

# Crop Profile for Cabbage in North Carolina

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## General Production Information

- North Carolina ranked fifth nationally in the production of cabbage in 2003, representing 8.1 percent of U. S. production.
- In 2003, 7,700 acres of cabbage were harvested in North Carolina.
- In 2003, 1,656,000 cwt. of cabbage were produced in North Carolina for a value of \$18,216,000.
- 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 of North Carolina.

## Cultural 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.

## Worker Activities

(The following information was taken from the March 2005 Virginia Cabbage Crop Profile and adapted for North Carolina cabbage production.)

During the growing season, worker activities in the field include seeding, transplanting (April-June), cultivating, scouting, spraying, occasional hand weeding, and harvesting (August-September for summer plantings and November-December for fall plantings). Strictly following re-entry intervals (REIs) should minimize any risk of exposure to pesticides during these activities. If workers are required to go back in the field before the proper time limit has expired then personal protective equipment (PPE) is worn. Activities that bring workers in direct contact with the plants during the growing season are generally limited to harvest time because the cabbage heads are hand picked by the workers.

## **Insect Pests**

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

## **Insecticides**

### **Azinphosmethyl (Guthion)**

Azinphosmethyl is used primarily for managing the cabbage maggot, but it also has cabbage looper activity.

### **Carbaryl (Sevin)**

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 cabbageworm.

### **Chlorpyrifos (Lorsban)**

Chlorpyrifos 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)**

Diazinon is a good weapon for managing aphids and cabbage maggots when applied in furrow.

**Dimethoate**

Dimethoate is used primarily for thrips management but also can reduce aphid and flea beetle problems.

**Endosulfan (Thiodan, Phaser)**

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 cabbageworms is limited.

**Esfenvalerate (Asana XL)**

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 cabbageworms. Some North Carolina growers question the efficacy of Asana for managing the diamondback moth.

**Imidacloprid (Admire, Provado)**

This material provides an alternative for managing aphids, but plant-back restrictions and cost may limit its use in North Carolina.

***lambda*-cyhalothrin (Warrior)**

This material may be a useful alternative to Lannate for managing beet armyworm, cabbage looper, corn earworm, diamondback moth, and imported cabbageworm.

**Methomyl (Lannate)**

Methomyl provides moderate protection from the diamondback moth and imported cabbageworm when used in combination with *Bacillus thuringiensis* (*Bt*)-based products. Lannate also provides excellent protection from beet armyworm, corn earworm, and thrips.

**Permethrin (Pounce, Ambush)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

**Bifenthrin (Capture)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

**Disulfoton (Di-Syston)**

This material is not used much in North Carolina.

**Emamectin benzoate (Proclaim)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

**Indoxacarb (Avaunt)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

**Spinosad (SpinTor)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

***zeta*-Cypermethrin (Mustang MAX)**

This material provides good protection from cabbage looper, diamondback moth, and imported cabbageworm.

**Biological Insecticides*****Bacillus thuringiensis* (Agree, Biobit, Dipel, Javelin, Mattch, MVP, Xentari)**

*B.t.* is used primarily for managing beet armyworm, cabbage looper, corn earworm, and diamondback moth larvae. *B.t.*-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.** Insecticides registered for cabbage use in North Carolina and their spectrum of activity.

Insecticide	Aphid	Beet armyworm	Corn earworm	Cabbage looper	Cutworm	Diamondback moth	Flea beetle	Harlequin bug	Imported cabbageworm	Cabbage maggot	Stink bug	Thrips
Azinphos-methyl	-	-	-	X	-	-	-	-	-	X	-	-
<i>Bacillus thuringiensis</i>	-	X	X	X	-	X	-	-	X	-	-	-
Carbaryl	-	-	-	-	X	X	X	X	X	-	X	X
Chlorpyrifos	X	-	-	-	X	-	-	-	-	X	-	-
Diazinon	X	-	-	-	-	-	-	-	-	X	-	-
Disulfoton	X	-	-	-	-	-	-	-	-	-	-	-
Dimethoate	X	-	-	-	-	-	X	-	-	-	-	X
Endosulfan	-	-	-	-	-	X	X	X	X	-	X	X
Esfenvalerate	-	X	X	X	-	X	-	-	X	-	-	-
Imidacloprid	X	-	-	-	-	-	-	-	-	-	-	-
Insecticidal soap	X	-	-	-	-	-	-	-	-	-	-	-
<i>lambda</i> -cyhalothrin	-	X	X	X	-	X	-	-	X	-	-	-
Methomyl	-	X	X	-	-	X	X	-	X	-	-	X
Permethrin	-	-	-	X	-	X	-	-	X	-	-	-

**Table 2.** Insecticide Use on Cabbage (head, fresh) in North Carolina in 2002. Source: Agricultural Chemical Usage: 2002 Vegetables Summary. July 2003. U. S. Department of Agriculture, National Agricultural Statistics Service.

Insecticide Active Ingredient	Area Applied <sup>1</sup> (Percent)	Number of Applications	Rate per Application (lbs./acre)	Rate per Crop Year (lbs./acre)	Total Applied (1,000 lbs.)
<i>Bacillus thuringiensis</i> <sup>2</sup>	51	2.8			
Carbaryl	1	3.0	0.96	2.91	0.4
Dimethoate	5	4.0	0.50	2.02	0.9
Esfenvalerate	36	2.4	0.02	0.04	0.1
<i>lambda</i> -cyhalothrin	15	1.5	0.02	0.02	-- <sup>3</sup>
Methomyl	14	1.7	0.41	0.72	1.0
Permethrin	8	1.9	0.12	0.24	0.2
Spinosad	61	2.8	0.03	0.09	0.5

<sup>1</sup> Planted acres in 2002 for North Carolina were 9,500 acres.

<sup>2</sup> Rates and total applied are not available because amounts of active ingredient are not comparable between products.

<sup>3</sup> Total applied is less than 50 lbs.

### Alternative Pest Management Practices

Two biological insecticides (CryMax, a *Bt*-based product, and spinosad [Spintor 2EC]), which have minimal non-target

effects on beneficial microorganisms and insects, are 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 common practices of 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 cabbageworm. 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).

### **Current Insecticide Recommendations for Cabbage**

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

Table 5-10: Insect Control for Commercial Vegetables <http://ipm.ncsu.edu/agchem/chptr5/510.pdf>

## **Diseases and Nematodes**

A seed treatment fungicide (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. 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.

**Fungicides and Nematicides**

**Captan, and Thiram**

These materials are often applied to cabbage seed alone or in combination prior to packaging and shipping. Captan and Thiram are used primarily for managing a wide variety of soil-inhabiting fungi that cause seed and seedling diseases.

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

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)**

Mancozeb is a good broad-spectrum fungicide for managing foliar diseases of cabbage, with excellent Alternaria but limited Sclerotinia activity.

**Pentachloronitrobenzene (PCNB, Terraclor)**

This material 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.

**Table 3.** Fungicide Use on Cabbage (head, fresh) in North Carolina in 2002. Source: Agricultural Chemical Usage: 2002 Vegetables Summary. July 2003. U. S. Department of Agriculture, National Agricultural Statistics Service.

Fungicide Active Ingredient	Area Applied <sup>1</sup> (Percent)	Number of Applications	Rate per Application (lbs./acre)	Rate per Crop Year (lbs./acre)	Total Applied (1,000 lbs.)
Chlorothalonil	9	3.7	1.14	4.30	3.5
Chloropicrin	*	1.0	27.87	27.87	0.7
Methyl bromide	*	1.0	59.72	59.72	1.5

\* Area applied is less than one percent.

<sup>1</sup> Planted acres in 2002 for North Carolina were 9,500 acres.

### Alternative Pest Management Practices

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.

### Current Fungicide and Nematicide Recommendations for Cabbage

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

Table 6-17: Vegetable Crop Disease Control Schedule

<http://ipm.ncsu.edu/agchem/chptr6/612.pdf>

Table 6-24: Nematode Control in Vegetable Crops

<http://ipm.ncsu.edu/agchem/chptr6/617.pdf>

## 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., lambsquarters, 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 cabbage production practice in North Carolina) and/or rainfall is required for herbicide activation.

## Herbicides

### **Bensulide (Prefar)**

Bensulide is used primarily as a preplant or preemergence herbicide for managing annual grasses and small-seeded broadleaf weeds. With preemergence application, irrigation is often needed for activation and improved efficacy. Bensulide may provide an effective alternative to Treflan and Dacthal.

### **DCPA (Dacthal)**

Dacthal is used primarily for managing annual grasses and small-seeded broadleaf weeds. Dacthal is the herbicide of choice among North Carolina cabbage 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)**

Devrinol may cause slight phytotoxicity and requires irrigation, rainfall or cultivation soon after application for activation.

### **Oxyfluorfen (Goal, Galigan, OxiFlo)**

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 phytotoxicity to cabbage.

### **Sethoxydim (Poast)**

Poast is used as a postemergence herbicide for managing annual/perennial grasses and volunteer wheat. The 30-day preharvest interval must be observed when using sethoxydim.

### **Trifluralin (Treflan)**

Treflan can be used in transplanted and direct-seeded cabbage, but is primarily a preplant herbicide for managing annual grasses and small-seeded broadleaf weeds. Some phytotoxicity may occur on direct-seeded cabbage.

### **Clethodim (Select)**

Clethodim is used as a postemergence herbicide for managing annual and perennial grasses including annual bluegrass. The 30-day preharvest interval must be observed with clethodim.

### **Clomazone (Command)**

Clomazone is registered in seeded and transplanted cabbage for controlling annual grasses and certain broadleaf weeds. It does not control pigweed species.

### **Clopyralid (Stinger)**

Clopyralid is used to control certain broadleaf weeds such as legumes, common ragweed, sowthistle, jimsonweed, and cocklebur.

### **Glyphosate (Roundup WeatherMax)**

Paraquat is used as a postemergence herbicide for row middles only. It is non-selective; thus, contact with the crop will result in crop injury.

## Biological Herbicides

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

**Table 4.** Herbicide Use on Cabbage (head, fresh) in North Carolina in 2002. Source: Agricultural Chemical Usage: 2002 Vegetables Summary. July 2003. U. S. Department of Agriculture, National Agricultural Statistics Service.

Herbicide Active Ingredient	Area Applied <sup>1</sup> (Percent)	Number of Applications	Rate per Application (lbs./acre)	Rate per Crop Year (lbs./acre)	Total Applied (1,000 lbs.)
Napropamide	9	1.0	1.04	1.04	0.9
Oxyfluorfen	33	1.0	0.43	0.43	1.4
Trifluralin	8	1.0	1.24	1.24	0.9
Chloropicrin	*	1.0	27.87	27.87	0.7
Methyl bromide	*	1.0	59.72	59.72	1.5

\* Area applied is less than one percent.

<sup>1</sup> Planted acres in 2002 for North Carolina were 9,500 acres.

### Alternative Pest Management Practices

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.

### Current Herbicide Recommendations for Cabbage

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

Table 8-15: Chemical Weed Control in Vegetable Crops

<http://ipm.ncsu.edu/agchem/chptr8/817.pdf>

## Contacts

### **Kenneth A. Sorensen**

Extension Specialist  
 Department of Entomology  
 North Carolina State University  
 Campus Box 7626  
 Raleigh, NC 27695-7626  
 Telephone: (919) 515-1662  
 E-mail: kenneth\_sorensen@ncsu.edu

### **David W. Monks**

Extension Specialist (Weed Management)  
 Department of Horticultural Science  
 North Carolina State University  
 Campus Box 7609  
 Raleigh, NC 27695-7609  
 Telephone: (919) 515-5370  
 E-mail: david\_monks@ncsu.edu

### **Marc A. Cubeta**

Extension Specialist

Department of Plant Pathology  
North Carolina State University  
Campus Box 7616  
Raleigh, NC 27695-7616  
Telephone: (919) 513-1227  
E-mail: marc\_cubeta@ncsu.edu

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2. Schooley, T.E., C. M. Waldenmaier, T. P. Kuhar, M. J. Weaver, H. P. Wilson, R. Sterrett, and S. E. Nessler (ed.). 2005. Crop Profile for Cabbage in Virginia. <http://www.ipmcenters.org/cropprofiles/docs/VAcabbage.html>
3. Sorensen, K.A. Cabbage worm complex. Department of Entomology Insect Note #12
4. 4. Cubeta, M.A., J. Hudyncia, and B.R. Cody. Sclerotinia head rot of cabbage. Plant Pathology Information Note
5. 5. U. S. Department of Agriculture, National Agricultural Statistics Service. 2003. Agricultural Chemical Usage: 2002 Vegetables Summary. July 2003.

## On-Line Resources

Commercial Vegetables Recommendations for the Southeastern U. S.

<http://ipm.ncsu.edu/vegetables/CommercialVegetables/SECommercialVegGuide.pdf>

Sustainable Practices for Vegetable Production in the South

<http://www.cals.ncsu.edu/sustainable/peet/>

North Carolina Pest News

[http://ipm.ncsu.edu/current\\_ipm/pest\\_news.html](http://ipm.ncsu.edu/current_ipm/pest_news.html)

Insects and Related Pests of Vegetables

<http://ipm.ncsu.edu/AG295/html/index.htm>

Insect Pests of Vegetables

[http://ipm.ncsu.edu/vegetables/pests\\_vegetables.html](http://ipm.ncsu.edu/vegetables/pests_vegetables.html)

Insect Notes – Vegetables

[http://www.ces.ncsu.edu/depts/ent/notes/Vegetables/vegetable\\_contents.html](http://www.ces.ncsu.edu/depts/ent/notes/Vegetables/vegetable_contents.html)

Plant Disease Information – Vegetables

[http://www.ces.ncsu.edu/depts/pp/notes/Vegetable/vegetable\\_contents.html](http://www.ces.ncsu.edu/depts/pp/notes/Vegetable/vegetable_contents.html)

Cabbage and Other Leafy Greens, Horticultural Commodity of North Carolina

<http://www.agr.state.nc.us/markets/commodit/horticul/leafy/>

## Prepared by:

Kenneth A. Sorensen, David W. Monks, Marc A. Cubeta, and Stephen J. Toth, Jr. (ed.)