	7	54	5
English walnuts	8	30	65	22	68	4	13	5
Hazelnuts	13	15	68	38	45	0	0	2
Pistachios	5	14	39	5	66	1	22	2
Fruit:								
Apples	24	16	66	70	73	9	22	10
Apricots	2	15	42	37	84	10	29	0
Avocados	26	32	9	35	33	8	15	9
Blackberries	3	31	24	50	83	0	11	0
Blueberries	11	27	39	41	57	2	6	8
Dates	28	0	0	39	57	2	8	0
Figs	0	19	0	61	71	19	31	19
Grapefruit	38	27	26	35	26	1	36	6
Grapes	18	31	14	56	64	21	41	16
Kiwifruit	14	11	17	20	41	0	50	5
Lemons	30	18	15	31	28	41	12	0
Limes	14	13	0	4	54	3	17	0
Nectarines	15	17	82	49	81	8	35	13
Olives	47	1	3	73	16	0	50	47
Oranges (except temples)	22	21	28	44	48	6	27	6
Peaches	9	20	28	46	66	15	15	6
Pears	20	28	61	71	67	18	32	11
Plums and prune	13	16	52	27	53	5	17	10
Pomegranates	35	1	41	24	76	4	28	0
Raspberries	6	47	55	47	48	6	27	14
Sweet cherries	16	19	27	48	66	6	18	5
Tangelos	17	14	18	28	37	2	19	7
Tangerines	15	12	2	19	24	31	3	21
Tart cherries	20	12	36	68	63	11	10	7
Temple oranges (Florida)	11	18	10	47	30	0	31	14
All fruits and nuts	19	22	37	47	60	11	31	9

[1] Crops planted to attract pests away from the crop susceptible to pest damage.

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey.

Table 10--Number of pest management practices, fruits and nuts, 1991[1]

Crop	None	One	Two	Three or more
	Percent of acres			
Nuts:				
Almonds	4	23	15	58
English walnuts	13	25	17	45
Hazelnuts	16	24	30	30
Pistachios	15	34	37	14
Fruit:				
Apples	5	14	22	59
Apricots	6	31	23	41
Avocados	35	24	17	23
Blackberries	8	26	41	25
Blueberries	15	34	20	31
Dates	35	23	13	28
Figs	10	48	11	31
Grapefruit	21	26	19	35
Grapes	24	14	10	51
Kiwifruit	12	52	21	15
Lemons	18	43	11	28
Limes	44	39	1	16
Nectarines	6	14	21	60
Olives	24	13	11	51
Oranges (except temples)	21	24	21	35
Peaches	17	23	29	31
Pears	8	17	21	54
Plums and prunes	14	37	24	26
Pomegranates	9	41	18	32
Raspberries	15	24	12	49
Sweet cherries	14	24	27	35
Tangelos	32	27	23	17
Tangerines	40	22	16	23
Tart cherries	15	17	28	40
Temple oranges (Florida)	38	15	24	22
All fruits and nuts	17	21	18	44

[1] Includes use of the following practices for pest management: beneficials, resistant varieties, pheromones, pruning and canopy management, field sanitation, planting locations, water management practices, and trap crops.

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey.

Vegetables

Scouting

In the 1992 Vegetable Chemical Use Survey, farmers reported all scouting, whether performed by themselves, an employee, a commercial service, or others. About 74 percent of all vegetable acres were scouted for insects, 72 percent for weeds, and 73 percent for diseases (tables 12-14). The extent of scouting ranged from 53 percent of acreage for carrots to almost 96 percent for celery and spinach. Survey responses included both formal methods recommended by Extension IPM programs and informal methods of scouting.

The primary source of scouting for insects was commercial services (21 percent of the vegetable acreage), followed by chemical dealers (19 percent) and operator and family members (19 percent). Extension Service personnel were the least used sources for insect scouting, reflecting in part the availability of commercial scouting services in the private sector. The primary role of the Extension Service has been to disseminate information on scouting techniques and to train growers and private consultants rather than to provide scouting services directly.

Commercial services and chemical dealers are much less active in weed scouting than in insect scouting. Scouting for weeds was carried out by the operator or family members on 34 percent of vegetable acreage, while commercial services scouted 11 percent of the acreage and chemical dealers 10 percent.

Disease scouting was done mainly by the operator and family (20 percent of the acreage) and commercial scouting services (20 percent). Chemical dealers scouted about 16 percent of vegetable acreage for disease, and operator's employees 7 percent.

Pesticide Application Decisions

In the vegetable survey, growers reported pesticide application decisions criteria separately for insecticides, fungicides, and herbicides. Economic thresholds ("as needed") were used by growers to determine insecticide applications on 71 percent of the scouted acres, to determine herbicide applications on 48 percent, and to determine fungicide applications on 56 percent. Vegetable growers applied herbicides on a preventive basis (routine schedule) on more than 40 percent of their scouted acres, compared with insecticides and fungicides at 10 percent (fig. 4, tables 15-17). Contract requirements were a relatively

Table 11--Use of an "IPM approach," fruits and nuts, 1991

Crop	Did not apply pesticides	No IPM	IPM		
			Low[1]	Medium[2]	High[3]
			Percent of acres		
Nuts:					
Almonds	15	30	1	21	32
English walnuts	20	37	2	10	31
Hazelnuts	1	80	0	5	14
Pistachios	8	6	13	58	14
Fruit:[4]					
Apples	2	55	1	14	27
Apricots	21	31	4	21	23
Avocados	36	29	3	15	17
Blackberries	1	92	0	6	0
Blueberries	6	73	2	7	12
Figs	36	27	0	18	19
Grapefruit	2	36	16	26	20
Grapes	7	40	6	11	37
Kiwifruit	54	9	0	26	10
Lemons	1	36	4	48	10
Nectarines	1	22	5	20	53
Olives	6	25	20	2	48
Oranges (except temples)	3	34	14	23	26
Peaches	2	72	2	12	13
Pears	2	58	3	11	26
Plums and prunes	9	57	2	15	17
Raspberries	2	77	0	2	19
Sweet cherries	2	64	1	16	16
Tangelos	8	43	9	26	14
Tangerines	7	22	29	27	14
Tart cherries	0	61	3	17	20
Temple oranges (Florida)	0	33	37	22	8
All fruits and nuts	8	42	6	17	27

[1] Defined as the use of professional scouting and economic thresholds to determine pesticide application decisions, and no additional practices used to control pests (possible practices are beneficials, resistant varieties, pheromones, trap crops, pruning/canopy management, field sanitation, planting locations, and water management practices).

[2] Low IPM plus 1-2 additional pest control practices.

[3] Low IPM plus 3 or more additional pest control practices.

[4] Insufficient data for reporting dates, limes, and pomegranates.

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey.

Table 12--Scouting for insects by crop and source of scouting service, vegetables, 1992

Crop	Scouted by						Scouted	Not scouted
	Operator/family member	Employee	Chemical dealer	Extension personnel	Commercial scouting service	Other		
	Percent of planted acres[1]							
Asparagus	5	16	27	1	0	6	55	45
Broccoli	*	0	38	0	56	0	94	6
Cabbage[2]	22	3	6	0	31	0	61	39
Carrots	9	9	9	0	25	1	53	47
Celery	86	0	0	0	10	0	96	4
Cucumber[2]	38	5	13	*	5	*	62	39
Green peas[2]	7	7	3	0	22	26	65	35
Lettuce	26	9	26	0	32	0	93	7
Melons	25	*	30	0	12	0	67	33
Onions	11	6	41	1	16	0	76	25
Peppers	25	14	*	0	15	0	54	46
Snap beans[2]	23	15	6	0	7	22	72	28
Spinach[2]	10	0	47	0	14	25	96	5
Strawberries	39	22	12	*	10	5	87	13
Sweet corn[2]	22	8	2	*	33	18	84	17
Tomato[2]	15	1	47	0	5	*	68	32
All vegetables	19	7	19	*	21	9	74	26

[1] Percentages may not add to 100 because of rounding. [2] Fresh and processing. * Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Table 13--Scouting for weeds by crop and source of scouting service, vegetables, 1992

Crop	Scouted by						Scouted	Not scouted
	Operator/family member	Employee	Chemical dealer	Extension personnel	Commercial scouting service	Other		
	Percent of planted acres[1]							
Asparagus	17	16	15	1	0	6	55	45
Broccoli	3	31	4	0	56	0	94	6
Cabbage[2]	32	3	1	0	24	0	60	40
Carrots	16	27	4	0	1	1	48	52
Celery	89	7	0	0	0	0	96	4
Cucumber[2]	45	5	9	0	3	*	62	38
Green peas[2]	9	7	5	0	20	21	61	39
Lettuce	47	20	20	0	6	0	93	7
Melons	30	7	20	0	10	0	66	34
Onions	49	15	8	1	2	0	76	25
Peppers	26	14	*	0	14	0	54	46
Snap beans[2]	37	15	4	0	2	7	64	36
Spinach[2]	57	0	0	0	14	25	96	5
Strawberries	56	22	7	0	3	0	87	13
Sweet corn[2]	44	10	2	*	11	14	82	18
Tomato[2]	39	1	23	0	5	0	68	32
All vegetables	34	11	10	*	11	7	72	28

[1] Percentages may not add to 100 because of rounding. [2] Fresh and processing. * Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Table 14–Scouting for diseases by crop and source of scouting service, vegetables, 1992

Crop	Scouted by: Operator/family member	Employee	Chemical dealer	Extension personnel	Commercial scouting service	Other	Scouted	Not scouted
	Percent of planted acres[1]							
Asparagus	5	16	27	1	0	6	55	45
Broccoli	*	0	38	0	56	0	94	6
Cabbage[2]	24	3	3	0	30	0	60	40
Carrots	10	9	8	0	25	1	53	47
Celery	86	7	0	0	3	0	96	4
Cucumbers[2]	38	5	13	*	4	*	61	39
Green peas[2]	7	7	3	0	22	24	62	38
Lettuce	4	9	49	0	32	0	93	7
Melons	25	*	30	0	12	0	67	33
Onions	11	6	16	1	16	26	76	25
Peppers	25	14	*	*	15	0	54	46
Snap beans[2]	23	15	5	0	7	23	72	28
Spinach[2]	57	0	0	0	14	25	96	5
Strawberries	40	21	12	*	9	5	87	13
Sweet corn[2]	22	8	2	*	33	18	83	18
Tomato[2]	36	1	26	0	5	*	68	32
All vegetables	20	7	16	*	20	10	73	27

[1] Percentages may not add to 100 because of rounding.
[2] Fresh and processing.
* Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey

minor factor (5-11 percent of acres) in pesticide application decisions.[4]

Although only about 4 percent of the scouted acreage was not treated with herbicides and 8 percent was not treated with insecticides, growers did not apply fungicides on 27 percent of their scouted acreage.

Pest Management Practices

While some traditional pest management techniques such as mechanical cultivation were used fairly extensively (on 85 percent of vegetable acres), other techniques usually associated with IPM were used less often. Growers alternated pesticides to reduce pest resistance on 44 percent of the vegetable acres. Growers selected pesticides and adjusted application rates to protect beneficials on 38 and 37 percent of the acres. Growers used purchased beneficials on only 3 percent of the acres and used pheromones to control pests on less than 7 percent of the acreage (fig. 5, table 18).[5]

Use of an "IPM Approach"

The level of IPM use is determined by the number of additional pest management practices used. For vegetables, such practices include the use of beneficials, pheromones to control pests, water management, adjustment of planting dates to control pests, alternating pesticides to reduce pest resistance, and soil testing for pests. Weed IPM programs also include mechanical cultivation and hand hoeing.

For vegetables, the levels of IPM used to manage insects, weeds, and diseases are reported separately. A producer is considered to be using low-level IPM to manage insects if scouting and economic thresholds

[4] Contract requirements refer to the cases in which pest management decisions are controlled/specified by the processor, produce company, or other buyer with whom the producer has a marketing or production contract for the commodity.

[5] According to the number of pheromones registered for control purposes on vegetable crops, this may be considered too high. Growers may have included other semiochemicals, such as feeding attractants, in their response, and pheromones intended for monitoring may have been used for control.

Figure 4

Pesticide application decisions, vegetables (percent of scouted acres), 1992

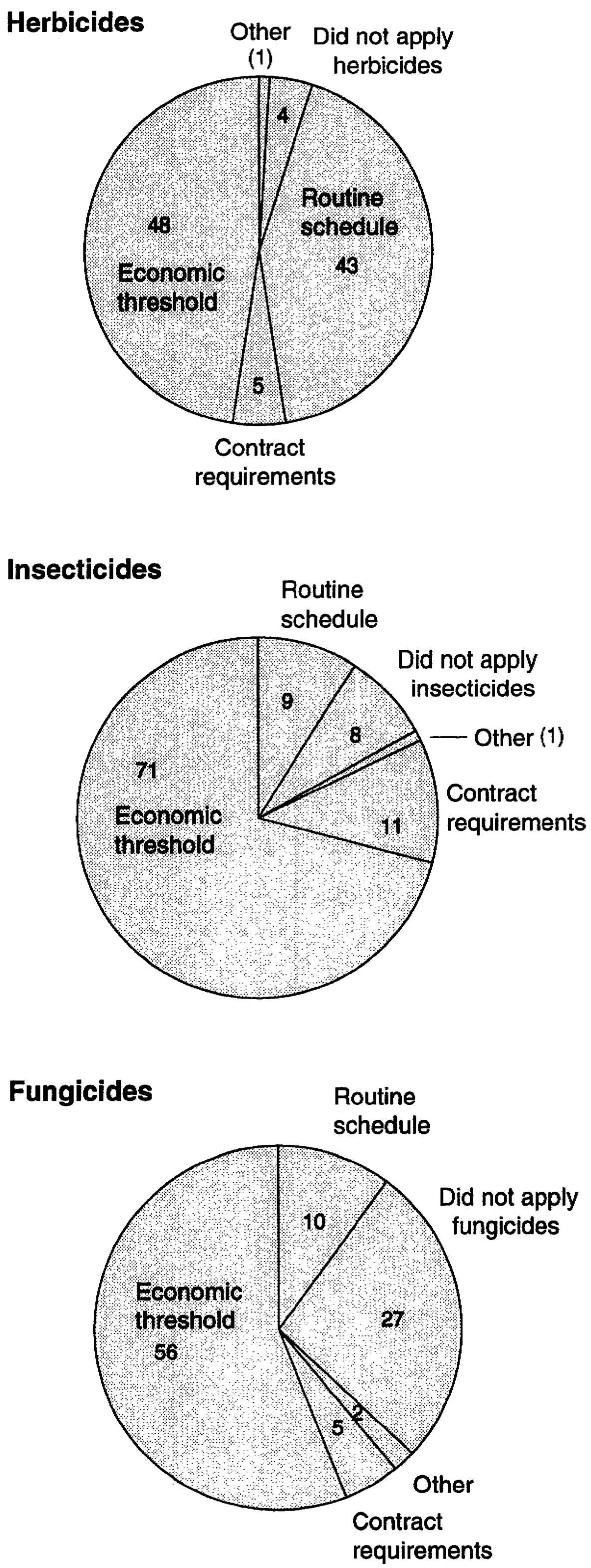


Table 15--Insecticide application decision criteria for scouted acreage, vegetables, 1992

Crop	Routine schedule	Economic thresholds	Contract requirements[1]	Other	Did not apply insecticides
	Percent of scouted acres[2]				
Asparagus	1	99	0	0	0
Broccoli	32	64	4	0	0
Cabbage[3]	7	78	0	15	0
Carrots	3	91	0	2	3
Celery	8	92	0	0	0
Cucumber[3]	5	73	0	0	22
Green peas[3]	3	49	24	1	23
Lettuce	10	88	0	2	*
Melon	6	83	0	0	11
Onions	12	52	0	2	34
Peppers	6	92	0	0	2
Snap beans[3]	15	72	12	0	1
Spinach	0	67	30	0	3
Strawberries	20	74	2	*	3
Sweet corn[3]	11	51	26	2	8
Tomato[3]	2	97	0	0	*
All vegetables	9	71	11	1	8

[1] Where pest management decisions are controlled/specified by the processor, produce company, or other buyer with whom the producer has a marketing or production contract for the commodity.

[2] Percentages may not add to 100 because of rounding.

[3] Fresh and processing.

* Less than 0.5 percent.

Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

are used to determine insecticide applications and no other insect management practice is used. A medium level of IPM use corresponds with the use of one or two other insect management practices in addition to scouting and economic thresholds. High-level IPM is defined as scouting for insects and using economic thresholds, along with three or more other insect management practices. Equivalent definitions are used to examine the level of IPM for weeds and diseases.

The use of IPM was most prevalent to manage insects, due in part to the pioneering efforts of entomologists, who first conceptualized and developed IPM techniques. Vegetable growers used IPM to manage insects on 52 percent of the acres, and more than half of the acreage planted by IPM users was classified as high-level IPM. Insecticides were applied on about 38 percent of the planted acreage not under IPM (table 19, fig. 6).

IPM was used by vegetable growers for weed management on only 35 percent of vegetable acres. However, a third of those acres were under high-level IPM. Herbicides were applied on about 60 percent of the planted acreage not under IPM (table 20).

Growers used IPM for disease control on about 41 percent of their acres, almost none of which was high-level. Fungicides were applied on about 29 percent of the planted acreage not under IPM (table 21).

Table 16--Herbicide application decision criteria for scouted acreage, vegetables, 1992

Crop	Routine schedule	Economic thresholds	Contract requirements[1]	Other	Did not apply herbicides
	Percent of scouted acres[2]				
Asparagus	4	96	0	0	0
Broccoli	37	56	4	3	0
Cabbage[3]	31	49	0	15	5
Carrots	49	51	0	0	*
Celery	8	92	0	0	0
Cucumber[3]	42	48	0	0	11
Green peas[3]	43	38	14	2	4
Lettuce	56	43	0	0	1
Melon	17	70	0	0	13
Onion	24	76	0	0	0
Pepper	37	63	0	0	0
Snap beans[3]	74	11	14	0	1
Spinach[3]	54	20	26	0	*
Strawberries	30	56	2	*	13
Sweet corn[3]	32	56	10	*	2
Tomato[3]	77	19	0	*	4
All vegetables	43	48	5	1	4

[1] Where pest management decisions are controlled/specified by the processor, produce company, or other buyer with whom the producer has a marketing or production contract for the commodity.
[2] Percentages may not add to 100 because of rounding.
[3] Fresh and processing.
* Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Table 17--Fungicide application decision criteria for scouted acreage, vegetables, 1992

Crop	Routine schedule	Economic thresholds	Contract requirements[1]	Other	Did not apply fungicides
	Percent of scouted acres[2]				
Asparagus	*	96	0	0	4
Broccoli	32	64	4	0	0
Cabbage[3]	11	53	5	15	15
Carrots	18	75	0	4	3
Celery	9	91	0	0	0
Cucumber[3]	24	67	0	0	10
Green peas[3]	2	25	13	3	57
Lettuce	10	86	0	0	4
Melon	11	79	0	0	9
Onion	25	32	0	9	34
Pepper	12	88	0	0	*
Snap beans[3]	17	41	15	1	27
Spinach[3]	1	67	30	0	3
Strawberries	31	64	2	*	3
Sweet corn[3]	2	41	8	2	47
Tomato[3]	7	60	0	*	33
All vegetables	10	56	5	2	27

[1] Where pest management decisions are controlled/specified by the processor, produce company, or other buyer with whom the producer has a marketing or production contract for the commodity.
[2] Percentages may not add to 100 because of rounding.
[3] Fresh and processing.
* Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Figure 5
Pest management practices, vegetables, 1992

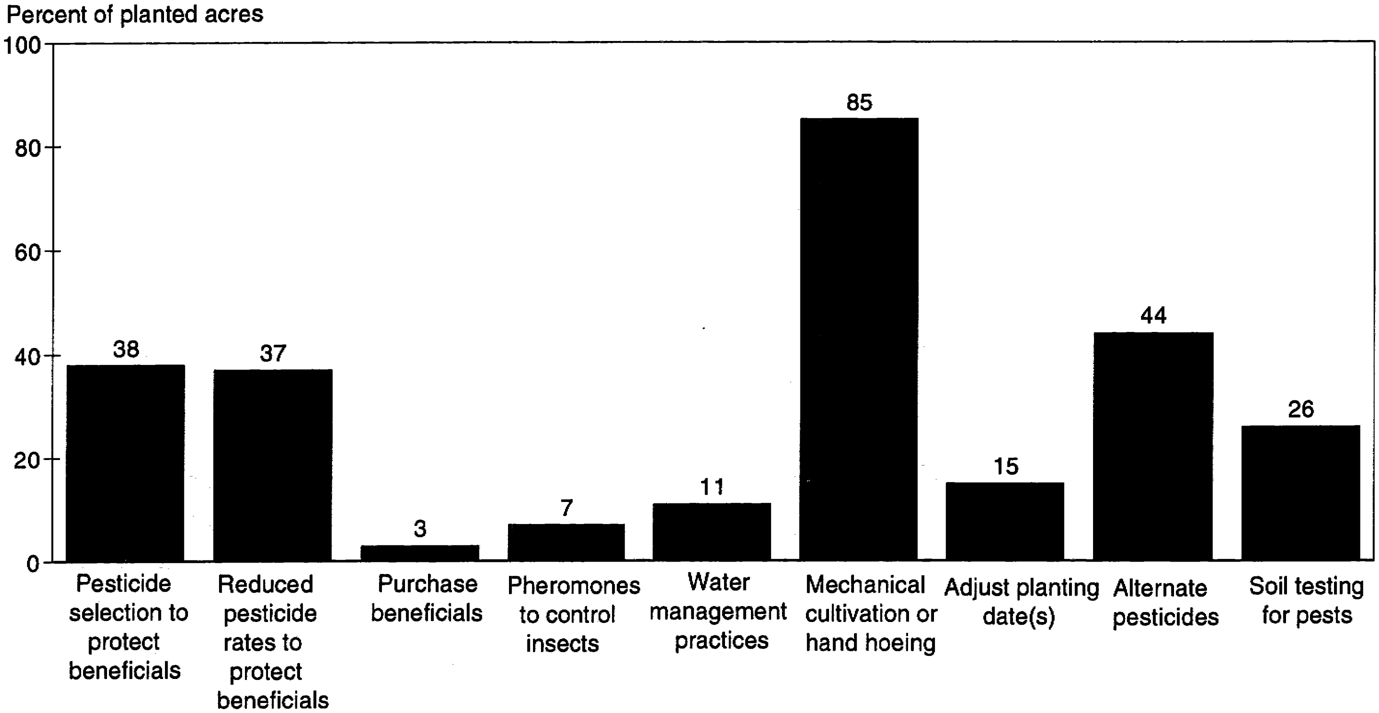


Table 18–Pest management practices, vegetables, 1992

Crop	Pesticide selection to protect beneficials	Reduced pesticide rates to protect beneficials	Purchase beneficials	Pheromones to control insects	Water management practices	Mechanical cultivation or hand hoeing	Adjust planting date(s)	Alternate pesticides used	Soil testing for pests
				Percent of planted acres					
Asparagus	41	40	0	2	30	83	2	55	20
Broccoli	63	62	4	0	52	100	3	62	58
Cabbage[1]	62	60	0	14	1	98	4	79	29
Carrots	76	23	0	18	3	93	20	45	36
Celery	89	85	0	12	0	100	0	99	80
Cucumber[1]	32	22	0	4	3	83	19	59	45
Green peas[1]	20	16	0	0	2	32	7	16	9
Lettuce	34	19	3	1	4	99	26	54	39
Melons	62	61	15	0	18	98	15	41	18
Onions	26	11	0	7	7	99	4	35	22
Peppers	41	43	6	9	15	93	5	33	0
Snap beans[1]	28	36	*	3	1	95	2	47	20
Spinach[1]	91	91	0	0	0	100	14	97	47
Strawberries	68	63	37	7	4	94	9	79	43
Sweet corn[1]	26	36	*	17	7	91	8	48	15
Tomato[1]	38	41	5	6	21	75	47	26	42
All vegetables	38	37	3	7	11	85	15	44	26

[1] Fresh and processing. * Less than 0.5 percent. Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Table 19–Use of an "IPM approach" for insects: vegetables, 1992

Crop	Did not apply insect-icides	No IPM	IPM		
			Low[1]	Medium[2]	High[3]
	Percent of planted acres[4]				
Asparagus	4	41	20	7	28
Broccoli	0	40	0	0	57
Cabbage[5]	*	53	2	13	32
Carrots	2	58	0	3	37
Celery	0	55	0	11	35
Cucumber[5]	22	34	2	8	34
Green peas[5]	32	36	11	13	9
Lettuce	1	17	22	31	28
Melon	12	33	8	8	40
Onion	28	33	1	26	13
Peppers	1	49	6	18	26
Snap beans[5]	2	46	6	36	10
Spinach[5]	3	33	0	3	61
Strawberries	4	31	2	13	50
Sweet corn[5]	11	47	9	9	25
Tomato[5]	1	33	11	24	31
All vegetables	10	38	9	16	27

[1] Defined as the use of scouting to determine insecticide application decisions and no other insect management practice (e.g., use of beneficials, pheromones, water management practices, adjustment of planting dates to control pests, alternating pesticides to reduce resistance.)

[2] Use of scouting to determine insecticide application decisions and 1-2 other insect management practices.

[3] Use of scouting to determine insecticide application decisions and three or more other insect management practices.

[4] Percentages may not add to 100 because of rounding.

[5] Fresh and processing.

* Less than 0.5 percent.

Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Table 20–Use of an "IPM approach" for weeds: vegetables, 1992

Crop	Did not apply herbicides	No IPM	IPM		
			Low[1]	Medium[2]	High[3]
	Percent of planted acres[4]				
Asparagus	11	37	4	30	20
Broccoli	0	47	*	1	52
Cabbage[5]	23	47	0	11	19
Carrots	*	93	0	2	5
Celery	0	54	0	46	0
Cucumber[5]	12	59	2	17	9
Green peas[5]	11	65	12	12	*
Lettuce	2	58	0	29	12
Melon	9	44	0	32	15
Onion	2	40	0	50	7
Peppers	1	65	0	25	9
Snap beans[5]	5	87	0	7	1
Spinach[5]	*	80	0	3	17
Strawberries	13	39	*	22	27
Sweet corn[5]	4	50	*	32	14
Tomato[5]	4	83	0	3	20
All vegetables	6	60	2	21	12

[1] Defined as the use of scouting to determine herbicide application decisions and no other weed management practice.

[2] Use of scouting to determine herbicide application decisions and 1-2 other weed management practices.

[3] Use of scouting to determine herbicide application decisions and three or more other weed management practices.

[4] Percentages may not add to 100 because of rounding.

[5] Fresh and processing.

* Less than 0.5 percent.

Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

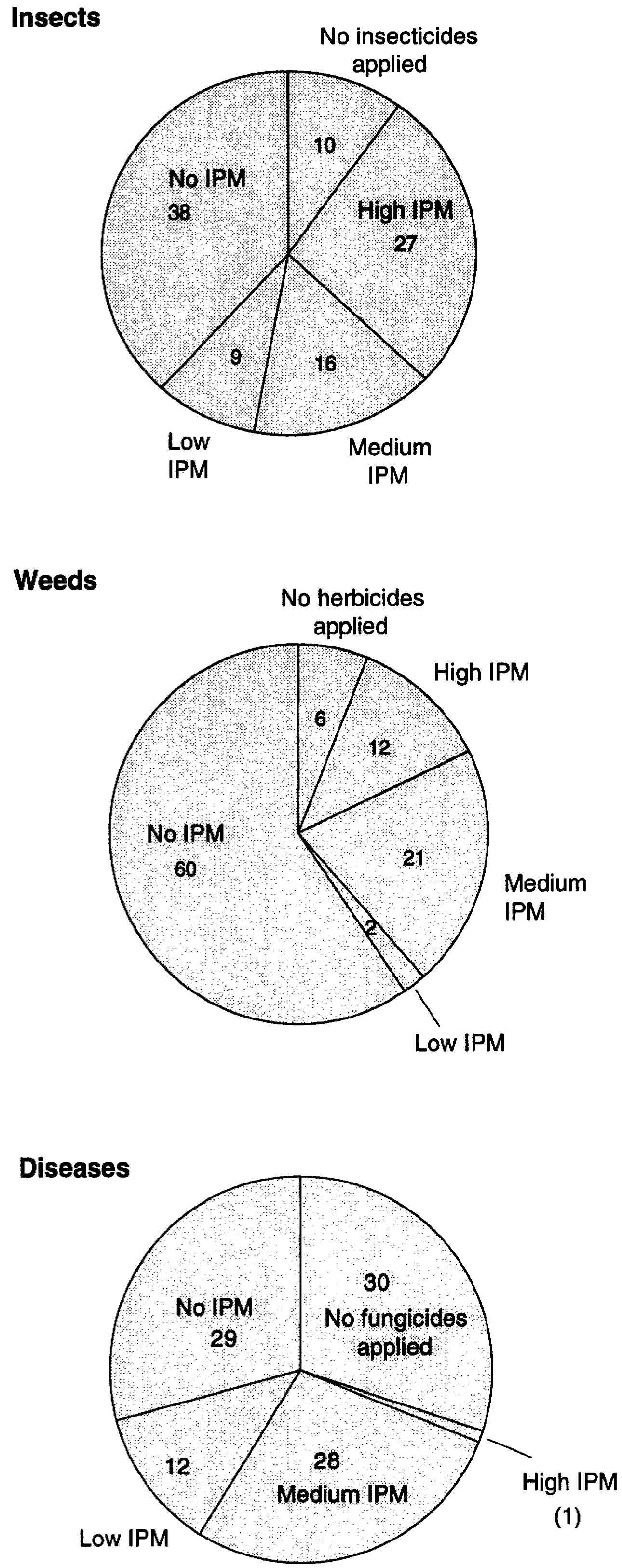
Table 21--Use of an "IPM approach" for diseases: vegetables, 1992

Crop	Did not apply fungicides	No IPM	IPM Low[1]	IPM Medium[2]	IPM High[3]
	Percent of planted acres[4]				
Asparagus	26	21	20	33	0
Broccoli	4	36	1	59	0
Cabbage[5]	16	53	0	31	0
Carrots	2	67	2	28	2
Celery	0	56	0	44	0
Cucumber[5]	17	44	4	34	2
Green peas[5]	72	14	10	4	0
Lettuce	10	10	38	41	1
Melon	9	39	18	34	*
Onion	30	46	7	16	1
Peppers	9	43	14	28	5
Snap beans[5]	26	45	14	16	*
Spinach[5]	2	33	3	61	0
Strawberries	4	40	6	47	4
Sweet corn[5]	53	13	9	24	1
Tomato[5]	24	36	5	31	5
All vegetables	30	29	12	28	1

[1] Defined as the use of scouting to determine fungicide application decisions and no other disease management practice.
[2] Use of scouting to determine fungicide application decisions and 1-2 other disease management practices.
[3] Use of scouting to determine fungicide application decisions and three or more other disease management practices.
[4] Percentages may not add to 100 because of rounding.
[5] Fresh and processing.
* Less than 0.5 percent.
Source: NASS/ERS 1992 Vegetable Chemical Use Survey.

Figure 6

Vegetables under an IPM approach, (percent of planted acres), 1992



Field Crops

Scouting

In the survey of field crops, respondents reported all sources of scouting rather than only the primary source. Scouting was reported on 65, 69, and 85 percent of corn, soybean, and fall potato acres (table 22, fig. 7). On-farm labor (including operator, family members, or employees) scouted over half the acreage in all three crops. Chemical dealers were the major off-farm providers of scouting services (9, 12, and 53 percent of corn, soybean, and fall potato acres). Private crop consultants and processors were also involved in scouting pests, mainly in fall potatoes.

Pesticide Application Decisions

The type and severity of pest problems differ by crop. However, weeds are a common pest problem in the production of all three crops examined in the survey.

Table 22--Pesticide application decisions: corn, soybean, and fall potatoes, 1993

Item	Corn	Soybeans	Fall potatoes
	Percent of planted acres		
Scouting for weeds, insects, or diseases	65	69	85
Source of scouting[1]:			
Farm operator/ family member/ employee	57	65	77
Extension	*	1	6
Dealer	9	12	53
Consultant	7	32	2
Processor (fieldman)	*	*	24
Other	1	*	*
Used scouting and economic thresholds:			
Herbicides	53	59	66
Insecticides	29	na	73
Fungicides	na	na	64
Treated with pesticides without using economic thresholds:			
Herbicides	45	36	30
Insecticides	15	na	25
Fungicides	na	na	14

[1] A field can be scouted by more than one of the six possible scouting sources. Farmers were asked whether or not they used each scouting source.

na = not applicable.

* Less than 0.5 percent.

Source: NASS/ERS 1993 Cropping Practices Surveys.

Insecticides are used on less than 2 percent of soybean acreage and on 30 percent of corn acreage. In addition to insect and weed problems, diseases are common in fall potatoes.

Economic thresholds were used to determine herbicide applications on 53, 59, and 66 percent of corn, soybean, and fall potato acres (table 22). Economic thresholds for insects were used on 29 percent of corn acres and 73 percent of fall potato acres. Rotating corn with other crops prevents corn rootworm problems, reducing the need for insecticide treatments and, therefore, economic thresholds. Economic thresholds were used on 64 percent of fall potato acres to determine fungicide applications.

Timing and Method for Herbicide Applications

Because weeds are the most common pest problems in the field crops surveyed, the surveys collect more detailed information on weed management techniques than on management of insects and diseases. Few alternatives to chemical treatments exist for weeds. Hence, herbicide application timing and methods are important management techniques.

Herbicides can be applied either preemergence or postemergence. Postemergence applications can facilitate the use of scouting and economic thresholds and allow reduced-rate applications when weeds are small (Lin and others, 1993). Among herbicide-treated acres, 45, 31, and 55 percent of corn, soybean, and fall potato acres used only preemergence herbicides; 20, 32, and 17 percent of corn, soybean, and fall potato acres used only postemergence herbicides (table 23). The remaining acres received both pre- and postemergence treatments. These results reflect the greater availability of postemergence herbicides for use in soybean production.

When applying preemergence herbicides, farmers can vary application rates by location according to the weed problems in previous years, a technqiue known as field mapping. Among the acres where only preemergence herbicides were applied, field mapping was used on 15-18 percent of the corn, soybean, and fall potato acres. Field mapping was used more frequently (25-29 percent) on those acres receiving both pre- and postemergence herbicides.

The use of postemergence herbicides allows farmers to treat weeds according to the species present and level of infestation (that is, by scouting and using economic thresholds). Generally, over three-fourths of farmers identified weed species and considered infestation levels when applying postemergence herbicides (table 22). When postemergence herbicides are applied, farmers can choose an application rate lower than the recommended rate to treat weeds when they are small. This practice was adopted on 56 percent of the corn and soybean acres and 71 percent of the fall potato acres where only postemergence herbicides were applied, and on 60-80 percent of acres receiving pre- and postemergence applications.

Herbicides are generally banded (applied in a narrow band) in rows or broadcast over the entire field; banded applications use less herbicides (Lin and others, 1993). Most often, herbicides were applied as broadcast-only treatments, averaging 84 percent of corn, 89 percent of soybean, and 97 percent of potato acres treated. While banding herbicides saves material costs over broadcasting, banding often requires mechanical cultivation to control weeds in the row middles.

Pest Management Practices

Crop rotation for pest management, mechanical cultivation for weed control, and alternating pesticides to slow pest resistance were the most commonly used practices in corn, soybean, and fall potato pest management (table 24). Potato farmers face more pest problems, and employ a greater variety of pest management tactics, than do corn and soybean producers. Over 20 percent of potato acres were treated with reduced rates or delayed applications of insecticides in order to build up populations of beneficial insects. Many fall potato growers also tested their soil for nematodes (51 percent of acres), insects (18 percent), and diseases (22 percent).

Table 23--Herbicide application timing and methods: corn, soybean, and fall potato production, 1993

Item	Corn	Soybeans	Fall potatoes
	Percent of herbicide-treated acres		
Application timing:			
Preemergence only--			
Area treated	45	31	55
Previous problem	90	91	92
Field mapping	16	18	15
Postemergence only--			
Area treated	20	32	17
Weeds present	88	92	80
Infestation level	73	70	80
Reduced rate	56	56	71
Pre- and postemergence--			
Area treated	35	38	29
Previous problem	89	92	82
Field mapping	26	29	25
Weeds present	90	94	91
Infestation level	76	84	74
Reduced rate	60	60	80
Application methods:			
Banding only[1]--			
Area treated	10	5	2
Broadcast only[2]--			
Area treated	84	89	97
Banding and broadcast--			
Area treated	6	6	2

[1] Banding includes infurrow and banded in/over row.
[2] Broadcast includes ground and aerial broadcast, chemigation, and directed spray.
Source: NASS/ERS 1993 Cropping Practices Surveys.

Table 24--Pest management practices: corn, soybean, and fall potato production, 1993

Item	Corn	Soybeans	Fall potatoes
	Percent of planted acres		
Release beneficials	na	na	2
Reduce insecticide use to protect beneficials	na	na	22
Remove volunteer plants to reduce diseases	na	na	31
Soil test for:			
All pests	2	*	na
Nematodes	na	1	51
Insects	na	na	18
Diseases	na	na	22
Crop rotation to control:			
Weeds	52	79	75
Insects	52	na	66
Diseases	na	na	80
Nematodes	na	na	61
Rotating pesticides to slow resistance to:			
Herbicides	52	55	61
Insecticides	51	na	72
Fungicides	52	38	89
Row cultivation to control weeds	52	38	89
Weed spot treatments	2	3	0

na = not applicable.
* Less than 0.5 percent.
Source: NASS/ERS 1993 Cropping Practices Surveys.

Use of an "IPM Approach"

In addition to scouting and economic thresholds, seven weed management practices determine the level of IPM: crop rotation, alternating herbicides, use of postemergence-only herbicides, mechanical cultivation, banding all herbicides, spot treatments or field mapping, and reduced application rates on small weeds. These practices, with the exception of crop rotation and mechanical cultivation, deal with pesticide management rather than weed management. During the past 30 years, soil-applied, preemergence herbicides have been the foundation of row crop weed control (Kapusta, 1992). Limited research has been devoted to developing nonchemical management techniques for weeds.

In corn insect management, low-level IPM entails either (1) scouting and economic thresholds, or (2) crop rotation without insecticides. Among IPM acres, three management practices characterize different levels of IPM: crop rotation, alternating pesticides to slow development of pest resistance, and soil tests.

Table 25--Use of an "IPM approach": corn, soybean, and fall potato production, 1993

Item	Corn	Soybeans	Fall potatoes
	Percent of planted acres		
Herbicides:			
Did not apply herbicides[1]	2	2	5
No IPM and applied herbicides	45	39	30
Low IPM	2	2	1
Medium IPM	23	21	17
High IPM	28	36	48
Insecticides:			
Did not apply insecticides[1]	11	na	3
No IPM and applied insecticides	15	na	25
Low IPM[2]	52	na	3
Medium IPM	22	na	31
High IPM	*	na	38
Fungicides:			
Did not apply fungicides[1]	na	na	22
No IPM and applied fungicides	na	na	14
Low IPM	na	na	5
Medium IPM	na	na	32
High IPM	*	na	26

[1] Excludes IPM farmers who did not apply pesticides.

[2] About 45 percent of corn acres were under crop rotations and were not treated with any insecticides, these acres were classified under low IPM even though economic thresholds were not used on these acres.

na = not applicable.

* Less than 0.5 percent.

Source: NASS/ERS 1993 Cropping Practices Surveys.

Scouting and economic thresholds are the initial criteria for insect and disease IPM in potatoes. Six additional practices are used to classify the level of IPM: crop rotation, release of beneficials, reduced insecticide rates or delayed applications to protect beneficials, removal of volunteer plants to reduce diseases, alternating pesticides to slow development of pest resistance, and soil tests.

The level of IPM use for weeds is comparable among corn, soybean, and fall potato acres (table 25, figs. 7-9). Over half of the acres in each crop were managed under medium- or high-level weed IPM.

Figure 7

Corn under an IPM approach, (percent of planted acres), 1992

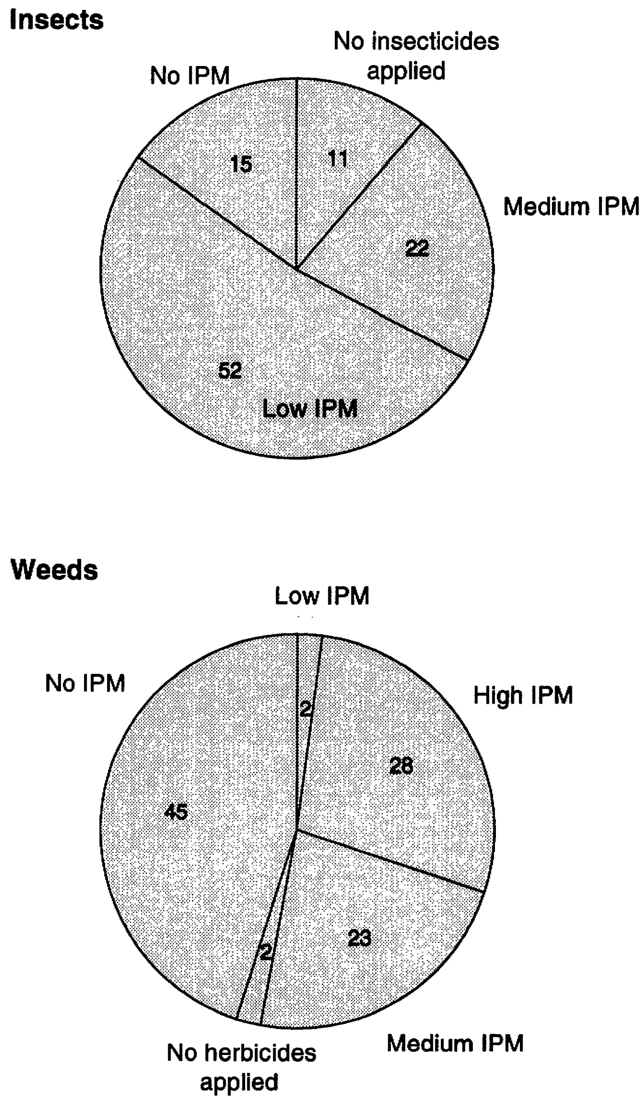
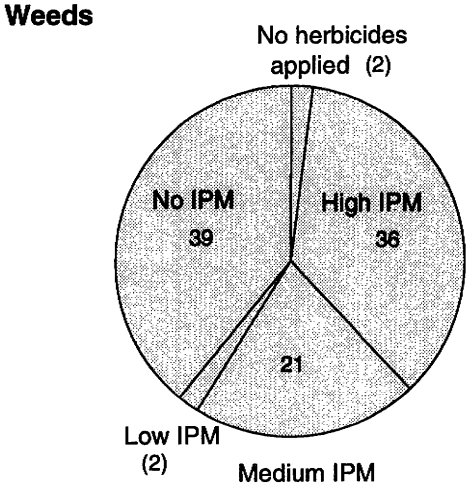


Figure 8

Soybeans under an IPM approach, (percent of planted acres), 1992



Corn acres rotated and not treated with insecticides account for most of the 52 percent of corn acres under low-level IPM. About 65 percent of the corn acres surveyed were rotated with another crop, and only about 11 percent of these acres were treated with insecticides. When corn was planted continuously, the percentage of treated acres increased to 45 and 60 percent for 2-year and 3-year corn.

Over half of fall potato acres were classified as medium- or high-level IPM for insects and diseases. This level of IPM adoption probably reflects potatoes' high value and many pest problems. Both of these factors would tend to increase incentives to adopt IPM, particularly if IPM increases yields, reduces yield variation, or reduces pesticide expenditures.

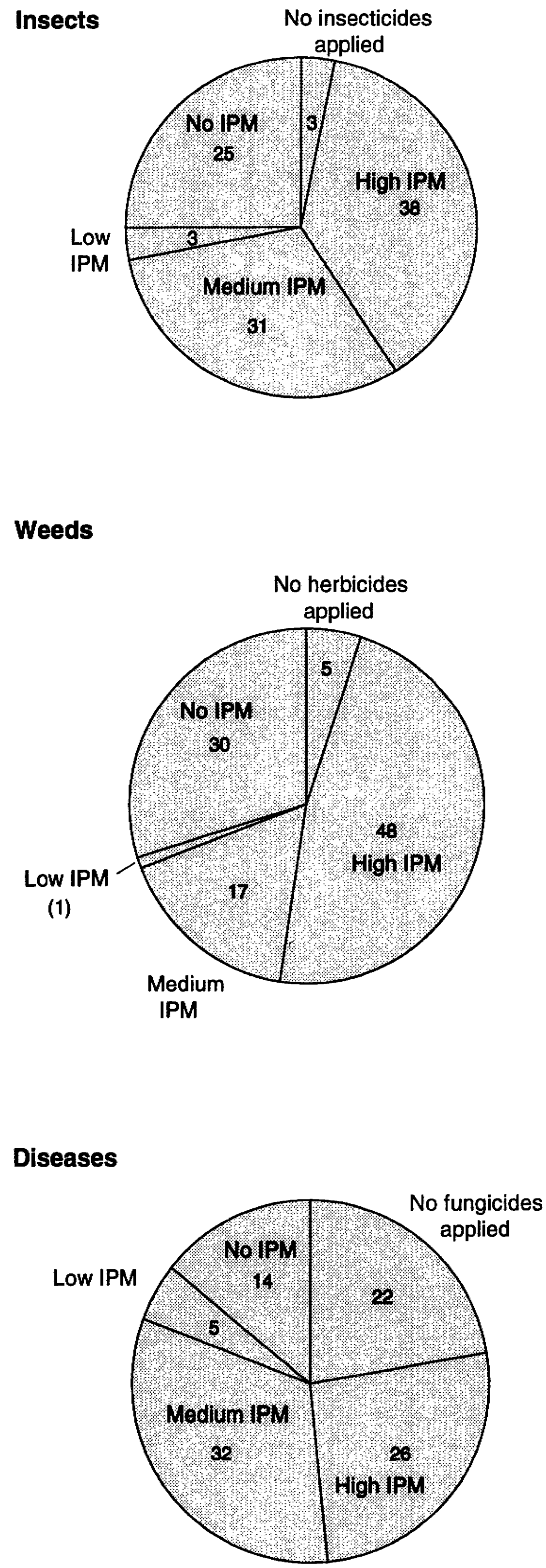
Conclusion

Twenty years of Federal support in IPM research, extension, and incentive programs have resulted in increased acceptance and use of IPM techniques. Farmers have adopted an IPM approach to pest management on about half of all fruit and nut, vegetable, and major field crop acreage (table 26).

Still, levels of adoption vary widely among crops and regions. Some crops have a longer history of IPM research and extension than others, and some regions have focused more resources on developing IPM programs. Pest problems are more severe in some regions, and effective and economically efficient

Figure 9

Fall potatoes under an IPM approach (percent of planted acres), 1992



alternatives to conventional pesticide applications may be unavailable for some crops. Inadequate knowledge of available IPM alternatives, too few crop consultants to deliver IPM services, and the higher managerial input necessary for IPM to be successful are all impediments to adoption.

This report summarizes information available from recent national surveys on pest management techniques and the adoption of IPM. Survey assessments have shortcomings when used as a sole measure of IPM adoption. For example, although a national survey is well suited to estimating the adoption of individual IPM practices, it may fail to measure IPM adopted as a comprehensive system of pest management. Also, regional differences in the content of IPM programs are lost in aggregate. ERS is working to improve data quality and the ability to measure the systems nature of IPM. ERS and NASS are consulting with IPM and crop specialists to refine survey questions, and the Extension Service is working toward developing regional definitions of IPM that can be incorporated in future assessments. Until better measures are available at the national level, this report should be used with other sources, such as the qualitative assessments provided by regional IPM specialists, for a more complete picture of IPM adoption.

Despite their limitations, however, the survey data do provide some insights into where progress can be made. First, IPM can advance through increased adoption of additional pest management practices where few are used. This will require the development and extension of new techniques in addition to those reported here. Second, there is potential for adoption of IPM on acreage where pesticides are still applied with no IPM practices--significant acreage in most crops.

This report is the first in a larger study of the impacts of IPM on pesticide use and farm income. The goal shared by USDA, FDA, and EPA is to reduce the health and environmental risks associated with pesticide use in agriculture. However, IPM may be unacceptable to farmers if it increases economic risks; IPM acceptance will increase only if its economic benefits can be demonstrated. Many studies have shown reductions in pesticide use under IPM with no change or a positive change in economic returns. The next step in analyzing these national surveys is to estimate the reductions in pesticide use and changes in returns that can be expected from IPM adoption.

Table 26--Percentages of fruit, nut, vegetable, and selected field crop acres under an IPM approach, 1991-93

Crop and treated pest	Did not apply pesticides	Applied pesticides	
		No IPM[1]	IPM[2]
	Percent of planted acres		
All fruits and nuts	8	42	50
All vegetables:			
Insects	10	38	52
Weeds	6	60	35
Diseases	30	29	41
Corn:			
Insects	11	15	74
Weeds	2	45	53
Soybeans:			
Weeds	2	39	59
Fall potatoes:			
Insects	3	25	72
Weeds	5	30	64
Diseases	22	14	65

[1] Excludes IPM farmers who did not apply pesticides.

[2] Defined as the use of scouting to determine pesticide application decisions or, in the case of corn, crop rotation to control corn insects.

Source: NASS/ERS 1991 Fruit and Nut Chemical Use Survey, 1992 Vegetable Chemical Use Survey, and 1993 Cropping Practices Survey.

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT #AIB-702

New Report Describes Marketing Practices for Vegetables

August 1994

Contact: Dennis R. Henderson, (202) 219-0866

A new report, *Marketing Practices for Vegetables,* just released from USDA's Economic Research Service describes vegetable marketing practices of first handlers (firms that receive growers' vegetables), provides estimates of each method's prevalence, and explains the basic motivation for each procedure. Over time, these practices have evolved and expanded with some becoming more important than others.

First handlers of vegetables use many methods to acquire and market vegetables. These methods and their prominence are strikingly different for fresh vegetables, fresh precut vegetables, and processed vegetables (see table).

Packer-shippers (firms that receive and sometimes sort, clean, pack, and ship produce) handle most fresh vegetables. These firms pack and sell fresh vegetables that they grow themselves, are grown in joint ventures, or are acquired from growers under marketing contracts. Retailers, wholesalers, institutions, foodservice establishments, and merchants are the principal buyers of fresh vegetables.

Packer-shippers perform different services based on volume of produce handled. For example, large-volume packer-shippers grow much of the fresh vegetables they pack and also sell much of it themselves. They typically use labels and brands to differentiate their products and inform buyers, including consumers, that they are a consistent supplier of known high-quality vegetables. Small-volume packer-shippers, by contrast, pack mostly fresh produce of independent growers and commonly contract with an agency for sales services.

Fresh precut vegetables, in contrast to fresh market vegetables, are mostly sold under agreements or marketing contracts that establish a tentative selling price for vegetables delivered over a 6- to 12-month period to retailers, institutions, and foodservice establishments.

Vegetable processors acquire supplies predominantly by production contracts with growers and also process vegetables they grow themselves. Grower bargaining associations and processors sometimes negotiate the price and other terms established in these contracts. Otherwise, processors establish terms and extend production contracts to selected growers. Processed vegetables are sold to retailers, wholesalers, institutions, and foodservice establishments, usually for spot delivery or deferred delivery as specified in a contract.

The report is the first in a series of bulletins that describe the methods first handlers use to acquire and market farm commodities and to price these commodities.

To Order This Report...

The information presented here is excerpted from ***Marketing Practices for Vegetables,*** AIB-702, by Nicholas J. Powers. The cost is $7.50.

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SUMMARY OF REPORT #AER-688

Costs of Extra Cleaning of U.S. Corn Would Exceed Benefits

June 1994

Contact: William Lin (202) 219-0840

Although foreign buyers have shown a strong preference for clean corn, there is no economic justification to mandate additional cleaning, according to a new report by USDA's Economic Research Service. Costs of additional cleaning to lower the level of broken corn and foreign material (BCFM) below the current level would exceed benefits by $49 million per year. The best strategy for addressing the corn cleanliness issue is to prevent kernel breakage in the first place.

Concern over the quality of grain exported from the United States versus the quality of competitors' grain has increased in recent years. Advocates believe that selling grain that contains higher levels of foreign material than that of our competitors has reduced U.S. competitiveness in the world grain market. (Foreign material includes dirt, weed seeds, pieces of cob, other grains, leaves, stalks, and finely broken corn.) They argue that improving the cleanliness of U.S. grain will increase or retain market share. Critics argue that improving cleanliness will increase marketing costs, reduce profits, and diminish U.S. competitiveness.

In response to a request from Congress, the Economic Research Service (ERS), in cooperation with researchers at land-grant universities and the U.S. grain industry, conducted a study on the costs and benefits of cleaning U.S. grain. *Costs and Benefits of Cleaning U.S. Corn* presents an overview and summarizes two other ERS reports produced in response to this study. The first, *Economic Implications of Cleaning Corn in the United States,* focuses on the costs and domestic benefits of cleaning corn. The second, *The Role of Quality in Corn Import Decisionmaking,* focuses on importers' preferences with respect to cleanliness and other quality factors, and assesses the benefits of cleaning export corn for international markets.

Selling cleaner corn in the international market could help maintain U.S. market shares, but would not likely result in premiums paid by foreign buyers for clean corn. Nor would it likely expand U.S. corn exports. Most exported corn is used for livestock and poultry feed. Feed manufacturers in those markets, like their counterparts in the United States, are tolerant of broken corn if aflatoxin (mold) and insects are not present. Dry millers in those markets use locally produced corn. Wet millers are more stringent in their cleanliness requirements than feed manufacturers, because they must remove BCFM prior to processing. Some are buying the U.S. No. 2 grade, but their quality preferences are not strong enough to induce them to pay a premium for cleaner U.S. corn, or switch their corn purchases from the current grade to better-grade corn.

To Order This Report...

The information presented here is excerpted from ***Costs and Benefits of Cleaning U.S. Corn: Overview and Implications,*** AER-688, by William Lin, Chin-Zen Lin, and Mack Leath. The cost is $9.00.

Two companion reports, ***Economic Implications of Cleaning Corn in the United States,*** AER-686, by Chin-Zen Lin and William Lin, and ***The Role of Quality in Corn Import Decisionmaking,*** AER-684, by Stephanie Mercier, each cost $9.00.

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