NC STATE UNIVERSITY

North Carolina Crop Profile
Cabbage

PRODUCTION FACTS

- North Carolina ranks sixth in total United States cabbage production.
- North Carolina produces approximately 11 percent of the total U.S. cabbage crop.
- About 7,000 acres of cabbage were produced with an estimated value of $11 million (three-year average, 1995-1997).
- Average production cost per acre was $500 (three-year average, 1995-1997). When harvesting and labor expenses were included, the average production cost was $1,500 per acre.
- Average yield per acre was 190 hundredweight (three-year average, 1995-1997). Grower estimates of average yield ranged from 200 to 320 hundredweight per acre.
- About 90 percent of the cabbage produced commercially in North Carolina is sold for fresh-market consumption.

PRODUCTION REGIONS

Cabbage is grown in most of the state's counties, but commercial production is concentrated primarily in northeastern North Carolina (Pasquotank County). Some commercial production also occurs in the southeastern (Columbus and Robeson counties) and northwestern (Alleghany and Ashe counties) regions.

PRODUCTION PRACTICES

Cabbage can be grown in a wide variety of soil types but prefers well-drained soil with an optimum pH between 6.0 and 6.5. In North Carolina, there are spring and fall cabbage production seasons. High-quality, certified transplants and seeds are often used to establish the spring (February planting) and fall (July to August planting) crops, respectively. Irrigation is highly desirable for establishing a good stand after direct seeding or transplanting. However, poor water quality (i.e., high soluble salts, particularly sodium) in certain production areas in eastern North Carolina limits this practice. Most growers practice a two- to three-year rotation out of cabbage and other related crucifer crops (e.g., Brussels sprouts, broccoli, cauliflower, collards, kale, mustard, oilseed rape, rutabagas, and turnips) and sample their soils for nematodes, nutrients, and pH. In general, fungicide and herbicide use on cabbage in North Carolina is minimal due to low disease pressure and effective cultural practices that are commonly employed for weed management. The greatest challenge facing cabbage growers in North Carolina is insect management.

INSECTS

The major insect pests of cabbage are the beet armyworm, cabbage looper, corn earworm, diamondback moth, and imported cabbage worm.

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Secondary insect pests are the aphid cabbage maggot, cutworm, flea beetle, harlequin bug, stink bug, thrips, and wireworm.

The diamondback moth is the critical factor limiting production of healthy cabbage in North Carolina. The larvae of the diamondback moth cause extensive damage to the cabbage heads, reducing their marketability. High populations of the larvae can develop very rapidly, particularly during hot, dry weather when naturally occurring fungal parasites and insect predators are not as active. Under these conditions, diamondback larvae often seek refuge at the base of the cabbage to conserve moisture, and thus are less likely to come into direct contact with insecticides. Although many cabbage growers use biological and synthetic insecticides throughout the production season to combat the diamondback moth, the management of this devastating pest remains a formidable and difficult task. In recent years, growers have commented on the relative ineffectiveness of many of the biological and synthetic insecticides used for managing the diamondback moth. Although diamondback moth field populations resistant to *Bacillus thuringiensis* (*Bt*) have been identified in other regions of the world, in North Carolina *Bt* resistance by diamondback moth field populations has not been well documented.

Also potentially very damaging to cabbage are the aphid, beet armyworm, cabbage looper, corn earworm, cutworm, flea beetle, harlequin bug, imported cabbage worm, stink bug, and thrips. The cabbage looper, a migratory pest in North Carolina, is a particularly serious problem in later stages of spring cabbage production season (usually in June), while beet armyworms, corn earworms, and flea beetles are especially damaging early in the fall production season in eastern North Carolina. Except for the diamondback moth, most of the insects that attack cabbage are readily managed with currently available biological and synthetic insecticides.

Occasionally growers encounter problems with insects that attack cabbage roots, such as the wireworm and cabbage maggot. The cabbage maggot is predominantly a problem in the cabbage-producing counties in western North Carolina at higher elevations, whereas the wireworm occurs throughout the entire cabbage production region.

Synthetic insecticides

Azinphosmethyl *(Guthion 2 L, 50 WP)*

This material was applied to 5 percent of the total cabbage acreage and was used approximately 1.4 times per season in 1994. About 2,000 pounds of active ingredient were applied per season at a rate of 0.9 pound per acre. In 1996, less than 1 percent of the crop was treated with this material. Azinphosmethyl is used primarily for managing the cabbage maggot, but it also has cabbage looper activity.

Carbaryl *(Sevin 50 WP, 80 S, XLR Plus)*

This material was applied to 10 percent and 4 percent of the total cabbage acreage and was used approximately 2 and 1.7 times per season in 1994 and 1996, respectively. About 900 and 500 pounds of active ingredient were applied per season at a rate of 0.84 and 1.35 pounds per acre in 1994 and 1996, respectively. Sevin is used to manage cutworm, flea beetle, harlequin bug, stink bug, and thrips; but it also has some activity on diamondback moth and imported cabbage worm.

Chlorpyriphos *(Lorsban, 4 EC, 15 EG, 50 W)*

This material was used on less than 1 percent of the cabbage crop in 1994 and 1996. Chlorpyriphos is used primarily for aphid, cabbage maggot, cutworm, and wireworm management. Without this material, there are no alternatives, or limited ones, for effective management of wireworm.

Diazinon *(Diazinon, Spectracide 4 EC, 50 WP)*

This material was applied to 1 percent of the total cabbage acreage and used approximately 3.1 times per season in 1994. Approximately 100 pounds of active ingredient were applied per season at a rate of 0.48 pound per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. Diazinon is a good weapon for managing aphids and cabbage maggots when applied in furrow.

Dimethoate

This material was applied to 10 percent of the total cabbage acreage and used approximately 2.5 times per season in 1994. About 400 pounds of active ingredient were applied per season at a rate of 0.32 pound per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. Dimethoate is used primarily for thrips management but also can reduce aphid and flea beetle problems.

Endosulfan *(Thiodan, Phaser, 3 EC, 50WP)*

This material was applied to 5 percent of the total cabbage acreage and used approximately 2 times per season in 1994. About 400 pounds of active ingredient were applied per season at a rate of 0.62 pound per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. Endosulfan may provide a cheaper alternative for managing aphids, flea beetles, harlequin bugs, stink bugs, and thrips populations; but its activity on diamondback moths and imported cabbage worms is limited.

Esfenvalerate *(Asana XL)*

In 1994 and 1996, this material was applied to 38

Table 1. Insecticides registered for cabbage use in N.C. & spectrum of activity

	Aphid	Beet army-worm	Corn earworm	Cabbage looper	Cutworm	Diamond -back moth	Flea beetle	Harlequin bug	Imported cabbage worm	Cabbage maggot	Stink bug	Thrips
Azinphosmethyl				✔						✔		
Bt		✔	✔	✔		✔			✔			
Carbaryl					✔	✔	✔	✔	✔		✔	✔
Chlorpyriphos	✔				✔					✔		
Diazinon	✔									✔		
Disulfoton	✔											
Dimethoate	✔						✔					✔
Endosulfan						✔	✔	✔	✔		✔	✔
Esfenvalerate		✔	✔	✔		✔			✔			
Imidacloprid	✔											
Insecticidal soap	✔											
Lambda-cyhalothrin		✔	✔	✔		✔			✔			
Methomyl		✔	✔			✔	✔		✔			✔
Permethrin				✔		✔			✔			

percent and 33 percent of the total cabbage acreage and used approximately 3.5 and 2.1 times per season, respectively. About 200 and 100 pounds of active ingredient were applied per season at a rate of 0.03 and 0.04 pound per acre in 1994 and 1996, respectively. Esfenvalerate is a good material for managing early season insects, and it also provides some suppression of beet armyworms, cabbage loopers, corn earworms, and imported cabbage worms. Some North Carolina growers question the efficacy of Asana for managing the diamondback moth.

Imidacloprid *(Provado 1.6F)*

This material was used on less than 1 percent of the cabbage crop in 1994 and 1996. It provides an alternative for managing aphids, but plant-back restrictions and cost may limit its use in North Carolina.

Lambda-cyhalothrin *(Karate 1 EC)*

This material was used on less than 1 percent of the cabbage crop in 1994 and 1996. It may be a useful alternative to Lannate for managing beet armyworm, cabbage looper, corn earworm, diamondback moth, and imported cabbage worm.

Methomyl *(Lannate 90 SP, LV)*

This material was applied to 54 percent and 9 percent of the total cabbage acreage and was used approximately 3.8 and 2.8 times per season in 1994 and 1996, respectively. About 5,100 and 400 pounds of active ingredient were applied per season at a rate of 0.46 and 0.3 pound per acre in 1994 and 1996, respectively. Methomyl provides moderate protection from the diamondback moth and imported cabbage worm when used in combination with *Bacillus thuringiensis (Bt)*-based products. Lannate also provides excellent protection from beet armyworm, corn earworm, and thrips.

Permethrin *(Pounce 3.2 EC, 25 WP; Ambush 2 EC 25 WP)*

This material was applied to 19 percent and 9 percent of the total cabbage acreage and was used approximately 2.5 and 1.9 times per season in 1994 and 1996, respectively. About 200 and 100 pounds of active ingredient were applied per season at a rate of 0.09 and 0.07 pound per acre in 1994 and 1996, respectively. It provides good protection from cabbage looper, diamondback moth, and imported cabbage worm.

Biological insecticides

Bacillus thuringiensis *(Agree WP, Biobit FC, Dipel 2X, 4L, Javelin WG, Mattch, MVP, Xentari WDG)*

Bt-based products were applied to approximately 75 percent and 20 percent of the total cabbage acreage and used approximately 5.8 and 3.3 times per season in 1994 and 1996, respectively. The application rate and amount of active ingredient applied per crop year are not available because amounts of active ingredient are not comparable among formulated products. *Bt* is used primarily for managing beet armyworm, cabbage looper, corn earworm, and diamondback moth larvae. *Bt*-based products are often rotated among themselves and other synthetic chemicals. Certain synthetic insecticides are often mixed with *Bt* (i.e., Dimethoate, Lannate).

Table 1 (page 3) provides a summary of synthetic and biological insecticides currently registered for use on cabbage in North Carolina and their spectrum of insect activity.

Alternatives

Two biological insecticides (CryMax, a new *Bt*-based product, and Spinosad [Spintor 2EC]), which have minimal nontarget effects on beneficial microorganisms and insects, have been recently registered for use on cabbage in North Carolina for managing the diamondback moth. As with any new product, there are concerns among growers about cost and efficacy. Insecticide efficacy is particularly important in situations where applications are delayed due to inclement weather, which results in an older and larger target insect population. Insecticidal soap (M-Pede) can be used for managing aphids, but it requires frequent application and has limited effectiveness under field conditions.

The destruction of crop residues and insect scouting are commonly practiced by cabbage growers in North Carolina. Black light and pheromone traps are used in an integrated pest management system to monitor and initiate insecticide applications for cabbage looper, diamondback moth, and imported cabbage worm. Although many growers practice crop rotation and residue management, the impact of these practices may be minimal, particularly in a concentrated cabbage production area (i.e., local versus regional management).

WEEDS

Weed management is accomplished primarily by hand labor, frequent cultivation (three to five per season), and preemergence or preplant herbicides for managing small-seeded broadleaf weeds (e.g., lambsquarter, pigweed, ragweed, smartweed, and purslane) and annual grasses. The management of ragweed is particularly important since the flowers of this weed can become infected by the plant pathogenic fungus *Sclerotinia sclerotiorum* and serve as a source of head rot disease. Wild mustard and radish, which are closely related to cabbage, are often difficult weeds to manage with herbicides and can also become a reservoir for the club root disease organism.

Occasionally, a postemergence herbicide will be used for managing grasses and volunteer wheat. Most of the currently registered herbicides can cause some phytotoxicity on cabbage, particularly when direct seeded. In certain instances, irrigation (which is not a common production practice in North Carolina) and/or rainfall is required for herbicide activation.

Synthetic herbicides

Bensulide *(Prefar 6E)*

This material was used on less than 1 percent of the cabbage crop in 1994 and 1996, primarily as a preplant or preemergence herbicide for managing annual grasses and small-seeded broadleaf weeds. Irrigation is often needed for activation and improved efficacy. Bensulide may provide an effective alternative to Treflan and Dacthal.

DCPA *(Dacthal 75 WP)*

This material was applied to 15 percent of the total cabbage acreage and used approximately 1.1 times per season in 1994. Approximately 4,300 pounds of active ingredient were applied per season at a rate of 4.98 pounds per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. Used primarily for managing annual grasses and small-seeded broadleaf weeds, Dacthal is the herbicide of choice among North Carolina growers because of its spectrum of activity and lack of phytotoxicity. However, market availability and cost may limit its use in the future.

Napropamide *(Devrinol 50DF)*

This material was applied to 2 percent of the total cabbage acreage and used approximately 1 time per season in 1994. Approximately 200 pounds of active ingredient were applied per season at a rate of 1.32 pounds per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. It may cause phytotoxicity and requires irrigation for activation.

Oxyfluorfen *(Goal, 2XL)*

This material was applied to 22 percent of the total cabbage acreage and used approximately 1 time per season in 1994. Approximately 300 pounds of active ingredient were applied per season at a rate of 0.28 pound per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. Goal can be used as a preplant herbicide on transplanted but not direct-seeded cabbage for managing many small-seeded broadleaf weeds. Goal is a cheaper alternative to Dacthal, but has less activity on annual grasses and may cause some phytotoxicty.

Sethoxydim *(Poast 1.53 EC)*

This material was used on less than 1 percent of the cabbage crop in 1994 and 1996, primarily as a postemergence herbicide for managing annual/perennial grasses and volunteer wheat. The 30-day preharvest interval needs to be considered when using sethoxydim.

Trifluralin *(Treflan 4EC)*

This material was applied to 24 percent of the total cabbage acreage and used approximately 1.4 times per

season in 1994. Approximately 1,100 pounds of active ingredient were applied per season at a rate of 0.6 pound per acre. In 1996, less than 1 percent of the cabbage crop was treated with this material. It can be used in transplanted and direct-seeded operations, but is primarily a preplant herbicide for managing annual grasses and small-seeded broadleaf weeds. Some phytotoxicity may occur on direct-seeded cabbage.

Biological herbicides

Biological herbicides are not available and/or registered for use on cabbage in North Carolina.

Alternatives

More frequent cultivation may provide an alternative, but this practice could possibly contribute to increased soil erosion and development of poor soil structure. In addition to cultivation, some hand-weeding would also be needed to manage weeds in the cabbage row, which would increase labor and production costs. At the present time, approximately 30 percent of cabbage production costs are associated with weeding and harvesting.

DISEASES

A seed treatment fungicide (Benlate, Captan, and/or Thiram) is almost always used to manage seed and seedling diseases. In transplanted cabbage, a fungicide may be applied directly to the transplant or in the furrow to manage club root disease. In general, fungicides are not usually applied to cabbage foliage during the growing season. When foliar diseases such as downy mildew and Alternaria leaf spot become problematic, the broad-spectrum fungicides chlorothalonil and mancozeb provide adequate protection against these diseases. Copper-based fungicides may be used for managing black rot, a bacterial disease, but they have limited effectiveness and may cause phytotoxicity. Currently, no fungicides are available for managing Sclerotinia head rot, a sporadic but emerging disease in commercial cabbage production fields in North Carolina.

Synthetic fungicides

Benomyl** (Benlate 50WP), **Captan, and Thiram.

No use data are available on these commonly used seed treatment fungicides. These materials are often applied to cabbage seed alone in combination prior to packaging and shipping. Benlate is used primarily for managing seedborne *Leptosphaeria maculans*, the black leg fungus. Captan and Thiram are used primarily for managing a wide variety of soil-inhabiting fungi that cause seed and seedling diseases.

***Chlorothalonil** (Bravo; many formulations and generic products)*

This material was applied to 10 percent and 12 percent of the total cabbage acreage and was used approximately 2.1 and 1.7 times per season in 1994 and 1996, respectively. Approximately 1,200 and 1,100 pounds of active ingredient were applied per season at a rate of 1.13 and 1.05 pounds per acre in 1994 and 1996, respectively. Bravo is a good, broad-spectrum fungicide for managing foliar diseases of cabbage, but it has limited Sclerotinia activity.

***Mancozeb** (Manzate, Dithane; many formulations and generic products)*

This material was applied to 9 percent of the total cabbage acreage and used approximately 1 time per season in 1994. Approximately 800 pounds of active ingredient were applied per season at a rate of 1.62 pounds per acre. In 1996, less than 1 percent of the cabbage crop was treated.

Mancozeb is a good broad-spectrum fungicide for managing foliar diseases of cabbage, with excellent Alternaria but limited Sclerotinia activity. It has been implicated as a possible carcinogen.

***Pentachloronitrobenzene** (PCNB 75WP)*

This material was applied to less than 1 percent of the cabbage crop in 1994 and 1996. It is used primarily for managing club root by dipping transplants in and/or adding fungicide directly in the furrow with hydrated lime (calcium oxide).

Biological fungicides

Some biological agents (e.g., Bio-Save, Deny, Kodiak, Mycostop, Root Shield, Soilgard, etc.) are commercially available for managing seed and seedling diseases. However, these materials will need to be examined for several years in different commercial cabbage fields in North Carolina to determine their efficacy and consistency.

Alternatives

A 2- to 3-year crop rotation away from other crucifers is an effective means of managing Alternaria leaf and head spot, black leg, black rot, and downy mildew. However, rotation is often of limited value on club root and Sclerotinia head rot because the pathogens that cause these diseases are capable of surviving for many years in soil.

Listed below are the major cabbage diseases in North Carolina, a description of their symptoms, and suggested management practices.

Alternaria leaf and head spot

These diseases are caused by *Alternaria brassicae* and *A. brassicicola*. Symptoms first appear as brownish-black, target-like spots on leaves and stems that spread to the head under wet conditions.

Management

Use disease-free seed. Apply fungicides when needed.

Black leg

This disease is caused by the fungus *Leptosphaeria maculans*. Symptoms first appear as black, round spots on leaves and stems. As the disease progresses, spots enlarge and become gray in the center with small black dots. Severely infected plants are stunted and may have a constricted stem at the soil line.

Management

Use disease-free seed and transplants. Bury (destroy) crop residue and rotate with a non-crucifer crop for at least two years. Apply a seed-treatment fungicide and, when needed, a foliar application of fungicide.

Black rot

This disease is caused by the bacterium *Xanthomonas campestris* pv. *campestris*. Black rot symptoms appear initially as V-shaped areas along the outer leaf edges. As the disease progresses, leaf veins turn black, and plants become stunted, wilt, and usually die.

Management

Use disease-free seed and transplants, bury (destroy) crop residues, and rotate with a non-crucifer crop for at least two years. Tolerant varieties are available.

Club root

Caused by the soilborne organism *Plasmodiophora brassicae,* club root presents several symptoms, including leaf wilting and yellowing (particularly on hot, sunny days), stunting, and formation of club-like galls on roots.

Management

Use disease-free transplants. Avoid moving infected transplants and/or infested soil on farm equipment to clean fields. Maintain soil pH at or above 7.3 with hydrated lime.

Downy mildew

This disease is caused by the fungus *Peronospora parasitica*. Symptoms first appear as purplish, irregular spots on leaves and stems. In the early morning, a purplish, fluffy growth is evident on the underside of diseased leaves. Cauliflower heads and stems can be invaded internally by the downy mildew fungus.

Management

Use tolerant varieties and fungicides, bury (destroy) crop residue, and rotate with a non-crucifer crop for at least two years.

Sclerotinia head rot

Caused by the fungus *Sclerotinia sclerotiorum,* the disease first appears as water-soaked spots on leaves. As it progresses, a white-cottony fungal growth appears on infected leaves with small, black structures (sclerotia).

Management

Avoid planting in fields with a history of Sclerotinia disease; maintain adequate fertility and proper insect and weed management.

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