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 63 percent of the U.S. total.
- North Carolina ranks sixth in the production of burley tobacco, growing about 3 percent of the U.S. total.
- Gross income from tobacco production in North Carolina was about $1.1 billion in 1997.
- The gross value of tobacco averages around $3,750 per acre and can reach nearly $7,000 per acre.
- Typical production costs for flue-cured tobacco in 1997 were about $2,660 per acre.

Production Regions

Flue-cured tobacco is produced in most coastal plain and northern piedmont counties (64 counties). Burley is produced in the mountains in the west (20 counties).

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.

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 burley tobacco is 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 85 percent) or in plastic-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 used on approximately 35 percent of acreage. 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 clean-up 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 two or three times.

Insect Pests

Cultural and biological controls are widely used to reduce the probability of damaging populations of several major pests. But damaging levels do develop in some fields, even when such controls are used. In 1989, 94.75 percent of growers surveyed reported making at least one insecticide application on at least some fields. Despite slight year-to-year variation, there is no evidence that this use rate has changed significantly since that survey. Treatment thresholds have been established for the four most common leaf-feeding pests and are used to direct foliar applications of insecticides.

Data on insecticide use in tobacco do not allow application rates to be accurately partitioned among target pests. Thus, insecticide use is dealt with here in general terms. Insecticide applications to control wireworms are discussed under that heading.

Insecticides used in plant beds and greenhouses

Acephate is the only conventional insecticide currently labeled for control of insects in greenhouses and plant beds. This material is used on an estimated 50 percent of seedlings an average of 1.5 times at 0.75 pound active ingredient per acre. An insecticidal soap labeled for control of small pests such as aphids offers only fair control and is little used.

Soil-applied systemic insecticides

Acephate is used at 0.75 pound active ingredient per acre as a transplant water treatment for flea beetle control and aphid suppression. Data on use of this material in this manner are combined with foliar applications below. Aldicarb is registered [24(c)] for use in North Carolina for control of nematodes and for systemic control of aphids and flea beetles. Growers reported using this material on 12.6 percent of acres in 1989 at an average rate of 1.6 pounds active ingredient per acre, one preplant-incorporated application. In 1996, aldicarb was used on 14 percent of acres at 1.7 pounds active ingredient per acre. The introduction of a new soil-applied systemic, imidacloprid, is estimated to have reduced the use of aldicarb to about 6 percent of acres in 1998. Disulfoton, carbofuran, and oxamyl were used on 4.9 percent, 1.8 percent, and 1.1 percent of acres, respectively, in 1989; but their use declined to negligible levels in 1996 and 1998. Imidacloprid was introduced for use in 1996, and little was used that year. In 1998, however, the material was used on an estimated 35 percent of acres, one application, at a rate of 0.02 pound active ingredient per acre.

Foliar insecticides

Acephate, a broad-spectrum material effective against most insect pests, is the most widely used insecticide in North Carolina tobacco production. However, the introduction of newer chemistry has reduced its use in recent years. In 1989, flue-cured producers reported using acephate on 91 percent of total acreage, making 2.4 applications per year. In 1996, growers reported using acephate on 87 percent of fields with an average of 1.4 applications annually (this figure includes use as a transplant water treatment). By 1998, this level of use had been further reduced by the introduction of imidacloprid (for aphid and flea beetle control) and spinosad (budworm and hornworm control). Estimated acephate use in 1998 was 1.2 applications on 70 percent of fields. Acephate is most commonly used at 0.75 lb active ingredient per acre for aphid, budworm, and flea beetle control and at 0.5 pound active ingredient per acre for hornworm control (about 20 percent of total use). Methomyl is used primarily for budworm and hornworm control at 0.45 pound active ingredient per acre. In 1986, this material was used on 11 percent of total acres, with 1 application per treated acre. Use in 1998 is estimated to have been similar. Carbaryl is little used in flue-cured tobacco production, used on less than 2 percent of fields in 1989 and not reported in 1986. Endosulfan was used, primarily for aphid control, on 7 percent of acres in 1996, 1 application per treated field, at 1 pound active ingredient per acre. Use in 1998 is estimated to have been slightly less, 5 percent of acres. *Bacillus thuringiensis* (*Bt*) was reported to have been used for budworm and/or hornworm control on 13.4 percent of acres in 1989, about 1.4 applications, and on 5 percent of acres in 1996, about 1.4 applications. It is estimated to have been used on 15 percent of acres in 1998. Spinosad is estimated to have been used on 13 percent of fields, 1.1 applications at 0.05 pound active ingredient per acre in 1998; and imidacloprid was used once on 2 percent of acres at 0.03 pound active ingredient per acre.

Significant Insect Pests

Tobacco budworm *(Heliothis virescens)* and corn earworm *(Helicoverpa zea)*

These pests, as a complex generally dealt with as "budworms," cause loss and require treatment on some acreage in virtually every year. In most years they are the first or second most-damaging insect pest of tobacco, requiring treatment on 40 to 60 percent of acres. Larvae of these species feed in the growing terminal bud of the plant, damaging and distorting leaves. Usually remaining deep in the bud, these pests are protected somewhat from chemical applications. Almost all treatment in the field occurs at least two weeks before first harvest. These pests very rarely attack tobacco seedlings in the greenhouse or plant bed before transplanting.

Cultural and biological control:
Postharvest stalk and root destruction denies later generations of these pests a ready food source 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 in 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 ovipositing moths and cuts infestation rates slightly (in flue-cured but not burley tobacco). Topping at the earliest practical point also reduces the attractiveness of the plants to ovipositing 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 single budworm-resistant variety is available and effective but is used little due to poor agronomic characteristics. A number of insect predators and parasitoids have significant effects on the budworm complex. Growers are advised to avoid, and many do, unnecessary foliar insecticide applications to preserve naturally occurring, beneficial insects.

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 displaced some acephate and methomyl use. *Bt* applied in a cornmeal or similar bait formulation is highly effective, but it is not used by many growers because it must be applied by hand. Applied as a conventional spray, *Bt* materials are only moderately effective. Methomyl is effective and endosulfan moderately effective, but both have high mammalian toxicity. Endosulfan residues are objectionable to tobacco buyers, who discourage the use of this material.

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

The tobacco aphid is the most consistently damaging insect pest of tobacco in North Carolina, affecting both crop yield and quality. Annually, 50 to 60 percent of fields require insecticidal treatment for this pest. Uncontrolled, it may reduce crop values by 10 to 20 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.

Cultural and biological control:
Reducing nitrogen fertilization to the lowest agronomically acceptable rate reduces 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 less suitable as a host. Population growth is slowed or stopped by topping, and the natural population crash is hastened. Chemical sucker control associated with topping (particularly when fatty alcohols are used) also helps kill aphids—through direct effects on the aphids and through elimination of suckers, which are 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.

Chemical control:
Two soil-applied systemic insecticides are available for preventative aphid control in North Carolina: imidacloprid (flue-cured and burley) and aldicarb (flue-cured only). The introduction of imidacloprid has recently reduced aldicarb use. Both are highly effective, but aldicarb is highly toxic and highly leachable. Two other systemic materials, acephate and phenamiphos, 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 the recently introduced imidacloprid. All provide good control. However, endosulfan residues are objectionable to tobacco buyers, and this product is not recommended for use after topping. It is also highly toxic. Methomyl is initially effective, but populations rebound more quickly than with other materials, and mammalian toxicity is high. Insecticide resistance is a major concern with the tobacco aphid; resistance developed to several insecticides in the mid-1980s. It is important that a range of chemistries be maintained to manage resistance buildup. In most years, 50 to 70 percent of fields are treated for this pest. Most, but not all, applications are made at least one week before harvest.

Tobacco hornworm *(Manduca sexta)* and tomato hornworm *(M. quinquemaculata)*

These pests, as a complex generally dealt with as "hornworms," cause loss and require treatment of some acreage virtually every year. In most years treatment is required on 25 to 50 percent of acres, and multiple treatment is sometimes necessary. Larvae of these species feed on leaves throughout the plant.

Hornworms are potentially the most damaging insect pests of tobacco, and a heavy infestation can totally destroy a crop. However, such heavy infestations are uncommon, and beneficial insects typically reduce populations significantly. Also, the pests are easy to detect, and control with several insecticides is very effective. Thus, yield losses are typically kept low.

Cultural and biological control:
Postharvest 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, thus, reduces the size of the overwintering generation and pest pressure on the tobacco crop in the following year. Most growers destroy stalks and roots, though in some cases they delay beyond the optimum. Reducing nitrogen fertilization to the lowest agronomically acceptable rate makes the plant less attractive to ovipositing moths and cuts infestation rates slightly (in flue-cured but not burley tobacco). Topping at the earliest practical point also reduces the attractiveness of the plants to ovipositing 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, and many do, unnecessary foliar insecticide applications to preserve naturally occurring beneficial insects.

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, however. These include acephate, *Bt*, carbaryl, methomyl, and the newly introduced spinosad. Methomyl is more highly toxic to mammals than other choices. Carbaryl is often avoided due to its tendency to increase aphid populations and its occasional phytotoxic effects.

<u>Tobacco flea beetle</u> ***(Epitrix hirtipennis)***

Both the larvae and adults of this pest species attack tobacco. 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. Adult beetles feed on leaves, chewing small "shot-holes" in the leaves. Several generations occur, but the most significant damage is caused by the first two.

Cultural and biological control:
Destroying unused plants in greenhouses or plant beds eliminates these sites as nurseries for flea beetles, which may then move into nearby fields. This is widely practiced. Postharvest 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. Most growers destroy stalks and roots, though in some cases they delay beyond the optimum.

Chemical control:

Several soil-applied systemic insecticides are available for preventative control of flea beetles in North Carolina. These include acephate (transplant water), aldicarb, carbofuran, disulfoton, imidacloprid (transplant water or greenhouse treatment), and oxamyl. One other systemic material, phenamiphos, which is used primarily to control other pests, may suppress flea beetle numbers. Before 1997, most treatments were acephate or aldicarb. However, the introduction of imidacloprid has reduced the use of these materials. Foliar insecticides available for flea-beetle control in 1998 included acephate, imidacloprid, methomyl, and carbaryl. All provide good to excellent control. Most, but not all, applications are made in the first few weeks after transplanting, several weeks before harvest.

Wireworms

Wireworms, the larvae of elaterid 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 an uneven stand that is difficult and costly to manage.

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.

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 1996, growers reported using this material at 2.3 pounds active ingredient per acre on 25 percent of acres, one application. By 1998, some growers were relying on imidacloprid, used for systemic control of leaf-feeding pests, to provide wireworm control as well. Two materials previously commonly used for wireworm control—diazinon and dyfonate—are no longer widely available, and their use was negligible in 1998. Ethoprop provides wireworm control, but it is also used for nematode control, and its use rates are reported in that section.

Minor or Occasional Pests

Several insect species occasionally cause significant yield or quality loss in tobacco production. These include grasshoppers, cabbage loopers, beet armyworms, stink bugs, Japanese beetles, and others. 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. Averaged across all fields, treatments for all minor pests combined total no more than 0.2 applications per field per year.

Diseases

Disease is a major factor in the production of seedlings in plant beds or greenhouses. Though statewide loss estimates are not available, in individual cases, diseases have reduced usable transplants by more that 50 percent. The most common diseases in greenhouses are caused by *Rhizoctonia*, *Sclerotinia*, *Pythium*, and *Erwinia*. Several cultural practices are important in the control of these diseases. 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; 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 140o 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. Fumigation with methyl bromide and/or sanitizing transplant trays by dipping them in a 10 percent bleach solution are sometimes used. Mancozeb or carbamate may be applied every week to prevent blue mold and anthracnose.

Tobacco diseases in the field caused North Carolina growers an average yield loss of 6 to 7 percent in 1996 and 1997. 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.

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 1996, surveyed growers reported using chloropicrin on 28 percent of acres (one application @ 79.8 lbs/acre) and 1,3-dichloropropene on 27 percent of acres (one application @ 89.5 lbs/acre). In 1998, it is estimated that growers treated 41 percent of their acres with chloropicrin and 35 percent with 1,3-dichloropropene (these figures include 23 percent of acres treated with combinations of the two).

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 64 percent of acres in 1989 and on 49 percent of acres (one treatment of 0.76 lb/acre) in 1996. The development of metalaxyl-resistant isolates of the blue mold fungus and changes in the disease threat brought the use of metalaxyl to 63 percent of fields in 1998. Reported use of mancozeb in 1989 and 1996 was negligible, but its use for control of resistant blue mold increased to 1 percent of fields in 1998.

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 (primarily *Meloidogyne incognita, M. aernaria, M. javanica*)

Root-knot nematodes are parasitic on the roots of tobacco plants and can cause severe stunting of plants. 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 0.38 percent in 1997 (despite extensive control measures, potential losses are much higher).

Cultural control:
Sanitation (fall stalk and root destruction) is almost universally practiced for control of nematodes and other pests. Resistant varieties are available and were used on approximately 97 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.

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 on page 5. Grower surveys indicate that 25 percent of acres were treated with one preplant incorporated (ppi) application of fenamiphos at 3 pounds active ingredient per acre; 14 percent of acres were treated with one application of aldicarb at 1.7 pounds active ingredient per acre for nematode and insect control; and

6 percent of acres were treated with one ppi application of ethoprop for nematode and wireworm control at 5.2 pounds active ingredient per acre. In 1998, growers were estimated to have treated 15 percent of their acres with one ppi application of fenamiphos, 6.5 percent of acres with one application of aldicarb for nematode and insect control, and 5.5 percent of acres with one ppi application of ethoprop for nematode and wireworm control.

Weeds

In 1997, weed populations in flue-cured tobacco caused an estimated loss of $3.3 million in yield, $0.55 million in quality, and $0.45 million in harvesting cost. Only six herbicides are labeled for use in North Carolina; therefore, growers are limited in their choices for control of problem weed species. Chemical weed control in flue-cured tobacco is becoming more important as growers expand their operations. Timely cultivations become 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.

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.

Chemical control:
Surveys indicate that approximately 75 percent of all flue-cured acreage in North Carolina is treated with at least one herbicide. The most commonly used are clomazone (0.75-1 lb active ingredient/acre), pendimethalin (0.5 lb active ingredient/acre) and sulfentrazone (0.25-0.375 lb active ingredient/acre). These three 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. Recent labeling of sethoxydim for field use should, however, give growers some remedial control measures for grass species.

Topping and Suckers

The floral parts of tobacco plants are removed (commonly called "topping") 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 34 percent of the crop are topped mechanically and 64 percent by hand.

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 shoots are called suckers, and two per leaf axil are commonly produced. Most plants are topped at 20 leaves, which results in 40 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 1997, 60 percent of the acreage received two contact applications and 17 percent received three. Twenty-three percent of the acreage was sprayed once with a contact. Typically, each application involves 2 gallons of commercial product.

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 certain size. 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 95 percent of the acreage in 1997. 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 (fluometralin 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. Prime+ (fluometralin) was applied in combination with MH to approximately 75 percent of the acreage in 1997. Butralin was used with MH on an additional 10 percent of the acreage. Five percent of the acreage received a dinitroaniline without MH.

The labeled MH rate is 1.5 gallons per acre (2.25 lb active ingredient/acre). Prime+ is typically applied at 0.5 gallons per acre (0.6 lb active ingredient/acre). Butralin is applied at 0.75 gallons per acre (2.25 lb active ingredient/acre).

On-Line Resources

North Carolina Integrated Pest Management

North Carolina Pesticide Impact Assessment Program

1999 Burley Tobacco Information

1999 Flue-Cured Tobacco Information

Tobacco Blue Mold Forecast

Plant Disease Information Notes - Tobacco

Pests og Tobacco

Tobacco Irrigation

Tobacco, Horticultural Commodity of North Carolina

Tobacco Budworms

Wireworms

Tobacco Flea Beetle

Tobacco Hornworm

Tobacco (Green Peach) Aphid

Cabbage Looper

Japanese Beetle

Beet Armyworm

Stink Bugs

Grasshoppers

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