Crop Profile for Tobacco in North Carolina

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General Production Information

- North Carolina produces two styles of tobacco, flue-cured and burley.
- North Carolina ranks first in production of flue-cured tobacco, raising about 77 percent of the U.S. total in 2015[1].
- North Carolina ranks sixth in the production of burley tobacco, growing approximately 1,400 acres in 2015[1].
- Gross income from tobacco production in North Carolina was over $911 million in 2014[2].
- The gross value of tobacco averages around $4,715 per acre and can reach nearly $7,000 per acre[2].
- Typical production costs for flue-cured tobacco in 2013 were roughly $3,500 per acre[3].

Production Regions

Flue-cured and burley tobacco have traditionally been produced in two very distinct regions of North Carolina; however, growing areas do overlap in certain situations. Flue-cured tobacco is produced in most Coastal Plain and Northern Piedmont counties (56 counties)[4]. The soil types found in these specific regions are extremely conducive to producing the flavor style tobacco typical of North Carolina, thanks in part to good internal drainage and low organic content. Burley is more commonly produced in the mountainous western region of the state, with limited acreage being found in the Northern Piedmont (13 counties)[4]. Burley tobacco has historically been produced in the mountains of North Carolina due to a favorable climate marked by moderate temperatures with high relative humidity and soil types suitable for nutrient retention.

Production Practices

Tobacco is grown on a wide variety of soils, from very sandy to clay. However, maximum yields are typically seen in sandy loam; soils with high organic content are not suitable. Soil nitrogen must be low after flowering/topping to successfully produce a good quality crop.

Nearly 80 percent of the crop is grown on at least a two-year rotation[5]. Flue-cured tobacco is typically grown on a high, wide row bed to allow for good drainage and aeration of the roots. Some flue-cured and most burley is grown on a flat field surface. Though some acres are grown as no-till or reduced-till, the overwhelming majority (>99 percent)[5] of flue-cured tobacco is grown with conventional tillage. No-till production is more prevalent in burley production, where soil type and topography are more favorable for its use.

Tobacco is mechanically transplanted into the field as seedlings produced in greenhouses. Greenhouses are typically sown from mid-February to mid-March, and field ready transplants are grown in 55 to 60 days. (Approximately 60 square feet of greenhouse space will produce one acre of transplants). Targeted planting density of flue-cured tobacco is 6,000 plants per acre. Burley is planted at a higher density of 7,200 plants per acre, due to a more erect leaf morphology. At the time of transplanting, water is applied in-furrow underneath tobacco seedlings. Water applied at transplanting often contains trace amounts of nutrients and Crop Protection Agent's (CPA's), all of which contribute to increased transplant vigor and more rapid growth. Overhead irrigation is utilized on approximately 20-25 percent of the acreage[5]. Between transplanting and layby (a crop stage that typically occurs four to six weeks after transplanting when tobacco plants are about 15 to 20 inches in height) tobacco is cultivated to remove weeds, incorporate CPA's, reduce soil crusting, improve aeration/drainage, and to continuously build a raised plant bed. Developing flower heads begin to appear eight to 10 weeks after transplanting and are removed (topped) to increase leaf yield and quality. Topping may be done by hand (59% of acreage[5]) or mechanically (41% of acreage[5]). Since tobacco is a terminally dominant plant, removal of flower heads induces growth of lateral shoots known as "suckers". In most cases, suckers are controlled chemically; however, some clean-up by hand is normally done.

Harvest of flue-cured tobacco is accomplished in multiple stages, with the ripest (lower leaves) removed first. Harvest is accomplished by hand (28% of acreage[5]) or mechanically (72% of acreage[5]). Following harvest, flue-cured tobacco is placed into a forced-air indirect-heated curing barn for a period of 6-8 days. During the curing process, the interior barn temperature is gradually increased from ambient to nearly 165°F. As the temperature is increased, relative humidity is gradually decreased to allow for complete moisture removal from leaf lamina and stems/midribs. The flue-curing process is broken into three distinct phases: yellowing, leaf drying, and stem drying. During the yellowing phase, starch within the leaf is converted into sugar and chlorophyll is degraded to reveal carotenoids, thus giving the leaf a pleasing smell/flavor and a yellow to orange color. Once yellowing is complete, the curing temperature is increased to stop enzymatic degradation of sugar and to remove additional moisture from the lamina and midrib. After the curing process is finished, leaves have essentially zero percent moisture content; therefore, moisture must be added for handling. This process is referred to as "ordering tobacco". Burley tobacco is harvested in a single pass. Burley tobacco is stalk cut with a knife or hatchet and the entire plant is hung on a stick to air-cure. The air-curing process will last in duration from one to two months depending upon climatic conditions. Once cured, burley tobacco is stripped and leaves are separated by stalk position. Flue-cured and burley tobacco leaves are compressed into bales weighing roughly 650 to 700 pounds and sold at receiving stations designated by individual contracts with various leaf dealers and/or manufacturers.

Diseases

Diseases can impact the yield and quality of tobacco, and may occur in the greenhouse, field, and even during curing. Disease can be a major factor in the production of seedlings in greenhouses. In 2015, the most common diseases reported in tobacco greenhouses were caused by *Pythium* (3% loss[5]), *Rhizoctonia* (2% loss[5]), and *Sclerotinia* (2% loss[5]). Minimizing disease losses in the greenhouse begins with the use of good cultural practices. Sanitation practices include cleaning mowers to avoid the spread of tobacco mosaic virus and bacteria; removing plant clippings, used media, and discarded seedlings well away from the greenhouse; sanitizing or changing foot gear; cleaning seedling trays between seasons; and using only clean water for float beds or overhead irrigation when needed. 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 any pathogens in the greenhouse. Keeping greenhouses free of weed hosts and avoiding the production of tobacco from October to February are also helpful in avoiding diseases. Fumigation with methyl bromide (where available) (48% of producers[5]), sanitizing transplant trays by dipping them in a 10 percent bleach solution (8% of producers[5]), and steaming of trays (25% of producers[5]) are sometimes used. Methyl bromide is no longer manufactured; therefore, availability is extremely limited and producers will be forced to utilize other methods of tray sanitation in the near future. When using a bleach solution for sanitation, great care must taken to ensure that bleach adequately penetrates into any cracks in the trays and then that it is sufficiently washed from each tray. If bleach is not removed, sodium and chloride concentrations will inhibit seedling growth. Limited chemical control options for disease control are available: mancozeb, aluminum tris, and ferbam are available for blue mold and anthracnose suppression; azoxystrobin can be used once for target spot control; and etridiazole (e.g., Terrazole) can help with Pythium root rot.

Tobacco field diseases caused North Carolina growers an average yield loss of 10 to 15 percent in 2015[5]. Integrated management plans are needed and widely used to control tobacco diseases in the field. Such plans include crop rotation, sanitation (timely stalk and root destruction), resistant varieties, row bedding, plant spacing, balanced fertilization, and the use of fumigants, fungicides, and nematicides. Almost all chemical control is preventative rather than curative and is applied pre-transplanting or initiated when diseases first appear in the field or area.

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 root rot, black shank, and Granville wilt. In 1989, growers reported treating 10 percent of acres with chloropicrin, 2.5 percent with 1,3-dichloropropene, and 16 percent with combinations of the two. In 1998, it was estimated that growers treated 41 percent of their acres with chloropicrin and 35 percent with 1,3-dichloropropene (these figures include 23percent of acres treated with combinations of the two). In 2015, reports indicate that 42 percent of acres were treated with chloropicrin, 2.5 percent with 1,3-dichloropropene, and 37 percent with combinations of the two[5].

Fungicides

Mefenoxam is used for the control of black shank and sensitive strains of blue mold. This material was used on 67 percent of the tobacco acreage in 2015, either alone or in combination with other CPA's, primarily for the suppression of black shank[5]. A new active ingredient, fluopicolide, was labeled in 2015 for black shank and blue mold and is estimated to have been applied to 32 percent of the acreage[5]. Azoxystrobin is used for control of target spot, and was applied to 47 percent of the acreage in 2015[5]. Multiple CPA's are labeled for blue mold, but are not commonly used in flue-cured tobacco production unless the pathogen is identified early in the season.

Nematicides

Root-knot nematodes, primarily *Meloidogyne incognita, M. arenaria, and M. javanica*, are parasitic on the roots of tobacco plants and can cause severe stunting. Stunting reduces yield and results in an uneven crop that is difficult and expensive to manage. These pests are widespread and are estimated to have reduced yields in North Carolina by about 1.7 percent in 2015[5] (despite extensive control measures, potential losses are much higher). The presence of root-knot nematodes may greatly increase the severity of diseases caused by other pathogens, so growers should routinely have soil tests done to determine if they have root-knot nematodes in their fields.

Cultural control:
Sanitation (fall stalk and root destruction) is almost universally practiced for control of nematodes and root pathogens of tobacco. Resistant varieties have been developed and are commercially available for most diseases. In addition, rotation by the use of such crops as small grains and grasses is effective in reducing pathogen populations.

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; however, contact type nematicides are not used. Fumigants are often used for multiple purposes and are most valuable in the prevention of disease complexes involving nematodes and fungi.

Weeds

Season-long weed suppression can be extremely difficult to achieve in a tobacco production system. Multiple factors contribute to this issue, but the primary reason is the length of the growing season, which can last longer than five months. Weeds are problematic because they can serve as alternate hosts for certain diseases, reduce leaf yield and quality, interfere with mechanical harvest, contribute to foreign matter contamination in marketable leaf, and can compromise export market opportunities.

Cultural control:
Crop rotation, cover crops, deep tillage, 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 timely cultivation, the most effective cultural control, from being as beneficial as in the past.

Chemical control:
At present, there are only seven herbicides labeled for use in tobacco production. Surveys indicate that over 97 percent of all flue-cured tobacco acreage in North Carolina is treated with at least one of these herbicides. The most commonly used are clomazone (0.75 to1.00 lb. ai/acre), sulfentrazone (0.25 to 0.38 lb. ai/acre), sethoxydim (0.19 to 0.28 lb. ai/acre), and pendimethalin (0.75 to 1.00 lb. ai/acre)[5]. Together, these four herbicides provide control for the majority of problem weeds encountered in tobacco production.

Growers will either incorporate or soil-apply herbicides before transplanting because of label restrictions and/or time constraints. Sethoxydim and carfentrazone are the only herbicides labeled for remedial control.

Insect Pests

A complex of pest insects, and other invertebrates, feed on tobacco during different parts of its production cycle (Figure 1.). Of these, hornworms, budworms, green peach aphids, and flea beetles are the most common pests that necessitate insecticide applications. Viruses spread by tobacco thrips and wireworm damage are also of impact in certain localized areas of NC.

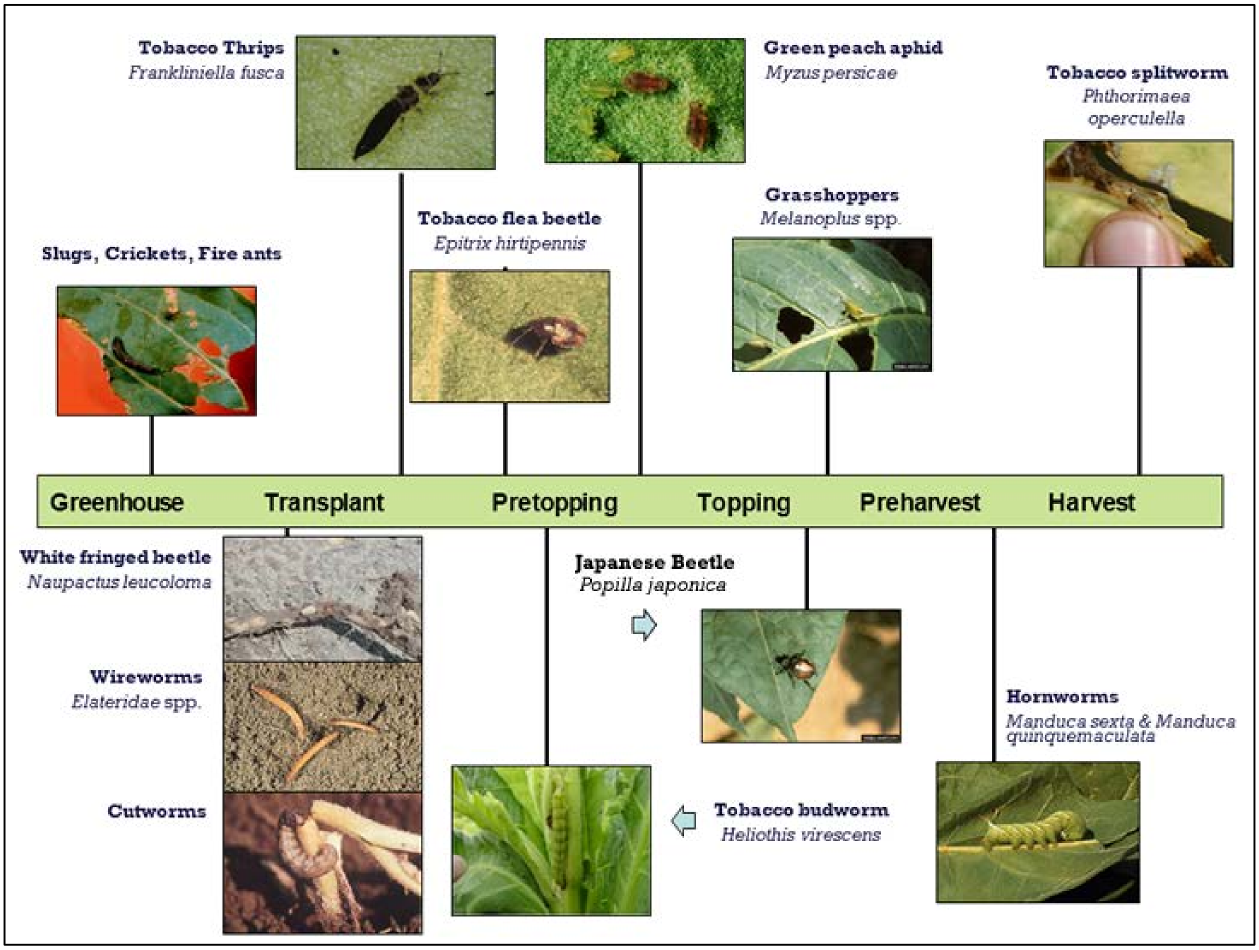

Figure 1. A timeline of tobacco pests. Origin: NC Tobacco Portal – Insect Pest Management. Timeline assembled by H. J. Burrack.

Pest	Damage	2016 economic threshold for insecticide treatment	For more information
Wireworms (*Elateridae* spp.)	Wireworms are immature click beetle larvae that live underground and feed on the roots of tobacco plants. This feeding can cause stunting of tobacco plants, and make plants more susceptible to soil-borne pathogens.	Since there are no "rescue treatments" available for wireworms, there are no economic thresholds. Soil fumigation or systemic insecticide applications are recommended only where field history indicates the potential for wireworm damage.	Check out the NC Tobacco Portal for additional information on wireworm biology and control. Current insecticide recommendations can be found in the North Carolina Agricultural Chemicals Manual (pg. 96 of the 'Insect Control' section in the 2016 version).
Tobacco Thrips (*Frankliniella fusca*)	Tobacco thrips cause little damage on their own, but they vector tomato spotted wilt virus (TSWV) which can severely stunt or kill tobacco plants.	The TSWV and Thrips Exposure Tool for Tobacco can be used for timing planting and insecticide applications to reduce damage from tomato spotted wilt virus.	Check out the NC Tobacco Portal for additional information on tobacco thrips. Current insecticide recommendations can be found in the North Carolina Agricultural Chemicals Manual (pg. 96 of the 'Insect Control' section in the 2016 version).
Tobacco flea beetle (*Epitrix hirtipennis*)	Adult beetles feed on leaves leaving tiny "shot holes". Heavy feeding on young transplants can stunt or kill them. Very high numbers of tobacco flea beetles around the time of harvest can result in lower leaves with a lacy appearance.	*Young plants*: 4 beetles/plant *Mature plants (post topping):* 60 beetles/plant	Check out the NC Tobacco Portal for additional information on flea beetle biology and control. Current insecticide recommendations can be found in the North Carolina Agricultural Chemicals Manual (pg. 93 of the 'Insect Control' section in the 2016 version).
Tobacco budworm (*Heliothis virescens*)	Caterpillars damage leaves directly, but usually this damage does not reduce yield. Of greater concern is caterpillar feeding that triggers excess	10% of plants infested with at least one budworm	Check out the NC Tobacco Portal for additional information on tobacco budworm biology and control. Current insecticide recommendations can

	sucker growth, which results in labor-intensive removal.		be found in the North Carolina Agricultural Chemicals Manual (pg. 94 of the 'Insect Control' section in the 2016 version).
Green peach aphids (*Myzus persicae*)	Heavy infestations result in stunting of tobacco plants and lower yields. Aphids also excrete a sugary-liquid called honeydew that can promote the growth of leaf-staining sooty molds on the leaves below.	10% of plants infested with more than 50 aphids per upper stalk leaf	Check out the NC Tobacco Portal for additional information on green peach aphid biology and control. Current insecticide recommendations can be found in the North Carolina Agricultural Chemicals Manual (pg. 91 for greenhouse and pg. 92 for field applications in the 2016 version).
Tobacco hornworm (*Manduca sexta*) and tomato hornworm (*M. quinquemaculata*)	Caterpillars feed on tobacco leaves, and mature caterpillars can cause rapid defoliation of whole tobacco plants.	One hornworm per 10 plants	Check out the NC Tobacco Portal for additional information on hornworm biology and control. Current insecticide recommendations can be found in the North Carolina Agricultural Chemicals Manual (pg. 94 of the 'Insect Control' section in the 2016 version).

Occasional pests include white fringed beetles, cutworms, grasshoppers, tobacco splitworms, Japanese beetles, stinkbugs, and various greenhouse pests. More information about the biology and control of these pests can be found in the Insect Pest Management section of the North Carolina Tobacco Portal.

Topping and Suckers

In a process referred to as "topping", the floral parts of tobacco plants are removed to increase 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 41 percent of the crop are topped mechanically and 59 percent by hand[5].

After the plants are topped, or after they reach the full flower stage, apical dominance is lost within the plant. This physiological response results in lateral shoot growth from each leaf axil. These axillary shoots are called suckers, and two or three per leaf axil are commonly produced. Most plants are topped at 20 leaves, which results in 40 to 60 potential suckers per plant. Excessive sucker growth also reduces yield and quality in the same manner as unremoved flowers. Therefore, sucker control is a very important management practice.

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

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) 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 suckers in each leaf axil. Control is regulated by concentration (4 to 5 percent commercial product on a volume basis), timing (earlier is best because coverage is better on small suckers), and application technique (high water volume, low pressure for rundown from leaf axil to leaf axil on the stalk). The purpose of the contact is to control sucker growth until the upper leaves on the plant are mature enough that a systemic suckercide to control suckers by stopping cell division can be applied. Typically, contacts are applied 2 to 3 times per acre per season. For example in 2015, 21 percent of the acreage received two contact applications and 68 percent received at least three[5]. Less than 5 percent of the acreage received one contact application[5]. Typically, each application involves a minimum of 2 gallons of commercial product per acre.

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 minimum of 8 to10 inches. 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 82 percent of the acreage in 2015[5]. Because of cured leaf residues, MH should be applied only once per season. Sucker control is not adequate with one application of MH; therefore, MH is usually applied in combination with one of two locally systemic materials. The local systemics are dinitroanilines (flumetralin and butralin), and they control suckers in the same manner as MH. Dinitroanilines are not true systemics and must be absorbed at the leaf axil. Flumetralin is more commonly used in flue-cured production, while butralin is used almost exclusively in burley production. In 2015, flumetralin was applied in combination with MH to approximately 61 percent of the acreage[5]. In addition, 23 percent of the acreage received flumetralin but no MH[5].

The labeled MH rate is 1.5 gallons per acre (2.25 lbs. ai/acre); however, 1.0 gallons per acre is recommended due to residue concerns. Flumetralin is typically applied at 0.5 gallons per acre (0.6 lbs. ai/acre). For burley production, butralin is applied at 0.5 to 0.75 gallons per acre (1.5 to 2.25 lbs. ai/acre

Online Resources

2015-2016 Burley & Dark Tobacco Production Guide

2015 NCSU Flue-Cured Tobacco Production Guide

NCSU Tobacco Portal

NCSU Plant Disease & Insect Clinic

2015 North Carolina Agricultural Chemicals Manual

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