Crop Profile for Peppers in North Carolina

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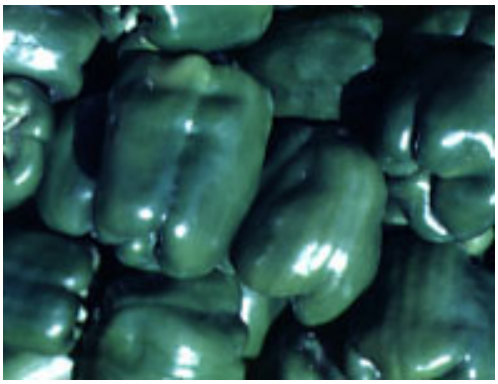

General Production Information

- North Carolina ranked fifth nationally in the production of bell peppers in 2003, representing 3.7 percent of U. S. production. A total of 600,000 cwt. of bell peppers were produced in North Carolina.
- In 2003, 5,000 acres of fresh market bell peppers were harvested in North Carolina.
- In 2003, 500,000 cwt. of fresh market bell peppers were produced in North Carolina for a value of $12,500,000.
- The majority of the industry is focused on bell pepper production for the fresh market. Processing peppers account for less than 20% of North Carolina production.

Production Regions

The majority of the pepper crop is produced in the central Coastal Plain. Prominent counties include Sampson, Duplin, Wayne, Pender and Columbus counties. Pepper production is also important in the western part of the state in Henderson County.

Cultural Practices

Two types of production systems are common for peppers. The first is a plasticulture system that depends on the use of methyl bromide in the spring to fumigate raised beds. The raised beds are covered with black plastic and a buried drip irrigation line is placed down the center. Transplants are planted in double rows per bed. Fertility includes pre-plant applications, with an emphasis on applying the recommended amount of potassium and phosphorous. Nitrogen pre-plant applications are complemented with nitrogen and potassium added through the

drip lines daily or weekly. After an early harvest, growers may utilize the plastic beds to produce a second crop such as cucumbers or summer squash.

The second type of system is referred to as bare-ground production. The land is ridged on 36 to 42 inch centers, the ridges are topped, and pepper transplants planted on the top of the squared-off ridges. Fertility includes pre-plant applications with several additional side-dress applications of additional nitrogen. All processing peppers are grown in this manner. Most bare-ground fields are irrigated using center pivots, irrigation traveling guns or traditional raised sprinklers.

Transplant production is an important component of the North Carolina industry. Historically transplants were imported as bare-root plants, but the industry has shifted to using plug plants; most are locally grown.

In eastern North Carolina, typical planting dates range from April 1 to April 15. First harvest may commence as early as June 10 but peak production occurs between July 1 and July 15. In western North Carolina, typical planting dates range from May 1 to May 30 and can continue through July 1. Harvest is initiated in mid July and continues to mid October.

Worker Activities

(The following information was taken from the February 2005 Tennessee Pepper Crop Profile and adapted for North Carolina pepper production.)

Field Preparation - fields are normally worked when soil moisture is great enough with a cultivator to remove weeds and assists in creating a good planting soil structure/tilth. A cultivator is also used to incorporated herbicide applications.

Transplants - transplants are grown in flats in the greenhouse prior to setting in the field.

Planting - Plants are individually placed by hand (using gloves) into a carousel type planter and placed by the planter into the soil.

Plastic - Embossed polyethylene plastic is laid over the bedded soil.

Fumigation - Fumigation materials are normally applied just prior to laying of plastic and two to six weeks prior to transplant. Products used include methyl bromide (MeBr) at 67% MeBr with 33% chloropricrin. Approximately 50% of the 2004 pepper acreage in North Carolina was treated with MeBr.

Irrigation - Irrigation or drip tape is laid when plastic is placed over the field. Workers attach main irrigation lines to row lines after the rows have been covered with plastic and soil. Each end of the row covered with plastic is covered with soil so fumigants will not escape. Irrigation/fertigation normally begins within a few hours after the plastic covering has been placed on the field. Fields may be entered the day of installation to check for leaking lines. Generally the initial irrigation process will proceed for two days.

Scouting - Scouting occurs within a few days after planting. Growers will enter the fields one to two days after transplant to inspect plants. They again enter the field the following week on a weekly basis to keep a check on any possible disease, insect or weed infestation. Observations may become more frequent after fruit development. At this time fields may be scouted twice each week to observe any threats from pests.

Pesticide Application - Applications begin with a preplant incorporated (ppi) application of one or more herbicides, if a soil fumigant is not used. Applications may be made 1 to 10 days prior to transplanting. If fumigants are applied, they may be applied during installation of plastic. Other herbicide applications may be directed to the row middles anytime after planting. Insecticide applications usually begin at transplant and additional products may be applied when scouting thresholds are recommended. Fungicides are applied to the foliage when conditions warrant their use. Usually they are applied when the foliage canopy is full just prior to or reached its peak.

Staking - With plasticulture plants are held upright by string which encircles an 18 inch stake placed every 10 plants. The plants may have one or two.

Harvesting - Harvesting is done by hand. Workers wear cotton or latex gloves to avoid skin irritation. Harvest dates depends on planting dates and weather patterns, however usually occurs from July 7 until October 10.

Packing - Peppers are hand packaged into 25 pound 1 1/9 bushel cartons, 14 to 15 pound half-bushel cartons, and 11 pound flat cartons. Sorters may or may not wear cotton and/or latex gloves.

Insect Pests

Insects are a primary concern for the pepper producer. Seven species are economically important. These include green peach aphids, Lepidoptera larvae (i.e., European corn borer, corn earworm, beet armyworm, fall armyworm, tobacco hornworm), and pepper maggots. Other insects of minor importance include flea beetles, cutworms, plant bugs, and pepper weevils.

Lepidoptera Larvae:

The European corn borer, corn earworm and fall armyworm are the most common larvae encountered. The European corn borer (*Ostriania nubilalis*) is a season-long pest but is most destructive in the second and third generation. Young larvae feed on the surface, and within a day or two, tunnel into the fruit around the seed caps. The larvae feed in the core of the fruit or in the seed cavity. The corn earworm (*Heliothis zea*) is a mid-to-late season pest and will feed extensively in the fruit. Often, the larvae leave a large entrance or exit hole on the shoulder of the fruit. The fall armyworm (*Spodoptera frugiperda*) usually moves into North Carolina around July 1. Larval feeding on the foliage may be extensive but damage to the fruit is of more concern. The beet armyworm (*Spodoptera exigua*) is a late season pest that ravages the foliage and later moves into the fruit. Tobacco hornworms (*Manduca sexta*) can be serious defoliators.

Pepper Maggots:

Pepper maggots (*Zonosemata electa*) feed on the fruit but are considered a sporadic pest. Female flies oviposit in fruit, which becomes dimpled or deformed. Legless, slender, headless maggots develop and feed in the core of the fruit. Infested fruit often ripen prematurely.

Aphids:

The green peach aphid (*Myzus pericae*) is usually found on the underside of leaves. Their feeding, secretions of honeydew and development of black sooty mold affects leaves and fruit. The aphids are also important vectors for several serious viruses.

Chemical Controls

Larvae are controlled most commonly by frequent applications of insecticides. Monitoring is conducted in key production regions to estimate time of adult moth activity. Once applications commence, sprays are applied every 5 to 7 days. The most common insecticides used are **acephate (Orthene), carbaryl (Sevin),** endosulfan (Thiodan, Phaser), **esfenvalerate (Asana)** and **permethrins (Pounce, Ambush).**

These sprays are targeted primarily for larval control. Aphid control using chemicals is used on a low percentage of the acreage and dimethoate is the favored product because of its systemic activity providing, control up to 3 weeks.

Additional insecticides and miticides used to manage insects and mites in peppers include abamectin (Agri-mek), Bacillus thuringiensis (Crymax, Ketch, Xentari), bifenazate (Acramite), imidacloprid (Admire), pymetrozine (Fulfill), spinosad (SpinTor), and Thiamethoxam (Platinum, Actara). Abamectin is used for leaf miners and mites, Bacillus thuringiensis for armyworms, corn earworms, loopers and hornworms, bifenazate for spider mites, imidacloprid for aphids and flea beetles, pymetrozine for aphids, spinosad for armyworms, corn earworms, loopers, hornworms and leafmniners, and thiamethoxam for aphids, flea beetles and pepper weevils.

Integrated pest management (IPM) programs include the use of light traps to provide peppers growers with estimated times to begin scouting fields and initiate the first application. However, most growers initiate sprays based on crop phenology. Growers also rotate chemicals to limit build-up of resistant pest populations. The four main chemicals listed above are highly efficacious on larvae. The efficacy of the permethrin insecticides is compromised under high temperature conditions.

Table 1. Insecticide use on bell peppers 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[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)
Acephate	89	2.1	0.58	1.28	8.4

Bacillus thuringiensis [2]	*	5.5			
Carbaryl	6	2.0	1.00	2.01	0.9
Endosulfan	12	1.0	0.75	0.77	0.7
Esfenvalerate	6	2.1	0.03	0.07	-- [3]
Permethrin	13	2.0	0.09	0.20	0.2

* Area applied is less than one percent.
[1] Planted acres in 2002 for North Carolina were 7,400 acres.
[2] Rates and total applied are not available because amounts of active ingredient are not comparable between products.
[3] Total applied is less than 50 pounds.

Current Insecticide Recommendations for Peppers

Current North Carolina Cooperative Extension Service recommendations for insecticide use on peppers (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

Cultural Control Practices

Recommended IPM and cultural practices include the adoption of as many as possible of the following practices:

Destruction or utilization of all crop residues and plant refuse in which corn borers may pass the winter. Clean plowing or planting to a cover crop will destroy and discourage corn earworms.

Avoid planting peppers adjacent to cornfields or in fields previously in corn.

Plant peppers early to ensure early harvest and avoidance of later generation borers, earworms, and the arrival of fall armyworms. The use of local plants grown in trays will help ensure early harvest. Fruit harvested after July 15 will contain larvae unless spraying is based on field sampling or applications are made every 5 days.

Adequate fertilizer, water and weed and disease control will favor vigorous plants and increased yields.

Black light insect traps should be located near fields and checked regularly to monitor for moth flights. Initial, peak and duration of moth flights will indicate relative population trends and when to scout fields for egg masses and small larvae. Twenty-five moths over 5 days is a good indication of when to intensify field scouting.

Remember, these traps only indicate insect levels, they do not control or prevent larvae. During mid-season, the *North Carolina Pest News* newsletter (Departments of Entomology and Plant Pathology, North Carolina State University) provides light trap data from selected North Carolina counties.

Careful examination of plants for egg masses and small larvae and fruit samples for entry signs around the stem cap or presence of larvae inside the seed cavity should be made in a systematic manner as determined by light traps. Be sure to keep records.

Immediate destruction of the pepper crop on completion of harvest will help reduce further insect buildup and lower overwintering borers and earworms.

Biological Controls

Currently, no biological controls are used on a significant number of acres.

Diseases and Nematodes

Disease has limited crop production efficiency for many growers and, in fact, has put some growers out of business. Minor disease problems encountered include Botrytis blight and Sclerotinia rot in transplant production greenhouses, Pythium and Phytophthora damping-off in transplant production or soon after field setting, various virus diseases, and occasional leafspot problems caused by Phoma or Cercospora species. However, the most important industry problems include Southern stem blight, Phytophthora root and crown rot and blight, bacterial spot, bacterial soft rot of the fruit, anthracnose fruit rot and root knot nematode.

Growers have few options for control of greenhouse diseases during transplant production. Key management inputs include sanitation within and around the greenhouse, and critical management of the environment including air movement, management of humidity and restricted use of overhead watering. Some growers use phage and products such as Oxidate to suppress bacterial diseases, although limited efficacy data is available.

In field production, the major diseases are:

Southern stem blight (*Sclerotium rolfsii*):

Southern stem blight is a disease of the crown and roots causing the plant to wilt and die. The pathogen can often be diagnosed by the presence of white stringy mold on the roots or crown. The fungus produces sclerotia that are small round structures able to persist in the soil for years. Heavily infested fields can result in substantial crop losses of 80% or more. The disease is present on many farms and is particularly aggravated when warm wet weather follows a period of stress, such as a dry period. There is no effective way to control the disease and an integrated management strategy must be adopted. Growers are advised to deep turn plow with a moldboard plow, to rotate away from problem fields, avoid growing susceptible crops in sequence, and to prevent hilling soil immediately around the base of the plant during cultivation. Chemical control is adopted to a certain extent

including the use of PCNB (Terraclor) in transplant water and soil fumigation.

Phytophthora root and crown rot (*Phytophthora capsici*):

This disease occurs in two phases: a primary phase that originates from soil-borne inoculum and results in colonization of roots, crowns and lower stems; and a secondary phase that originates from rain-slashed dispersal of spores and affects the upper stems, leaves and fruit. This disease is becoming increasingly prevalent on many farms in the last 5 to 10 years and is able to persist in soils. Complete crop losses have been observed, especially after severe weather such as a hurricane or other heavy rain and wind episodes. The disease often originates in poorly drained sections of the field and spreads with drainage patterns. Chemical control has proven marginally successful under heavy disease pressure. The disease is controlled primarily by 2 to 3 applications of Ridomil Gold starting at planting and then at 30-day intervals. Recently, strains resistant to mefenoxam (the active ingredient of Ridomil Gold) have been isolated in numerous production fields in North Carolina. Management of the disease must occur through an integrated approach with emphasis on water management. Host resistance and fumigation have become important components of management.

Bacterial spot (*Xanthomonas axonopodis* pv. *vesicatoria formely Xanthomonas campestris* pv. *vesicatoria*):

Bacterial spot has become less prevalent in recent years as seed companies have enhanced their quality assurance programs. Inoculum is usually introduced on seed and bacterial populations can build up on the surface of the leaf. Spotting on leaves and subsequent defoliation, black margins along the leaves and scabby round lesions on the fruit characterize the disease. Warm, wet weather favors disease progress. Use of disease free seed is the most important disease management strategy. Resistant varieties are available to several specialized bacterial genotypes (races) but races exist which can overcome all know sources of host resistance. Copper sprays, especially when combined with maneb, can reduce disease progress and result in an acceptable crop, but not under conditions highly conducive to disease progress.

Bacterial soft rot (*Erwinia spp.*):

This can be a serious post-harvest problem especially under conditions of hot, wet weather. Soft rot is aggravated and favored by wounding of fruit tissue. Affected fruit will turn mushy and deteriorate rapidly, often starting as small circular water-soaked lesions. Control includes the use of copper sprays during the growing season, cooling of fruit after picking, and use of chlorine in heated wash water.

Anthracnose fruit rot (*Colletotrichum capsici and C. acutatum*):

Historically, anthracnose was not a serious industry-wide problem in eastern North Carolina except in operations attempting to produce red bell peppers. In western North Carolina, anthracnose occurs more frequently. When it does occur, it is as the fruit matures. Sunken circular lesions occur characterized by a series of concentric rings. The pathogen likely becomes established in the fruit early during fruit development but causes symptoms as the fruit matures. Few growers specifically spray to manage this disease but maneb fungicide applications during fruit formation and growth may be helpful. More recently, a new strain has emerged and this pathogen, *C. acutatum*, aggressively attacks young green fruit and can cause severe crop loss. Symptoms do not occur on the plant but only on the fruit as large sunken and circular lesions with orange spore masses. The strobilurin-based chemistries provide effective control.

Root knot nematode (*Melodogyne* spp.):

Root knot is not a major industry problem in part because many growers apply nematicides prolifically. Nematicides used include methyl bromide, 1,3-dichloropropene (Telone II) and metam sodium (e.g. Vapam, Sectagon 42, Metam-CLR). The pathogen is an obligate parasite and colonizes pepper roots resulting in lost plant productivity. Control is best achieved using an integrated program of rotation with a non-susceptible host and use of nematicides. Pepper lines with nematode resistance are available but not incorporated into commercially acceptable lines for North Carolina production.

Chemical Control

Foliar fungicides are not used extensively by all pepper growers. Likewise, pre-plant and transplant treatments are used by growers who have had a history of Southern stem blight or Phytophthora. The most common fungicides used are **copper ammonium, copper hydroxide, maneb (Maneb, Manex), mefenoxam (Ridomil Gold)**, the strobilurins (Quadris or Amistar, Cabrio), famoxidone plus cymoxinil (Tanos) and **dichloropropene (Telone II).**

Table 2. Fungicide use on bell peppers 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[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)
Chlorothalonil	*	4.0	1.67	6.68	0.1
Copper hydro	35	6.1	0.30	1.84	4.8
Mancozeb	12	3.9	0.76	3.02	2.7
Maneb	23	7.2	1.45	10.48	17.9
Chloropicrin	5	1.0	52.83	52.83	20.3
Methyl bromide	5	1.0	107.25	107.25	41.3

* Area applied is less than one percent.

[1] Planted acres in 2002 for North Carolina were 7,400 acres.

Current Fungicide and Nematicide Recommendations for Peppers

Current North Carolina Cooperative Extension Service recommendations for fungicide and nematicide use on peppers (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

Cultural Control Practices

Cultural control practices play a significant role in plant disease management. Crop rotation and cropping sequence are important for Southern stem blight and Phytophthora management. Resistance has been an important strategy for bacterial spot control and is an emerging possibility for Phytophthora and root knot management. The USDA recently released pepper varieties resistant to root knot but these have not been evaluated in North Carolina. Water management issues such as good drainage, no "ponding" in fields, judicious use of overhead watering and formation of planting ridges is essential to limit Phytophthora root and crown rot incidence.

Biological Controls

Very limited information is available concerning biological controls. Research results have demonstrated *Gliocladium virens* (brand name SoilGaurd) can be used successfully to limit Southern stem blight but this has not been adopted commercially. Some growers are using bacteriophage preparations to suppress *Xanthomonas* bacterial spot. Otherwise, no biologicals are used.

Weeds

Annual and perennial broadleaf and grass weeds are encountered in pepper production. Perennial weeds are managed best by pre-plant tillage operations (such as a tractor-mounted tiller or shallow disking) or use of herbicides in a stale bed system (such as **paraquat (Gramoxone MAX)** or **glyphosate (Roundup)).** Weeds in a plasticulture production system are successfully controlled by the **methyl bromide** soil fumigation. Subsequent between-row weed control is accomplished using a contact kill herbicide such as paraquat (**Gramoxone MAX** and a shielded sprayer). Certain glyphosate formulations (Roundup WeatherMax) can be applied using a shielded sprayer to control most weeds growing between pepper rows in bareground and plasticulture systems. If grasses are the predominant problem, **sethoxydim (Poast) or clethodim (Select) are options.** Halosulfuron-methyl (Sandea) is also an option for preemergence and postemergence control of yellow and purple nutsedge and certain broadleaf weeds in the middles between pepper rows. It is registered in plasticulture and bareground pepper production systems. In bare-ground production systems, many growers apply preplant herbicides for annual grass and small-seeded broadleaf weed control. However, many growers do not use the preplant herbicides for fear of plant damage and rely extensively on cultivation and hoeing instead. Preplant herbicides include **clomazone (Command), napropamide (Devrinol), trifluralin (Treflan)** and **DCPA (Dacthal).** As

with the plasticulture system, between-row weed control is accomplished by using halosulfuron-methyl, glyphosate (Roundup WeatherMax), **paraquat, sethoxydim (Poast) or clethodim (Select)**. In bare-ground production, once cultivation stops, weeds become established and are numerous by the end of the season.

Table 3. Herbicide use on bell peppers 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[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)
Clomazone	24	1.0	0.57	0.57	1.0
Napropamide	21	1.0	1.11	1.11	1.7
Paraquat	8	1.0	0.75	0.79	0.5
Chloropicrin	5	1.0	52.83	52.83	20.3
Methyl bromide	5	1.0	107.25	107.25	41.3

[1] Planted acres in 2002 for North Carolina were 7,400 acres.

Current Herbicide Recommendations for Peppers

Current North Carolina Cooperative Extension Service recommendations for herbicide use on peppers (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

Cultural Control Practices

As highlighted above, may growers rely heavily on cultivation and hand hoeing for weed control in bare-ground production systems. This is costly but many growers feel it results in less plant damage and enhanced yield. Cultivation is done at the time of fertilizer side-dressing and is accomplished 2 to 3 times before the plants fill out. Some work has been done using no-till production and a heavy over-wintered mulch of rye residue for weed suppression. However, this research is in the beginning stages for pepper production and has not been extended or implemented in North Carolina.

There are no biological controls available for weed control.

Contacts

Frank J. Louws
Extension Specialist
Department of Plant Pathology
North Carolina State University
Campus Box 7616
Raleigh, NC 27695-7616
Telephone: (919) 515-6689
E-mail: frank_louws@ncsu.edu

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

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

Douglas C. Sanders
Extension Specialist
Department of Horticultural Science
North Carolina State University
Box 7609
Raleigh, NC 27695-7609
Telephone: (919) 515-1222
E-mail: doug_sanders@ncsu.edu

Wilfred R. Jester
Extension Associate
Department of Horticultural Science
Cunningham Research Station
202 Cunningham Road
Kinston, NC 28501
Telephone: (252) 526-4445

E-mail: bill_jester@ncsu.edu

Allan C. Thornton
Extension Associate
Department of Horticultural Science
Sampson County Extension Center
369 Rowan Road
Clinton, NC 28328
Telephone: (910) 592-7161
E-mail: allan_thornton@ncsu.edu

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2. Sherrell, E. M. (ed.). 2004. North Carolina Agricultural Statistics 2004. Publication No. 204. North Carolina Department of Agriculture & Consumer Services, Raleigh.
3. K. A. Sorensen. 1996. Pepper Worms And Their Management. Vegetable Insect Note 30.
4. 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

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

Insect Notes – Vegetables

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

Know and Manage Pepper Pests
http://ipm.ncsu.edu/vegetables/pamphlets/peppers/peppers.html

Peppers and other Summer Vegetables, Horticultural Commodity of North Carolina
http://www.agr.state.nc.us/markets/commodit/horticul/sumveg/peppers.htm

Prepared by:

Frank J. Louws, David W. Monks, Kenneth A. Sorensen, Douglas C. Sanders, Wilfred R. Jester, and Stephen J. Toth, Jr. (ed.)

The image of green bell peppers is provided by the Department of Communication Services at North Carolina State University.