

# Crop Profile for Tobacco in Virginia

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## General Production Information



Four types of tobacco are produced in Virginia: flue-cured, dark fire-cured, light air-cured (burley) and dark air-cured (sun-cured). Virginia produces 28 percent of the flue-cured tobacco grown in the United States. Flue-cured tobacco is used almost exclusively in cigarettes. Approximately 40 percent of that grown in Virginia is exported as non-manufactured leaf. Almost 8 percent of all dark fire-cured tobacco is produced in Virginia. The majority of dark fire-cured tobacco is exported for the manufacture of smoking tobacco, chewing tobacco, and cigars. The primary domestic use is for dry snuff. Virginia farmers produce 4 percent of the light air-cured (burley) tobacco grown. Burley tobacco is used primarily in cigarette blends with a small amount used in the manufacture of pipe and chewing tobacco products. Approximately 30 percent of the burley tobacco grown in Virginia is exported. Virginia produces about 1.5 percent of the dark air-cured (sun-cured) tobacco grown in the United States. Most of it is exported for making smoking and chewing tobacco. A small portion is used domestically for plug chewing tobacco (9,14,15). In 1994, the gross income from tobacco production in Virginia was approximately \$182 million. The gross value of tobacco averages between \$3,750 and \$7,000 per acre. Typical production costs for flue-cured tobacco in 1994 were about \$2,673 per acre (10).

## Production Regions

Flue-cured tobacco is produced mostly in the southern Piedmont region of Virginia. Production is concentrated in Pittsylvania, Franklin, Halifax, Mecklenburg, Brunswick, Charlotte, and Lunenburg counties. Virginia fire-cured tobacco is produced on heavier textured soils in the Piedmont region. Sun-cured tobacco is produced in a small region in central Virginia, north of the James River (primarily in Louisa County). Burley is produced in the mountain regions of southwest Virginia. Production is concentrated in Washington, Scott, Lee, Russell, and Smyth counties (14,15).

## Cultural Practices

Tobacco requires well-drained soils that are productive but not necessarily highly fertile. Optimum yields are usually obtained on soils with a loamy to sandy loam texture. Particularly with flue-cured tobacco, residual soil nitrogen should be minimized and fertilizer nitrogen supplied to the crop so that available nitrogen is depleted after topping to produce desired maturation and ripening of the tobacco (2,3,4,15).

Approximately 90 percent of the crop is grown on at least a two-year rotation. Flue-cured tobacco is typically grown on a high, wide-row bed to allow good drainage and aeration of the roots. Some flue-cured, and most of the other tobacco types are grown on a flat field surface. Though some acres are grown as no-till or reduced-till, the great majority (99 percent) of flue-cured tobacco is grown with conventional tillage. No-till production is used much more often in burley tobacco.

Tobacco is transplanted into the field as seedlings produced in greenhouses (about 95 percent) or in plastic- or spun-bonded cotton-covered outdoor plant beds. (Approximately 60 square feet of greenhouse space produce enough plants for transplanting one acre in the field. Approximately 720 square feet of plant beds produce one acre of transplanted tobacco.) Irrigation is essentially limited to flue-cured and dark fire-cured tobacco. As much as 90 percent of the acreage of these tobaccos may be irrigated. Developing flower heads are removed (topped) to increase yield and leaf quality. This may be done by hand or mechanically. Since tobacco is a terminally dominant plant, removal of flower heads induces growth of lateral shoots (suckers). In most cases, suckers are controlled chemically, but some cleanup by hand is normally done. Harvest of flue-cured tobacco is accomplished in stages, with the ripest (lowest) leaves removed mechanically (approximately 60 percent) or by hand. In 1997, 85 percent of flue-cured tobacco was harvested three or four times. The other types of tobacco are stalk cut and cured on wooden sticks in specially constructed curing barns (1,2,3,4,12,15,).

## Transgenic Tobacco

Although not an established crop at this point in time, transgenic tobacco may be the tobacco crop of the

future. It is genetically altered tobacco that is developed to be cut and processed to extract economically valuable chemicals which, may be used as pharmaceuticals, intermediates, and final products for one use or another.

In Virginia, transgenic tobacco crops are just being established through a production model developed as a cooperative research project between Virginia Tech's Center for Biotechnology, CropTech, Inc., and Tobio (a cooperative formed between growers, CropTech, and the Virginia Farm Bureau). The potential outcome could be a resurgence of tobacco production in the region, which would be an economic boom for growers now being impacted by the downturn in the production of tobacco for smoking and chewing products.

One major concern for this crop is the need to control pests effectively and without an impact on the chemicals being produced by the crop for later processing. If pest control chemicals in some way taint the "chemical factory" working inside these genetically altered tobacco plants, the pest controls might not be viable.

There has been an effort made to seek IR-4 Minor Use Pest Control Clearance Program and USDA research support to clear chemical pest controls for this form of tobacco. As a result, USDA has agreed to support research funding, but it will be a long road ahead to clear pesticides that will be guaranteed not to impact the final chemical products produced by the crop.

At this point it is only known that this tobacco will be vulnerable to practically the same pests that other forms of tobacco are vulnerable to and will need similar pest controls available. It is therefore important to weight this potential need those pests and needs describing here for other forms of tobacco. It is especially important to understand the incredible economic potential of this important new crop, which in Virginia, could exceed 50,000 acres in the next five years and equal or even exceed the value of the present tobacco crop.

## **Insect Pests**

Tobacco insects have the potential to cause serious reductions in tobacco yield and value. For instance, uncontrolled infestations of the tobacco aphid and the green peach aphid can reduce yield and value of flue-cured tobacco by 10 to 25 percent in most years. Wireworms and flea beetles cause uneven plant stands, budworms destroy the buds and distort the upper leaves, and hornworms cause extensive defoliation. Over the last five years (1995 to 1999), about 95 percent of the flue-cured tobacco acreage and 50 percent of the burley acreage were treated annually with at least one insecticide application to control various pest insects. Treatment thresholds have been established for the four most common leaf-feeding pests and are used to determine when foliar applications of insecticides are needed (8,14,16).

## **Insecticides used in plant beds and greenhouses**

Insects can cause serious problems on transplants produced in greenhouses and plant beds. The most common pests of greenhouse transplants are ants, aphids, crickets, cutworms and vegetable weevils. Cutworms, aphids, vegetable weevils and flea beetles are the most common insect problems in tobacco plant beds. Acephate at 0.75 pounds active ingredient per acre (0.017 pounds active ingredient per 1000 square feet) is the primary insecticide used to control pests in greenhouses and plant beds. About 50 percent of the greenhouses and 25 percent of the plant beds are treated with acephate each year. Less than 5 percent of the greenhouses are treated with methaldehyde for slug control (8,14,16).

Imidacloprid was registered for use on tobacco as a greenhouse tray drench in 1996 and as a transplant water treatment in 1997. When applied in either method, it provides extended control of aphids, flea beetles and wireworms on field tobacco. Imidacloprid is not registered to control insect pests in greenhouses or plant beds, but when it is applied as a tray drench to greenhouse plants just before transplanting it controls aphids, flea beetles and wireworms on the crop in the field. A single application of imidacloprid was used on an estimated 70 percent of greenhouse transplants at 1.0 to 1.4 fluid ounces per 1000 plants. About 75 percent of the imidacloprid used on tobacco is applied to greenhouse transplants as a tray drench treatment and the remaining 25 percent is applied in the transplant water (14,16).

## **Soil-applied systemic insecticides**

Acephate is used at 0.75 pounds active ingredient per acre as a transplant water treatment for flea beetle and cutworm control and aphid suppression on about 40 percent of the burley tobacco acreage and an estimated 30 percent of the flue-cured tobacco acreage in 1999 and 2000. In 1995, acephate was applied as a transplant water treatment to over 80% of the tobacco acreage in Virginia. The introduction of imidacloprid for use as transplant water and tray drench treatments has contributed to the decrease in the amount of acephate applied in the transplant water. Aldicarb is registered only on flue-cured tobacco in Virginia for control of nematodes and for systemic control of aphids and flea beetles. Before imidacloprid was introduced, aldicarb was used for aphid control on about 50 percent of the flue-cured tobacco acreage in 1995. There have been increases in its use for nematode control and reductions in its use for aphid control. In 1995, aldicarb was used on about 50 percent of the acreage at 2.0 pounds active ingredient per acre. About 30 percent of the flue-cured tobacco acreage was treated with aldicarb in 1999 and 2000. Imidacloprid was introduced for use in 1996, but little was used during that first year. In 1999 and 2000, imidacloprid was used on an estimated 60 to 70 percent of the tobacco acreage, at a rate of 0.12 pounds active ingredient per acre. Chlorpyrifos was used for wireworm control on about 30 percent of the acreage in 1995 and about 10 percent of the acreage in 1999 and 2000. Carbofuran, ethoprop and disulfoton are used on less than 2 percent of the acreage (8,11,14,16).

## **Foliar insecticides**

Acephate, a broad-spectrum material effective against most insect pests, is the most widely used insecticide in Virginia tobacco production. However, the introduction of two newer materials has reduced its use in recent years. In 1995, acephate was used on an estimated 90 percent of tobacco acreage, at 2.5 applications per year on flue-cured tobacco and about 1.5 applications per year on burley tobacco (these figures include its use as a transplant water treatment). In 1999, the use of acephate was reduced by the earlier introductions of imidacloprid for aphid and flea beetle control and spinosad for budworm and hornworm control. Estimated acephate use in 1999 was 1.0 applications on 70 percent of fields. Acephate is used at 0.75 pounds active ingredient per acre for aphid, budworm, and flea beetle control and at 0.5 pounds active ingredient per acre for hornworm control (about 40 percent of total use in 2000). Unusually high budworm and hornworm populations in 2000 resulted in an increase in the use of acephate over 1999 figures. Methomyl is used primarily for budworm and hornworm control at 0.45 pound active ingredient per acre. In 1995, this material was used on 5 percent of total acres, with 1 application per treated acre. Use in 1999 was about 3 percent. Carbaryl was used on less than 2 percent of the acreage. It is often avoided due to its tendency to increase aphid populations and its occasional phytotoxic effects. Endosulfan was used, primarily for aphid control, on 5 percent of acres in 1995, one application per treated field, at one pound active ingredient per acre. Use in 1999 is estimated to have been slightly less, only three percent of total acreage. *Bacillus thuringiensis* (*Bt*) was used for budworm and/or hornworm control on an estimated 20 percent of acres in 1995, about 1.4 applications, and on 30 percent of tobacco acreage in 1999. Spinosad was used on 15 percent of the acreage, at 1.1 applications of 0.05 pounds active ingredient per acre in 1999, and about 30 percent of the acreage in 2000 (8,11,14,16).

### **Significant Insect Pests**

#### **Tobacco budworm (*Heliothis virescens*)**

This pest causes loss and requires treatment on some acreage in virtually every year. In most years it is the first or second most-damaging insect pest of tobacco, requiring treatment on 40 to 50 percent of tobacco acreage. Larvae feed in the growing terminal bud sometimes destroying it and damaging and distorting leaves. Usually remaining deep in the bud, it is often protected from chemical applications. Almost all treatment in the field occurs at least two weeks before first harvest. The pest rarely attacks tobacco seedlings in the greenhouse or plant beds before transplanting (8,12,16).

#### **Cultural and biological control:**

Post-harvest stalk and root destruction greatly reduces food sources for the later generations of budworms and may disrupt overwintering pupae in the soil. This practice, thus, reduces the size of the overwintering generation and pest pressure on the tobacco crop during the following year. The great majority of growers destroy stalks and roots, though in some cases they delay beyond the optimum time. Reducing nitrogen fertilization to the lowest agronomically acceptable rate makes plants less attractive to egg-laying moths and reduces infestation rates slightly (in flue-cured but not other tobacco). Topping at the earliest practical point also reduces the attractiveness of the plants to egg-laying moths and

eliminates a high-quality food source. Late planting (in comparison to the local average) may reduce infestation rates, but it is not recommended for agronomic reasons. A number of insect predators and parasitoids have significant effects on the budworm. Growers are advised to avoid unnecessary foliar insecticide applications to preserve naturally occurring, beneficial insects. One variety of flue-cured tobacco, CU 263, has moderate resistance to the budworm, but it has relatively low yield, quality and disease resistance (8,12,16).

### **Chemical control:**

No soil-applied systemic insecticides are effective against budworms. Foliar insecticides available before 1998 included acephate, methomyl, *Bt*, and endosulfan. A new insecticide, spinosad, became available in 1998 and has displaced some acephate and methomyl use. *Bt* applied in a cornmeal or similar bait formulation is highly effective when applied by hand or with a granular applicator. It was used on an estimated 20 percent of the acreage in 1995 and 1999 and on about 15 percent of the acreage in 2000. Applied as a conventional spray, *Bt* materials are only moderately effective. Methomyl is effective and endosulfan is moderately effective, but both have high mammalian toxicity. Endosulfan residues are objectionable to tobacco buyers, who discourage its use (8,16).

### **Tobacco aphid (*Myzus nicotianae*) and green peach aphid (*M. persicae*)**

The tobacco aphid is the most consistently damaging insect pest of tobacco in Virginia, affecting both crop yield and quality. Annually, 70 to 80 percent of acreage requires insecticidal treatment for this pest. Uncontrolled, it may reduce crop values by 10 to 25 percent. Aphids (including many non-colonizing species) also vector several viral diseases. However, aphid control is not effective in reducing the spread of these diseases, and disease control is seldom, if ever, a motive for aphid control (8,12,16).

### **Cultural and biological control:**

Reducing nitrogen fertilization to the lowest agronomically acceptable rate decreases the probability that plants will be significantly infested and may reduce the number of aphids per plant at peak infestation (in flue-cured but not burley tobacco). Early topping is effective in physically removing aphids from the plant and begins making the plant a less suitable host. Population growth of aphids is slowed or stopped by topping, and their natural population crash is hastened. Chemical sucker control associated with topping (particularly when fatty alcohols are used) also helps kill aphids—by direct contact with the aphids and through elimination of suckers, a preferred substrate. Early or late planting (in comparison to the local average) may reduce infestation rates, but late planting is not recommended for agronomic reasons. Insect predators and parasitoids and an entomophagous fungus occur naturally but do not typically prevent aphids from reaching damaging levels. No commercial varieties with aphid resistance are available (8,12,16).

### **Chemical control:**

Two soil-applied systemic insecticides, imidacloprid and aldicarb (flue-cured only) are available for preventative aphid control in Virginia. The introduction of imidacloprid has reduced the use of aldicarb and remedial foliar treatments for aphid control. However, aldicarb is still used extensively for control of nematodes in the eastern one-third of the production area. Both insecticides are highly effective, but aldicarb is highly toxic and leaches readily. Two other systemic materials, acephate applied in the transplant water and fenamiphos, which are used primarily to control other pests, may suppress or slow aphid buildup, but are not highly effective. Foliar insecticides available for aphid control in 1998 included acephate, endosulfan, and imidacloprid. Pymetrozine, a reduced risk insecticide that inhibits aphid feeding was introduced in 2000, but it was used on less than one percent of the acreage. All of these materials provide good control. However, endosulfan is highly toxic and its residues are objectionable to tobacco buyers so it is not recommended for use after topping. Methomyl is initially effective, but aphid populations rebound more quickly than with other materials and mammalian toxicity is high. Insecticide resistance is a major concern with the tobacco aphid. It is important that a range of chemistries be maintained to manage resistance buildup. In most years, 70 to 80 percent of fields are treated for this pest. Most, but not all, applications are made up to one week prior to harvest (8,12,16).

### **Tobacco flea beetle (*Epitrix hirtipennis*)**

Both the larvae and adults of this pest species attack tobacco. Adults chew many small 'shot-holes' in the leaves and stalks of tobacco plants. Damage can occur in plant beds and in the field. Larvae feed on the roots and tunnel in underground stems, potentially stunting the plant and causing an irregular crop that is more difficult to manage. Several generations occur, but the most significant damage is caused by the first and third generations (8,12,16).

### **Cultural and biological control:**

The widely practiced destruction of unused plants in greenhouses or plant beds eliminates these sites as nurseries for flea beetles that would otherwise move into nearby fields. Post-harvest stalk and root destruction denies later generations a ready food source and a primary overwintering site. This practice, thus, reduces the size of the overwintering generation and pest pressure on the tobacco crop in the following year (16).

### **Chemical control:**

Several soil-applied systemic insecticides are available for preventative control of flea beetles in Virginia. These include acephate (transplant water), aldicarb, carbofuran, disulfoton, imidacloprid (transplant water or greenhouse treatment) and oxamyl. One other systemic material, fenamiphos, which is used primarily to control other pests, may suppress flea beetle numbers. Before 1997, most treatments

included either acephate or aldicarb. However, the introduction of imidacloprid has reduced the use of these materials. Foliar insecticides available for flea beetle control in 1999 included acephate, endosulfan, imidacloprid, methomyl and carbaryl. All provide fair to good control. Most applications are made in the first few weeks after transplanting, but others are made around the first and second harvests (8,16).

### **Tobacco hornworm (*Manduca sexta*); tomato hornworm (*M. quinquemaculata*)**

Hornworms are potentially the most damaging insect pests of tobacco. A heavy infestation may completely destroy a crop. However, such heavy infestations are uncommon, and beneficial insects typically reduce populations significantly. These pests cause loss and require treatment of some acreage virtually every year. In most years treatment is required on 25 to 75 percent of the acreage, and multiple treatments are sometimes necessary. Larvae of these species feed on leaves all over the plant. The pests are easy to detect, and control with several insecticides is very effective. Thus, yield losses are typically kept low (8,16).

#### **Cultural and biological control:**

Post-harvest stalk and root destruction denies later generations of these pests a ready food source and may disrupt emergence of moths from overwintering pupae in the soil. This practice reduces the size of the overwintering generation and the resulting pest pressure on the tobacco crop in the following year. Reducing nitrogen fertilization to the lowest agronomically acceptable rate makes the plant less attractive to egg-laying moths and cuts infestation rates slightly in flue-cured tobacco. Topping at the earliest practical point also reduces the attractiveness of the plants to egg-laying moths and eliminates a high-quality food source. Early planting (in comparison to the local average) may reduce infestation rates. No hornworm-resistant varieties are currently available. A number of insect predators and parasitoids have significant effects on the hornworm complex. Growers are advised to avoid unnecessary foliar insecticide applications to preserve these naturally occurring beneficial insects (8,16).

#### **Chemical control:**

No soil-applied systemic insecticides are effective for preventative control of the major generations of this pest. Hornworms are typically easily controlled with any of several foliar insecticides. These include acephate, *Bt*, carbaryl, methomyl, endosulfan and the newly introduced spinosad. Methomyl and endosulfan are more highly toxic to mammals than the other choices (12,16).

### **Wireworms**

Wireworms, the larvae of elaterid 'click' beetles, feed on the roots of the tobacco plant, often tunneling into the stem of newly set transplants below the soil line. This feeding may kill or stunt the plant, resulting in yield reductions and uneven stands that are difficult and costly to manage (8,12,16).

### **Cultural and biological control:**

While natural enemies and cultural practices almost certainly affect wireworms, the effects are poorly understood. Thus, these factors are not managed for wireworm control (12,16).

### **Chemical control:**

Remedial control is not possible, and effective predictors of pest populations in a field are not available. Thus, preventative, soil-applied treatments are commonly used. Chlorpyrifos is the most widely used insecticide for wireworm control. In 1995, chlorpyrifos was applied one time per season at the rate of 2.0 pounds active ingredient per acre on 30 percent of the tobacco acreage. By 1998, some growers were relying on imidacloprid, used for systemic control of leaf-feeding pests, to provide wireworm control as well. Carbofuran (flue-cured only) and ethroprop were used for wireworm control on less than 1 percent of the acreage in 2000. Carbofuran also aids in the control of budworms (8,12,16).

### **Minor or Occasional Pests**

Several other insect species occasionally cause significant yield or quality loss in tobacco production. These include grasshoppers, cutworms, beet armyworms, stink bugs, Japanese beetles, White-fringed beetles and tobacco split worms (potato tuberworms). For such minor pests, cultural controls have not been adequately studied, and growers rely almost entirely on foliar-application rescue treatments. Many of these pests may have only one or two insecticides labeled for their control in tobacco or none at all (8,12,14,16).

## **Weeds**

Only six herbicides are labeled for use in Virginia; therefore, growers are limited in their choices for control of problem weed species. Chemical weed control in tobacco is becoming more important as growers expand their operations. Timely cultivation becomes difficult, and the increased use of mechanical harvesters makes weed-free fields of much greater importance in order to prevent foreign-matter contamination during harvest (13,14).

## **Cultural control:**

Crop rotation, cover crops, and cultivation are the primary means of cultural weed control, but none of these provides adequate control for most fields. Time limitations associated with increased farm size prevent cultivation, the most effective cultural control, from being as beneficial as in the past (8,13).

## **Chemical control:**

An estimated 75 percent of all tobacco acreage in Virginia is treated with at least one herbicide. The most commonly used are clomazone (0.75-1 pounds active ingredient per acre), sulfentrazone (0.25-0.375 pounds active ingredient per acre), pendimethalin (0.5 pounds active ingredient per acre), and napropamide (1.0-2.0 pounds active ingredient per acre). These four herbicides together provide control for the majority of problem weeds encountered in tobacco production. Growers generally incorporate herbicides before transplanting because of label restrictions and/or time constraints, but sulfentrazone is commonly used as a soil surface application approximately 24 hours before transplanting. Some additional herbicide application is made at layby. Recent labeling of sethoxydim for field use should, however, give growers some remedial control measures for grass species (8,13,14).

## **Topping and Suckers**

The floral parts of tobacco plants are removed (commonly called "topping") to produce optimum yield and quality. Research has shown that delaying topping from the early flower stage (button) to the late flower stage results in a yield loss of 1 percent per acre per day. Thus, early topping increases yields by approximately 250 pounds per acre. Surveys indicate that 34 percent of the crop are topped mechanically and 64 percent by hand (15).

After the plants are topped, or after they reach the full flower stage, apical dominance is lost within the plant. This results in lateral shoot growth from each leaf axil. These axillary buds or shoots are called suckers with three per leaf axil commonly produced. Most plants are topped at 20 leaves, which results in 60 potential suckers per plant. Excessive sucker growth also reduces yield and quality in the same manner as non-removal of flowers. Suckers that get into the harvested leaves are undesired and considered an important foreign material that must be removed from the cured tobacco. Therefore sucker control is a very important management practice (12,15).

## **Chemical control:**

Chemical sucker control is used on nearly 100 percent of tobacco acreage in Virginia. Suckercides are divided into two categories, contact and systemic, based on their mobility in the plant and mode of action.

Contact materials (85 percent by weight of a combination of C-6, C-8, C-10, and C-12 fatty alcohols in

the commercial product and straight C-10 fatty alcohols) control suckers through the dehydration that results from the spray solution dissolving the layer of waxy cuticle on the epidermis. Contacts are not systemic and therefore must touch (i.e., contact) the developing bud in each leaf axil. As the sucker grows in the leaf axil, the axillary bud grows away from the leaf axil and is out of the path of the applied material as it travels down the stalk. Therefore, suckers must not be longer than 1-inch for effective control. Proper application technique is also important as the material must be applied to the top of the plant and allowed to flow down the stalk. Leaning plants or crooked plants will adversely impact sucker control for contact applications. Contact fatty alcohols are applied at a 4% concentration at topping followed by a 5% concentration within a week. The purpose of the contact is to control sucker growth until the upper leaves on the plant are fully developed. Typically, 2 contact applications may be made unless the tobacco growth is uneven and then a third application may be necessary (2,12,15).

Systemic suckercides control suckers by inhibiting cell division. They do not affect cell enlargement, so they are applied after the upper leaves on the stalk reach a desired size (i.e., greater than 10 inches long). Contacts provide immediate, but temporary control of the suckers they touch, but systemics give residual, long-lasting control. Maleic hydrazide (MH) is a true systemic that was used on 77 percent of tobacco acreage in 1992. The labeled MH rate is 1.5 - 2.0 gallons per acre (1.5 pounds active ingredient (ai) per gallon) and 1.0 to 1.3 gallons per acre (2.25 pounds ai per gallon). In 1992, 121,976 pounds ai of MH were applied on 39,347 acres at the rate of 3.1 pounds ai per acre. Residues of MH are relatively high compared to other tobacco pesticides and are important marketing consideration. Residues may be minimized by applying only labeled rates, making only one application (unless rainfall occurs within 3 hours of application), and not harvesting within 7 days of MH application. Sucker control is generally adequate with one application of MH. However, occasionally MH is applied in combination with a locally systemic material. The local systemics are the dinitroanilines: flumetralin and butralin. Local systemics are not true systemics and must be absorbed at the axillary bud. Thus suckers must not be greater than 1-inch long at the time of the application. Sucker control problems on Virginia flue-cured tobacco are usually addressed by using one of two options:

1. Sequential control with 2 contact applications followed by MH or MH and flumetralin in a tank-mix which is applied over the top as a foliar spray; or
2. Individual plant methods where plants are treated individually with a 2% flumetralin application once, making the application down the stalk with jugs or droplines.

Burley tobacco is somewhat different in that contacts are not generally used and MH or MH+flumetralin or MH+butralin is applied once. Sucker control is easier with burley since the crop is harvested 3 to 5 weeks after topping compared to flue-cured which requires 10+ weeks of control (2,11,12,15).

## Diseases

Disease is a major factor in the production of tobacco seedlings in plant beds or greenhouses. Though statewide loss estimates are not available, in individual cases, diseases have reduced usable transplants by more than 50 percent. The most common diseases in greenhouses are caused by *Rhizoctonia*, *Sclerotinia*, and *Pythium*. *Erwinia* may also cause soft rot problems in burley tobacco greenhouses and float beds. Several cultural practices are important in the control of these diseases. Sanitation practices include cleaning and disinfecting mowers to avoid the spread of tobacco mosaic virus and bacteria; removing plant clippings; used media and discarded seedlings are kept well away from the greenhouse; sanitizing or changing foot gear; cleaning and fumigating seedling trays; and using only clean water for float beds or irrigation. Proper ventilation, air circulation, and temperature control are also important. Closing greenhouses in July and August and bringing the temperature to 140° F for seven days will help kill pathogens. Keeping greenhouses free of weed hosts and avoiding the production of tobacco from October to February are also helpful in avoiding disease. Trays are routinely fumigated with methyl bromide and/or dipped in a 10 percent bleach solution. Mancozeb or carbamate may be applied every week to prevent blue mold and anthracnose and to aid in control of other fungal diseases (8,12,13,14).

Tobacco diseases in plant beds caused growers losses in crop value from less than 1 to 8 percent in 1998. In that same year diseases in the greenhouse resulted in less than 1 to 4 percent loss in crop value. Root and stem infecting diseases in the field caused Virginia growers an average loss in crop value of less than 1 to 2.8 percent in 1998. Foliar diseases in the field (mostly local lesion Blue Mold) resulted in losses in crop value ranging from 2 to 20 percent during the same year. Abiotic factors (primarily drought) resulted in crop value losses ranging from 2 to 27 percent. Complex management plans are widely used to control tobacco diseases in the field. Such plans include crop rotation, sanitation (stalk and root destruction), resistant varieties, row bedding, plant spacing, balanced fertilization, and fumigants, fungicides, and nematicides. Almost all chemical control is preventative rather than curative and is applied pre-transplant or initiated when diseases first appear in the field or area (8,12,13,14).

Data on application of pesticides for disease control cannot in all cases be partitioned accurately by the targeted disease. Thus, general data on their use are given here, and, where possible, more specific use data may be given under the heading of individual diseases.

## **Fumigants**

Fumigants are used for control of nematodes, black shank, and Granville wilt. An estimated 15 percent (5,000 acres) of the flue-cured tobacco acreage in Virginia is fumigated with chloropicrin, 1,3 dichloropropene, or methyl bromide. The most common fumigants are combinations of chloropicrin with either 1,3 dichloropropene or methyl bromide. A very limited quantity of metam sodium is now being used (8,13,14).

## **Fungicides**

Metalaxyl is used for the control of black shank and blue mold, but it is not used within five weeks of

first harvest. Growers used this material on 75 percent of tobacco acreage in 1992. The development of metalaxyl-resistant isolates of the blue mold fungus and changes in the disease threat brought the use of metalaxyl down to 60 percent of fields in 1998. Reported use of mancozeb in 1989 was negligible, but its use in tobacco greenhouses for general fungal disease control and in the field for control of resistant blue mold increased to an estimated 50 percent of greenhouses and 10 percent of fields in 1998 (8,11,13,14).

## **Nematicides**

All non-fumigant nematicides have alternate uses as systemic or soil-applied contact insecticides. Use rates and patterns are reported under Nematodes, below.

## **Nematodes**

**Nematodes (primarily *Meloidogyne incognita*, *M. aerenaria*, *M. javanica*; *Globodera tabacum* subsp. *solanacearum*, *Pratylenchus brachyurus* and *P. penetrans*).**

Root-knot, lesion, and tobacco-cyst nematodes are parasitic on the roots of tobacco and can cause severe stunting of plants (flue-cured and dark fire-cured, but less so in burley and sun-cured tobacco). Stunting reduces yield and results in an uneven crop that is difficult and expensive to manage. Known damage to tobacco by lesion nematodes is rare. Although root-knot nematodes are common in tobacco fields in Virginia, many currently planted varieties are resistant, and effective nematicides are commonly used. Most reported crop losses in Virginia attributed to nematodes are caused by a tobacco cyst nematode. This nematode continues to spread to new fields, farms, and counties within Southside Virginia. Nematodes are estimated to have reduced crop values in flue-cured tobacco in Virginia by 3 percent in 1998 (despite extensive control measures, potential losses can be much higher) (8,12,13,14).

### **Cultural control:**

Sanitation (fall stalk and root destruction) is almost universally practiced for control of nematodes and other pests, although the timeliness of use varies significantly, reducing potential benefits. Varieties resistant to one or more important tobacco diseases are available and were used on approximately 90 percent of crop acreage in 1998. However, nematode species and races exist for which no commercially available resistant varieties are available. Rotation by the use of such crops as small grains and grasses is effective in reducing populations (12,13).

### **Chemical control:**

Soil assays and tobacco root evaluation can be used to predict future populations and to design management programs, including cultural and chemical practices. Both fumigants and contact nematicides are available. Fumigants are often used for multiple purposes and are described previously. An estimated 50 to 75 percent of flue-cured tobacco acres are either fumigated or treated with a contact nematicide. About 15 percent of the flue-cured tobacco acreage is fumigated, while 35-55 percent is treated with 3 pounds active ingredient of aldicarb or 3-6 pounds active ingredient of fenamiphos, usually tank-mixed with another soil insecticidal material (8,13).

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