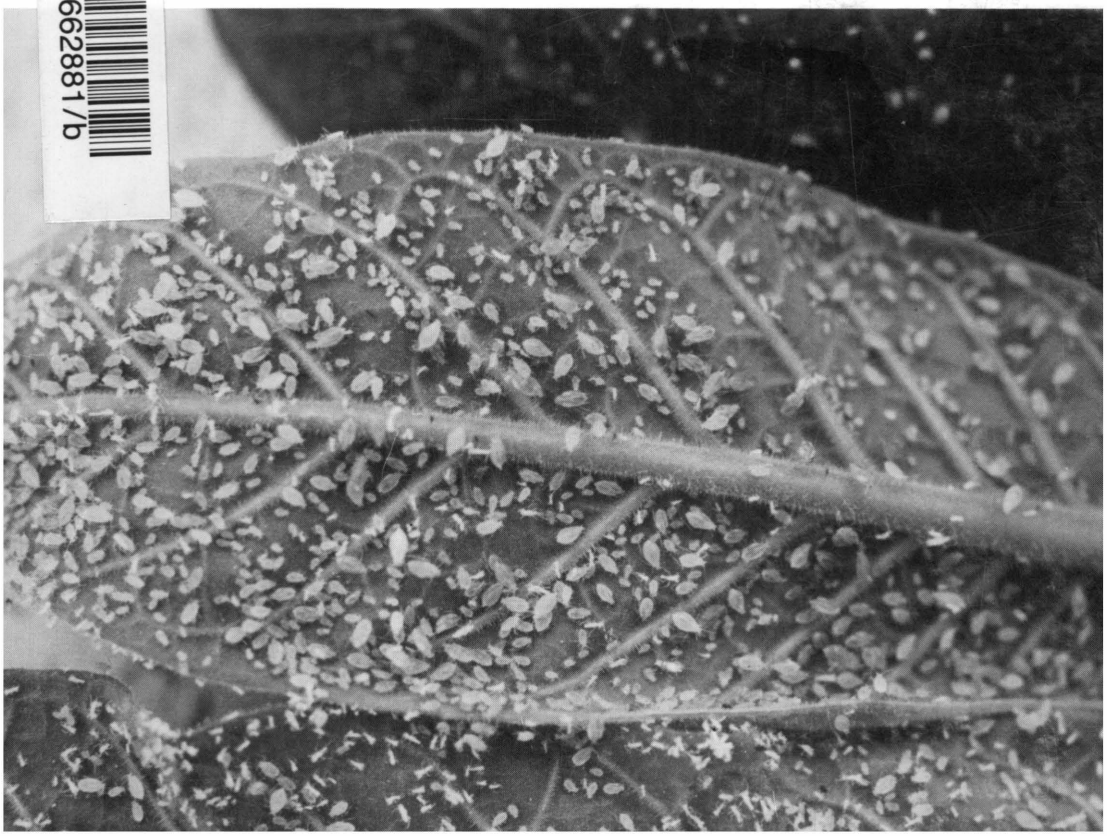
icultural Experiment Station
ytechnic Institute and State University

Bulletin 82-2

Insects and Insecticide Use on Flue-Cured Tobacco in Virginia during 1979

Paul J. Semtner



James R. Nichols, Director

Virginia Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

The Virginia Agricultural and Mechanical College came into being in 1972 upon acceptance by the Commonwealth of the provisions of the Morrill Act of 1862 "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." Research and investigations were first authorized at Virginia's land-grant college when the Virginia Agricultural Experiment Station was established by the Virginia General Assembly in 1886.

The Virginia Agricultural Experiment Station received its first allotment upon passage of the Hatch Act by the United States Congress in 1887. Other related Acts followed, and all were consolidated in 1955 under the Amended Hatch Act which states "It shall be the object and duty of the State agricultural experiment stations . . . to conduct original and other researches, investigations and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including the researches basic to the problems of agriculture and its broadest aspects and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contributions by agriculture to the welfare of the consumer . . . ."

In 1962, Congress passed the McIntire-Stennis Cooperative Forestry Research Act to encourage and assist the states in carrying on a program of forestry research, including reforestation, land management, watershed management, rangeland management, wildlife habitat improvement, outdoor recreation, harvesting and marketing of forest products, and "such other studies as may be necessary to obtain the fullest and most effective use of forest resources."

In 1966, the Virginia General Assembly "established within the Virginia Polytechnic Institute a division to be known as the Research Division . . . which shall encompass the now existing Virginia Agricultural Experiment Station . . . ."

Insects and Insecticide Use on Flue-Cured Tobacco in Virginia during 1979

Paul J. Semtner
Assistant Professor, Entomology

Virginia Polytechnic Institute and State University
Southern Piedmont Research and Continuing Education Center
Blackstone, Virginia 23824

Virginia Agricultural Experiment Station
Bulletin 82-2 May 1982

ABSTRACT

Person-to-person interviews of flue-cured tobacco producers were conducted to determine the major insect pests and insect control practices used on tobacco farms in Virginia during 1979.

Sixty-eight percent of the producers reported no problems with insects in their plant beds during the 1974 to 1979 period. The tobacco flea beetle was the most important insect pest of plant beds while cutworms were second. Sixty-nine percent of the producers used an insecticide on their plant beds; 59% made preventive applications of Di-Syston; and 13% used foliar insecticides.

Tobacco flea beetles and cutworms were considered the most important pests of newly set tobacco during the 1974 to 1979 period, while budworms, hornworms, grasshoppers, and green peach aphids were the major pests of field tobacco. The green peach aphid was, by far, the most serious pest on tobacco during 1979.

Twenty-five percent of the producers used insecticides in the transplant water, 82% used soil insecticides, and 91% made at least one application of foliar insecticides. Isotox (Lindane) was used most frequently in the transplant water. Of the soil insecticides applied before transplanting, Di-Syston, Mocap, and Furadan were used on 47, 38 and 25% of the acreage, respectively. Orthene and Azodrin were the most frequently used foliar insecticides. During 1979 foliar insecticides were applied to flue-cured tobacco an average of 1.65 times. Twenty percent of the producers tank-mixed soil insecticides with herbicides, fertilizer and other chemicals, while 36% of the producers mixed foliar insecticides and sucker control agents.

Of the insecticides used on flue-cured tobacco during 1979, foliar insecticides accounted for only 18% of the actual material, while Mocap, Furadan, and Di-Syston accounted for 35, 20, and 19%, respectively.

ACKNOWLEDGMENTS

Many people provided assistance in planning, data collection and data analysis for this publication. I wish to thank the faculty at the VPI & SU Southern Piedmont Research and Continuing Education Center and the members of the Extension Tobacco Industry Committee for their assistance in developing the questionnaires and planning the survey. Special thanks go to the State Executive Director, the County Executive Directors and the secretaries of the United States Department of Agriculture-Agriculture Stabilization and Conservation Service for permission to use their files and for their assistance in selecting producers for this study. I am indebted to those County Extension Agents who helped to contact, and, in some cases, interview participating growers. I would like to express my gratitude to the interviewers for the fine jobs they did in contacting and interviewing the growers. Most of all I would like to thank the producers who took time out from their busy schedules to respond to our questions.

This project was funded by a grant from the Virginia Bright Flue-Cured Tobacco Commission.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

LIST OF APPENDIX TABLES

INTRODUCTION

Tobacco is the leading cash crop in Virginia. Annually it accounts for about one-third of the state's income from crops. Of the four types of tobacco grown in Virginia, flue-cured tobacco represents 80% of the acreage. During 1979, flue-cured tobacco was grown on 52,000 acres and had a gross farm value of $127.5 million.

Despite its unique chemical composition, flue-cured tobacco is attacked by insects in the field from the time it germinates in the plant bed until it is harvested. Rabb et al. (1955) reported eight insect pests of tobacco plant beds. However, during the last two decades most research on insects in tobacco plant beds has been concentrated on the control of the tobacco flea beetle, Epitrix hirtipennis (Melsheimer) (Dominick 1972, Mistric and Smith 1972). The tobacco flea beetle, several species of cutworms [including the black cutworm, Agrotis ipsilon (Ratt); the granulated cutworm, Feltia subterranea (F.); and the variegated cutworm, Peridroma marguritosa (Haw.)] and wireworms, primarily Conoderus spp., are serious pests of newly transplanted tobacco (Rabb et al. 1955). The insect pests of field tobacco include the tobacco hornworm, Manduca sexta (L.); the tomato hornworm, M. quinquemaculata (Haw.); the tobacco budworm, Heliothis virescens (F.); the green peach aphid, Myzus persicae (Sulzer); the tobacco flea beetle; grasshoppers, primarily the redlegged grasshopper, Melanoplus femurrubrum (De Geer), and the differential grasshopper, M. differentialis (Thomas); and the Japanese beetle, Popillia japonica Newman (Rabb et al. 1955).

Baumhover (1981) listed nine insecticides that were labeled for the control of specific insects in tobacco plant beds. These include diazinon, Dylox, malathion, Orthene, Parathion, Proxol and a systemic insecticide, Di-Syston (disulfoton), which provides

good control of tobacco flea beetles and green peach aphids (Mistric and Smith 1972, Dominick 1972).

Since water is used during transplanting, insecticides are frequently added to it to help control soil insects and, sometimes, insects feeding on the tobacco foliage (Guthrie et al. 1960 and Johnson 1980). Insecticides applied in the transplant water include diazinon, Vydate and Orthene (Semtner 1982).

Several insecticides are labeled for application to the soil prior to transplanting for wireworms, or to act as a systemic insecticide to control insects that feed on tobacco foliage. Di-Syston and Furadan are labeled as pretransplant soil treatments for insects feeding on tobacco foliage,while Dasanit, Mocap, Dyfonate, Diazinon and Parathion are applied in the same manner for wireworms (Semtner 1982).

Baumhover (1981) listed 14 insecticides that are labeled as foliar treatments for at least one of 10 different insect pests of tobacco. These insecticides include: Azodrin, Bacillus thuriengensis (Berlinger) (Biotrol/Dipel/SOK-BT/Thuricide), Cygon/Defend, Diazinon, Dylox/Proxol, Guthion, Lannate/Nudrin, Malathion, Orthene, Parathion, Penncap M, Sevin, Supracide and Thiodan. Mistric and Smith (1973 a, 1973 b), Mistric et al. (1978), and Mistric and Clark (1979) have reported on the efficacy of a number of these insecticides for various insects on tobacco.

There have been several studies of pesticide use on tobacco in recent years. Carter et al. (1980) reported that Sevin, Di-Syston and diazinon were the most commonly used insecticides on burley tobacco in Ohio during 1978, while small amounts of Furadan, malathion, Orthene and Dylox were also used. A similar report for burley and cigar tobaccos grown in the North Central states (Ohio, Indiana, Missouri, and Wisconsin) (Waldron and Park 1981) indicated that Sevin and Diazinon were most heavily used, while Di-Syston, Furadan, Supracide, Cygon, Malathion, Dylox and Orthene were used to a lesser extent. Fox et al. (1968), Andrilenas (1975) and Eichers et al. (1978) conducted extensive pesticide-use surveys for all crops grown in the United States during 1966, 1971 and 1976, respectively. Eichers et al. (1978) reported that 76% of

the tobacco acreage in the United States (80% in the Appalachian region - Virginia, North Carolina, West Virginia, Kentucky and Tennessee) was treated with insecticides during 1976. This was a slight reduction from 82% of the acreage treated with insecticides during 1971. Only 59% of the producers used insecticides during 1976 because producers with small acreages used fewer insecticides than those with large acreages. Producers used an average of 4.1 lbs. of active ingredient (a.i.) of insecticide/acre during 1976, compared to 5.7 lbs. a.i. of insecticide/acre during 1971. During 1976, Mocap, Lannate/Nudrin and Sevin accounted for 25, 22, and 16% of the insecticides used on tobacco, respectively (Eichers et al. 1978). Other insecticides in order of the amount used included Di-Syston, Azodrin, Dasanit, malathion, Thiodan, Furadan, parathion, diazinon, methyl parathion, Bacillus thuringiensis, Cygon, and Dylox. None of the papers mentioned here give a good indication of insecticide use on flue-cured tobacco in Virginia. Carter et al. (1980) and Waldron and Park (1981) surveyed pesticide use on different types of tobacco in different regions of the United States. Eichers et al. (1978) combined all tobacco types by region when reporting on insecticide use. This report included Virginia in the Appalachian region (Virginia, North Carolina, Tennessee, Kentucky and West Virginia), which is the major production area for both the burley and the flue-cured tobacco types. Since insecticide-use patterns between the two types of tobacco are very different, the insecticide use on flue-cured tobacco is probably different than that reported by Eichers et al. for all tobacco types.

A thorough knowledge of the strengths and weaknesses of flue-cured tobacco production in Virginia is important for the development of effective research and extension programs and of programs to enhance existing production methods and help solve major production problems. This study contributes to that necessary knowledge by providing information on the insecticides used on tobacco.

Data on major insect problems, insecticide use, and application methods will also be helpful in studying many tobacco insecticides during the Rebuttable Presumption Against Registration (RPAR)

process. The Environmental Protection Agency (EPA) has the responsibility of re-evaluating those pesticides that may present important hazards to the user, to nontarget organisms, and to the environment. The EPA has developed a list of the pesticides that are now in the process of being reviewed for re-registration; and several of these pesticides are currently used on tobacco. The risks of major concern are: potential mutagencity, reproductive effects, chronic toxicity, and harmful effects on nontarget organisms. The review process (RPAR) is being used to assess both the economic benefits of the pesticide and its harmful effects. The primary benefits that are considered include the pests controlled, alternatives to the pesticide, and changes in crop production costs if the chemical is not used and if no chemical is used in its place. To develop accurate estimates of an insecticide's value to a crop, it is necessary to determine how much is being used, the primary target pests, and a list of chemicals that can be used to replace it.

During 1979, selected growers were interviewed; the results of these interviews were used to develop a profile of flue-cured tobacco production in Virginia. This paper reports on the producers' responses to questions related to insects and insect control practices on tobacco, and recommendations are made to help improve insect control practices. The specific information obtained in the survey included: 1) insecticides used in plant beds, as soil treatments, transplant water treatments, and foliar sprays on field tobacco; 2) the number of insecticide applications made during the season; 3) the methods of insecticide application; and 4) the common insect pests on plant beds, newly transplanted tobacco, and larger field tobacco.

PROCEDURES

Flue-cured tobacco producers were selected at random within four farm allotment-size strata and seven regional (county) strata. Samples were taken from tobacco allotment files maintained in the county offices of the United States Department of Agriculture-Agricultural Stabilization and Conservation Service (ASCS). The allotment-size categories (strata) and their estimated percentage of total flue-cured tobacco production in Virginia were as follows: I, less than 6 acres, 21%; II, 6 to 11 acres, 25%; III, 12 to 21 acres, 25%; and IV, more than 21 acres, 29%.

Samples were taken from 14 counties that controlled 96.3% of the flue-cured tobacco allotment in Virginia. The counties were grouped into seven regions (Figure 1, Table 1). The regions and the percent of total flue-cured tobacco allotment within the regions are: Southwest, Patrick-Henry, 3.9%; West-Central, Pittsylvania-Franklin, 31.1%; South-Central, Halifax, 20.8%; East-Central, Mecklenburg, 14.4%; Northwest, Campbell-Charlotte 7.8%; Northeast, Amelia-Nottoway-Prince Edward, 4.0%; and Southeast, Brunswick-Dinwiddie-Lunenburg, 18.0%.

Three questionnaires were prepared to cover all aspects of flue-cured tobacco production. Yes-no, multiple choice, and fill-in-the-blank questions were included on each. The first, second, and third questionnaires included 82, 46 and 31 main questions, respectively. Appendix I contains the insect and insect control questions from each questionnaire. The first questionnaire, which was completed during June and July, had questions on insect pests of plant beds, newly transplanted tobacco, and field tobacco during May and June and questions on the insecticides used on tobacco plant beds and newly transplanted tobacco. The second questionnaire, completed between August 10 and September 15, included questions on insect pests on field tobacco and pesticide use. The third questionnaire, completed between October 15 and December 15, included questions

on late season insect pests and insecticide applications. To establish background information, producers were also asked which insects had caused the most problems on their crop during the 5 previous seasons and which foliar insecticides they had used during that time period.

In addition to questions dealing with insects and insect control, producers were asked questions about transplant production, transplanting, fertilization, weed and disease problems and their control, topping and sucker control, harvesting, curing, labor requirements and equipment use. Responses to these will be published in the future. There were 244, 226, and 216 respondents to questionnaires 1, 2, and 3, respectively.

Interviewers contacted and interviewed the producers selected to participate in this survey. To help standardize the interview techniques, the interviewers were trained during two 3-hour workshops conducted by an extension agronomist, a plant pathologist and physiologist, and an entomologist. The workshops were held before each of the first two interview periods (questionnaires #1 and #2). They covered information on tobacco production recommendations, major production practices, pest problems, survey and interview techniques, and simulated interviews using the questionnaires.

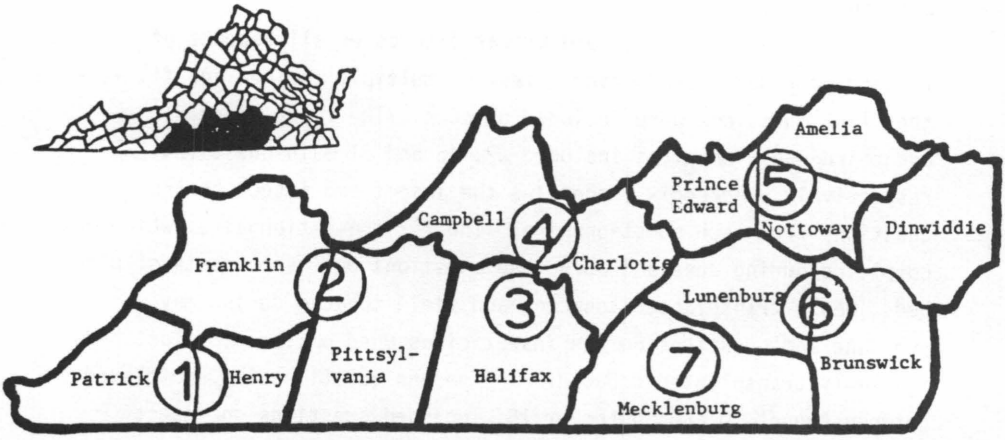


Figure 1. Regions of Virginia used in the survey of flue-cured tobacco production during 1979. The regions are as follows: 1) Southwest; 2) West-Central; 3) South-Central; 4) Northwest; 5) Northeast; 6) Southeast; and 7) East-Central.

Table 1. Flue-cured tobacco acreage, pounds marketed, and number of producers participating, by region, Virginia, 1979*

Region** and county	Allotted acreage	Pounds marketed (1000 lbs)	Number of producers interviewed — Farm size category† I	II	III	IV	Total
Northeast							
Amelia	845	1,182					
Nottoway	999	1,413					
Prince Edward	679	929					
TOTAL	2,523	3,524	5	4	5	6	20
Northwest							
Campbell	1,341	2,543					
Charlotte	2,832	4,437					
TOTAL	4,173	6,980	7	14	5	8	34
Southeast							
Brunswick	4,177	6,456					
Dinwiddie	2,359	3,818					
Lunenburg	3,781	5,781					
TOTAL	10,317	16,055	10	8	16	12	46
East Central							
Mecklenburg	8,744	12,799	4	3	6	10	23
South Central							
Halifax	12,029	18,462	9	13	7	12	41
West Central							
Franklin	2,144	3,582					
Pittsylvania	14,578	24,042					
TOTAL	16,722	27,624	13	13	16	11	53
Southwest							
Henry	967	1,392					
Patrick	1,730	2,106					
TOTAL	2,697	3,498	16	7	3	1	27
Other	2,178	3,323					
State total	59,383	92,265	64	62	58	60	244

* The acreage allotments and pounds marketed are from ASCS annual report for 1979. Virginia Agricultural Stabilization and Conservation Service of the United States Department of Agriculture, Richmond, VA.

** See Figure 1 for a map of the tobacco-producing counties included on the survey.

† The allotment farm-size categories are: I, fewer than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

Interviewers and Extension Agents telephoned the participating producers and established schedules for interviews. A questionnaire was completed during each interview. If a producer could not respond to a specific question, a list of possible answers was read to him and his choice was recorded. Most problems experienced by interviewers were corrected through telephone conversations or personal contacts. Producers normally responded to the questions from memory, but they sometimes had to consult their records or their pesticide storage building to determine which insecticides they had used. The major insect pests that occur on tobacco are normally easy to separate by the novice, since each has a distinctive physical characteristic or feeding habit. Some responses, however, were incomplete and had to be excluded from the analysis.

Responses were coded and entered into a computer for analysis by allotment-size and geographical region. State averages for each variable were determined by weighting the responses of the producers from each region to that region's percent of the total acreage or number of producers in the seven regions that were sampled. The equation used to make those determinations is:

$$SA = (RA_1 \times CF_1) + (RA_2 \times CF_2) + (RA_3 \times CF_3) + (RA_4 + CF_4) + (RA_5 \times CF_5) + (RA_6 \times CF_6) + (RA_7 \times CF_7)$$

SA = state average;

RA_x = the percent of producers in the region who performed a specific practice; and

CF_x = the conversion factor used to weight the regional results.

The conversion factors for each region were: CF_1, Northeast, 0.039; CF_2, Southeast, 0.180; CF_3, Northwest, 0.078; CF_4, West-Central, 0.311; CF_5, South-Central, 0.208; CF_6, Southwest, 0.039; and CF_7, East-Central, 0.144.

RESULTS

The growers who participated in this survey produced about 8% of the flue-cured tobacco grown in Virginia during 1979, but they made up only 3% of the growers in the state. The stratification by farm size contributed to the difference in percentage of the producers and the allotments they controlled. Table 1 summarizes the allotment-size ranges and geographic regions of participating growers. The farm-size stratification worked fairly well in most regions, but the sample from the Southwest region was larger than planned and was skewed to the smaller farm allotments. Samples from most other regions were fairly well distributed among the farm-size strata. Data presented in this paper are based on the assumption that the responses of producers within farm-size and regional strata are representative of that classification.

Plant Bed Insects

During the 1974 to 1979 period, insects caused limited damage to flue-cured tobacco seedlings grown in plant beds in Virginia (Table 2). For example, 83 and 68% of the producers indicated that insects were not a problem in plant beds during 1979 and the five previous seasons (1974-1978), resectively. The tobacco flea beetle was, by far, the most important pest during both periods, while green peach aphids and cutworms caused occasional problems.

Insect problems on tobacco plant beds were reported most often in the Southwest, South-Central, and Northeast regions and least frequently from the West-Central region (Table 2). During the 1974 - 1978 period, 41 and 30% of the producers in the Southwest region had problems with flea beetles and cutworms, respectively. In contrast, producers in the West-Central region reported no problems with flea beetles, and only 2% of the beds were infested with cutworms.

Table 2 also shows the frequency of insect damage to tobacco plant beds on farms with different allotment sizes. Plant beds on

Table 2. Insect problems on plant beds of flue-cured tobacco by region and farm allotment size, Virginia, 1979.

Region*	1974 through 1978				1979	
	Tobacco** flea beetles	Cut-worms	Green peach aphids	No insect problem	Tobacco** flea beetles	No insect problem
	Percent of producers					
NE	40	0	0	55	20	60
SE	38	2	0	64	13	80
NW	25	6	17	51	0	94
WC	0	2	0	94	2	96
SC	52	2	2	47	24	70
SW	45	30	7	33	15	78
EC	22	0	0	70	8	83
Weighted state average†	27	3	2	68	10	83
Allotment-size category ††						
I	25	9	2	64	10	83
II	37	6	9	56	12	87
III	32	5	0	58	8	81
IV	24	2	3	72	14	77

* See Figure 1 for counties in each region.

**Includes 'flies' which is a common name for tobacco flea beetles found in plant beds.

† See formula on page 8.

††Allotment-size categories are as follows: I, fewer than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

farms in size Category II (6-11 acres) had the highest incidence of flea beetles, while cutworms were most common on farms in Category I (less than 6 acres).

Insecticide Use in Tobacco Plant Beds

Sixty-nine percent of the growers used insecticides on their plant beds during 1979 (Table 3). Di-Syston was used by 59% of the producers, while insecticides applied as foliar sprays (Orthene, Dylox/Proxol, Sevin, malathion and parathion) were used by another 13% (Table 3). Of the producers using Di-Syston on plant beds, 57% applied it when the leaves of seedlings were 0.5 to 1.2 inches in

Table 3. Insecticide use and methods of application to flue-cured tobacco plant beds by region and farm-allotment size, 1979

Region*	Insecticides used			Time of Di-Syston application		
	Di-Syston	Other**	Total	At seeding	Dime to half-dollar in size	2 weeks before pulling
	Percent of producers					
NE	45	10	50	35	15	0
SE	51	4	55	24	26	0
NW	40	15	51	14	26	3
WC	83	14	88	31	48	6
SC	52	17	69	21	29	2
SW	44	23	63	33	7	0
EC	49	13	62	8	39	0
Weighted state average†	59	13	69	23	34	2
Allotment-size category††						
I	42	16	56	19	21	2
II	57	15	72	23	34	0
III	53	9	62	28	24	5
IV	66	7	69	26	38	2

* See figure 1 for counties in each region.

**Orthene, Dylox/Proxol, Sevin, Malathion, and Parathion.

† See formula on page 8.

††Allotment size categories are as follows: I, fewer than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

diameter, 41% applied it at seeding, and 3% made an application about a week before transplanting. Producers with large allotments (farm-size Category IV - more than 21 acres) used Di-Syston on plant beds most frequently, while those in Categories I and II had the most frequent use of insecticides applied as foliar sprays (Table 3). Of the producers using insecticide sprays on plant beds, 27% applied treatments on a regular schedule, 25% treated when insects were first observed, 40% used visual population assessments to determine when to treat and 8% treated only when serious damage was observed.

Table 4 shows the number of insecticide applications made to tobacco plant beds. Sixty-one percent of the producers made one

Table 4. Number of insecticide applications to flue-cured tobacco plant beds by region and farm allotment-size, Virginia, 1981.

Region*	Number of insecticide applications				
	0	1	2	3	4-6
	----------Percent of producers----------				
NE	50	35	15	0	0
SE	44	53	2	0	0
NW	49	34	11	3	3
WC	12	85	0	2	2
SC	31	57	7	3	0
SW	37	41	11	7	4
EC	39	57	0	4	0
Weighted state average**	31	61	4	2	1
Allotment-size category†					
I	44	47	5	2	2
II	28	59	6	4	1
III	38	57	2	2	0
IV	29	57	10	2	2

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment size categories are as follows: I, fewer than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

insecticide application per season, 7% made two or more applications and 31% did not use an insecticide on their plant beds during 1979. Table 4 also presents the percent of producers using specific numbers of insecticide applications within each allotment-size category. In addition to the insecticides, 94% of the growers used methyl bromide on their plant beds for weed and disease control and some control of soil-inhabiting insects may have resulted.

Seventy-eight percent of the producers destroyed their plant beds from 1 week to 1 month after transplanting was completed; 17% destroyed plant beds 1 to 3 months after transplanting; and 3% of the plant beds were not destroyed until the fall or the following spring. Early destruction of the plant bed reduces the potential for disease buildup and it may play a role in reducing insect problems.

Insects on Newly Transplanted Tobacco

Cutworms and tobacco flea beetles were considered the most important pests of newly transplanted tobacco, while wireworms were less important (Table 5). During 1979, cutworms were considered problems on 10 to 17% of the farms in all regions except the Southeast and East-Central (Table 7). Over the five previous seasons, cutworms were most frequently reported on tobacco in the Southwest, Northwest, South-Central and Northeast regions. Problems with tobacco flea beetles and wireworms were reported most frequently in the Northwest and Southwest regions. Producers in farm-size Categories I and II reported the highest frequency of problems with cutworms and wireworms on newly transplanted tobacco (Table 5). Producers with farms in Category II reported the highest incidence of flea beetles.

Table 5. Insect problems on newly transplanted flue-cured tobacco by region and farm allotment-size category, Virginia, 1974-1979.

	Time period and insect					
	1974 through 1978			1979		
Region*	Cut-worms	Wire-worms	Tobacco flea beetles	Cut-worms	Wire-worms	Tobacco flea beetles
NE	25	5	10	10	5	5
SE	13	4	9	0	0	7
NW	46	9	34	11	6	17
WC	13	4	4	17	2	6
SC	23	7	26	12	2	7
SW	30	15	26	15	15	44
EC	9	4	0	0	0	0
Weighted state average**	18	5	14	10	2	8
Allotment-size category†						
I	30	9	17	13	4	6
II	27	8	34	10	3	15
III	16	3	12	3	2	14
IV	14	2	9	12	2	7

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, fewer than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

Insects on Field Tobacco, 1974 to 1978

The tobacco budworm, Heliothis virescens (F.), was considered a serious pest by 34% of the growers during the 1974 to 1978 period, while hornworms (Manduca spp.), grasshoppers (Melanoplus spp.), green peach aphids, and tobacco flea beetles were considered major pests by 27, 27, 18, and 11% of the growers, respectively (Table 6). Budworms were most common in the Southeast and South-Central regions and least abundant in the Southwest region. Hornworms were most serious in

Table 6. Frequency of insect problems on established field tobacco by region, Virginia, 1974-1979.

Time period and insect	Region*							Weighted state avg.**
	NE	SE	NW	WC	SC	SW	EC	
	----------Percent of producer----------							
1974 through 1978:								
Tobacco budworms	25	40	26	30	49	7	30	34
Hornworms	40	40	23	23	30	7	17	27
Green peach aphids	35	33	43	2	12	22	26	18
Tobacco flea beetles	10	9	17	9	14	33	4	11
Grasshoppers	5	11	46	55	12	4	9	27
June 1 to July 15, 1979:								
Tobacco budworms	25	31	11	25	33	19	13	25
Hornworms	40	18	26	25	2	15	13	17
Green peach aphids	35	27	26	2	0	22	43	16
Tobacco flea beetles	0	0	9	6	9	59	0	7
Grasshoppers	10	4	31	4	5	4	0	6
July 1 to Sept. 1, 1979:								
Tobacco budworms	0	2	12	6	7	4	5	5
Hornworm	10	11	3	14	3	9	10	9
Green peach aphid	90	78	86	88	70	74	57	77
Tobacco flea beetles	0	0	6	6	9	4	5	5
Grasshoppers	0	0	15	6	12	4	10	7
August 15 to Oct. 15, 1979:								
Hornworms	59	72	71	36	50	22	52	51
Tobacco flea beetles	29	8	77	21	53	43	14	30

* See Table 1 for a list of counties in each region.

**See formula on page 8.

Table 7. Frequency of insect problems on established flue-cured tobacco by farm-allotment size, Virginia, 1974 to 1979.

Time period and insect	Allotment-size category* I	II	III	IV
	--------Percent of producers---------			
1974 through 1978:				
Tobacco budworms	22	29	31	50
Hornworms	24	31	33	22
Green peach aphids	9	24	28	26
Tobacco flea beetles	15	16	7	14
Grasshoppers	33	24	24	19
June 1 to July 15, 1979:				
Tobacco budworms	19	24	26	26
Hornworms	15	24	24	17
Green peach aphids	11	18	24	17
Tobacco flea beetles	4	13	14	3
Grasshoppers	7	5	9	12
July 1 to Sept. 1, 1979:				
Tobacco budworms	4	7	2	9
Hornworms	6	8	11	9
Green peach aphids	64	83	77	75
Tobacco flea beetles	8	7	2	4
Grasshoppers	11	3	5	9
August 15 to Oct. 15, 1979:				
Hornworms	36	56	57	75
Tobacco flea beetles	29	43	31	41

*Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; and IV, more than 21 acres.

the Northeast and Southeast regions, while the Southwest region had the lowest incidence. Tobacco flea beetles were most serious in the Southwest region. Green peach aphids were of greatest concern to producers in the Northwest, Northeast and Southeast regions, while they caused the least problem in the West-Central and South-Central regions. Grasshoppers were most frequently a problem in the West-Central (55%) and Northwest (46%) regions. In each of the other regions 12% or fewer producers reported problems with grasshoppers.

Insects on Tobacco, 1979

During the early season (June 1 to July 15), budworms caused the greatest concern among tobacco producers (Table 6). Twenty-five to 33% of the growers in the West-Central, South-Central, Southeast and Northeast regions reported problems with budworms. However, they caused few problems in the East-Central and Northwest Regions. Tobacco flea beetles caused early season injury on 59% of the farms in the Southwest region, while 10% or fewer of the tobacco farms in other regions were seriously affected. Grasshoppers were considered problems on 31% of the acreage in the Northwest region, while less than 10% was affected in the other regions (Table 6). The first brood of hornworms (June and early July outbreaks) caused the greatest concern in the Northeast, Northwest, and West-Central regions, while they were least common in the South-Central region. A small number of producers also reported problems with the Japanese beetle, Popillia japonica Newman.

The green peach aphid, which affected the tobacco on 77% of the farms, was the most serious pest between July 15 and September 1 (Table 6). The most serious infestations of green peach aphids occurred in the Northeast (90% of the farms) and the West-Central (88% of the farms) regions. All other regions except the East-Central (48%) had aphid problems on 70% or more of the tobacco farms. Other insects caused very few problems on tobacco during this period (Table 6). Hornworms, grasshoppers, flea beetles, budworms and other insects were reported as problems on 8, 7, 5, 5 and 3% of the acreage, respectively.

After August 15, 1979, hornworms and flea beetles were the most important insect pests (Table 6). Hornworms were of greatest concern on tobacco in the Northwest and Southeast regions, while they were least serious in the West-Central and Southwest regions. Tobacco flea beetles were most common in the Northwest region, while they caused little injury in the Southeast and East-Central regions.

There were a number of differences in the frequency of insect problems among the farm-size categories (Table 7). For instance, producers in farm-size Category IV were more concerned with budworms

than producers in Category I; while producers in Category I reported fewer problems with green peach aphids and more problems with grasshoppers during the 1974 through 1978 period than did producers in other farm-size categories. During the August 15 to October 15, 1979 period, hornworms were considered more serious on farms in Category IV (Table 10).

Insecticides in the Transplant Water

The use of insecticides in the transplant water is still popular among tobacco producers because it is relatively easy to do and provides some protection for young transplants (Table 8).

Table 8. Insecticides used as transplant water treatments on flue-cured tobacco by region and by farm-allotment size, Virginia, 1979.

Region*	Insecticide				
	Diazinon	Isotox**	Vydate	Other	Total insecticides
	Percent of producers				
NE	10	0	5	5	25
SE	0	7	2	2	13
NW	11	20	0	3	34
WC	13	13	2	6	34
SC	2	16	5	0	23
SW	7	7	4	4	22
EC	13	9	0	0	22
Weighted state average †	8	12	2	3	25
Allotment-size category††					
I	9	9	0	6	24
II	10	18	2	2	32
III	5	14	5	3	27
IV	7	7	2	2	18

* See Figure 1 for counties in each region.

**Lindane

† See formula on page 8.

††Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

Table 9. Soil insecticide-nematicides used on flue-cured tobacco by region and farm allotment-size, Virginia, 1979

Region*	Insecticide-nematicide									Soil insecticides nematicides used††
	Dasanit-Di-Syston or Dasanit	Di-Syston alone	Di-Syston total**	Furadan	Mocap	Mocap plus	Mocap total	Fumigants†	Other insecticides	
	Percent of producers									
NE	0	5	80	20	15	60	75	0	0	90
SE	2	2	55	11	18	51	69	2	2	89
NW	3	20	57	34	0	34	34	0	3	79
WC	13	11	47	23	11	23	34	2	0	87
SC	18	5	42	35	5	19	24	2	0	74
SW	0	15	15	11	0	4	4	4	6	37
EC	4	13	43	35	9	26	35	9	0	83
Weighted state average†††	9	9	48	25	10	29	39	3	<1	82
Allotment-size category††††										
I	11	2	35	19	9	26	35	2	2	69
II	10	13	52	18	5	31	36	3	3	79
III	7	9	56	21	7	40	47	0	0	83
IV	3	2	40	36	10	34	44	0	0	88

* See Figure 1 for counties in each region.

** Di-Syston alone and in combination with Mocap, Dasanit, and Furadan.

† Shell D-D, Telone C-17 and Terr-o-cide 30.

†† Line totals are not equal to the total for insecticide-nematicides used because combinations of two or more chemicals were used on the same farm.

††† See formula on page 8.

†††† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

One-fourth of the producers interviewed used some type of insecticide in the transplant water. Isotox (Lindane), which was not recommended because of reports of wireworm resistance and residue problems, Diazinon, and Vydate were used by 12, 8 and 2% of the producers, respectively (Table 8). Transplant water treatments were most widely used in the Northwest and West-Central regions and least frequently used in the Northeast region. Transplant water treatments were used least frequently on large farms (Table 8).

Soil Insecticide - Nematicides

Table 9 shows that soil insecticides-nematicides were applied to 82% of the flue-cured tobacco acreage in Virginia during 1979. The soil insecticide-nematicides used and the percent of the acreage

Table 10. Formulation of soil insecticide-nematicides applied to flue-cured tobacco by region and farm-allotment size, Virginia 1979.

Region*	Pesticide formulation	
	Granular	Liquid
	---Percent of producers----	
NE	50	40
SE	72	13
NW	37	23
WC	75	9
SC	37	33
SW	26	7
EC	48	35
Weighted state average**	57	21
Allotment-size category†		
I	59	9
II	52	21
III	53	28
IV	55	33

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

treated with each are as follows: Di-Syston (alone or in combination with Mocap, Dasanit, or Furadan), Mocap (alone or in combination with Di-Syston or Furadan), Furadan, Dasanit, and fumigants (Telone C-17, Telone II and Terr-o-cide) were applied to 47, 38, 25, 9 and 3% of the acreage, respectively.

The amounts of soil insecticide-nematicides used by producers differed considerably among the regions (Table 9). For instance, only 41% of the flue-cured tobacco acreage in the Southwest region was treated with soil insecticide-nematicides, while more than 70% of the acreage in all other regions was treated. The percent of producers using soil insecticides was related to allotment size

Table 11. Methods used to apply soil insecticide-nematicides to flue-cured tobacco by region and farm-allotment size, Virginia, 1979.

Region*	Application Method	
	Band	Broadcast
	---Percent of producers----	
NE	5	85
SE	7	82
NW	20	51
WC	62	25
SC	30	45
SW	30	7
EC	35	48
Weighted state average**	35	46
Allotment-size category†		
I	33	35
II	32	45
III	28	53
IV	26	62

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

Table 12. The use of tank-mix combinations of pesticides for weed, disease, insect and sucker control on flue-cured tobacco by region and by farm-allotment size, Virginia, 1979.

Region*	Tank-mix combination: Pretransplant for weed disease and insect control	Tank-mix combination: Insecticide-sucker control chemical
	Percent of producers	
NE	35	50
SE	13	47
NW	23	65
WC	13	25
SC	33	30
SW	11	14
EC	13	19
Weighted state average**	20	36
Allotment-size category†		
I	16	35
II	16	33
III	19	38
IV	30	46

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

(Table 9). Soil insecticide usage ranged from 69% for Category I to 88% for Category IV.

Granular formulations of soil insecticides were used on 59% of the tobacco acreage, while liquids were used on 21% (Table 10). Liquid formulations were most widely used in the Northeast and East-Central regions, while granules were used most frequently in the West-Central region. Liquid formulations of soil insecticide-nematicides were most frequently used on farms in allotment-size Categories III and IV, while they were rarely used on farms in Categories I and II (Table 10).

Soil insecticide-nematicides were applied broadcast to 46% of the acreage, while band applications were made to 35% (Table

Table 13. Equipment used to apply preplant soil-incorporated insecticide-nematicides on flue-cured tobacco by region and farm-size, Virginia, 1979.

Region*	Equipment			
	Granular Applicator	Fertilizer Spreader	Grain Drill	Tractor Sprayer
	----------Percent of producers----------			
NE	5	15	30	40
SE	16	20	36	13
NW	14	17	6	23
WC	62	9	4	9
SC	28	9	0	33
SW	15	11	0	7
EC	22	9	17	35
Weighted state average**	33	12	12	21
Allotment-size category†				
I	33	9	11	9
II	29	11	11	21
III	28	10	16	28
IV	21	21	12	29

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

11). Band applications were most popular in the West-Central region, while broadcast applications were used most frequently in the Northeast and Southeast regions (Table 11). Of the producers who used soil insecticide-nematicides, 48, 42, 35 and 30% made band applications in Categories I, II, III and IV, respectively. Table 11 also shows the use of band and broadcast applications of soil insecticides by allotment-size category during 1979.

About 20% of the tobacco acreage was treated with various tank-mix combinations of insecticides, herbicides and liquid fertilizers (Table 12). Since liquid formulations of soil insecticide-nematicides were applied to 21% of the acreage, it appears that most were used in tank-mix combinations.

Table 13 shows the types of equipment used to apply soil insecticide-nematicides. Granular formulations were applied most frequently with granular applicators, while tractor sprayers were used most often to apply liquid formulations.

Tank Mixes of Insecticides, Other Pesticides or Fertilizers

Tank-mix combinations of preplant soil-incorporated insecticides, herbicides and fertilizers were used by 20% of the growers, while 36% tank-mixed insecticides and sucker control agents (Table 12). Pretransplant tank mixes of insecticides with other pesticides or liquid fertilizers were used most frequently in the Northeast and South-Central regions, and least frequently in the Southwest, West-Central and East-Central regions. Producers in Category IV used pretransplant tank-mix combinations most often (Table 12).

Insecticides Applied to Field Tobacco

Table 14 lists the insecticides applied as foliar sprays to flue-cured tobacco during the 1974 to 1978 and 1979 periods. Orthene was used most frequently during both periods, but it was used only slightly more often than Azodrin during 1979. However, more Azodrin (lbs. of active ingredient) was used because its application rates are higher than Orthene's (Table 15). Lannate was third in acres treated, but the amount of active ingredient used on tobacco was less than that for malathion, Sevin, and Penncap M.

Orthene was used most frequently in the Southeast and Northwest regions, while it was used least often in the West-Central and Southwest regions (Table 14). The highest level of Azodrin use was in the West-Central region, while the lowest level of use was in the South-Central and East-Central regions. The highest percentage of Lannate and Malathion was in the Northeast region; Sevin and Penncap M were used most often in the Southwest region and Dipel was used most frequently in the Southeast and Northeast regions. These differences in insecticide-use patterns are probably related to the availability, advertising and the acceptance of new insecticides in the various regions.

Orthene was used most frequently by producers in farm-size Categories II and III, while Azodrin was used most often by producers

Table 14. Insecticides used on flue-cured tobacco by region, Virginia, 1974 through 1979.

Insecticide and Period	Region* NE	SE	NW	WC	SC	SW	EC	Weighted state avg.**
	---------Percent of producers----------							
1974 to 1978:								
Orthene	40	58	85	29	33	26	48	43
Azodrin	40	29	65	45	9	32	10	31
Lannate/Nudrin	40	33	15	8	12	0	19	16
Malathion	20	13	15	18	0	0	0	10
Sevin	25	20	12	2	5	11	10	9
Penncap M	15	9	6	2	14	0	0	6
Dipel Spray	10	11	3	6	9	0	0	6
Dipel Bait	5	4	0	0	0	0	0	1
Parathion	5	9	3	2	0	11	0	3
Sevin + Parathion 5 & 1 Dust	0	0	0	2	2	0	0	1
Little John	5	9	0	0	2	0	0	2
Diazinon	5	2	0	0	0	5	0	<1
Other	5	7	3	0	2	5	0	2
1979								
Orthene	40	53	47	18	36	32	48	36
Azodrin	30	26	49	49	23	32	14	33
Lannate/Nudrin	30	23	9	5	15	9	19	14
Malathion	15	4	14	10	3	4	0	6
Sevin	10	13	9	5	10	11	10	9
Penncap M	5	3	9	8	15	26	5	9
Dipel	10	10	9	5	8	4	10	8
Parathion	0	2	0	2	0	16	0	2
Other	5	4	0	2	2	5	0	2

* See Table 3 for a list of counties in each region.

**See formula on page 8.

in Category III (Table 16). Most Lannate/Nudrin and Dipel were used on farms in Category IV, while malathion and Penncap M were used most heavily on farms in Category I.

Total Insecticide Use on Tobacco

Table 15 lists the most frequently used insecticides on flue-cured tobacco in Virginia during 1979. This information is based on the assumption that the chemicals were used at the recommended

Table 15. Amount of foliar insecticide used on flue-cured tobacco in Virginia 1979.

Insecticide	Applications/acre (State Avg)	Estimated rate* (lbs ai/acre)	Amount used on ** flue-cured tobacco (lbs. ai.)
Mocap	0.39	6.0	121680
Di-Syston	0.48	3.0	69120
Furadan	0.25	5.0	65000
Dasanit	0.09	6.0	28080

* The estimated rate of application is based on the labeled rate. If there is a range in the rate, an average of the high and low rates is used.

**The indicated amount was estimated for 52,000 acres grown during 1979.

Table 16. Insecticides used on flue-cured tobacco by farm-allotment size in Virginia, 1979.

Insecticide	Allotment-size category* I	II	III	IV
	----------Percent of producers----------			
Orthene	36	41	42	34
Azodrin	14	30	47	34
Lannate/Nudrin	6	7	12	30
Dipel	6	7	4	18
Penncap M	12	15	6	6
Sevin	8	17	6	9
Malathion	16	9	4	2
Parathion	4	2	0	3
Other	7	4	2	4

*Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; and IV, more than 21 acres.

rate and that the soil insecticides were applied as broadcast treatments. Mocap accounted for about 35% of all insecticides used on tobacco, while Di-Syston, Furadan, Dasanit and the foliar insecticides accounted for 20, 19, 8 and 18% of the insecticides used on tobacco, respectively.

Number of Insecticide Applications

During 1979 producers made an average of 1.65 applications of foliar insecticides per season, ranging from 1.1 in the East-Central region to 2.6 in the Northeast region (Table 17). A large percentage of these applications was made for green peach aphid control. Of the flue-cured tobacco acreage, 9%, 41%, 31%, 16%, and 3% received 0, 1, 2, 3, and 4 or more applications, respectively. Table 17 also shows that farmers in allotment-size Categories I and II made slightly fewer insecticide applications than those in Categories III and IV (Table 17).

Criterion Used to Determine When to Apply Foliar Insecticides

Producers were asked what criterion they used to determine when to apply foliar insecticides. Of the total producers only

Table 17. Number of foliar-insecticide applications to flue-cured tobacco by region and farm-allotment size, Virginia, 1979.

Region*	Number of insecticide applications						Regional average
	0	1	2	3	4	5	
	----------Percent of producers----------						
NE	5	15	20	40	15	5	2.6
SE	5	16	55	23	2	0	2.0
NW	3	38	35	21	3	0	1.9
WC	6	46	27	19	2	0	1.7
SC	14	49	26	9	2	0	1.4
SW	18	23	23	14	18	5	2.1
EC	17	61	17	4	0	0	1.1
Weighted state average**	9	41	31	16	3	1	1.65
Allotment-size category†							
I	23	32	21	16	7	2	1.60
II	14	36	32	17	2	0	1.59
III	7	28	41	21	3	0	1.85
IV	2	48	32	15	3	0	1.69

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres, III, 12-21 acres; IV, more than 21 acres.

5% applied foliar insecticides on a regular schedule, 55% treated when insect pests were first observed, 34% used a threshold guideline to determine when treatment was necessary, and 2% waited until severe damage was observed.

Equipment for Applying Foliar Insecticides

Tractor sprayers (88%) were, by far, the most frequently used equipment for applying insecticides during 1979 (Table 18). Both high clearance sprayers and cloth bags were used by 2% of the producers, while 11% did not apply foliar insecticides. Table 18 also shows the equipment used to apply insecticides within each allotment-size category.

Table 18. Equipment used to apply insecticides to flue-cured tobacco by region and farm-allotment size, Virginia, 1979.

Region*	Insecticide application equipment				
	Tractor sprayer	High clearance	Duster	Cloth bag	Other
	Percent of producers				
NE	80	10	0	0	5
SE	93	0	0	2	0
NW	97	0	0	0	0
WC	90	4	2	4	0
SC	86	0	0	2	0
SW	90	0	0	0	0
EC	76	0	0	0	0
Weighted state average**	88	2	< 1	2	< 1
Allotment-size category†					
I	78	0	2	6	0
II	95	0	0	0	0
III	95	2	0	0	0
IV	86	5	0	2	2

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

Desire for Pest Scouting

Only 13% of the producers by region indicated that they would be interested in a pest-scouting program that provided them with weekly information on the insect, nematode, weed, disease, and sucker conditions in their fields, if the cost of the program is $10/acre (Table 19). Producers in the Southwest region expressed the greatest interest in a scouting program, while those in the Northwest region were not interested. Producers in allotment-size Category I had the least interest in a pest scouting program (Table 19).

Table 19. Flue-cured tobacco producers who said that they were interested in a pest scouting program on their crop if it cost $10/acre by region and farm allotment size, Virginia, 1979.

Region*	Percent of Producers Interested in Pest-Scouting Program
NE	12
SE	13
NW	0
WC	13
SC	13
SW	39
EC	14
Weighted state average**	13
Allotment-size category†	
I	3
II	15
III	20
IV	16

* See Figure 1 for counties in each region.

**See formula on page 8.

† Allotment-size categories are as follows: I, less than 6 acres; II, 6-11 acres; III, 12-21 acres; IV, more than 21 acres.

DISCUSSION AND RECOMMENDATIONS

Tobacco Plant Beds

Several factors have probably contributed to the low incidence of insect pests in tobacco plant beds. First, a large portion (59%) of the beds were treated with Di-Syston for tobacco flea beetle and green peach aphid control. The lowest incidence of insect problems was reported from the West-Central region, which had the highest level of Di-Syston usage in plant beds. Second, about 80% of the tobacco acreage was treated with a soil nematicide-insecticide during 1979. Harrison (1971) and Dominick (1962) have demonstrated that the use of Di-Syston and other soil insecticides greatly reduces the development of flea beetle larvae on the roots of tobacco plants. Therefore, the widespread use of various soil insecticides probably reduced the buildup of flea beetles during the late season and fewer beetles were able to overwinter and infest plant beds during the following season. A third factor is the widespread use (94%) of methyl bromide for disease and weed control in tobacco plant beds. This practice has essentially eliminated problems with many soil-inhabiting insects during the last 20 to 25 years. For instance, Rabb et al. (1955) listed green June beetle grubs, midge larvae, and crane fly larvae as pests of tobacco plant beds. However, these pests have not been reported as problems in plant beds in Virginia during the last 10 years. The use of better plant bed covers is a fourth factor that may also have contributed to a reduction in insect damage to plant beds. Gilmore and Levin (1944) demonstrated that the proper construction of plant beds helped to reduce damage caused by tobacco flea beetles.

Only 13% of the tobacco plant beds were treated with insecticides other than Di-Syston. Sevin was used on 5% of the plant beds although it is not recommended for that purpose because it frequently causes chemical injury to young tobacco plants (Semtner 1982). Dylox/Proxol,

Malathion, Parathion and Orthene are recommended for use in tobacco plant beds in Virginia, but only 8% of the beds are treated with one of these compounds.

Since 59% of the beds were treated with Di-Syston, which requires only one application, 61% of the beds received single applications of insecticides, while 7% were treated more than once. This low level of insecticide usage indicates that insects are not normally a serious problem in plant beds.

Since healthy transplants are the first step in the production of a high-yielding, top-quality tobacco crop, it is essential that good insect control practices be maintained through the use of preventive applications of Di-Syston for flea beetle and green peach aphid control, or the application of a foliar insecticide when examinations of plant beds (every 2 or 3 days) indicate that an insect pest may become a problem. This study indicates that more than 90% of the producers in Virginia follow recommended insect control practices in their plant beds. The major exceptions to the use of these practices were those producers who waited until severe injury was observed before they applied an insecticide.

Newly Transplanted Tobacco

Cutworms and tobacco flea beetles were the most frequently reported pests of newly transplanted tobacco. However, the extensive use of soil insecticides has probably helped to reduce the importance of both pests. For instance, flea beetle damage has been much less severe than that caused by heavy infestations of flea beetles during the late 1930's (Schoene 1938, Shands et al. 1938). Cutworms can cause serious reductions in stands in tobacco fields (Rabb et al. 1955). My study indicated that about one-fifth of the acreage in Virginia had been injured to a certain extent by cutworms during the 1974-1978 period, while 10% of the acreage was affected by cutworms during 1979. These findings indicate that cutworms are still a concern to tobacco farmers in Virginia. Therefore, additional research is needed to develop techniques for monitoring cutworm densities and for applying insecticides at the proper time to reduce their damage.

Wireworms were probably reported less frequently than flea beetles and cutworms because of the extensive use of soil insecticides that are labeled for wireworm and nematode control, and because their below-ground feeding habits and the resulting damage are less visible to the growers.

Other soil insects have been reported as pests of newly-transplanted tobacco in Virginia during the last 20 years. A white-fringed beetle, Graphognathus spp., has been collected from tobacco fields in Pittsylvania and Halifax counties during the last 5 years (Semtner, unpublished data). In addition, Dominick (1960) reported that sod webworms, Crambus spp., were pests on newly transplanted tobacco in Virginia. However, improved cultural practices and the use of soil insecticides seem to have eliminated this problem in recent years.

Insects on Field Tobacco

The tobacco budworm was the most frequently mentioned insect pest on flue-cured tobacco in Virginia for the 5-year period (1974 to 1978) immediately before the survey. However, the timing of the first interview period, June and early July, may have favored responses for the budworm, since it is most active at that time. In addition, budworm damage to tobacco is fairly easy to recognize during the early season and the larvae are fairly difficult to control.

The tobacco hornworm was rated as the second most important pest on tobacco during the 5 seasons before the survey. The hornworm and its damage were relatively easy for growers to observe, but it was also easier to control than the budworm. If good cultural control practices are carried out on an area-wide basis, the damage caused by hornworms can be greatly reduced. In a North Carolina study, Gentry et al. (1967) demonstrated that an area-wide stalk-cutting and root-destruction program in combination with light traps for adult moths reduced hornworm densities by 77 to 91%. In addition, early transplanting, proper nitrogen fertilization, early topping and good chemical sucker control help to reduce hornworm densities (Reagan et al. 1974, 1978).

The high incidence of grasshopper problems in the Northwest and West-Central regions were probably the result of high populations

that existed in those regions during 1977 and 1978. In many cases, grasshoppers migrated out of pastures and hayfields into tobacco fields (Semtner unpublished observations). I recommend that producers maintain a buffer zone around tobacco fields by cutting the grass and weeds at regular intervals to reduce the area's favorability to grasshoppers.

Although producers rated the green peach aphid as only the fourth most important pest on flue-cured tobacco during the five previous seasons, it was, by far, the most important pest of tobacco during 1979. In addition, during 1979 and 1981 aphid control with Di-Syston, the widely used aphicide, was inadequate. This poor control with Di-Syston was probably related to the high level of precipitation that raised the soil moisture level and helped to increase rate of decomposition of the insecticide in the soil (Agnihotri et al. 1975). In addition, aphids persisted on tobacco much later in the season than was observed during the 1975 to 1978 period.

Since Di-Syston has not given adequate control of the green peach aphid in recent years, producers may wish to switch to the use of foliar insecticides applied at the economic threshold level (10 plants of 50 with 100 or more aphids on individual leaves) (Semtner 1982).

Research is needed to develop improved application techniques, better timing of applications, more effective insecticides and innovative cultural practices for aphid control.

The tobacco flea beetle, only fifth in importance among the insect pests on tobacco during the five previous seasons, was third in importance during 1979. Because insufficient information is available on the effect of the tobacco flea beetle on tobacco, there is a need for research to determine its effects (adults and larvae) on tobacco yield and quality. Results of this survey indicate that flea beetles are one of the most serious insect problems in the Southwest region.

Insecticide Usage in the Transplant Water

The fact that Isotox (lindane) was the most frequently used insecticide in the transplant water was surprising, since Isotox had

not been recommended for use on tobacco for 10 years. Jewett (1954) demonstrated that several insecticides, when applied in the transplant water, provided control of wireworms on tobacco. Lindane and several other insecticides were then used extensively for wireworm control during the 1950's and early 1960's. However, during the early 1960's, wireworms in many fields in North Carolina had developed a resistance to the insecticide (Guthrie et al. 1963). The registration of lindane for use on tobacco was cancelled in North Carolina during 1969 (Robertson, 1971). However, lindane, applied in the transplant water, was still a legal product in Virginia during 1979. But it has not been listed in the Virginia Extension Service recommendations since the early 1970's (Roberts and Dominick 1974), and the recommendations contained a statement saying that it should not be used on growing tobacco plants. Diazinon and Vydate are labeled as transplant water treatments for the control of wireworms and flea beetles, respectively (Baumhover 1981), while Orthene 75SP was granted a Virginia State 24c label in 1981 for use as a transplant water treatment for the early-season control of tobacco flea beetles (Semtner 1982). Although the costs are low, the use of insecticides in the transplant water may not be necessary where a soil nematicide-insecticide has been used.

Soil Insecticide-Nematicides

The extensive use of soil-incorporated insecticide-nematicides (82% of acreage) has probably contributed to a reduction in the use of foliar insecticides. For instance, Di-Syston gives fair to good control of aphids, and Furadan gives good control of hornworms and tobacco flea beetles; therefore, their use reduces the need for foliar insecticides. Eichers et al. (1978) reported that Mocap was the most widely used soil insecticide-nematicide on tobacco in the United States. This was also the case in Virginia during 1979 when about 35% of the insecticide used on flue-cured tobacco was Mocap, compared to the 25% reported by Eichers et al. (1978). Di-Syston and Furadan each accounted for about 20% of the insecticide used on tobacco; Dasanit accounted for about 8%, while the foliar insecticides amounted to only 18% of the total. Since 1976, there has been an increase in the amount of insecticide applied to tobacco because of the increased use of insecticide-nematicide for the control

of nematodes in addition to wireworms and foliage feeding insects. According to Eichers et al. (1978) the average amount of insecticide used on all types of tobacco was 3.9 lbs. active ingredient (a.i.) per acre during 1976. However, our 1979 study indicated that 6.7 lbs. ai/acre was used on flue-cured tobacco in Virginia. Most of this increase can be attributed to increases in the use of soil-applied insecticide-nematicides. Although there was actually a sizeable decrease in the use of foliar insecticides, Furadan, Mocap and Di-Syston each had sizeable increases in use on tobacco during 1979. In addition, a single application of Mocap Plus, first available in 1977, would add 9 lbs. of insecticide/acre, and in some cases the recommended rate is 12 lbs ai/acre (8 lbs. of Mocap and 4 lbs. of Di-Syston).

Findings presented in this paper and the surveys by Carter et al. (1980) and Waldron and Park (1981) indicate that soil insecticide-nematicides are used much more frequently on flue-cured tobacco than on burley tobacco. This probably accounts for the discrepancy between my findings and those of Eichers et al. (1978).

Granular soil insecticide-nematicides were applied with granular applicators, fertilizer spreaders, and grain drills. The liquid formulations were applied with a tractor sprayer. Since 1979, however, there has been an increase in the use of liquid formulations of soil insecticide-nematicides.

Foliar Insecticides

Compared to findings by Eichers et al. (1978), the use of foliar insecticides was greatly reduced during 1979. Foliar insecticides accounted for only about 20% of the insecticide-active ingredients applied to tobacco. The present study indicates that there has been a strong move to more dependence on soil insecticides for the control of foliar feeding insects. During the 3-year period between 1976 and 1979, there was a major shift in the foliar insecticides used. For instance, Eichers et al. (1978) reported that during 1976 Lannate and Sevin were the most heavily used foliar insecticides, while Azodrin, Malathion and Thiodan were the third, fourth and fifth. During 1979, Orthene and Azodrin were the most heavily used foliar insecticides, while Malathion, Sevin, Penncap M, Lannate/Nudrin, and Dipel/Thuricide

(Bacillus thuringiensis) followed in order. The greatest shift in usage was to Orthene which was first available for use on tobacco during the 1975 season. This shift was probably related to Orthene's broad spectrum control of insects, especially against the green peach aphid, and its safety to the applicator. The use of Azodrin also increased, probably because it was relatively inexpensive and effective against the green peach aphid. The use of Malathion continued to be relatively high because of the aphid problems during 1979 and because malathion is applied at a fairly high rate of active ingredient. Penncap M, first labeled for use on tobacco in Virginia during 1975, also increased in the level of use. Sizeable reductions in the use of Sevin and Lannate/Nudrin were observed between 1976 and 1979.

Tank Mix Combinations

Many tobacco growers are mixing herbicides, insecticides, and fungicides so that they can reduce the number of trips they have to make over their fields. By doing this, they are able to reduce the equipment, fuel and labor costs. Although 20% of the acreage was treated with tank mixes during 1979, I believe the percent treated with tank mixes in 1980 and 1981 was much higher because of the extensive use of Ridomil (Metalaxyl) as a pretransplant soil treatment for blue mold.

Insecticide-sucker control tank mixes were used by more than one-third of the producers during 1979. This combination has been effective in fields where hornworms or aphids are a problem. Although harmful interactions resulting from the combination of two or more chemicals are possible, none were reported in this survey.

Insecticide Applications

During 1979, Virginia's tobacco producers made an average of 1.65 applications of foliar insecticides to their crop. Since 1975 there has been a reduction of 1 to 2 foliar applications of insecticides per season. This reduction can be attributed to an increase in the acceptance by producers of the insect-pest-management concept for tobacco, improved cultural control practices, and the increased use of soil insecticides (especially Furadan).

Application Equipment

Tractor sprayers were used to apply foliar insecticides to 95% of the treated acreage. High clearance sprayers were used on 2% of the acreage, cloth bags on 2% and dusters on less than 1%. None of the acreage sampled during 1979 had insecticides applied by airplane or knapsack sprayer.

Some producers still use cloth bags to apply dust formulations to individual plants. This practice should be discontinued because it can result in mechanical and chemical injury to the crop.

Scouting Programs

Only about one-fifth of the producers indicated that they would be willing to support a pest scouting program on their crop if the cost was a minimum of $10/acre. The producers with medium to large acreages were most interested in a pest scouting program. This question was probably too specific and a more general question would probably have shown that a higher percentage of producers are actually interested in a pest-scouting program.

A pilot pest-scouting program on flue-cured tobacco in North Carolina during the 1971-1973 seasons resulted in reduced use of foliar insecticides, but the economic benefits to the producers were marginal (Von Rumker et al. 1975). Although scouting programs for tobacco have been improved to include disease, topping and sucker control information during the last 5 years, none of the tobacco pest-management programs are self supporting at this time.

LITERATURE CITED

Agnihotri, N. P., H. K. Jain, S. Y. Pandey, R. S. Dewan, A. N. Sexena and K. M. Peshwani. 1975. Influence of soil moisture on the dissipation of phorate and disulfoton in soil and mustard crop. Indian J. Entomol. 37:68-71.

Andrilenas, P. A. 1975. Farmers' use of pesticides in 1971 . . . extent of crop use. Agric. Econ. Rept. 268. Econ. Res. Serv. U.S. Dept. Agric. 25 p.

Baumhover, A. H. 1981. Tobacco pests. In. guidelines for the control of insect and mite pests of foods, feeds, ornamentals, livestock, households, forests and forest products. Agriculture Handbook 571. U.S. Dept. of Agric., Science and Education Administration and Forest Service. p. 392-406.

Carter, H. L., M. A. Evans, and A. C. Waldron. 1980. Pesticide use on major crops in Ohio - 1978. Res. Bull. 1117 and Ext. Bull. 666. Ohio Agric. Res. Development Cntr. and Ohio Coop. Ext. Serv. Ohio St. Univ. 47 p.

Dominick, C.B. 1960. Control of the corn root webworm., J. Econ. Entomol. 53:670-672.

Dominick, C. B. 1962. Tests with insecticides applied to the soil and foliage for tobacco flea beetle control J. Econ. Entomol. 55:874-876.

Dominick, C. B. 1972. Tests with insecticides for tobacco flea beetle control in plant beds and on newly transplanted tobacco. Tob. Sci. 14:104.

Eichers, T. R., P. A. Andrilenas, and T. W. Anderson. 1978. Farmers' use of pesticides in 1976. Agric. Econ. Rept. 418. U. S. Dept. Agric., Econ., St. and Coop. Serv. 58 p.

Fox, A., T. R. Eichers, P. A. Andrilenas, R. Jenkins, and H. Blake. 1968. Extent of farm pesticide use on crops in 1966. Agric. Econ. Rept. 147. U.S. Dept. Agric., Econ. Res. Serv. 23 p.

Gentry, C. R., F. R. Lawson, C. M. Knott, J. M. Stanley, and J. J. Lam, Jr. 1967. Control of hornworms by trapping with blacklight and stalk cutting in North Carolina. J. Econ. Entomol. 60:1437-1442.

Gilmore, J. U. and C. Levin. 1944. Control of the tobacco by cultural practices in the plant bed. J. Econ. Entomol. 37:13-15.

Guthrie, F. E., W. E. Splinter, R. L. Rabb, and T. G. Bowery. 1960. Mechanical transplanting of bright leaf tobacco. IV. Tobacco wireworm control with row treatment of insecticides. Tob. Sci. 4:95-100.

Guthrie, F. E., R. L. Rabb, and D. A. Mount. 1963. Distribution and control of cyclodiene-resistant wireworms attacking tobacco in North Carolina. J. Econ. Entomol. 56:7-10.

Harrison, F. P. 1971. The tobacco flea beetle response to disulfoton on Maryland tobacco. J. Econ. Entomol. 67:766.

Jewett, H. H. 1954. Control of wireworms injuring tobacco plants. Bulletin 617. Kentucky Agric. Expt. Sta., Univ. Kentucky, Lexington, KY, 17 p.

Johnson, A. W. 1980. Tobacco flea beetle control on flue-cured tobacco with acephate in the transplant water. J. Ga. Entomol. Soc. 15:361-363.

Mistric, W.J., Jr., and F.D. Smith. 1972. Carvofuran and disulfoton applied to soil in flue-cured tobacco plant bed for control of certain insects attacking plants in bed and transplants in field. J. Econ. Entomol. 65:1203-1204.

Mistric, W. J., Jr. and F. D. Smith. 1973 a. Orthene and other insecticides for control of insects attacking flue-cured tobacco. Tob. Sci. 17:134-136.

Mistric, W. J., Jr. and F. D. Smith. 1973 b. Tobacco hornworm. Methomyl, monocrotophos and other insecticides for control on flue-cured tobacco. J. Econ. Entomol. 66:581-583.

Mistric, W. J., Jr., Z. Siddiqi and G. B. Clark. 1978. Control of flue-cured tobacco insects with CG-A-15324, N-2596, and other insecticides. Tob. Sci. 22:148-151.

Mistric, W. J., Jr. and G. B. Clark. 1979. Synthetic pyrethroids and other insecticides for control of insects on flue-cured tobacco. Tob. Sci. 23:135-138.

Rabb. R. L., F. E. Guthrie, H. E. Scott and C. F. Smith. 1955. Tobacco Insects Bulletin 394. Agric. Expt. Sta., North Carolina State University, Raleigh, NC, 32 p.

Reagan, T. E., R. L. Rabb, and W. K. Collins. 1974. Tobacco budworm: Influence of early topping and sucker control practices on infestations in flue-cured tobacco. J. Econ. Entomol. 67:551-552.

Reagan, T. E., R. L. Rabb and W. K. Collins. 1978. Selected cultural practices as affecting production of tobacco hornworms on tobacco. J. Econ. Entomol. 63:535-536.

Roberts, J. E., Sr. and C. B. Dominick. 1974. Virginia tobacco insect control recommendations. Va. Polytech. Inst. and St. Univ., Blacksburg, VA, Coop. Ext. Serv. Bull. 345. 12 p.

Robertson, R. L. 1971. An insect management program for tobacco. In Tobacco Information for 1971. Misc. Ext. Publication 59. The North Carolina Agric. Ext. Serv. p 28-34.

Schoene, W. J. 1938. Tobacco flea beetle outbreak. J. Econ. Entomol. 31:456.

Semtner, P. J. 1982. Insects-Tobacco In. Chemical control of insects, plant diseases and weeds in Virginia - 1982. Va. Coop. Ext. Serv. Pub. 456-001. pp 48-56.

Shands, W. A., R. F. Poole and E. G. Moss. 1938. Conditions involved in the severe losses of newly set tobacco in North Carolina, 1937. 31:715-719.

Von Rumker, R., G. A. Carlson, R. D. Lacewell, R. B. Norgaard and D. W. Parvin, Jr. 1975. Tobacco Pest Management Programs In. Evaluation of pest management programs for cotton, peanuts, and tobacco in the United States. Office of Pesticide Programs, Office of Water and Hazardous Materials, Environmental Protection Agency, Washington, D.C. pp 93-104.

Waldron, A. C. and E. L. Park. 1981. Pesticide use on major crops in the North-Central Region - 1978. OARDC Res. Bull. 1132. 32 p.

APPENDIX I. List of survey questions on insects and insecticide use.

A. Questionnaire 1

1. What insects have caused problems in your plant bed this year? 1) flea beetles; 2) cutworms; 3) aphids (plant lice); 4) vegetable weevils; 5) slugs; 6) flies; 7) Other (specify) _____; 8) insects were not a problem.
2. What insects have caused problems in your plant bed during the last five years? Use answers from question 1.

_____

3. Did you use an insecticide on your plant beds this year? 1) yes; 2) no.
4. If so, what insecticide did you use on your plant beds? 1) Di-Syston; 2) Sevin; 3) Malathion; 4) Dylox/Proxol; 5) Parathion; 6) Orthene; 7) Other (specify) _____; 8) none.
5. How many times did you treat your plant beds for insect control this year? _____
6. If Di-Syston was used in plant beds, when was it applied? 1) at seeding; 2) after plants are up and leaves are between a dime and a half dollar in size; 3) a week or less before transplanting.
7. When do you destroy your plant beds? 1) less than a week after transplanting has been completed; 2) 1 week to 1 month after completion of transplanting; 3) 1 to 3 months after transplanting; 4) in the fall; 5) the following spring.
8. Did you use a preplant soil incorporated insecticide or nematicide on your crop this year? 1) yes; 2) no
9. If a contact nematicide or insecticide was applied, what formulation was used? 1) granular; 2) liquid; 3) wettable powder.
10. What kind of soil incorporated nematicide or insecticide did you use? 1) Dasanit; 2) Dasanit-Di-Syston; 3) Di-Syston; 4) Diazinon; 5) Dyfonate; 6) Furadan; 7) Mocap; 8) Mocap Plus; 9) Nemacur; 10) Nemacur-Dasanit; 11) Parathion; 12) Temik; 13) Other (specify) _____.

11. What type of equipment did you use to apply soil insecticide-nematicides? 1) granular insecticide applicator; 2) fertilizer spreader; 3) grain drill; 4) tractor sprayer; 5) Other (specify) _____.
12. How did you apply the insecticide-nematicides? 1) band; 2) broadcast; 3) Other (specify) _____.
13. Were tank mixes of insecticides, nematicides, herbicides, or liquid fertilizer applied to your tobacco land? 1) yes; 2) no.
14. If so, what combinations were used? _____
15. Have you had any problems with insects immediately after transplanting this year? 1) yes; 2) no.
16. If so, which ones? 1) cutworm; 2) wireworm; 3) flea beetle; 4) Other (specify) _____.
17. Which insects have caused problems on newly transplanted tobacco during the last 5 years? Use responses from question 16.

    _____
18. Have you treated for cutworms during the past 5 years? 1) yes; 2) no.
19. If yes, what did you use? 1) Orthene; 2) Dylox/Proxol; 3) Other (specify) _____.
20. Which insects have caused the most problems on your field tobacco the last 5 years? 1) Aphids (plant lice); 2) budworms; 3) flea beetles; 4) grasshoppers; 5) hornworms; 6) Other (specify) _____.
21. Which insects have caused the most problems on your tobacco so far this year? Use responses from question 20.

    _____

B. Questionnaire 2

22. Which insects have caused the most serious problems on your tobacco so far this year? 1) aphids (plant lice); 2) budworms; 3) flea beetles; 4) grasshoppers; 5) hornworms; 6) Other (specify) _____; 7) insects were not a problem.
23. Have you applied any insecticides to your tobacco since transplanting? 1) yes; 2) no.
24. Which insecticide(s) have you applied to your tobacco this season (since transplanting)? Use answers from question 25.

_____

25. Which insecticides have you used on your field tobacco during the last 5 years? 1) Azodrin; 2) Cygon/Defend; 3) Diazinon; 4) Dipel/Biotrol/Thuricide bait; 5) Dipel/Biotrol/Thuricide spray; 6) Guthion; 7) Lannate/Nudrin; 8) Little John; 9) Malathion; 10) Orthene; 11) Parathion; 12) Penncap M; 13) Sevin; 14) Sevin + Parathion-5 and 1 dust; 15) Supracide; 16) Thiodan; 17) Other (specify) _____.
26. Did you obtain satisfactory insect control with the insecticide(s) that you used this season? 1) yes; 2) no.
27. If insect control was not satisfactory, which insect(s) were you trying to control? _____
28. Which insecticide(s) did not give satisfactory control?

_____

29. When do you apply insecticides to your tobacco following transplanting? 1) on a regular schedule whether insects are present or not; 2) when a pest insect is first observed; 3) only after examination of a specific number of plants in a field indicates that at least one insect will cause economic damage to the crop if an insecticide is not used; 4) only after severe damage is observed; 5) Other (specify) _____.
30. How many insecticide applications have you made to your crop since transplanting this year. _____
31. What type(s) of spraying or dusting equipment do you use to apply insecticides to your tobacco? 1) tractor sprayer; 2) high clearance; 3) airplane; 4) knapsack sprayer (backpack); 5) duster; 6) cloth bag; 7) Other (specify) _____.

C. Questionnaire 3

36. How many insecticide applications have you made to your tobacco since transplanting? _____

37. Which insecticides did you use? 1) Azodrin; 2) Dipel; 3) Lannate/ Nudrin; 4) Malathion; 5) Orthene; 6) Penncap M; 7) Sevin; 8) Other (specify) _____.

38. Which insect did you treat for? 1) aphids (plant lice); 2) flea beetles; 3) hornworms; 4) Other (specify) _____.

39. A tobacco pest scouting service would provide producers with weekly information on insect, weed, and disease problems in their fields, plus soil testing and nematode sampling service at the end of the season. If such a scouting service were available, would you participate at the cost of $10 per acre/year? 1) yes; 2) no.

Appendix II. Trade and common names of insecticides used on tobacco in Virginia during 1979.

Trade name	Common name	Formulation
Azodrin	monocrotophos	5 WM
Dasanit	fensulfothion	10G
Diazinon	diazinon	50WP, 4EC
Dipel	Bacillus thuringiensis	WP
Di-Syston	disulfoton	15G, 8EC
Dylox	trichlorfon	80SP
Furadan	carbofuran	10G, 4F
Isotox	lindane	
Lannate	methomyl	90SP, 1.8EC
Little John	endosulfon + parathion	EC
Malathion	malathion	5EC
Mocap	ethoprop	10G, 6EC
Mocap Plus	ethoprop + disulfoton	10-5G, 4-2EC
Nudrin	methomyl	90SP, 1.8EC
Orthene	acephate	75SP
Parathion	parathion	EC
Penncap M	microencapsulated methyl parathion	2FM
Proxol	trichlorfon	80SP
Sevin	carbaryl	4F, 50WP, 80WP
Sevin + Parathion	carbaryl + parathion	5 + 1D
Vydate	oxamyl	2L

Virginia's Agricultural Experiment Stations

1—Blacksburg
Virginia Tech

2—Steeles Tavern
Shenandoah Valley Research Station

3—Orange
Piedmont Research Station

4—Winchester
Winchester Fruit Research Laboratory

5—Middleburg
Virginia Forage Research Station

6—Warsaw
Eastern Virginia Research Station

7—Suffolk
Tidewater Research and Continuing Education Center

8—Blackstone
Southern Piedmont Research and Continuing Education Center

9—Critz
Reynolds Homestead Research Center

10—Glade Spring
Southwest Virginia Research Station

11—Hampton
Seafood Processing Research and Extension Unit