

Crop Profile for Field Corn in North Carolina

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Revised: November 1999, June 2005



General Production Information

- North Carolina ranked eighteenth nationally in the production of corn for grain in 2003, representing 0.7 percent of U. S. production.
- In 2003, 680,000 acres of corn for grain were harvested in North Carolina.
- In 2003, 72.1 million bushels of corn for grain were produced in North Carolina for a value of \$195 million.
- In 2003, 55,000 acres of corn was harvested for silage. Production of silage totaled 880,000 tons in 2003.

Production Regions

Corn is grown throughout North Carolina, including the mountain counties. Major acreage of grain corn is grown in the Coastal Plain and Tidewater regions with some grain produced in the Piedmont (Figure 1). Most silage corn acreage is in the Piedmont and is associated with livestock production (Figure 2).

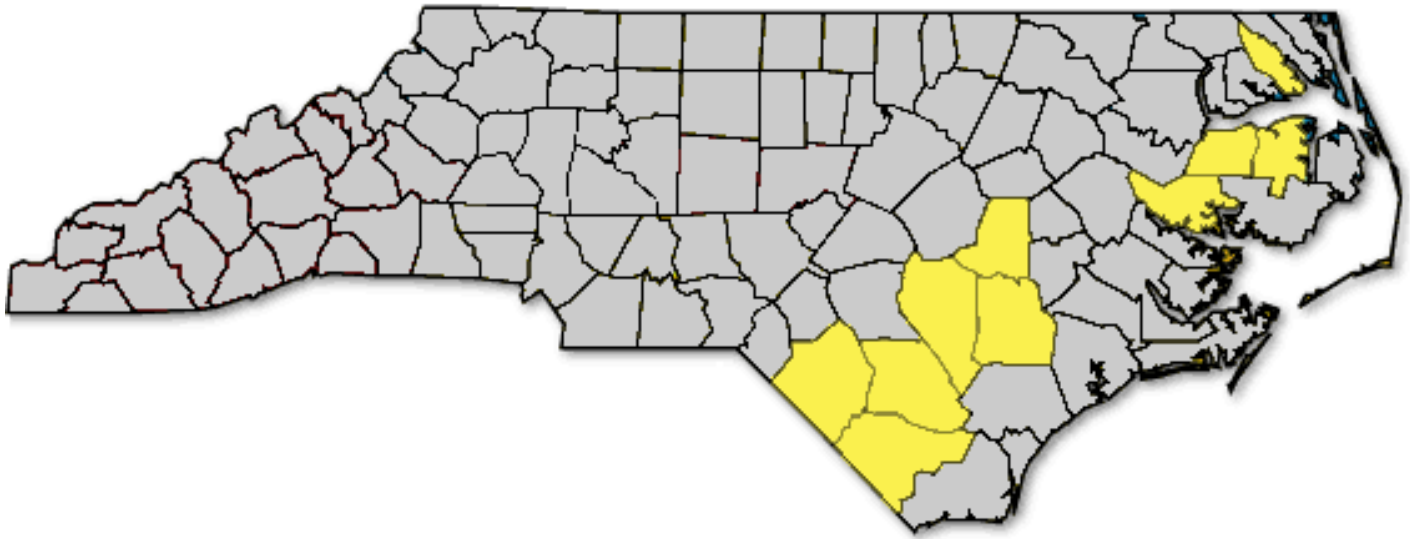


Figure 1. Leading corn (for grain) producing counties in North Carolina, including Beaufort, Duplin, Robeson, Sampson, Columbus, Pasquotank, Washington, Wayne, Tyrrell and Bladen counties.

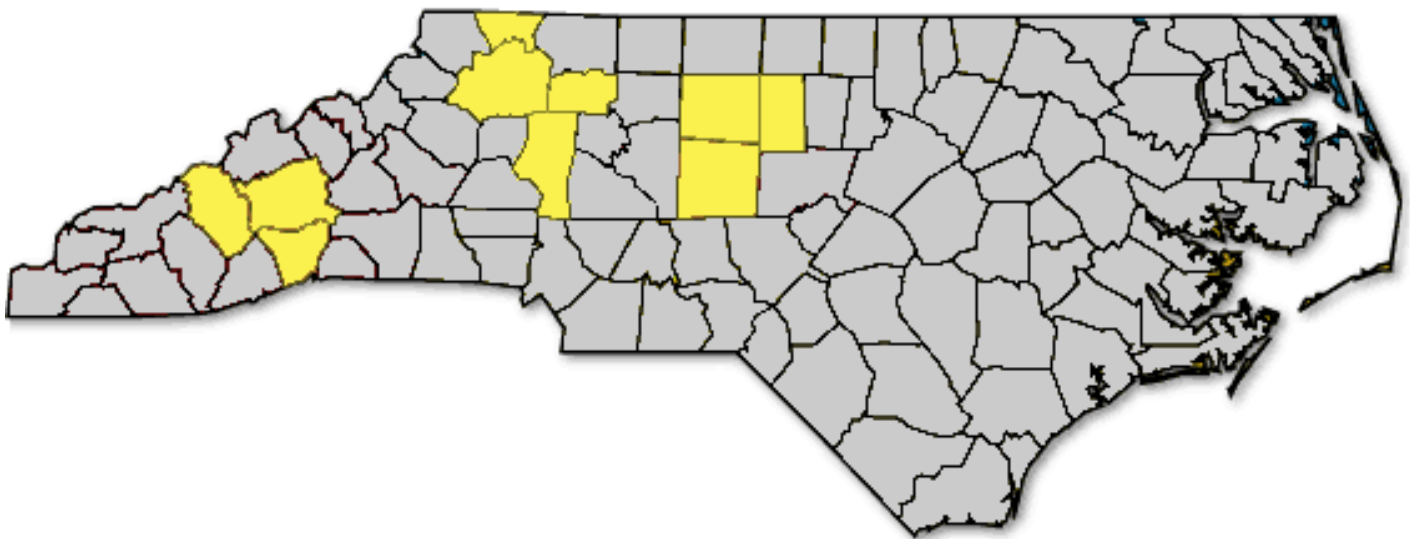


Figure 2. Leading corn (for silage) producing counties in North Carolina, including Iredell, Wilkes, Yadkin, Alleghany, Randolph, Haywood, Buncombe, Guilford, Henderson and Alamance counties.

Cultural Practices

The vast majority of corn is grown under non-irrigated conditions (rain-fed); sweet corn is more typically irrigated. Corn is grown on a wide variety of soil types from loamy sands to clays to organic soils. Conventional, strip-tillage, and no-tillage cultures are all widely practiced. Recently, there has been a shift to conservation tillage (no-till, strip-till, minimum-till), and this trend continues today. Typically, corn grown in the Coastal Plain is rotated. Most corn in the Piedmont is rotated; it is mainly dairy producers who have

continuous corn. Field corn is characterized by early inputs of fertilizer, herbicide, and insecticide followed by little attention until harvest. Field corn culture, including harvest and postharvest handling, is totally mechanized.

Worker Activities

(The following information was taken from the June 2004 Pennsylvania Field Corn Crop Profile and adapted for North Carolina field corn production.)

Field corn production presents the opportunity for applicator exposure to pesticides at many times throughout the production season.

With the exception of scouting fields to monitor weed populations, worker activities prior to planting are mostly tractor-driven operations limited to one herbicide application. This occurs from March to late-June depending upon weather, field use, and crop rotation. Field scouting is done prior to any pesticide application and therefore poses no risk of exposure.

At planting from March to early May, fungicide and insecticide treatments are the primary exposure concerns. Exposure is most likely to occur when treated seed is placed into the planter boxes, and does not often occur at any other time during the production cycle. The amount of this type of exposure varies based on the number of acres planted, which dictates how many times planter boxes must be refilled. Organophosphate insecticides are the most commonly used type for corn insect control. Personal protective equipment (PPE) is dictated by the label requirements, however, at a minimum gloves must be worn to avoid exposure when transferring insecticides and treated seeds into the planter. In some cases nematicides may also be used at time of planting.

New technologies (i.e., Roundup Ready crops) make herbicide application more common after plants emerge. This is likely to occur from early May to mid-June. However, only one herbicide application would be made at this stage and worker activity is limited to tractor-driven operations.

Applicator exposure at post harvest is limited to insecticides either those used to treat empty grain bins, or grain that is being prepared or held in storage. This would occur only once if necessary after grain has been put into storage. Because of inhalation potential, fumigation poses the greatest potential for harm from exposure.

Insect Pests

Corn is attacked by a wide variety of insect pests, about 25 species. All stages of the crop and all plant parts are attacked by one or more insects. The crop is most susceptible in the planted seed/seedling stages, and management with insecticides most often involves the at-planting application of insecticide to the seed-furrow and include granular, liquid, and seed-treatment applied chemicals to both field and sweet corn. In field corn, the whorl and reproductive stages are also attacked. Ear-feeding insects are a severe problem in sweet corn due

to the low tolerance of insects by the marketplace. Sweet corn is intensely treated with insecticide in the reproductive stage. Cultural practices enhancing insect pest levels include planting late, conservation tillage, and restricting rotation. The most commonly encountered insect pests include several wireworm species, southern corn billbug, western corn rootworm (in the Piedmont and mountains), black cutworm, fall armyworm, European corn borer, corn earworm, brown stink bug, and southern cornstalk borer. Insect pests that are infrequently encountered at economically damaging levels include armyworm, cereal leaf beetle, corn leaf aphid, corn root aphid, grasshopper, green bug, Japanese beetle, maize billbug, northern corn rootworm, seedcorn beetle, sod webworm, southern corn rootworm, stalk borer, sugarcane beetle, and white grubs.

Wireworm

Two or more wireworm species infest corn, with *Melanotus sp.* being the most important. Wireworms have an erratic distribution in time and space. The larvae eat the germinating seed as well as the seedling. When populations are high, wireworm feeding can severely reduce seedling stands and significantly reduce yield. These insects sometimes have multi-year life cycles, and their associations with other crops and weeds are not well understood. Wireworms are very difficult to predict or monitor (they are within the soil and cannot be readily observed); therefore, insecticide-use decisions tend to be based on history of infestations, tillage type, soil type, certain rotation patterns, and other associated factors that lead to increased risk.

Control:

A preventative insecticide treatment of an in-furrow applied granular or liquid insecticide, as well as insecticide seed coatings, are commonly used at planting time in areas where wireworms are perceived to be a significant risk. A single application is used on field corn. Granular or liquid formulations include: Chlorpyrifos (Lorsban), carbofuran (Furadan), permethrin (Pounce), phorate (Thimet), tefluthrin (Force) and terbufos (Counter). Seed coated insecticides are limited to clothianidin (Poncho) and thiamethoxam (Cruiser). Reduced tillage corn, especially when following no-tillage soybeans planted into wheat stubble, and corn planted to set-aside land tend to have greater wireworm infestations. In conventional tillage, most serious wireworm infestations are in corn rotated with soybeans. There are no cultural control methods directed specifically to wireworm management. There is no treatment for wireworms that can be applied after planting. On organic soils, terbufos, carbofuran, clothianidin and thiamethoxam are used, as others are not effective on these soil types.

Billbugs

Two species of billbugs infest North Carolina corn: the southern corn billbug, *Sphenophorus callosus*, and the maize billbug, *S. maidis*; there are other species of minor importance to corn. The southern corn billbug is the most common species. Billbug adults feed on seedling corn and lay eggs into the stalks. Larvae develop within the root crown. If billbug numbers are high, they can severely damage the corn crop, especially when weather or other conditions inhibit the growth of seedlings.

The insects have a one-year life cycle, have few alternate hosts, and move primarily by crawling, although distribution via flight is sometimes recognized. Consequently, rotation can be very influential unless alternate hosts are available, primarily nutsedges; rotation should emphasize isolation from the previous corn crop. Billbugs are most common in the tidewater areas and in cleared lowlands across the coastal plain. However,

they can become significant pests almost anywhere if ecological situations favor their development and survival.

Control:

An integrated approach is essential to successful billbug management in most areas of the coastal plain. The strategy includes rotation, promotion of rapid seedling development, early planting, at-planting insecticide use, scouting, and postemergence insecticides. At-planting and postemergence insecticides include terbufos (Counter), chlorpyrifos (Lorsban), clothianidin (Poncho) and thiamethoxam (Cruiser). These are the only effective insecticides (of any class) currently registered for these purposes. On organic soils, where much of the billbug problem occurs, chlorpyrifos is not effective (due to organic matter tie-up).

Insecticides are used to reduce adult billbug numbers, thereby protecting the current year crop as well as limiting the population the following year. If billbugs are allowed to build-up, crop loss and insecticide use dramatically increase. Successful billbug management relies completely on an integrated use of cultural controls and insecticides, as neither approach is adequate alone.

Corn rootworms

The rootworm complex consists of three species: western corn rootworm, *Diabrotica vergifera*; southern corn rootworm, *D. undecimpunctata howardi*; and northern corn rootworm, *D. barberi*. Western and northern corn rootworms are similar in habit, overwintering as eggs in last year's corn fields and having one generation a year. Southern corn rootworm overwinters as an adult and has two to three generations per season. Economic infestations of western and northern corn rootworms occur in the mountains and Piedmont, but adult western corn rootworm have spread into eastern North Carolina. Southern corn rootworm is distributed throughout the state. The most important species of the complex is the western corn rootworm. Larvae hatch and feed on seedling to whorl stage corn, eating the roots. Damaged plants are less thrifty and often blow over. Southern corn rootworm also attacks seedlings, feeding into the meristem and killing the plant. Under high populations rootworms can seriously reduce the yield of corn (grain or silage). The incidence of western corn rootworm has greatly increased in the last decade in western North Carolina.

Control:

Rotation is very effective against western and northern corn rootworms but not the southern. However, farmers in the western half of the state have limited opportunity to rotate and thus use at-planting insecticide or GMO Bt corn to reduce rootworms. Phosphate insecticides used against rootworms include terbufos (Counter), phorate (Thimet, Phorate), and chlorpyrifos (Lorsban). The carbamate insecticide carbofuran (Furadan) is used to a minor extent. Another insecticide used for corn rootworms is tefluthrin (Force). At planting seed treatments for cornworms include clothianidin (Poncho) and thiamethoxam (Cruiser).

In the last five years insecticide use for management of these pests has greatly increased and is predicted to climb further. In the eastern corn-growing areas, early generation southern corn rootworms are fortuitously controlled by at-planting insecticide used against wireworms and/or billbugs

Black cutworm

Black cutworm, *Agrotis ipsilon*, is a sporadic pest of many crops, including all types of corn. This insect is a threat to the seedling stage of the crop. Cultural conditions which favor early weed growth, poor crop growth, and plant residue on the soil surface (e.g., conservation tillage) are favorable to increased black cutworm problems. Typically, when the corn crop is planted, the caterpillars are in the field as larvae. Young caterpillars eat foliage, and larger stages cut the plants off and drag the seedlings into the soil where they eat it. On soft soil, like organic soils, the black cutworm may be mostly subterranean in habit. Plants that are cut-off soon after emergence will recover, but plants cut after the three-leaf stage die. When populations are high, this insect can destroy a crop, often forcing replanting.

Control:

In North Carolina black cutworm is primarily managed through scouting, use of thresholds, and applying foliar insecticide as needed. In some instances, at-planting insecticides (e.g., chlorpyrifos) used for wireworms, rootworms, or other soil insects also have activity against moderate infestations of cutworms. In other instances, where a history of chronic cutworm problems exist and corn is grown without tillage, the grower may add an insecticide (usually a pyrethroid) to the burn-down herbicide mixture. GMO Bt corn hybrids expressing the Cry1F *Bacillus thuringiensis* protein (Herculex® Bt corn) are partially resistant to black cutworm. Only a small percentage of the overall corn acreage is treated for cutworm.

Corn earworm

The corn earworm, *Helicoverpa zea*, is a major insect in corn. It may infest whorl leaves, tassels, and the ear. Wherever corn is grown in the southern U.S. and up through the mid-Atlantic states, the corn earworm uses the crop as a nursery. Ear stage corn is an almost ideal habitat, and high numbers are reared in this crop that later move to other crops (e.g., cotton, peanuts, soybeans, vegetables), causing the primary insect problem in these crops. Corn earworm feeds on the distal end of corn ears, causing direct damage; it is also implicated in mycotoxin contamination of the grain. Sweet corn ears that contain a caterpillar or damage are considered unmarketable. In sweet corn, corn earworm is the primary damaging pest of a complex of three ear-infesting caterpillars (corn earworm, European corn borer, and fall armyworm).

Control:

Early planting helps to avoid heavy corn earworm infestation in most circumstances. However, in field corn it is not possible economically to control corn earworm with any technique, including insecticide. Farmers growing field corn accept yield reduction and contamination due to the insect. GMO corn hybrids that express Cry1Ab protein from *Bacillus thuringiensis* (Yieldgard® Bt corn) reduce ear damage by corn earworm. In sweet corn, extensive use of insecticide is required to produce insect-free ears that are acceptable to the market. Carbamate, pyrethroid and other insecticides are heavily used to control ear-feeding caterpillars, of which corn earworm is the primary pest.

Fall armyworm

Fall armyworm, *Spodoptera frugiperda*, does not overwinter in North Carolina. It migrates into the state from the south and arrives in May. As the growing season progresses, fall armyworms become increasingly abundant. This insect favors corn but infests many crops. However, it is not considered a significant pest in field corn, which is usually planted early in the season (mainly March and April). By the time fall armyworms become abundant, field corn has matured and is unattractive to egg-laying moths. However, it can be a significant pest of late-planted corn (e.g., silage corn). Infestation begins in the whorl but may progress to the ear and stalk. It can be very damaging.

In sweet corn, the insect pest infests ears and makes them unmarketable. It is one of the ear-infesting complex in sweet corn (fall armyworm, corn earworm, and European corn borer).

Control:

Early planting and using field corn hybrids that mature within 120 days are the major tactics that growers employ against fall armyworms. In late-planted field corn, scouting, thresholds, and insecticides are used to manage problem infestations. These infestations are uncommon. Recommended insecticides include lambda-cyhalothrin (Warrior) and spinosad (Tracer). GMO Bt corn hybrids expressing the Cry1F *Bacillus thuringiensis* protein (Herculex® Bt corn) effectively reduce fall armyworm infestations. In sweet corn, insecticide applications designed to control ear-feeding caterpillars target fall armyworms.

European corn borer

European corn borer, *Ostrinia nubilalis*, is a common insect pest of several North Carolina crops. It can sustain up to three yearly generations on field corn. However, either first or second generations infest early-planted corn, with second and third generations on late-planted corn. Larvae infest the whorl, stalks, and ears. Infestation can result in physiological disruption, stalk breakage, and ears falling from the plants. Yield loss in field corn can be as high as 50 percent. In sweet corn, European corn borer is one of the ear-infesting insects (European corn borer, corn earworm, and fall armyworm) that can greatly affect marketability of the product.

Control:

Management of European corn borer is presently based on cultural techniques that focus on maturing the crop early to avoid high, late-season populations. These techniques do not affect first- and second-generation corn borers. An insecticide program that includes pheromone trapping, sequential scouting, application of thresholds, and insecticide application is available. However, the high variation of damaging infestations across time and space makes the program only marginally cost effective. Consequently, growers do not rely on this approach. GMO Bt corn hybrids expressing the Cry1Ab or Cry1F *Bacillus thuringiensis* protein (Yieldgard® or Herculex® Bt corn, respectively) effectively reduce European corn borer infestation. In sweet corn, European corn borer is intensively managed with insecticide as part of the overall effort to control ear-feeding caterpillars.

Sap beetles

Larvae of the sap beetle (picnic beetle), *Nitidulidae*, infest the ears of corn and puncture kernels. Often they are associated with injury caused by other ear-feeding insects, but this relationship is not essential for infestation.

They are not considered a problem in field corn, although their presence may be associated with increased mycotoxin contamination.

Control:

Sap beetles are not managed in field corn. In sweet corn, insecticides used against the ear infesting caterpillar complex successfully eliminates sap beetles as long as a beetle-active product is used in the typical insecticide rotation.

Brown stink bug

The brown stink bug, *Euschistus servus*, attacks grass crops. In corn, it can feed on all above-ground plant parts and reproduce when ears are present. Until the advent of no-tillage corn, the brown stink bug was considered only a minor pest, not justifying management expense. However, it appears that the bug overwinters in crop residues preceding the planting of no-tillage corn. The brown stink bug has become a greater pest as acreage of no-tillage corn has increased. Corn seedlings and adult bugs become active in concert, and the bugs feed at the plant meristem. Feeding can cause plant death and deformation. Brown stink bugs also invade corn fields as first generation adults emerge from wheat fields and other hosts, move to corn fields, and feed upon pre-silking ears. When bug numbers are high, very serious crop damage can ensue.

Control:

Scouting, thresholds, and insecticide application are the only tactics that work against brown stink bugs. At-planting granular and liquid insecticides used for soil-dwelling insect pests and billbugs have little effect on stink bugs. Clothianidin (Poncho) seed coated insecticide may be moderately effective on brown stink bug if used at a high rate (e.g., 1.25 mg per kernel).

Sod webworms

Sod webworms and other webworms, *Crambus* sp., are limited, as pests, to no-tillage corn culture. The caterpillars attack plants in the early seedling stage and can defoliate corn and eat the meristem, causing plants to die. Webworm damage declines rapidly after plants reach the 6- to 8-leaf stage. They are very minor pests.

Control:

Scouting, thresholds, and insecticide application are the primary tactics used against webworms. At-planting insecticides used for soil-dwelling insects and billbugs have little effect on webworms. If populations are adequately high, a remedial insecticide is often recommended. Bifenthrin (Capture), carbaryl (Sevin), esfenvalerate (Asana XL), *lambda*-cyhalothrin (Warrior), and *zeta*-cypermethrin (Fury, Mustang Max) are recommended.

Aphids

Several species of aphids attack corn, mainly corn leaf aphid, *Ropalosiphum maidis*, and greenbug, *Schizaphis graminum*. They are minor pests.

However, greenbug has become more significant with the growth of no-tillage corn culture. Early greenbug infestations develop on bluegrass, a winter grass, and move to corn seedlings after the bluegrass is herbicide-killed. Greenbugs inject a phytotoxin that kills or stunts corn seedlings. Corn leaf aphids can become a problem on sweet corn.

Control:

Scouting, thresholds, and insecticide application are the primary tactics used against aphids. At-planting insecticides used for soil-dwelling insect pests and billbugs can reduce aphid populations.

Grasshoppers

Grasshoppers (several species) frequently inhabit corn fields, but they are minor pests in North Carolina. They can be a significant local problem, especially in seasons following a dry year and especially where conservation tillage is practiced. Small grasshoppers can defoliate corn seedlings. Later in the season, high numbers of large grasshoppers invade fields from the edges where they developed. Defoliation of plants along the edges of fields can be significant. Whole fields are usually not defoliated unless the fields are small.

Control:

Insecticide is usually applied to defoliating populations of grasshoppers. Application is often confined to field edges, where they interface with habitat that supplies cover for large grasshopper populations.

Chinch bug

Chinch bug, *Blissus leucopterus leucopterus*, infestations are limited to organic soil areas in the Tidewater region and to cleared pocosins. They are very minor pests. Bugs attack corn in the seedling stage and suck sap from the plants. Plants can be stressed and suffer abnormal growth.

Control:

Chinch bugs are usually fortuitously controlled by the at-planting systemic insecticide used for wireworms and billbugs. If high populations occur on seedlings, a foliar insecticide may be used.

Armyworm

The armyworm, *Pseudaletia unipunctae*, is occasionally found in grassy or no-tillage corn where grasses are abundant. Moths will not lay eggs on corn but will infest many species of wild grasses. In conventional corn, poor grass control may lead to caterpillars that eat the grass and move to corn plants to feed. In no-tillage corn,

the caterpillars are present before planting. After the grasses are herbicide-killed and corn seedlings emerge, caterpillars move to the seedlings to feed. If caterpillar numbers are high, damage can be severe.

Control:

Armyworms are an infrequent problem. Therefore, growers are encouraged to scout their fields. If damaging populations are found, an insecticide is recommended. Early burn-down of weeds, well ahead of corn planting, is recommended for conservation tillage fields.

Table 1. Insecticide use on corn in North Carolina in 2003. Source: Agricultural Chemical Usage: 2003 Field Crops Summary. May 2004. U. S. Department of Agriculture, National Agricultural Statistics Service.

Insecticide Active Ingredient	Area Applied ¹ (Percent)	Number of Applications	Rate per Application (lbs./acre)	Rate per Crop Year (lbs./acre)	Total Applied (1,000 lbs.)
Chlorpyrifos	8	1.0	1.06	1.06	63
Terfufos	18	1.0	1.01	1.01	133

¹ Planted acres in 2003 for North Carolina were 740,000 acres.

Current Insecticide Recommendations for Field Corn

Current North Carolina Cooperative Extension Service recommendations for insecticide use on field corn (including information on formulations, application rates, and precautions/limitations) are provided in the following table from the *North Carolina Agricultural Chemicals Manual*:

Table 5-2: Insect Control in Field Corn

<http://ipm.ncsu.edu/agchem/chptr5/502.pdf>

Diseases and Nematodes

Each year plant diseases caused by fungi, bacteria, plant-parasitic nematodes, viruses and air pollution result in some losses in corn production in North Carolina. All parts of the plant may be attacked -- the ears, leaves, stalks and roots -- at various stages of development. In many instances diseases result in lower yields, but also reduce the value and quality of the grain and may increase harvesting costs when affected plants lodge.

Disease management tactics include rotating crops, destroying crop residue, planting resistant varieties, observe proper planting dates, fertilizing properly, harvesting at the proper time, storing corn properly, treating seed,

controlling nematodes with nematicides according to recommendations, and using best management practices to minimize other pest problems.

Fungi

Seed Rots and Seedling Blights (caused by species of *Fusarium*, *Stenocarpella*, *Pythium*, and other fungi). Germinating corn kernels may be attacked by a number of soilborne or seedborne fungi that cause seed rots and seedling blights. The terms "preemergence" and "postemergence damping-off" are often used to specify the affected growth stage. These diseases are more prevalent in poorly drained, excessively compacted, or cold, wet soils. Planting old or poor quality seed with mechanical injury to the pericarp will increase seed rot and seedling blight, as will planting seed too deep in wet, heavy soils. Hybrids differ in genetic resistance to the fungi that cause seed rot and seedling blight. Seed treatment with a good fungicide is an important method for control of these fungi.

Southern Corn Leaf Blight (caused by the fungus *Bipolaris maydis* [*Helminthosporium maydis*]). Southern corn leaf blight occurs worldwide, but is particularly damaging in regions of warm, moist weather. Lesions on the leaves caused by the fungus are elongated between the veins, tan, up to one inch long, with limited parallel margins and buff to brown borders. The fungus overwinters on corn debris in the field. Thus, rotation and destruction of residue will reduce losses due to this disease. Resistant hybrids are also available.

Northern Corn Leaf Blight (caused by the fungus *Exserohilum turcicum* [*Helminthosporium turcicum*]). Symptoms of this disease are long elliptical, grayish-green or tan lesions ranging from 1 to 6 inches in length, developing first on lower leaves and later causing severe damage to the upper leaves under moderately warm and moist weather conditions. This disease is favored by somewhat cooler weather than southern leaf blight and has been quite severe in the mountain counties. Northern corn leaf blight can cause premature death and gray appearance of foliage that resembles frost or drought injury. As with southern corn leaf blight, control is by rotation, destruction of crop debris, and use of resistant hybrids. There are at least three pathogenic races of the fungus, but moderate to good resistance is available to all of them.

Anthracnose (caused by the fungus *Colletotrichum graminicola*). Symptoms of this disease vary widely, depending on the hybrid, age of the leaf, and environment. Small, oval to elongate, water-soaked spots first appear on the leaves at any stage of growth. The spots may enlarge up to one-half inch long and become tan at the center with red, reddish-brown, or yellow-orange borders. The lesions may grow together, blighting the entire leaf. Leaf symptoms are most common early in the season on the lower leaves and late in the season on the upper leaves.

Lesions on stalks usually appear initially as black linear streaks under the epidermis. On susceptible plants the lesions may develop into large oval, black areas measuring 1/2 to 1 inch, or larger. In severe infections, large areas of the stalk may be blackened. When the infected stalks are split, a mottled brown discoloration may be seen, particularly at the nodes. This discoloration may be present even when lesions are not apparent on the surface of the stalk. It is common with anthracnose for the upper 1/3 of the plant to prematurely die. Anthracnose is a very important cause of lodging in North Carolina.

Anthracnose is favored by warm, moist conditions during the growing season. Plants are most susceptible in the seedling stage and later as they approach maturity. There is a wide range of susceptibility in hybrids. The fungus

over-winters on plant debris left above ground. Thus, control of this disease is based upon crop residue destruction, rotation, and use of tolerant or resistant hybrids.

Southern Rust (caused by the fungus *Puccinia polysora*). Southern rust can be recognized by the bright orange or golden brown, circular to oval pustules, which give a rusty appearance to the leaves. The pustules are about the size of a pinhead and are filled with powdery masses of orange spores, which can be rubbed off. These spores are readily dislodged and blown about in the wind. The spores can survive and infect plants after being transported hundreds of miles by the wind.

The southern rust fungus has no known means of survival in the absence of living susceptible plants. During the winter months it is limited to tropical areas where corn is grown year round. The extent to which it spreads into temperate areas depends upon weather patterns and the susceptibility of the corn along the path of spread.

Southern rust is favored by the warm, humid conditions found in many lowland tropical areas where corn is grown. However, even in those areas, corn with good resistance suffers little or no damage. In temperate areas less ideal for the growth of the fungus, damage can occur in corn hybrids that lack good resistance.

Since southern rust cannot survive the winter in North Carolina, the initial infections must result from spores blown into North Carolina from the south. The fungus can multiply very rapidly on susceptible corn, and the amount of damage that occurs depends upon how early the first spores arrive. Epidemics may result from unusual weather patterns that cause mass air movements from the tropics where the rust is present. Southern rust causes significant yield losses in North Carolina about 1 year in 5. Late planted corn is especially vulnerable because of delayed maturity. The fungicides propiconazole (Tilt), azoxystrobin (Quadris), and pyraclostrobin (Headline) are labeled for application on corn for this disease.

Common Rust (caused by the fungus *Puccinia sorghi*). Common rust occurs in temperate to sub-tropical areas. It differs from southern rust by the darker, more reddish-brown color of the pustules. Also, pustules of common rust tend to be longer than those of southern rust and they occur more often in scattered clumps on the leaves. Pustules of southern rust are usually quite uniformly distributed over the surface of the leaf. Common rust is able to survive the winters in temperate areas because it produces teliospores, which are resistant to weathering. These spores germinate in the spring to produce basidiospores. The basidiospores infect wood sorrel (*Oxalis* spp.) and the spores produced in infections on wood sorrel complete the life cycle of the fungus by infecting corn.

Common rust has been present for many years in all major corn producing areas of the world. It has not been regarded as a major cause of damage in any of those areas. In 1951 in one of the heaviest outbreaks of common rust known in the United States, estimated average losses ranged from less than 1 percent to 3 percent. Resistance and tolerance to common rust are prevalent and effective in corn hybrids throughout the world.

Common Smut (caused by fungus *Ustilago maydis*). Common smut occurs wherever corn is grown. Losses to smut are generally light, but may be important in some situations, particularly sweet corn. Young actively growing parts of the plant are susceptible to infection. Large galls may appear on stalks at the nodes, on ears, or rarely on tassels. Leaf infections may result in small inconspicuous galls. On ears or stalks the galls expand rapidly and are covered with a thin greenish-white or silvery-white tissue. As the galls mature, the covering ruptures exposing masses of black spores within. Individual galls on stalks may be up to 6 inches in diameter. On infected ears, a large number of galls originating from individual infected kernels may combine to form the

compound gall mass that replaces most of the ear. Some corn plants may form ears in the tassles.

Smut is usually more severe on plants heavily fertilized with nitrogen. The severity is increased by injury from hail, cultivators, etc. Control involves avoiding highly susceptible varieties, avoiding mechanical injury to plants during cultivation and spraying, and providing well-balanced soil fertility.

Gray Leaf Spot (caused by the fungus *Cercospora zeae-maydis*). The fungus can infect leaf blades and, to a much lesser extent, leaf sheaths. The gray or pale brown lesions are long and narrow with parallel sides delimited by leaf veins. The ends are usually blunt, giving the lesions a long rectangular shape. Lesions commonly are about 1/4 inch wide by about 1 inch long. When the disease is severe, lesions merge into long stripes. Eventually the entire leaf may be killed.

Gray leaf spot has caused moderate to severe damage to corn in the mountain valleys of the Appalachian region. In North Carolina, the disease is most severe in the mountains and western piedmont, but it has become common in the coastal plain and tidewater in recent years.

The gray leaf spot fungus survives the winter as resistant mycelium in corn debris left in the field. The disease is usually more severe in no-till planted corn without rotation. Thus, rotation, debris destruction, and resistant hybrids offer the best methods of controlling this disease. The fungicides propiconazole (Tilt), azoxystrobin (Quadris), and pyraclostrobin (Headline) are labeled for application on corn for this disease.

Brown Spot (caused by the fungus *Physoderma maydis*). Brown spot is favored by high temperatures and high humidity. It attacks leaf blades, sheaths, and stalks, producing small, reddish-brown to purplish-brown spots which may merge together to form large brown blotches. Weakened stalks frequently lodge and leaf sheaths may be reduced to shreds. Good cultural practices and the use of tolerant varieties offer the best control.

Stalk Rots (caused principally by the fungi *Stenocarpella zeae* and species of *Fusarium* as well as *Colletotrichum graminicola*). Stalk rots are present each year and may cause considerable damage, particularly if abundant rainfall occurs during the latter part of the growing season. Stalks previously injured by cold, leaf diseases, or insects are especially susceptible to attack by these fungi. Diseased stalks ripen prematurely and are subject to excessive stalk breaking. Stalk rots not only add to the cost of harvesting but also bring the ears in contact with the ground, increasing their chance of rotting.

Charcoal rot (caused by the fungus *Macrophomina phaseolina*). Charcoal rot is a destructive disease of corn, soybean, cotton and many other crops. Charcoal rot becomes most evident with the onset of hot dry weather. It may cause a stalk rot, stunting, and death of the corn plant. Symptoms are a silver to black discoloration of the stem tissue when the stalk is cut open. This disease is often considered to be a stress related. Typically when this disease occurs in North Carolina soil fertility and pH are at very low levels. Although the fungus typically survives in the soil, rotation is not generally an option since most crops are susceptible to this disease. Reduction of nutrient and water stress are the principle means of control. Hybrid resistance has not been documented.

Ear and Kernel Rots (caused by species of *Stenocarpella*, *Fusarium*, *Aspergillus*, and many other fungi). Some of the same fungi that cause stalk rots of corn also (Fig. 12) also cause ear and kernel rots. Ear and kernel rots are most serious with warm, wet conditions at harvest time. Severe infection not only reduces yield but also

lowers the quality and grade of the grain produced. The two principle ear and kernel rot fungi found in North Carolina are *Aspergillus* and *Fusarium*.

Red ear rot is caused by the fungus *Fusarium graminearum* (*Gibberella zeae*), and also causes a stalk rot of corn and head scab in wheat. The fungus may cause a reddish discoloration of the cob and kernels. Red ear rot caused by *F. graminearum* is favored by warm wet weather after silking. Disease tends to be worse when corn is grown without rotation or after wheat, as this pathogen also infects wheat. It may be worse when corn is grown in reduced tillage situations.

Fusarium moniliforme is another species of *Fusarium* that causes a kernel rot, but the mycelium of the fungus is typically white to salmon color. Kernels infected with *Aspergillus* usually have a greenish to gray color.

Mycotoxins

Toxic metabolic by-products of fungi, known as mycotoxins, have received considerable attention during the past several years. Aflatoxin, produced by the fungus *Aspergillus flavus*, has been considered to be the most serious problem in North Carolina in recent years. The detection of aflatoxin in corn can result in a reduced price for the grain or even rejection. The concentration of aflatoxin in corn for interstate trade is regulated at 20 parts per billion (ppb) by the Food and Drug Administration (FDA). Another class of mycotoxins are referred to as fumonisins. These toxins are produced by the fungus *Fusarium moniliforme* and are quite common in corn produced in North Carolina. It appears likely that fumonisin levels will be regulated in the near future. Corn shipped to Europe will probably be monitored for levels of fumonisin as well as aflatoxin. Allowable levels of fumonisin in corn have not yet been established at this time.

Mycotoxins are known to cause serious health problems in animals including reduced weight gain, capillary fragility, reduced fertility, suppressed disease resistance, and even death. No animal is known to be resistant, but in general, older animals are more tolerant than younger animals. Mycotoxins have been implicated in deaths from acute toxicoses in young animals, particularly poultry, as well as several animal health problems, including reduced fertility and growth rate.

Both *Aspergillus flavus* and *Fusarium moniliforme* are widely distributed in nature and are favored by high temperature. Temperatures ranging from 80 to 100 degrees F and a relative humidity of 85 percent (18 percent moisture in the grain) are optimum for fungal growth and toxin production. Growth of these fungi does not occur below 12 to 13 percent moisture in the grain.

Aflatoxin contamination is higher in corn that has been produced under stress conditions. Thus, drought, heat, insect, and fertilizer stress are all conducive to high levels of aflatoxins. Factors that influence fumonisin production in corn are not well understood at this time. Certainly, insects provide an avenue of infection for both *Aspergillus* and *Fusarium*. High rainfall and humidity at silking may increase infection of corn kernels by *Fusarium spp.* Hybrids genetically engineered to resist insects have been shown to have lower levels of fumonisin. Therefore, in order to minimize the level of mycotoxins, the following practices should be followed:

1. Use recommended production practices.
2. Plant early.
3. Irrigate to reduce drought stress.

4. Harvest early.
5. Avoid kernel damage during harvest.
6. Dry and store corn properly.
7. Keep storage facilities clean.

More information on mycotoxins is available in *Mycotoxins in Corn*, Corn Disease Information Note, Department of Plant Pathology, North Carolina State University <http://www.ces.ncsu.edu/depts/pp/notes/Corn/corn001.htm>.

Nematodes

Nematodes attack corn roots, thereby limiting their development and restricting the uptake of water and nutrients. Thus, affected plants are stunted and appear deficient of nutrients. Since nematodes do not occur at a uniform population density throughout the field, stunted plants likewise are not uniformly distributed. They often appear in roughly circular areas in the field. Nematode damage occurs most often when the preplant densities of certain nematodes are high and corn seedlings get off to a slow start because of unfavorable growing conditions. Damage to corn from plant-parasitic nematodes is most severe in the coastal plain area. The two most damaging nematodes on corn in North Carolina are the stubby-root and sting nematodes.

Stubby-root (*Paratrichodorus minor*). The stubby-root nematode does not enter the roots of corn plants, but remains outside the roots and feeds on the growing root tips. Their feeding prevents the further development of the root tip, resulting in short, stunted or stubby roots. The damage to the root system by stubby-root nematodes resembles that caused by several herbicides. A plant heavily parasitized with these nematodes is stunted, turns yellow, often exhibits magnesium deficiency, and produces a small ear. Since these nematodes are so widespread in the coastal plain area, they may very well be the most damaging nematodes on corn in North Carolina.

Sting (*Belonolaimus longicaudatus* sp.). The sting nematode feeds on roots from the outside without penetrating or becoming attached to roots. They feed at root tips and along the sides of succulent roots. Injured roots show blackened, sunken dead areas along the root and at the root tip. These areas may girdle the root causing it to die. Sometimes the damage done to young plants is quite severe and infected plants may obtain a height of only 8 to 10 inches. Sting nematode is found in soils that contain at least 80 percent sand. This nematode, especially when combined with the stubby-root nematode, causes severe yield losses.

Columbia lance (*Hoplolaimus Columbus*). The Columbia lance nematode can be damaging to corn, especially if numbers are high and poor conditions for early corn growth occur. The Columbia lance nematode is damaging to corn, whereas a related species of lance nematode, *Hoplolaimus galeatus*, does not generally affect corn. Currently, the Columbia lance nematode is restricted to sandy soils in parts of the southeastern North Carolina coastal plain, whereas the common lance nematode (*Hoplolaimus galeatus*) is found in many parts of the state. Lance nematodes feed on the root surface but may also penetrate the root system causing internal damage. Columbia lance nematode can be extremely damaging to cotton and soybean, but usually causes only slight-to-moderate damage on corn.

Root-knot and Lesion (*Meloidogyne* and *Pratylenchus* spp.). Most species of root-knot and lesion nematodes

will reproduce on corn. Ordinarily, corn is very tolerant of these nematodes, but may be damaged if populations are very high.

Nematode Management

In order to determine whether or not a field should be treated with a nematicide to control nematodes, a soil sample should be collected in September-November and sent to the North Carolina Department of Agriculture and Consumer Services for an assay. Soil cores collected from the corn root zone need to be taken in a zig-zag pattern across the field and mixed in a bucket. Each sample should cover 5 to 10 acres, and sections with different crop histories should be sampled separately.

Based on estimates from the North Carolina Department of Agriculture and Consumer Services, about a third of the corn acreage in eastern North Carolina should be treated to control nematodes. Where the population density is high enough to justify treatment, a grower can expect an increase of about 20 to 25 bushels per acre. Nematodes are controlled by use of the nematicide terbufos (Counter), rotation, and crop destruction.

Viruses

There are two major viruses of corn in North Carolina, maize dwarf mosaic virus (MDMV) and the maize chlorotic dwarf virus (MCDV). These two virus diseases can cause serious yield reductions, with reported losses ranging from 5 to 90 percent in some fields. Much of the loss due to these two diseases in North Carolina is confined to the piedmont section of the state, although losses in the coastal plain and mountain areas have been reported. This may be due to two factors: 1) there is less johnsongrass in the coastal plain area; and 2) the johnsongrass in the Piedmont is infected with the two viruses while the johnsongrass in other sections of the state is not as heavily infected, or not infected at all. The two viruses are transmitted from infected johnsongrass to corn by insects. MDMV is transmitted by aphids (principally the corn leaf aphid, *Aphid maidis* and MCDV is transmitted by leafhoppers (*Graminella nigrifrons*).

Maize Dwarf Mosaic Virus. Symptoms of MDMV first appear on the youngest leaves as an irregular, light and dark green mottle or mosaic which may develop into narrow streaks along veins that appear as dark green "islands" on a lighter green background. As infected plants mature, leaves become yellowish-green. Plants with these symptoms are sometimes stunted with excessive tillering, multiple ear shoots and poor seed set. Early infection may predispose corn to root and stalk rots and premature death. Symptoms can appear in the field within 30 days after seedling emergence.

Maize Chlorotic Dwarf Virus. MCDV, previously called corn stunt, causes more severe stunting than does MDMV. Infected leaves become yellow, but no mosaic pattern develops. Such leaves usually develop a deep, reddish discoloration later in the season. The internodes of infected plants fail to elongate, resulting in very stunted plants. Quite often infection occurs late in the season. Thus, the lower portion of the plant develops normally with the upper portion being red and stunted. Infection can result in severe reduction in ear size if susceptible varieties are grown and infection occurs early enough in the development of the plant.

Losses from both MDMV and MCDV can be avoided by growing hybrids that are resistant, or tolerant, to these viruses. There are several hybrids adapted to North Carolina that are resistant to both viruses.

Bacterial Diseases

There are two major bacterial diseases of corn in North Carolina, bacterial leaf blight (sometimes called Stewart's bacterial wilt) and bacterial stalk rot.

Bacterial leaf blight (caused by the bacterium *Erwinia stewartii*) is more of a problem with sweet corn than it is with field corn; however, it can be a problem with certain hybrids. The symptoms are short to long, irregular, pale green to yellow streaks in the leaves. The streaked areas, which die and become straw-colored, originate from feeding marks of the corn flea beetle. Sometimes entire leaves die and dry up. When leaves die prematurely, yield is reduced and weakened plants become more susceptible to stalk rots. The bacteria overwinter in corn flea beetles, which also spread the bacteria. Although insect control is important in controlling this disease in sweet corn, it is not a sound practice for field corn producers. Resistance to the disease, which is available in many hybrids, is the preferred method of control.

Bacterial stalk rot (caused by the bacterium *Erwinia chrysanthemi* pv. *zea*) can be a problem where overhead irrigation is used and the water is pumped from a lake, pond, or slow-moving stream. Quite often the infection occurs at about ear height, and the upper portion of the plant breaks over due to a collapse of the stalk. Often, an unpleasant odor is associated with this disease. The bacteria usually do not spread from plant to plant, so diseased plants are quite often found scattered throughout the field.

Fungicide and Nematicide Use on Field Corn

Except for seed treatments, fungicide use in corn is minimal. A significant amount of corn was treated with turbofos (Counter), an insecticide and nematicide, but most was treated at insecticidal rates that would have minimal impact on nematodes. The popularity of seed treatments for early season insect control has reduced or eliminated the use of turbofos in corn in North Carolina.

Current Fungicide and Nematicide Recommendations for Field Corn

Current North Carolina Cooperative Extension Service recommendations for fungicide and nematicide use on field corn (including information on formulations, application rates, and precautions/limitations) are provided in the following table from the *North Carolina Agricultural Chemicals Manual*:

Table 6-4: Corn Disease Control

<http://ipm.ncsu.edu/agchem/chptr6/602a.pdf>

Weeds

Grasses and sedges infesting field corn in North Carolina include bermudagrass, broadleaf signalgrass, crabgrass, fall panicum, foxtails, goosegrass, johnsongrass (seedling and rhizome), shattercane, Texas panicum,

purple nutsedge and yellow nutsedge. Numerous annual broadleaf weeds are found in corn, but some of the more common species include pigweed species, common lambsquarters, morningglory species, common cocklebur, common ragweed, sicklepod, prickly sida, and smartweed species. Perennial broadleaf species include Carolina horsenettle, trumpetcreeper, common milkweed, hemp dogbane, and alligatorweed.

Cultural Control

Crop Rotation

Crop rotation is an integral component of a weed management program for field corn. Crop rotation generally leads to healthier crops that are more competitive with weeds. Moreover, certain weeds are more easily or more economically managed in one crop than in another. In general, most weeds are more easily managed in corn or soybeans than in other agronomic or horticultural crops. Good control in corn can reduce weed problems in rotational crops. Additionally, crop rotation allows use of different herbicide chemistries on the same field in different years. This can prevent weed population shifts (changes in the species composition), avoid evolution of herbicide resistance, and help to keep the overall weed population at lower levels. Some herbicides may carry over and damage rotational crops. Before using any herbicide, grower must consider their rotational plans and check the rotational restrictions on the label.

Cultivation

Most corn is no longer cultivated as more growers use no-till methods and more effective herbicide programs are available. However, cultivation can supplement chemical control, and used alone it may be sufficient for light weed infestations. Weed control is the only benefit of cultivation except where special soil problems such as severe crusting or poor drainage occur. Cultivation should be shallow to reduce crop root damage and to avoid breaking through any residual herbicide layer and bringing up untreated soil and weed seed. Cultivation is most effective when weeds are small. If postemergence herbicides are planned, growers should not cultivate for at least a week before or after herbicide application.

Chemical control

Burndown in No-Till Systems

A general recommendation for burndown in no-till corn is paraquat at 0.75 pound of active ingredient per acre or glyphosate at 0.75 pound of acid equivalent per acre. These burndown herbicides may be mixed with any preemergence herbicide.

Preemergence Herbicides

Annual grasses and control or suppression of yellow nutsedge: acetochlor (Degree, Harness, Surpass, TopNotch), alachlor (Lasso, Micro-Tech), dimethenamid-P (Outlook), flufenacet (Define), S-metolachlor (Dual II Mangum, Cinch)

Annual broadleaf weeds: atrazine (AAtrex), mesotrione (Callisto)

Most annual grasses and broadleaf weeds: acetochlor + atrazine (Degree Xtra, FullTime, Harness Xtra), alachlor + atrazine (Bullet, Lariat), atrazine (Aatrex) + simazine (Princep), dimethenamid-P + atrazine (Guardman Max), S-metolachlor + atrazine (Bicep II Magnum, Cinch), S-metolachlor + atrazine + mesotrione (Lumax), pendamethalin (Pendimax, Prowl, Prowl H₂O) + atrazine (AAtrex), rimsulfuron + thifensulfuron methyl (Basis)

Early Postemergence Herbicides

Small annual grasses and certain broadleaf weeds: rimsulfuron + thifensulfuron methyl (Basis)

Small annual broadleaf and grass weeds: acetochlor + atrazine (Degree Xtra, Fulltime, Harness Xtra), alachlor + atrazine (Bullet), atrazine (AAtrex), dimethenamid-P + atrazine (Guardman Max), S-metolachlor + atrazine (Bicep II Magnum, Cinch ATZ), S-metolachlor + atrazine + mesotrione (Lumax, Lexar), nicosulfuron + rimsulfuron + atrazine (Basis Gold)

Postemergence Herbicides

Annual broadleaf weeds: bentazon (Basagran), bromoxynil (Buctril), carfentrazone (Aim), dicamba, dimethylamine salt (Banvel), dicamba, diglycolamine salt (Clarity), dicamba, potassium salt + atrazine (Marksman), dicamba, sodium salt + diflufenzopyr, sodium salt (Distinct), flumiclorac, pentyl ester (Resource), mesotrione (Callisto), thifensulfuron methyl (Harmony GT), 2,4-D amine (various brands)

Annual grasses, broadleaf weeds and johnsongrass: dicamba, sodium salt + diflufenzopyr + nicosulfuron (Celebrity Plus), foramsulfuron + iodosulfuron + methyl-sodium (Equip), nicosulfuron + rimsulfuron (Steadfast), nicosulfuron + rimsulfuron + atrazine (Steadfast AZT)

Yellow nutsedge: bentazon (Basagran)

Yellow and purple nutsedge: halosulfuron-methyl (Permit)

Annual grasses, johnsongrass and shattercane: foramsulfuron (Option), nicosulfuron (Accent)

Clearfield Corn Hybrids:

Annual broadleaf weeds, yellow and purple nutsedge, and some annual grasses: imazethapyr + imazapyr (Lightning)

Liberty Link Corn Hybrids:

Annual grasses and annual broadleaf weeds: glufosinate-ammonium (Liberty), glufosinate-ammonium + atrazine (Liberty ATZ)

Roundup Ready Corn Hybrids:

Annual grasses and broadleaf weeds, johnsongrass, and suppression of perennial broadleaf weeds: glyphosate (numerous brands), glyphosate isopropylamine salt + atrazine (Ready Master ATZ)

bermudagrass, and yellow and purple nutsedge: glyphosate (numerous brands)

Layby Herbicides

Annual broadleaf weeds and grasses: ametryn (Evik), linuron (Lorox, Linex)

Preharvest Herbicides

Broadleaf weeds: 2,4-D trisopropanolamine salt + dimethylamine salt (Formula 40)

Annual grasses and broadleaf weeds: paraquat (Gramoxone Max)

Annual grasses, johnsongrass and broadleaf weeds: glyphosate (numerous brands)

Postharvest Herbicides

Horsenettle and other perennial and annual broadleaf weeds: 2,4-D amine (various brands), dicamba (Banvel, Clarity)

Bermudagrass, other annual and perennial weeds: glyphosate (numerous brands)

Table 2. Herbicide use on corn in North Carolina in 2003. Source: Agricultural Chemical Usage: 2003 Field Crops Summary. May 2004. U. S. Department of Agriculture, National Agricultural Statistics Service.

Herbicide Active Ingredient	Area Applied ¹ (Percent)	Number of Applications	Rate per Application (lbs./acre)	Rate per Crop Year (lbs./acre)	Total Applied (1,000 lbs.)
2,4-D	10	1.1	0.36	0.40	30
Alachlor	18	1.0	1.82	1.82	239
Ametryn	10	1.0	1.12	1.12	82
Atrazine	78	1.0	1.18	1.22	699
Dichlorprop	4	1.1	0.26	0.31	8
Glyphosate	27	1.4	0.69	1.00	202
Linuron	2	1.0	0.80	0.80	13
Metolachlor	16	1.0	1.35	1.35	163
Nicosulfuron	11	1.0	0.02	0.02	2

Paraquat	14	1.0	0.50	0.52	52
Rimsulfuron	4	1.1	0.01	0.01	2
S-Metolachlor	23	1.0	1.10	1.10	188
Simazine	14	1.0	1.14	1.14	115

¹ Planted acres in 2003 for North Carolina were 740,000 acres.

² Total applied is less than 500 pounds.

Current Herbicide Recommendations for Field Corn

Current North Carolina Cooperative Extension Service recommendations for herbicide use on field corn (including information on formulations, application rates, and precautions/limitations) are provided in the following tables from the *North Carolina Agricultural Chemicals Manual*:

Table 8-1A: Chemical Weed Control in Corn

<http://ipm.ncsu.edu/agchem/chptr8/801.pdf>

Table 8-1B: Weed Response to Preplant Incorporated and Preemergence Herbicides – Corn

<http://ipm.ncsu.edu/agchem/chptr8/801.pdf>

Table 8-1C: Weed Response to Postemergence Herbicides in Corn

<http://ipm.ncsu.edu/agchem/chptr8/801.pdf>

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4. U. S. Department of Agriculture, National Agricultural Statistics Service. 2004. Agricultural Chemical Usage: 2003 Field Crops Summary. May 2004.

On-Line Resources

North Carolina Corn Production Guide

<http://www.ces.ncsu.edu/plymouth/cropsci/cornguide/index.html>

Corn (Maize) Disease Information Notes

http://www.ces.ncsu.edu/depts/pp/notes/Corn/corn_contents.html

Major Corn Diseases in North Carolina

http://ipm.ncsu.edu/corn/diseases/corn_diseases.html

Insect Pests of Corn from Insect and Related Pests of Field Crops

http://ipm.ncsu.edu/AG271/corn_sorghum/corn_sorghum.html

Management of Insect Pests of North Carolina Grain Crops

<http://www.ces.ncsu.edu/plymouth/pubs/ent/index2.html>

Pesticides and Wildlife – Corn

http://ipm.ncsu.edu/wildlife/corn_wildlife.html

Scouting Corn in North Carolina

http://ipm.ncsu.edu/corn/Scouting_Corn/coverpage.html

North Carolina Pest News

http://ipm.ncsu.edu/current_ipm/pest_news.html

Grain Market News (North Carolina Department of Agriculture and Consumer Services)

<http://www.agr.state.nc.us/markets/mktnews/grain.htm>

Field Crops: Grains and Oil Seeds (North Carolina Department of Agriculture and Consumer Services)

<http://www.ncagr.com/markets/commodit/horticul/grain/index.htm>

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