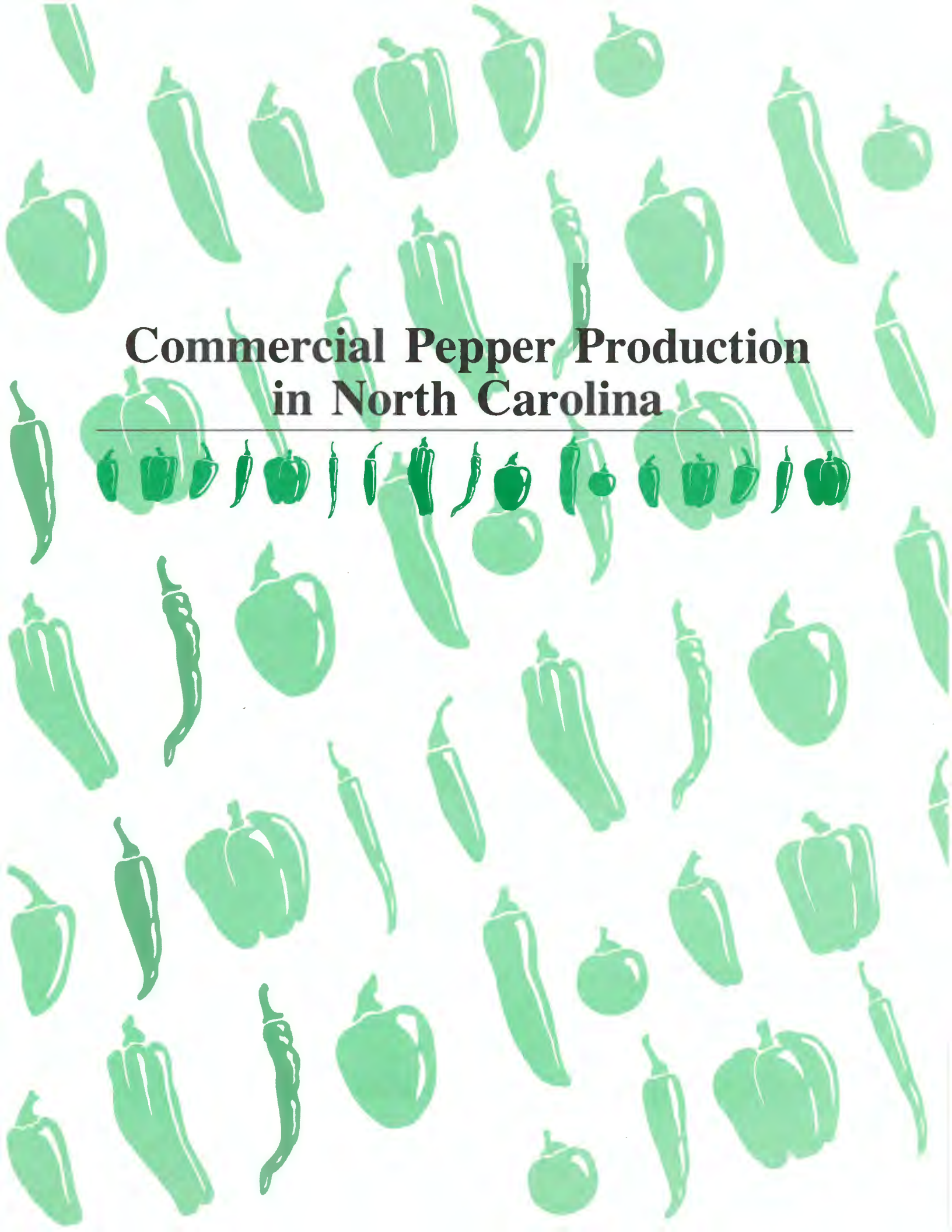
Commercial Pepper Production in North Carolina



Contents

Commercial Pepper Production in North Carolina

Prepared by:
D.C. Sanders, C.W. Averre,
K.A. Sorensen
E.A. Estes,
E.O. Beasley, and A.R. Bonanno

Fresh Market Peppers

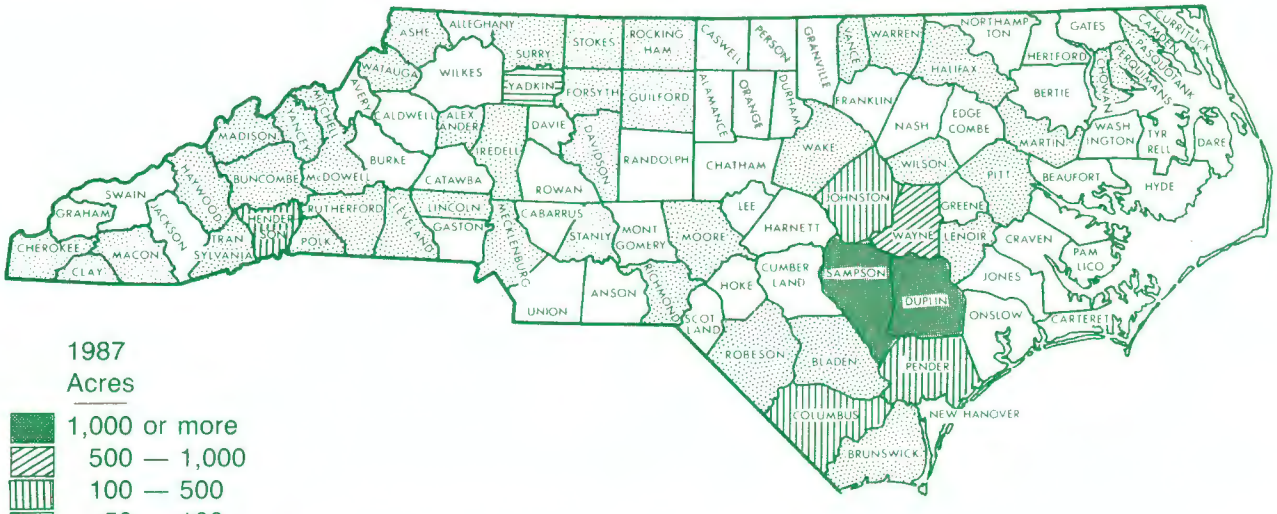


Figure 1. Acreage of fresh market peppers by county in 1987.

Processing Peppers

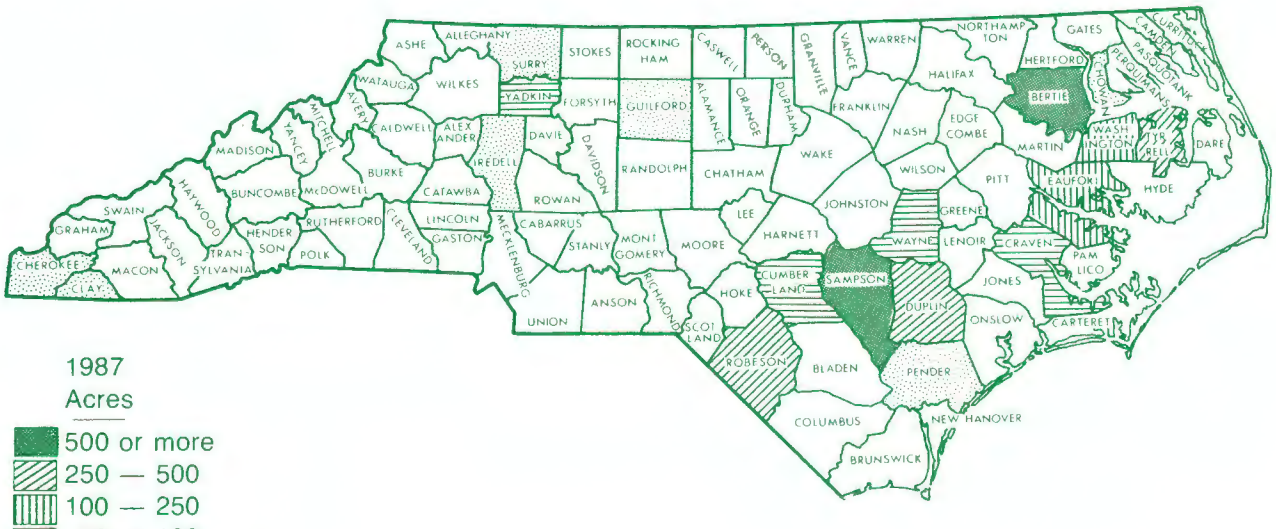
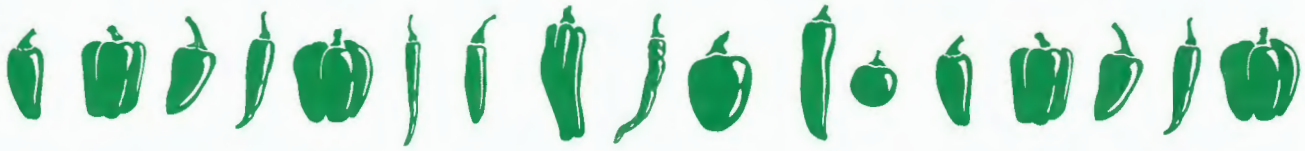


Figure 2. Acreage of processing by county in 1987.



Introduction

North Carolina with its long growing season and diversity of fertile soils and climates is ideally suited for production of all types of peppers (Figures 1 and 2).

Pepper yields vary with growers and location. In general, yields are higher in the mountains because of thicker fruit walls and longer harvest periods.

North Carolina has a long history of pepper production, especially bell types which are sold in well established local cannery and fresh markets. Other traditional outlets include markets in Atlanta, New York, Chicago, and eastern Canada. Acreage of all types of peppers could be expanded to satisfy increasing demands from traditional and specialty markets. This expansion is contingent upon efficient production and marketing peppers. Production and marketing practices for peppers are constantly improving and growers need to keep abreast of these changes in order to maintain high levels of efficiency.

Commercial Types

Peppers are classified as bell, specialty, or long types. All can have sweet flesh or hot (pungent) flesh; bells are usually sweet. The degree of pungency is dependent upon variety, location of growth, degree of maturity, and part of the pepper pod. Pungency is caused by an oily compound called capsaicin which is located in small sacks or pustules on the inside wall of the pepper pod. Pepper varieties (Table 1 on the next page) also vary in fruit shape, flesh thickness, fruit size, color, plant size, and leaf size.

Bell Types. Bell peppers constitute the major fresh market type and have either pendant or upright fruits that are blocky and large. First quality pods are usually three or four lobed, three and one half to four inches in diameter, and four to five inches long. Usually, 70 to 80 pods will fill a 30 pound bushel. Larger pods command a premium price and 60 pods per bushel is ideal. Bell types are usually sold green, and the intensity of color should be medium to dark for the North Carolina market. Mature bell types can also be red, yellow, or orange, and they tend to be sweeter and have thicker pod walls.

Hot or Chili Types. Chili pepper pods are usually pungent, pendent, and thin walled. They range in size from one-fourth inch in diameter and less than an inch long to one and three-fourths inches in diameter and seven inches long.

Some are as large as two and one-fourth inches in diameter and eight inches long. Chili peppers are usually green when immature and turn red, yellow, or orange at maturity. Pungency of chili varieties varies from mild (Anaheim TMR) to very hot (Bohemian Chili and Cayenne).

Pimento Types. These fruits are generally heart shaped, pointed at the blossom end, have very thick walls of very sweet flesh, and may be red to reddish orange. Pods range from two to three and one-half inches in diameter and three to five inches long. Pimentos are used for canning and in processed meats, olive stuffing, cheese, or as strips in small glass jars. Plants are usually large and rank growing.

Table 1. General characteristics of pepper varieties for North Carolina production.

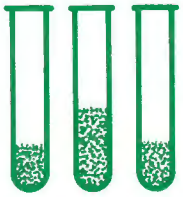
Variety[1]	Approximate days from transplanting to harvest	Bush size[2]	Fruit size (in) (LxD)	Degree of cover[3]	Lobes/ fruit	Mature color[4]	Use[5]	Disease tolerance
Bell types								
Bell Captain	72	ML	4½ × 4	G	4	R	MP	TMV
Bell Tower	80	L	4½ × 5½	G	3-4	R	MP	TMV, PVY
California Wonder 300	74	L	4½ × 4	G	4	R	M	TMV
Early California Wonder	70	S	4 × 3½	P	3-4	R	M	---
Emerald Giant	76	L	4 × 3½	G	4	R	MP	TMV
Gatorbelle	68	L	3½ × 3	G	3-4	R	M	TMV
Hybelle	72	L	4½ × 4	G	4	R	MP	TMV
Keystone Resistant Giant Strain #3	74	L	4 × 3¾	G	4	R	MP	TMV
Lady Bell	70	M	4 × 3½	G	3-4	R	MP	TMV
Mercury	74	M	4 × 3½	G	4	R	MP	TMV
Marengo	75	M-L	4½ × 5	G	4	Y	M	---
Pip	75	M	3½ × 4	M	3-4	R	MP	---
Purple Bell (Purple Early)	70	S	4¼ × 4	M	3-4	R	M	TMV
Skipper	69	M-L	3½ × 4½	G	4	R	MP	TMV, PVY
Summer Sweet 860	76 to green 86 to yellow	M-L	4½ × 4½	G	4	Y	M	TMV, PVY
VR-2	74	M	3½ × 3¼	M	3-4	R	MP	TMV, PVY
Yolo Wonder B	74	S	4 × 3¾	M	4	R	M	TMV
Yolo Wonder L	75	L	4½ × 3¾	G	3-4	R	MP	TMV
Other types								
Anaheim Chili (H)	79	L	7 × 1¾	G	1	R	MP	---
Anaheim TMR23 (H)	75	L	7½ × 2	G	1	R	MP	TMV
Big Bertha	71	L	6 × 3½	G	4	R	MP	TMV
Cherry Sweet	79	S	1 × 1½	G	1	R	PK	---
Cubanelle	65	S	5½ × 2½	F	2	Y	M	---
Gypsy	62	M	5 × 2½	M	3	O	M	---
Hungarian Yellow Wax (H)	67	S	5½ × 1½	P	2	Y	MPK	---
Hy Fry	63	M	5½ × 2	P	2	R	MPK	---
Jalapeno M (H)	73	L	3½ × 1½	G	1	R	MPK	---
Key Largo	65	M	7 × 2	M	2-3	O-R	MPK	---
Red Cherry Large (H)	77	M	1 × 2	F	1	R	PK	---
Red Cherry Small (H)	77	M	1 × 1¼	F	1	R	PI	---
Serrano Chili (H)	79	L	2¼ × ½	G	1	R	MPK	---
Pimento Select	73	L	3½ × 2½	G	1	R	P	---
Pimento L	79	S	4½ × 3½	M	1	R	P	---

[1] (H) = hot, not marked indicates sweet
[2] Bush size large (L), Medium (M), Small (S)
[3] Degree of cover Good (G), Medium (M), Fair (F), Poor (P)
[4] Mature fruit color red (R), yellow (Y), orange (O)
[5] Use as Market (M), Processing (P), Pickling (PK)

Site Selection and Soil Conditions

Drainage and Soil Types. Most soils in North Carolina can produce a profitable crop of peppers if surface drainage is good. If surface drainage is poor, high beds should be formed to enhance drainage. Peppers grow best on well drained soils, such as sandy loams, which warm readily in the spring. Extremely drought prone sandy soils should be avoided unless irrigation is used. A two-day water stress can cause blossom shedding or blossom end rot, both of which reduce yields. For long season production, peppers should not be located next to tobacco fields because of the danger of virus disease spread.

Crop rotation is very important in pepper production both for promoting soil tilth and for disease reduction. Corn, grain sorghum, and small grain are excellent crops to precede peppers. Peppers should not follow crops from the same family such as tomato, eggplant, tobacco, potato, or pepper. Soybean, sweet potato, and peanut crops are not recommended in a pepper rotation because they increase Southern blight and nematodes.



Soil Test. Soil testing is one of the most important steps in efficient pepper production; however, it is one of the most neglected. In a recent survey of North Carolina pepper fields, 65 per cent had a pH below the suggested pH 6.0, and 25 per cent were below pH 5.0. At these low soil pH's, fertilizer utilization by peppers is very inefficient. The nitrogen required to grow a pepper crop increases at soil pH below 6.0. Liming to raise soil pH should be done two to three months before planting. If lime is needed, it should be applied regardless of crop stage. This survey also showed that magnesium was low in 20 per cent of the fields, and 80 per cent of the fields required no phosphorus fertilizer. The soil test report would have indicated liming requirement, type of lime (dolomitic or calcareous), and need for expensive phosphorus fertilizer.

Soil samples should be taken yearly. Often, only one soil sample is required from each four to five acres of field. Proper field sampling is extremely important for satisfactory soil reports. These procedures are detailed in bulletin AG-372 or assistance can be obtained from the county agent or consultant. Soil testing is done at no charge by the Agronomic Division of the North Carolina Department of Agriculture and for a fee by private laboratories.

Nematode Assay. Nematodes, which cause diseases, live in the soil. They are small roundworms, and they can be found throughout North Carolina. Some nematodes can severely damage pepper roots and reduce yields. Soil samples for a nematode assay should be taken in early fall. The results will indicate if you need to treat the soil with a nematicide. Soil samples for nematode assays are taken in much the same way as are those for fertilizer requirements. However, these samples must be protected from drying by placing the soil in a plastic bag, by keeping it cool, and by sending it to the assay office immediately. The same agencies that do soil testing will also assay your samples for nematodes. Nematicide products are included in the pesticide supplement sheets.

Stand Establishment

Excellent pepper stands in the field may be established by either direct seeding or by using transplants. Each method has advantages, and each is suitable for specific production systems.

For example, transplanting usually results in early production and uniform stands; however, the risk of foliar pests may be a problem. Direct seeding requires less labor and is less costly and time consuming; however, irrigation usually is necessary. Direct seeding is not recommended for early pepper production. When properly done, both methods ensure proper plant spacing and uniform stands of plants.

Direct Seeding. Prior to seeding, the soil should be free of plant trash and well worked to a good tilth. Then level, uniformly shaped beds are formed. To enhance seedling emergence, 2.0 pounds of P_2O_5 per 1,000 feet of row is banded in the seed line two inches below the seeding depth just prior to seeding. Seed should be placed one-half to three-fourths inches deep.

The three types of seeders used for peppers are "dribble seeders," precision seeders, and plug mix seeders. The "dribble seeder" should be adjusted to drop 12 seed per foot. Precision seeders, such as Stan Hay or John Deere 33, clump three to five seeds per site at the selected spacing (see Table 2). Plug mix seeders, such as the Mechanical "Plug Mix" planter, place "plug mix" at the desired spacing.

"Plug Mix" is made as follows:
4 cubic feet of suitable peat lite mix,
4 ounces of medium grade magamp,
1.5 ounces of pepper seed,
1 to 2 gallons of water.

Mix ingredients dry for five minutes in a tumble mixer (concrete mixer); then gradually add water until the mix is of a moist, flowable consistency. Continue mixing for three to five minutes to break up clumps.

Transplants. Peppers are generally transplanted in North Carolina. Transplants can be either "bare root" or container grown. Transplanting is necessary for an early crop and generally assures a good stand. Container grown plants are earlier and more uniform in production than bare rooted plants.

Locally produced transplants have the advantage of being fresher, starting regrowth more rapidly when transplanted, and being readily available. Also they are more nearly free of diseases, insects, and weed seed than shipped-in plants.

Purchased Plants. Growers receiving shipped-in plants should require a certified inspection of all plants to ensure insect and disease-free transplants. Avoid accepting pepper plants containing blossoms and fruit buds, because pepper weevils can be transported in them. Once established, pepper weevils can cause total loss of fruit due to abortion or deformed pods infested with tiny, legless grubs.

On Farm Plant Production

Growers producing their own plants should follow the procedures outlined in *Commercial Transplant Production,* Extension publication AG-337, and the requirements of the North Carolina Crop Improvement Association for plant certification. This will minimize risk of serious seed and plant-borne diseases.

The table below indicates the proper time to seed peppers for transplants. Do not seed too early, because plants get elongated and can harden too much.

Time to Plant	Sow Seedbed	Set in Field (After frost)
Coastal Plain	Jan.15-Feb.15	April
Piedmont	Feb. 1-March 1	April—May
Mountains	Feb.15-March 15	May

Many growers still broadcast seed, but this results in uneven plant production because of non-uniform seed placement. Pepper plants need a minimum of 1.5 square inches to produce a high quality, stocky transplant. As much as nine square inches per plant will enhance earliness and profit.

Seeding peppers in rows four to five inches apart with eight to twelve seed per foot of row is an acceptable method of producing good transplants. Regardless of seeding method, no more than one-fourth ounce of seed is needed per yard of plant bed.

Plant Bed Insect Control. A number of insects can be troublesome in the pepper bed. Several species of cutworms, once established in the plant bed, can cut plants at the ground level. Crickets can be a nuisance, as is the foliar feeding done by slugs and snails. However, the major insect pest in pepper beds is the green peach aphid which spreads virus. Insects in the pepper bed can be effectively managed and controlled. Sanitation is the number one key to success. Such cultural practices as thorough seedbed preparation, site selection and rotation, isolation from overwintered greens in home gardens, the use of prebed contact fumigant, and selection and application of insecticide as needed will prevent insect damage in the plant bed. For more details, see Extension publication AG-337 mentioned above.

Plant Bed Disease Control. Even though sterilized media are used or soil is fumigated, diseases can cause problems in plant production. Damping-off (See Poster) often occurs in plant beds, especially where plantings are spaced too close and plants get "leggy." Damping off is caused by soil-borne fungi, eg. *Pythium* and occasionally by *Rhizoctonia*. Damping-off from *Pythium* usually appears at the soil line and affects the seedling stem or upper tap root; with high humidity, cottony growth appears on the lesions. Later these spots turn tan, then brown. Damping-off from *Rhizoctonia* usually causes a reddish spot on the stem. In general, good sanitation and care in watering are the best methods to prevent damping-off. Drenches with various fungicides may reduce the spread of damping-off after it appears. *Botrytis* is another common seedling disease which arises when seedlings are kept damp. Continuous air movement and ventilation is critical in controlling this disease. A low relative humidity in the plant canopy will help reduce the spread of this disease. Initially, a gray fuzz appears on cotelydons or leaflets, and, eventually, the entire plant is consumed.

Leaf spot diseases such as bacterial leaf spot and, occasionally, early blight may occur in the plant bed. Unfortunately, bacterial leaf spot is common and occurs as small tan spots on leaves. This blight usually starts as small irregular spots on leaves, and, as the spot enlarges, concentric circles appear. It is seed-borne, and seed should be treated with chlorine. (See the *North*

Carolina Agricultural Chemicals Manual.) A spray with copper fungicide, streptomycin sulfate, and maneb just prior to removing plants from the plant bed is an inexpensive, efficient method of protecting transplants from early disease infection. (See Poster)

Plant Bed Weed Management. If a sterilized artificial growing medium is not used, then the plant bed should be fumigated with methyl bromide at a rate of 5.5 pounds per 1,000 square feet. Even when proper fumigation practices are performed, certain weeds may still pose a problem. Tea weed, iron weed, annual sedges, sicklepod, clovers, and morningglory are difficult to control even under the best of conditions. As a result, weed management in the plant bed is a year-round task. Weeds should not be allowed to go to seed in the plant bed area. One or two sprays during the summer or early fall in the plant bed area with Gramoxone Super or Roundup will kill existing vegetation as well as prevent weed seed production from occurring. (See Poster)

Plant Bed Heating. The night temperature should not be allowed to drop below 50°F, but 60°F nights are optimum for good growth. There are many types of heating systems for plant beds. You should be sure you have a large enough system to heat your greenhouse. If fuel oil burners are used, proper stack ventilation is required. Open flame or propane burners must be adjusted for complete combustion, or plants may be damaged by fumes.

Plant Ground Bed Irrigation. Plant ground beds should be well-watered before seeding but not again until seedlings emerge. Usually two or three thorough waterings of an inch are sufficient to produce good transplants.

Ground beds should not be watered the last two to three weeks before transplanting. This will allow plants to harden. Plants should be watered well one day prior to pulling to make pulling easier and to minimize root damage. It is a good idea to include a soluble high phosphate starter fertilizer such as 10-52-17, 15-30-15, or 10-34-0 in this watering. Dissolve four ounces of fertilizer per ten gallons of water and apply one gallon per square yard. This starter fertilizer will "charge" the plant with phosphate to encourage new root development after transplanting.

Self-propelled lawn sprinklers work very well in most small plastic houses. Small impact sprinklers on risers or on overhead supply lines also work well. Some impact sprinklers can be used upside down. Water all areas of the house uniformly, and sprinklers should be placed to account for supports and rafters. Caution: sprinkler irrigation increases the risk of spreading bacterial leafspot and should not be used if disease appears.

When plants are pulled, they should be placed in clean containers and kept in the shade until they are transplanted.

Container Grown Transplants. Plants grown in containers have many advantages for commercial growers. These "containerized" plants are earlier, more uniform, and stockier than bare rooted plants and help to ensure complete stands. Containerized plants are easier to handle and make for more efficient field operations. Improved uniformity results in fewer harvests required to achieve good yields, thus reducing total harvest costs. Containers allow each plant equal space and help reduce crowding often found in bed plantings.

There are many different sizes, shapes, and types of containers. Larger containers produce stockier transplants and earlier yields. Peppers are grown in one to four inch diameter containers. Each container type requires slightly different cultural practices, and these must be learned to produce the best plants possible. For more information see Extension publication AG-337.

Field Practices

Peppers are very susceptible to poor drainage. Thus using high beds (six to eight inches) is an important consideration in planning for your pepper crop. High beds will also warm up faster in the spring, thus speeding pepper growth. If single rows are used, the bed or beds can be listed with disk hillers and flattened with a bed press or shaper or with a plate on the transplanter. Shaped beds with a flat bed top are easier to maintain and cultivate. Also, shaped beds can be cultivated to reduce soil movement toward the plant, thus avoiding the spread of diseases like Southern stem blight.

Plant Spacing. Closer spacing results in earlier pepper production and more production per acre. The proper spacing for various plant types and row widths are listed in Table 2 on the next page.

Cultivation. Peppers have a shallow root system that will be injured by deep cultivation. Cultivators should be set to disturb only the top inch of soil, and they should not throw soil to the plant because that can increase Southern stem blight. A rolling cultivator does a good job. Breaking up the crust will help get oxygen into the soil.

Table 2. Recommended row spacing and plant population for 2 types of peppers.

Row Spacing (inches)	In Row Spacing (inches)		Plant Population (1000/A)	
	Single Row	Double Row	Single Row	Double Row
Small plant types				
30	12-18	---	17.4-11.6	---
36	12-14	---	14.5-12.4	---
38	9-12	12-18	18.3-13.8	27.6-18.3
40	9-12	12-14	17.4-13.1	26.2-22.6
42	9	12	16.6	24.9
48	---	9-14	---	14.5- 9.3
60	---	9-12	---	11.6- 8.7
Large plant types				
36	14-24	---	12.4- 7.3	---
38	14-18	---	11.9- 9.2	---
40	12-16	---	13.1- 9.8	---
42	12-14	14-24	12.4-10.7	21.5-12.4
48	---	12-18	---	21.7-14.5
60	---	12-16	---	17.4-13.1

Some advantages have been found in growing in double rows on 60 to 66 inches centered beds. Adjacent plants provide better cover for fruit, and this reduces sunburning. The double rows tend to produce fruit earlier and usually produce more yield per acre. Double rows are grown on beds formed with a rotary tiller and bed shaper which results in a bed top 42 to 48 inches. Spacing between double rows is 12 to 18 inches.

Full plastic bed mulch and drip irrigation are used with the double row system. Fertilizer is either broadcast and mixed into the soil during bed forming or applied to the surface in bands six inches from the plant rows. Contact your county agricultural agent for more details.

Fertilization. Pepper plants use 100 to 150 pounds per acre of nitrogen (N), 100 to 200 pounds per acre of phosphate (P_2O_5), and 100 to 300 pounds per acre of potash (K_2O) in bare ground culture and 300, 150, 450 pounds respectively with plastic mulch. The amount of fertilizer applied will vary with previous cropping history, soil type, and the inherent fertility of the soil and yield objective. A soil test is the best way to determine fertilizer needs. Usually all of the phosphate, some or all of the potash, and one-third to one half of the nitrogen should be applied preplant. Fertilizer is usually placed in bands six inches to the side of each plant row and three inches below the surface of the bed. The remaining N and K should be applied in two or three sidedressings of 20 pounds of N per acre, depending on conditions (pimentos may require more N). Plastic-drip systems are more complex in fertilization.

Sidedressing should be done two to three weeks after transplanting and at two to three week intervals thereafter. Only half of the N should be nitrate-nitrogen. Supplies of N should be sufficient to maintain vigorous growth until flowering begins. If small, stressed plants flower and set fruit, both plant growth and fruit development will be adversely affected. Some of the slow-release N sources should be investigated to reduce the amount of N used due to reduced losses from leaching.

When peppers are grown on sandy soils, N and K fertilizers such as 15-0-14, 14-0-14, and 13-0-44 have increased yields. This is especially true when leaching is severe. A sidedress application should never exceed 20 to 25 pounds of N per acre. Peppers are subject to salt injury, and higher rates of N are not economical due to the potential loss from leaching. (Table 3 gives guidelines for adjusting for leaching losses).

Table 3. Nitrogen adjustment for losses due to leaching.[1]

Top soil depth (to clay) in inches	Estimated inches of excess[2] water percolated through soil	Replacement percent of recommended N applied weeks after transplanting		
		1 to 3	4 to 5	6 to 7
Less than 10	1	40	30	20
	2	50	40	30
	3 or more	80	60	40
10 to 16	1	60	50	30
	2	70	60	40
	3 or more	80	70	50
17 to more	1	80	60	20
	2	90	70	30
	3 or more	100	80	50

[1] Growers may wish to use 1 pound potash (K_2O) for each pound of N used in adjustment.

[2] Excess water is that percolating through the soil after the soils water holding capacity has been satisfied; most pepper soils hold about 1 inch of water per foot of top soil.

Irrigation. In most North Carolina soils, peppers have a root system which reaches 12 to 18 inches deep, but more than half of these roots are in the upper six inches of soil. These roots can be severely injured by prolonged dry periods. Flowers and young fruit will shed if the plants are stressed. If fruits are stressed when they are one

inch in diameter, they can develop a brown spot on the blossom end called blossom end rot. Generally, peppers require one to one and a half inches of water per week, either as rain or irrigation. If no rain occurs for seven to ten days, peppers should be irrigated. Pimento peppers also suffer from drought stress, but usually dry periods of 21 days or more are necessary to justify the cost of irrigation.

Pest Management

Peppers are susceptible to injury from many different pests (disease causing microorganisms, nematodes, insects, and weeds), and the successful grower must develop a management strategy that is compatible with his farming procedures to monitor them in order to keep them under control. Often, some of the farming procedures must be modified somewhat in order to avoid or to reduce losses from pests.

As a general rule, most pests cannot be eradicated, but they can be controlled (managed) so that the risk of occurrence or loss is minimized. Pests are best controlled (often with little expense) by taking action before they become serious. After a pest problem is well established, it is usually difficult to control.
Pest management involves a great deal more than pesticides. Pest management has three steps:
(1) knowledge of the pest, (2) determination of pest levels (systematic checking all year and intensive weekly monitoring during the cropping season), and (3) appropriate action.

Disease Management. Disease control (or management) is based on prevention by using disease-free seed, reduction of nematodes, bacteria, and fungi, and timely scheduled sprays with equipment that delivers 200 to 400 pounds per square inch (psi) spray pressure. Consult the chemical recommendations in the current edition of the *North Carolina Agricultural Chemicals Manual.*

Bacterial leaf spot. Bacterial leaf spot, caused by the bacterium *Xanthomonas vesicatoria*, is probably the most serious disease of pepper in North Carolina. It causes small, yellowish green to dark brown colored, raised spots on young leaves and fruits (See Poster). On older leaves these spots are dark, water soaked, and not noticeably raised. Leaves turn yellow and drop at any stage of the disease development. It can attack pepper plants in the plant bed or the field.

On the fruit, this disease causes small, blister-like, irregular spots that may be a quarter inch in diameter. These spots turn brown and develop a watery appearance.

This disease is seed borne. Limited overwintering on nondecomposed pepper plant residues in the soil is possible for a few months. Seed and infected plant material are the main sources of infection. Bacterial leafspot spreads rapidly during warm, rainy weather. The best control procedures are to use western grown disease free seed. All seed, but especially seed that has been saved, should be treated by soaking in 1.31 percent sodium hypochlorite (one to four liquid household bleach solution (5.25 percent)) for 40 minutes under constant agitation. One gallon of this solution treats one pound of seed. Wash seed thoroughly and put one cup of vinegar in the last rinse; then dry seed promptly by spreading on newspaper. If pepper exhibited bacterial leaf spot, the field should not be planted to peppers, tomatoes, or eggplant for at least one year. If the field must be planted to peppers, it should be moldboard plowed to cover all the crop residue.

Southern stem blight. This disease, caused by the soil-borne fungus *Sclerotium rolfsii*, lives on susceptible crop refuse in the upper inch of the soil. It causes plants to wilt as a result of stem girdling and rot at the soil surface (See Poster). Southern blight usually attacks pepper in early summer after the onset of hot and wet weather. Occurrence is usually in islands or "hot spots" in the field, with a few infected plants scattered throughout the field.

The control procedure is a combination of tactics: (1) rotating with corn or small grain, (2) moldboard plowing with a trash colter to deeply bury crop residues, (3) using a chemical in transplant water, (4) cultivating in such a manner that dirt is not thrown up on plants, (5) removing infected plants promptly, and (6) avoiding problem fields. Recent research has shown that an application of eight gallons of Vapam per acre in one inch of irrigation water provides good control.

Cercospora leafspot. This disease is also called "frogeye leafspot" and is caused by *Cercospora capsici*, a fungus. This disease also causes stem rot of pepper (See Poster). Although its occurrence is common, it is rarely a problem.

Frogeye leafspot causes large, oblong, circular spots on leaves and stems. The spots become dark brown on the margins and usually have a light gray center. Spots may be as large as one-half inch in diameter. Stems and fruits are especially susceptible to this disease.

This disease is seed-borne, and good quality western seed is the best control procedure. But once the disease is in the field, weekly sprays are beneficial.

Blue mold (or downy mildew). This foliar blight is caused by *Peronospora tabacini*, the same fungus that caused blue mold of tobacco. The disease has been observed during cool, wet weather but seldom develops into a significant problem. Timely fungicide sprays will control the disease.

Anthracnose. This disease is caused by the fungus *Colletotrichum phomoides* (See Poster). It usually occurs as target shaped spots on fruit which may reach three-eighths inch in diameter. It may be a serious problem, especially on ripe fruit.

This disease seldom attacks pepper foliage in eastern North Carolina, but it may be a severe problem under the colder climate of the mountains. When the disease occurs, weekly sprays are necessary.

Bacterial soft rot. Bacterial soft rot of fruit is caused by *Erwinia* spp. (See Poster). The disease is common and often causes significant losses on the plant during hot, warm weather. The rot can be devastating after harvest, in transit, and in the market. Copper sprays prior to harvest during hot, wet weather will reduce disease losses. Harvested fruit should never be washed in a tank of water unless the chlorine level in the wash water is maintained at 50 ppm. Laundry bleach such as Clorox may be used. Mixed solutions deteriorate rapidly in an hour or so. Keeping peppers cool, below 70°F, is helpful.

Early blight. The fungus *Alternaria solani* causes this disease on both leaves and fruit. The disease appears as small, irregular, brown, dead spots usually found on older leaves (See Poster). The spots enlarge until they are one-quarter to one-half inch in diameter. The spots are ridged and have a target pattern.

Early blight is usually more abundant than anthracnose. This fungus is usually no problem in eastern North Carolina, but it can be a serious problem in the mountains. Weekly sprays may be necessary in the mountains most years.

Viruses. Tobacco mosaic virus and tobacco etch virus occur frequently and are the most common pepper viruses. Pepper mottle virus and pepper rattle virus are also found in North Carolina. Plants may be stunted, leaves are crinkled, and yield is diminished (See Poster). Affected fruits are small, off color, and mottled. Leaves may also become chlorotic when some of these viruses attack.

Control is difficult, especially in tobacco growing areas. Viruses are controlled by controlling their aphid vectors and the lance nematode in the case of tobacco rattle virus. Spring oils have provided some control in Florida where aphid spread viruses are severe problems. However, five-day spray schedules must start prior to infection (usually a week after transplanting), and sprays must be applied at pressures above 400 psi.

Blossom end rot. This disorder is fairly common; however, it is not an infectious disease. The first symptom is a water soaked, light colored area at the blossom end of the pepper pods. The area increases in size, and with time it usually turns tan and later black (See Poster). Blossom end rot is the result of collapse of the cells near the blossom end due to a calcium deficiency in the tissue. Calcium deficiency can be avoided by maintaining adequate and uniform moisture during the growing season, liming, and maintaining soil pH between 6.0 and 6.5. If detected early, losses can be reduce by spraying the plants with calcium nitrate (four pounds in 100 gallons of water).

Sunscald. This disorder occurs when pepper fruits are suddenly exposed to the sun as a result of leaf fall caused by stress and bacterial leafspot. It usually occurs on the side of the fruit facing the sun as a large spot which increases in size with time. Good foliage cover helps to prevent sunscald.

Nematodes. Peppers are susceptible to injury from sting, stubby-root, and root-knot nematodes (See Poster). The dagger nematode can transmit tobacco rattle virus. If the soil is heavily infested with these nematodes, it should be avoided or treated with a nematicide. Crop rotations, prompt crop destruction, and two diskings in the fall are excellent means of reducing nematode infestations. Shallow cultivation also helps.

Insect Management. Over 35 species of insects and mites are pests of peppers. However, only 12 species occur in North Carolina, and only eight species may be considered of economic importance. These are the *European corn borer, corn earworm, beet armyworm, fall armyworm, pepper maggot, plant bugs* and *aphids*, and the *tobacco hornworm. Flea beetles, cutworms*, and the *pepper weevil* are minor pests of pepper in North Carolina.

Insects damage pepper by feeding on the foliage, the fruit, or by spreading virus diseases. Obviously, those feeding within the fruit are of most importance and concern to the processor.

European corn borer. This insect overwinters in the borer stage inside infested stems of corn and weeds, and here they change to moths in late April (See Poster). Adults emerge over several weeks with peak activity in early May. There are usually three generations per year in North Carolina. However, the second and third generations are most troublesome on peppers. Eggs are laid in masses of 15 to 20 on stems and undersides of pepper leaves (also on the weed dock) and hatch in four to nine days. Tiny borers immediately crawl to protected places on the plant, where they feed prior to entering stems of fruit. Fruit entrance occurs at the cap and is detected by the presence of fecal matter. Borers feed primarily in the seed cavity. These larvae become full grown in about a month, change to pupae, and 10 to 14 days later emerge as adults. Moths live from 10 to 24 days and lay about 400 eggs. They are active fliers during the evening and may move several miles.

Corn borers are difficult to control because: (1) eggs hatch over a long period, (2) foliar insecticides are effective for only two or three days after application, (3) thorough coverage to the undersides of leaves is necessary to contact tiny borers, and (4) insecticides are not effective against eggs, adults not present in the field, or borers in the fruit.

Once eggs or damage is found, treatments should begin within five days. Weekly foliar sprays should continue through the moth flight period. Granular insecticide can be applied, but again the timing and period of effectiveness are critical.

Corn earworm. Earworms feed on a wide variety of hosts and overwinter as pupae in the soil (See Poster). Adults emerge in the spring, and three or more generations occur each year. The generation occurring in late July or August is of particular concern to pepper growers. Eggs are laid singly on pepper, and, upon hatching, tiny worms chew into developing fruit where they feed for several weeks. Earworms are more colorful and much larger than borers and leave extensive feeding material inside the pod.

Earworms are difficult to control in that egg hatch extends over an extremely long period. Sprays every five days may be needed when populations are high. Otherwise, weekly sprays as for corn borers are suggested.

Fall armyworm. Armyworms overwinter in Florida, and egg-laying moths appear in North Carolina in the middle of July (See Poster). Each female lays about 1,000 eggs in masses of fifty to several hundred each. Two to ten days later, small larvae emerge and scatter in search of food. They enter pepper pods similar to earworms, are usually darker than earworms, and have a characteristic inverted Y marking on the head. The control is similar to that for the corn earworm.

Beet armyworm. Beet armyworms, more sporadic than armyworms, migrate into North Carolina (See Poster). They lay about 600 eggs in clusters over a three to seven day period. Eggs hatch in two to three days, and small worms spin webs and feed in groups on plant foliage. They then scatter and feed for one to two weeks. After a week in a resting stage, moths emerge, mate, and several generations follow.

Beet Armyworms are more difficult to control than fall armyworms and corn earworms. Hence, growers are forced to use Lannate or Orthene when needed.

Pepper maggot. Pepper maggots attack hot cherry peppers, eggplant, tomatoes, and the weeds horsenettle and ground cherry (See Poster). Bell and sweet peppers are occasionally subject to infestation. Maggots overwinter in the soil in the resting stage. Flies emerge in May and June, mate, and lay eggs beneath the skin of young peppers. Eggs hatch in about 10 days, and worms feed within for about 18 days. When full grown, larvae cut exit holes, emerge, and drop to the soil to pupate. There is only one generation each year.

Destruction of alternate hosts (horsenettle and ground cherry) is helpful. Sprays applied on a weekly basis are needed when initial fruit is about half grown and flies have been detected in yellow sticky traps.

Pepper weevil. Weevils spend the winter on live pepper or nightshade plants in southern California, Texas, or Florida (See Poster). They move into North Carolina with imported transplants. Females lay 200 or more eggs in buds and fruits over a thirty-day period. Eggs hatch in three to five days, and larvae bore into pods and feed for eight to ten days. Four to six days later, weevils emerge through a hole in infested fruit. A two- to three-week life cycle is typical; hence, several generations occur each year.

The chance of infestation is greatly reduced by using home-grown pepper plants. Rigid spray programs in Florida pepper beds and inspection by regulatory personnel are helpful in preventing this insect's entrance into North Carolina. Thorough inspection of pods for deformities or presence of aborted fruit should indicate the need for regular sprays. To discourage weevils overwintering in North Carolina, early and thorough destruction of weevil-infested peppers is encouraged.

Green peach aphid. Green peach aphids extract sap from plants and excrete a sweet, sticky substance called honeydew (See Poster). Black sooty mold grows on honeydew and blocks out sufficient light to reduce yields. Infested plants are weakened and may be inoculated with viruses. Adult aphids pass the winter on greens and such hosts as cabbage, collards, turnips, wild mustard, and dock. Winged forms migrate to other hosts, including pepper beds, in the spring and are moved to the field on transplants.

Winter host plants near plant beds should be destroyed. Certified seed from an area free of virus is helpful. Aphids also build where repeated applications of certain carbamate insecticides are made. In these cases a selective aphicide may be needed.

OVERALL CONSIDERATIONS: Three critical periods exist when insect damage is common: mid June, aphids can establish colonies in pepper fields; early July, adults of second generation borers and earworms and pepper maggots can build up; early August, is the most critical period; adults of third generation borers, armyworms, and earworms can reach devastating levels.

Prepare for potential insect destructiveness by periodic scouting. Black light trap collections indicate initial and peak periods of adult activity. These traps are most effective in the detection of night-flying moths such as the European corn borer, corn earworm, cutworms, and armyworms. Pepper maggot flies are caught by yellow sticky traps. Yellow pan traps are attractive to winged aphids and give some lead time before significant colonization. All of these trapping devices are tools which should be used in conjunction with systematic field sampling.

Insecticides can control pepper insects when used with crop management. Choose to follow a preventive program using a granular insecticide at two to four weeks after transplanting followed by a second application four to six weeks later. (See Pesticide Inserts). Or choose to follow a foliar insecticide application program based on need. In either program, the need for close scrutiny of pests and frequent sprays from mid July on is encouraged. In any event, consider all possible factors in pest management and integrate as many as possible into the overall production system. For specific insecticide recommendations, see the current edition of the *North Carolina Agricultural Chemicals Manual.*

Weed Management. The primary goal of weed control is to optimize yields by minimizing weed competition. Weeds can reduce yields by competing with the crop for water, light, and nutrients. Timely cultivation, wise use of herbicides, crop rotation, and never permitting weeds to go to seed are an integral part of a good weed control program.

Selection of a growing site will often dictate the success or failure of a herbicide program. Avoid areas infested with perennial weeds such as johnsongrass, nutsedge, or bermudagrass, or hard to control annuals such as morningglory, cocklebur, jimsonweed, prickly sida, or sicklepod. Consult the chart of relative susceptibility (Table 4) for specific information on the weeds that each chemical controls. Each chemical must be applied evenly and at the proper rate. The lower rates given are for coarse, sandy soils with low organic matter. The highest rates are for fine textured clay and clay loam soils or soils with high organic matter content. Current information may be obtained from the *North Carolina Agricultural Chemicals Manual.* (See Pesticide Insert)

If black plastic mulches are used, weed control is still necessary in the middles. Do not use herbicides which are not registered for use in pepper production or damage to the peppers through root uptake of the herbicide will occur. In addition to the preemergence herbicides listed in Table 4, Paraquat may be used as a shielded spray to control emerged weeds in the middles. Use extreme care when using this material. It is nonselective and will kill any green plant tissue which it contacts. **ALWAYS READ THE LABEL WHEN USING ANY PESTICIDE.**

Figure 3. Harvesting aid.

Harvesting and Handling

Fresh market peppers are hand harvested into buckets or onto the belt of a harvesting aid like the one pictured in Figure 3. The peppers are then conveyed or placed in a bulk bin (20 bushels) for transit to the packing shed.

Table 4. Effectiveness of Pepper Herbicides[1]

	Ambien	Dacthal	Devrinol	Enide	Paraquat	Treflan
Barnyardgrass	G	F	G	G	E	G
Crabgrass	G	E	E	E	E	E
Crowfootgrass	G	G	E	E	E	E
Fall panicum	G	F	G	G	E	G
Foxtails	G	E	E	E	E	E
Goosegrass	G	E	E	E	E	E
Johnsongrass(s)	F	G	P	F	E	G
Broadleaf signalgrass	F	G	G	P	E	G
Texas panicum	G	G	P	F	E	G
Carpetweed	E	G	G	G	E	P
Chickweed	E	F	E	G	E	E
Common cocklebur	P	P	P	P	E	P
Evening primrose	G	F	G	G	E	P
Galinsoga	F	P	E	F	E	P
Jimsonweed	F	P	P	P	E	P
Lambsquarter	E	E	G	F	E	G
Morningglory	P	P	P	P	E	P
Pigweed	E	E	G	E	E	G
Prickly sida	P	P	P	P	E	P
Purslane	E	G	G	G	E	G
Ragweed	E	P	P	P	E	P
Sicklepod	P	—	P	P	E	P
Smartweed	G	P	P	P	E	P
Velvetleaf	P	P	P	P	E	E
Bermudagrass	P	P	P	P	*	E
Johnsongrass(R)	P	P	P	P	*	F
Nutsedge	P	P	P	P	*	P

[1] At recommended rates for your soil type:
E = 90-100% control
G = 75-90% control
F = 59-75% control
P = less than 50% control

* Suspression only, will not kill root system

Figure 4. A mechanical harvester with helical picking system, (courtesy of Dr. Dale Marshall).

Fresh market bell peppers are harvested by workers walking through the field or riding on harvesting aids. Many of the harvesting aids have conveyors to carry the harvested product to a centrally located container. Some have grading and packing facilities on the harvester so that the peppers can be off-loaded from the harvester directly onto a truck for transport to market. Harvesting aids make the work less strenuous, thereby improving worker productivity and permitting the use of workers who might not otherwise be physically able to harvest peppers.

Mechanical Harvesting. All peppers going to the market fresh are hand harvested, as are most of those to be processed. Recently, there has been some development of a mechanical harvester for the pimento, chili, cherry, jalapeno, and other processing type peppers. Some machines have been built and used by growers. Several harvesting machines are in existence around the United States and in Europe, but they will require additional development to become commercially acceptable. One such machine is shown in Figure 4.

Most of the mechanical harvesters use a stripper principle with the stripper element consisting of a pair of open helixes, round rods mounted spirally on contra-rotating incline rollers, or round stripper fingers mounted on a chain. The major problems have been extensive damage to the plant and fruit, too much trash in the harvested product, too much damage to the peppers, or inability to harvest selectively (red vs. green, or mature vs. immature). Plugging of the machine due to the large amount of green plant material stripped off has also been a problem.

Post Harvest Handling. Harvested peppers are brought from the field to a central packing area, dumped from bulk bin containers, and run across soft brushes. Fruit then moves across an inspection belt where sorting crews remove culls, sort, size, and grade fruit according to federal and industry standards. (Table 5). In smaller operations, fruit surfaces may be wiped with a soft cloth or dipped into small water tanks. More sophisticated packing operations may utilize high pressure spray nozzles to remove dirt from the fruit surface. If peppers are washed, the water should contain chlorine (25 to 50 ppm), and the fruit should be dried before packing in order to reduce rots caused by bacteria. Growers should check with buyers to determine their preference for shipping containers, but most growers pack fruit in wire-bound crates, bushel baskets, or one and one-nineth bushel corrugated cartons. Shipping containers should not be under or over filled, since both will result in buyer dissatisfaction. Containers must provide good ventilation for the peppers with at least five to ten percent of any container side being open so as not to restrict air movement through the containers.

While several cooling methods could be used for peppers, the recommended practice is 'forced-air' cooling. Cooled air is moved rapidly through the peppers by use of a high pressure static fan. (Consult your county agent for specific information.) Precooling peppers before loading into transit trailers will reduce rotting during transit, minimize opportunities for load rejection, and increase buyer acceptability. In addition, precooling peppers can benefit growers in that some buyers are willing to pay premium prices for cooled peppers since cooling adds to the shelf life. Remember, truck coolers were *not* designed to reduce temperature of peppers—they have the refrigeration capacity only to maintain temperatures. Peppers which are loaded into a transit trailer at 90°F will likely arrive at market at nearly 90°F.

Table 5. Federal grades and sizes for bell-type peppers; U.S. Fancy, U.S. No. 1, and U.S. No. 2.

Grade	Minimum Size		Uniformity of Color[1]	Firmness	Shape	Damage[2]
	length	diameter				
U.S. Fancy	3.5"	3"	90%	Firm	Well shaped	Free
U.S. No. 1	2.5"	2.5"	90%	Firm	Fairly well shaped	Free
U.S. No. 2	None	None	90%	Firm	Not seriously misshapen	Free from serious

[1] All green, all red or mixed are acceptable color grades.
[2] Damage includes sunscald, freezing injury decay, scars, hail, sunburn, disease, insect, mechanical.

Processing peppers (bell and pimentos) are usually harvested into burlap bags or buckets. They may be transported to the processor's plant or field buying station in bags, bulk boxes, or bulk trailer loads, depending on the processors' preference. Cleaning and grading are usually done at the field station or processor's plant. In general, pimento types are graded more extensively than bell types. Pimentos are usually sold as full red peppers while the bell types may be sold as green, chocolate (partial red), or full red peppers. Mature red peppers weigh more than green peppers of a similar volume and are preferred by most processing companies. As a result, mature red peppers command a higher price. Processing peppers are harvested two to three times.

Chilis are usually harvested in the green and red or yellow stage of maturity, and they may be packed and handled like bell types for fresh sales or handled in bulk for processing sales. Processing chilis are usually machine harvested using a specially designed machine or a modified snapbean harvester.

Marketing

In a typical year, North Carolina pepper producers need to market over 27 million pounds of peppers during the June to September period. The perishability of peppers requires that they be marketed quickly, efficiently, and orderly. While North Carolina is a major producer of peppers (sixth in the United States), fresh sales and prices of peppers are affected by production in other states which have substantial quantities of peppers available at the same time we do. During early June, Florida and Texas represent major competitors. In July and August, California, Virginia, New Jersey, and Ohio peppers are available. During early July, North Carolina is the dominant supplier of fresh peppers in the United States and ships nearly 33 percent of all fresh bell peppers. Principal out-of-state markets include New York, Boston, Philadelphia, Pittsburgh, and Montreal.

Marketing Strategy and Methods. It is important to develop a marketing plan before a crop is planted. Quantities available (both locally and nationally), the approximate date of harvest, the availability of labor, and packing requirements should be considered and discussed with various buyers. Such meetings will assist growers in identifying which marketing methods can be utilized in their operation. Early in the development of a marketing plan, several marketing decisions must be made. Of fundamental importance is the issue of who will handle and arrange sales. The options include the farmer himself, hiring an experienced sales agent, or employing a broker. The need for a salesman or broker will depend on the volume grown and the marketing alternatives available to the producer. Peppers can be sold to a custom fee packer, a marketing cooperative, a trucker, local grocery stores, a wholesaler, a chain store, an operator at a terminal produce market, or directly to the consumer. Growers in eastern North Carolina also have the option of offering peppers for sale on the Faison Auction Market located in Faison, N.C. Growers with less than three acres of peppers should consider direct farmer-to-consumer sales or selling to a packer-shipper, since this limited volume is usually unattractive to wholesale or retail operators.

As acreage increases, growers can provide buyers with a sufficient volume of peppers over an extended period of time. Although exact rules of thumb are difficult to determine, growers of between five and 50 acres of peppers generally utilize the service of a broker, a marketing cooperative, or a fee packer-shipper. If brokers are used, growers should be willing to communicate honestly with their broker concerning their acreage planted and yields, their normal production season, the variety planted, the packing equipment and grade standards used, the type of containers used in their operation, and if precooling procedures are utilized. In general, most brokers handle sales on a percentage basis, that is, they receive a percentage (five to ten percent) of the per unit price paid by the buyer. Growers can obtain the names of potential brokers from fellow farmers, in the *Blue Book* or *Red Book*, or from trade publications. Using a broker requires that the farmer trust and truthfully communicate with the broker, or their relationship will be unsatisfactory.

Large volume producers often find it to their advantage to employ a sales agent who is responsible for initiating contacts with buyers, arranging delivery, negotiating price, and handling complaints. A professional sales agent differs from a broker in that the sales agent works directly for the farmer and must protect the interest of the grower. Larger acreage commercial producers typically arrange sales with distant wholesalers and terminal market buyers or deal directly with buyers of retail chain stores. Chain store buyers are most interested in purchasing a large volume of consistently graded peppers from a single supplier for from six to eight weeks.

As a final consideration, growers should examine more than one method of marketing in selling their peppers. A grower's primary marketing plan may rely on direct sales to grocery stores, but growers should consider an alternative, back-up plan in case their primary deal does not develop. An important feature for growers to recognize is that different marketing plans and methods require different combinations of services to be provided by the grower, and each farmer should select his own best method. Above all, growers should not plant more acreage than they can efficiently and effectively manage.

Marketing Advantage. An important element in successful marketing is the need to coordinate production and marketing plans. In developing a marketing plan, the critical role of production practices is most evident in their affect on harvest timeliness. In general, higher prices are received in early June, and then prices decline seasonally as supplies increase. Growers will also notice that regions where local supplies are unavailable must receive shipments of peppers from regions where supplies are plentiful. For example, pepper consumers in the New York City area purchase peppers grown in areas further south such as North Carolina or Georgia where milder climates permitted earlier planting. If North Carolina and Georgia producers have similar quality peppers available at the same time and are available at the same cost at North Carolina and Georgia shipping points, then the area closest to the consuming region (in this case North Carolina) will have a marketing advantage over Georgia since shipping costs will be less, all other things being equal. This marketing advantage will exist until more northern areas begin harvesting peppers.

It should be realized, however, that marketing advantage can be offset by more distant growers if their production and packing costs are substantially lower. Under the condition of equal costs among competitive supply areas in the South, Tarheel pepper producers should examine northern markets early in the harvest season and then, as the harvest season progresses, investigate markets south of North Carolina where harvesting has ceased. For western North Carolina producers, where the peak harvest season occurs in August, growers should examine more southern markets where harvesting has ended. Growers should remember, however, that the search for market outlets requires persistence and an ability to take advantage of temporary gaps or interruptions in supplies. Successful marketing requires the development of long term relationships with buyers that are built on trust and dependability. Marketing plans will not be successful every year since many elements are beyond the control of an individual grower, but the development of a marketing plan will reduce risks and minimize losses over time.

After market plans are finalized, adjustments to planting intentions are finalized by obtaining situation and outlook information available from the North Carolina Agricultural Extension Service, the federal and state departments of agriculture, fellow farmers, and trade publications such as *The Packer*. Farmers should be cautious about large acreage increases following a year of exceptionally high prices since the favorable prices will likely attract new growers. Rather, growers should examine prices reported during the last three or four years during their expected harvest time period to determine a reasonable expectation concerning the price they will receive this year.

Processed Markets. Large variability in fresh market prices and uncertain marketing alternatives have caused some farmers to contract a portion of their production with processors. While this reduces price and marketing risks, contract prices for peppers are much lower than fresh market prices. Pepper processors can provide a valuable service for many producers by purchasing quality peppers which are not marketable as fancy or No. 1 quality products. Alternatively, processors could contract for the entire production from a field to assure a steady supply of quality peppers they need to continue plant operations. Growers should contact the North Carolina Department of Agriculture—Markets Division to obtain a list of bonded processors contracting with North Carolina farmers.

Costs and Returns

In the production of peppers, it is useful for growers to remember that their primary objective is to make a profit rather than to save money. That is, efficiency and per unit cost of production are more important considerations than total cost levels. Each grower should develop an accurate record of expenses in order to calculate per unit production costs. Major operating costs include seed or transplant costs, fertilizer expenses, chemical treatments, and harvesting costs. Other major expenses include interest on money borrowed, ownership of equipment and machinery (depreciation, taxes, and insurance), repair costs and labor.

Pepper production is a management intensive, labor extensive crop, and growers should have access to dependable family or hired labor during critical periods such as planting and harvesting times. If recommended treatments and practices are followed by a grower, it can be expected that total production costs will range between $1,000 and $1,300 per acre including harvesting but excluding grading, packing, shipping container, and marketing expenses.

Thus, if a grower averages approximately 300 bushels of large and medium peppers, then per unit production costs will range between $3.65 and $4.35 per bushel. However, these values are only possible cost ranges (packing and marketing expenses must be added), and growers need to maintain their own records to determine their true costs.

In addition, the use of plastic and/or irrigation will increase total costs but may reduce per unit costs. Growers need to evaluate the added benefit (increased yields, improved prices) from plastic and/or irrigation with the added cost of the practices to determine if these practices are economically viable for their operation.

Production Schedule

This outline is presented to bring the critical material of this publication into a concise form. The dates refer to coastal plain area growers. Locations further west could delay or hasten some operations by from one to four weeks.

AS EARLY AS PRACTICAL IN THE FALL:

By November 1:

1. Select a field that did not have soybeans, sweet potatoes, peanuts, tomatoes, tobacco, eggplant, or peppers last year. It should be fertile, well drained, and uniform.
2. Note predominant weeds and check roots of susceptible plants and weeds for root-knot nematode and Southern blight.
3. Take soil sample for fertility and nematodes.
4. Apply lime to bring pH to 6.0 to 6.5 and incorporate by plowing.
5. Order "western grown seed" from a reputable seedsman and test germination.
6. Keep weeds out of transplant growing area.
7. Sow small grain cover crop.

By November 15:

1. Cover your plant growing structure with plastic.
2. Fumigate plant growing area, and decontaminate equipment.

By January 1:

1. Apply plastic tarp to soil in plant growing structure to warm soil in ground bed systems.
2. Fertilize plant bed with one-fourth pound 10-6-6 per square yard.
3. Apply lime to field.

Between January 15 and February 15:

1. Remove prewarming tarp.
2. Treat seed for bacterial spot.
3. Sow seed in rows so each plant has at least two square inches. Do not seed earlier than necessary (eight to ten weeks is sufficient for peppers); rapid growth in warm conditions is better than protracted slow growth in cool conditions and energy costs are similar. Containers usually require less time from seeding to field planting.

Between January 15 and April 1:

1. Spray transplants one to three times with appropriate fungicides as needed to control damping-off and foliage diseases.
2. Practice suggested watering and ventilating procedures for plant beds or containers.
3. Withhold water and ventilate to harden plants during the last two weeks before field setting.
4. Monitor pepper plants at least twice a week for leaf spots, damping-off, and botrytis blight.
5. Spray plants with 1.0 pound streptomycin sulfate 17 WP plus a copper fungicide prior to movement to the field.
6. Water well before pulling and transfer to the field.
7. Service sprayer and nematicide applicators.

Between March 1 and April 1:

1. Apply recommended fertilizer and nematicide and form beds in the field.
2. Wait 10 to 14 days before planting if treated with certain nematicides.

Between April 1 and April 15:

1. "Strike-off" bed top or use bed shaper.
2. Apply herbicide to beds if preplant incorporated type, using rolling cultivator.
3. Transplant at prescribed spacing for the type of pepper you are growing.
4. Use PCNB and starter solution fertilizer in transplant water.
5. Apply over-the-top herbicides when weather is warm enough (see label).

Between April 15 and May 15:

1. Sidedress with 20 pounds per acre of N at least once and as indicated by leaching conditions.
2. Apply second over-the-top herbicide at first sidedressing if needed and up to six weeks after transplanting.
3. Spray copper fungicide and maneb at first sign of bacterial spot and weekly thereafter.
4. Apply granular insecticide as recommended for processing peppers.

Starting at Planting:

1. Watch fields for insects, and spray as needed.
2. Irrigate when rainfall is not one inch during the preceding week or soon when plants show stress.
3. Irrigate daily for plastic culture.

Starting June 1 to June 15:

1. Harvest mature peppers, and move out of field to cover as soon as practical.
2. Grade fruit closely for top quality.
3. Quickly cool all fruit for fresh market.
4. For processing, harvest when a practical yield is available for efficient harvest and low labor cost per unit.
5. Spray for corn borers and diseases as needed.

Acknowledgments

The authors wish to acknowledge the assistance and advice of Dr. C. H. Miller, Dr. S. F. Jenkins, Mr. G. R. Hughes, Dr. T. R. Konsler, and Mr. P. J. Westerbeek in reviewing the manuscript.

Published by

THE NORTH CAROLINA AGRICULTURAL EXTENSION SERVICE

North Carolina State University at Raleigh, North Carolina Agricultural and Technical State University at Greensboro, and the U.S. Department of Agriculture, Cooperating. State University Station, Raleigh, N.C., Chester D. Black, Director. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. The North Carolina Agricultural Extension Service offers its programs to all eligible persons regardless of race, color, or national origin, and is an equal opportunity employer.

6-88-2M-ER—180376

AG-387

PRICE: $3.00

Supplement to

COMMERCIAL PEPPER PRODUCTION IN NORTH CAROLINA

NEMATODE CONTROL IN VEGETABLE CROPS

Follow manufacturer's label in all cases

Crop losses due to nematodes can be avoided by using the following control tactics:

1. Practice crop rotation.
2. Plow out and expose roots immediately after the last harvest.
3. Plow or disc the field two to four times prior to planting.
4. Use nematode-free plants.
5. Sample soil and have it assayed for nematodes, preferably in the fall. There is a $1.00 fee for each sample. Mail or send samples to:

   Nematode Advisory Section
   Agronomic Division — N.C.D.A.
   Blue Ridge Road Center
   Raleigh, N. C. 27611

6. Where warranted, fumigate according to guidelines listed in the table. (Soil should be warm, well worked, and free from undecomposed plant debris and have adequate moisture for seed germination.)
7. For in-row application, chisel should be inserted 6 to 8 inches deep and a high, wide bed thrown up over it; do not rework rows after fumigating.
8. For broadcast treatments, insert chisels 6 to 8 inches deep and space chisels 12 inches apart for most fumigants; use 8-inch spacing for Vorlex.
9. Row rates are stated for rows on 40-inch spacing. For other row spacings multiply the stated acre rate by the appropriate conversion factor (C.F.) to get the amount of material applied per acre (Do not alter stated amount per 100-foot row). This will be a guide to the amount of material to purchase for the acreage you want to treat:

Your row spacing (inches)	Conversion factor (C.F.)
24	1.67
26	1.54
28	1.43
30	1.33
32	1.25
34	1.18
36	1.11
38	1.05
40	1.00
42	.952
44	.909
46	.870
48	.833
5 ft.	.667
6 ft.	.556
7 ft.	.476
8 ft.	.417

For example, 10 gallons per acre are used on 40-inch rows. For 36-inch rows, it will take 11.1 gallons to treat an acre.

Commodity	Material	Application Method For Given Soils	Formulated (Rate/Acre)	Formulated Rate (oz/100 ft row or 100 sq ft)	Schedule & Remarks
Most vegetables	dichloropropene (TELONE II)	Broadcast, mineral soil	9 to 15 gal	2.6 to 4.4	Fall application usually preferred to spring application. Wait 3 weeks before planting, longer if soil is cold or very wet.
		Broadcast, peat or muck soil	24 to 36 gal	7.0 to 10.6	
		Row, mineral soil	4.5 to 6.0 gal	4.5 to 6	
		Row, peat or muck soil	9 to 12 gal	9 to 12	
Most vegetables (multipurpose fumigants)	Vapam	Broadcast, mineral soil	40 to 100 gal	12 to 29	Fall application often is preferred to spring application. Wait 3 weeks before planting or longer in cold, wet soil, or if odor persists. Read label for row application use in organic soils, chisel depth and spacing, exact rates, and special uses. Inject Vorlex and Vorlex 201 on 8-inch spacing. Vapam can also be used in a sprinkling system. When used with plastic covers, all products are more effective and lower rates can be used. Terr-O-Gas fumigants are mixtures of methyl bromide and chloropicrin. Terr-O-Gas 35, 50, 57, 70, 75 and 80 formulations are also available; use amount specified in label. Use products with 15% or more chloropicrin (Vorlex 201, Telone C-17 and Terr-O-Gas) for bacterial soil-borne diseases.
	Vorlex	Broadcast, mineral soil	25 to 40 gal	7 to 12	
	Vorlex 201	Row, mineral soil	1.5 to 12 gal	1.5 to 12	
	chloropicrin 96.5% (1.0 gal = 13.85 lb)	Broadcast, mineral soil	35 to 77 gal	10 to 22	
	Telone C-17	Row, mineral soil	15 to 25 gal	4.4 to 7.3	
		Broadcast, mineral soil	5.1 to 27.5 gal	1.5 to 8.1	
Asparagus, broccoli, cauliflower, eggplant, lettuce, muskmelon, dry onion, pepper, tomato (multipurpose fumigants)	Terr-O-Gas 67 (methyl bromide 67% chloropicrin 33%)	Broadcast, mineral soil	225 to 350 lb	0.5 to 0.8 lb	
	methyl bromide		430 to 860 lb	1.0 to 2.0 lb	
Pepper (Bell)	oxamyl (Vydate -L)	Transplant water	2 pt/acre in 200 gal water	—	Do not treat within 7 days of harvest.

Vegetable Crop Disease Control Schedule

Commodity	Disease	Material	Rate of Material to Use: Formulation	Rate of Material to Use: Active Ingredient	Min. Days: Harv.	Min. Days: Reentry	Method, Schedule & Remarks
PEPPER	Pythium damping-off, phytophthora	Ridomil 2 E	2.0 qt/acre	1.0 lb/acre	7	0	Apply to 18-inch band at seeding.
			1.0 qt/acre	0.5 lb/acre	7	0	Apply two post-directed drenches at 30-day intervals.
	Bacterial spot (seed)	sodium hypochlorite (Clorox 5.25%)	2.0 pt/8.0 pt water	Same	—	—	Wash for 40 minutes in solution with continuous agitation; air dry promptly. Use 1.0 gal of solution/ 1.0 lb seed.
	Damping-off (plant bed)	captan 50 W	2.0 lb/100 gal Drench 10 to 15 gal/1000 sq ft	1.0 lb/100 gal Drench 10 to 15 gal/1000 sq ft	—	0	Drench or heavy spray after seeding and at first appearance of disease. Continue at 10-day intervals.
		zineb 75 W	2 lb/100 gal 0.5 gal/sq yd	1.5 lb/100 gal 0.5 gal/sq yd	—	0	
		soil treatment	—	—	—	—	See table on Sanitizing Greenhouses & Plant Beds.
	Leafspots (plant bed)	captan 50 W ferbam	3.0 lb/100 gal see label	1.5 lb/100 gal 0.76 to 1.14 lb/gal	—	0	Spray first appearance, 3- to 7-day interval.
	Bacterial spot[2] (plant bed)	streptomycin sulfate 17 W + copper fungicide	1.0 lb/100 gal	0.17 lb/100 gal (200 ppm)	—	—	Spray first appearance, 7- to 10-day interval; before transplanting. Use spreader sticker.
			see label	see label	—	—	
	Bacterial spot[2] (field)	maneb 80 W + copper fungicide	1.5 to 2.0 lb/100 gal plus copper	1.2 to 1.6 lb/100 gal	0	0	Spray first appearance, 7- to 10-day interval.
			see label	see label	0	0	
	Anthracnose fruit rot Cercospora leaf spot Downy mildew (Blue mold)	maneb 80 W[4]	1.5 to 2.0 lb/100 gal	1.2 to 1.6 lb/100 gal	0	0	Spray first appearance, 7- to 10-day interval. Use spreader sticker.
		zineb 75 W	1.0 to 2.0 lb/100 gal	0.75 to 1.5 lb/100 gal	0	0	
		captan 50 W	3.0 lb/100 gal	1.5 lb/100 gal	0	0	Not on label: maneb—downy mildew
	Southern blight[3] (*Sclerotium*)	Terraclor 75 W	10.0 lb/100 gal per 14,500 ft row	7.5 lb/100 gal per 14,500 ft row	—	—	Keep suspension agitated while mixing and spraying. Spray in trench at planting.
			3.0 to 5.0 lb/100 gal	2.25 to 3.75 lb/100 gal	—	—	Keep suspension agitated while mixing and spraying. Use 0.5 pt/ plant.
	Blossom end rot	calcium nitrate calcium chloride	4.0 lb/100 gal	4.0 lb/100 gal	—	—	Spray after appearance before fruit set.
	Powdery mildew	sulfur W	see label	2.0 to 4.0 lb/100 gal	0	0	Spray first appearance, 7- to 10-day interval.
	Postharvest rots	Dowcide-A 97% (SOOP)	4.3 to 8.6 lb/100 gal	0.5 to 1.0% solution	1	—	Dip or spray; rinse.
		Clorox	1 gal/1050 gal	50 ppm			

[2]Use sanitation, seed treatment. [3]Use crop rotation. [4]4F formulation available.

Insect Control For Commercial Vegetable Producers

Commodity	Insect	Insecticide and Formulation	Amount of Formulation Per Acre	Active Ingredient Per Acre	Minimum Interval (Days) Between Last Application and Harvest	Precautions and Remarks
PEPPER	Aphid	acephate (Orthene)				On foliage as needed. Aphids also spread virus diseases.
		75 S	11 oz	8 oz	7	
		demeton (Systox)				
		2 EC	1½ pt	6 oz	3	
		6 EC	½ pt	6 oz	3	
		diazinon (Diazinon, Spectracide)				
		(AG 500) 4 EC	½ pt	4 oz	5	
		(50 W) 50 WP	8 oz	4 oz	5	
		dimethoate (Cygon, De-Fend)				One application will provide systemic protection for 3 weeks. Do not exceed rate as leaf injury will result.
		2.67 EC	¾ to 1 pt	4 to 5.3 oz	0	
		4 EC	½ to 2/3 pt	4 to 6 oz	0	
		endosulfan (Thiodan)				On foliage as needed.
		2 EC	2 qt	1 lb	4	
		50 WP	2 lb	1 lb	4	
		methomyl (Lannate, Nudrin)				
		90 SP	0.5 lb	0.45 lb	3	
		1.8 L	1 qt	0.45 lb	3	
		mevinphos (Phosdrin)				
		4 EC	¼ to ½ pt	2 to 4 oz	2	
		naled (Dibrom)				
		8 EC	1 pt	1 lb	1	
		phosphamidon (Dimecron)				
		8 EC	½ pt	8 oz	6	

Insect Control For Commercial Vegetable Producers (Continued)

Commodity	Insect	Insecticide and Formulation	Amount of Formulation Per Acre	Active Ingredient Per Acre	Minimum Interval (Days) Between Last Application and Harvest	Precautions and Remarks
PEPPER (continued)	European corn borer	acephate (Orthene) 75 S	1 to 1 1/3 lb	12 to 16 oz	7	Treat every 5 to 7 days during moth flight. Orthene is not registered for corn borer on nonbell peppers.
		permethrin				
		(Pounce) 3.2 EC	8 oz	0.2 lb	3	
		25 WP	12 oz	0.2 lb	3	
		(Ambush) 2 EC	12 oz	0.2 lb	3	
		25 WP	12 oz	0.2 lb	3	
		carbofuran (Furadan)*				
		10 G	20 lb and 30 lb	2 lb and 3 lb	21	Apply low rate of Furadan in furrow 2 to 4 weeks after transplanting.
		15 G	13 lb and 20 lb	2 lb and 3 lb	21	Apply high rate of Furadan in furrow 4 to 6 weeks after first application. Foliar insecticides may also be needed some years.
	Corn earworm, armyworm, hornworm, and stinkbug	acephate (Orthene) 75 S	1 to 1 1/3 lb	12 to 16 oz	7	See comments under corn borer above.
		azinphosmethyl (Guthion) 50 WP	1 lb	8 oz	14	
		fenvalerate (Pydrin) 2.4 EC	5 1/3 to 10 2/3 oz	0.1 to 0.2 lb	7	Minor bleaching of tender leaves on some varieties may occur with high rate of Pydrin during plant stress.
		esfenvalerate (Asana) 1.9 EC	1.7 to 3.4 oz	0.03 to 0.05 lb	7	
		methomyl (Lannate, Nudrin)				
		90 SP	0.5 lb	0.45 lb	3	
		1.8 L	1 qt	0.45 lb	3	
		permethrin				
		(Pounce) 3.2 EC	4 to 8 oz	0.1 to 0.2 lb	3	Permethrin may be used for 8 sprays per season on bell peppers.
		25 WP	6 to 12 oz	0.1 to 0.2 lb	3	
		(Ambush) 2 EC	6 to 12 oz	0.1 to 0.2 lb	3	
		25 WP	6 to 12 oz	0.1 to 0.2 lb	3	
	Flea beetle	carbaryl (Sevin)				On foliage as needed.
		50 WP	2 lb	1 lb	0	
		80 WP	1¼ lb	1 lb	0	
		4 XLR	1 qt	1 lb	0	
		endosulfan (Thiodan)				
		2 lb/gal EC	1 qt	8 oz	1	
		50 WP	1 lb	8 oz	1	
		methoxychlor (Marlate)				
		50 WP	4.5 lb	2.25 lb	1	
		2 lb/gal EC	4.5 qt	2.25 lb	1	
		naled (Dibrom) 8 EC	1 pt	1 lb	1	
		azinphosmethyl (Guthion) 50 WP	1 lb	8 oz	14	
	Leafminer	diazinon (Diazinon, Spectracide)				
		(AG 500) 4 EC	½ pt	4 oz	5	
		(50 W) 50 WP	8 oz	4 oz	5	
		dimethoate (Cygon, De-Fend) 2.67 EC	¾ to 1½ pt	4 to 8 oz	0	
		trichlorfon (Dylox, Proxol) 80 SP	20 oz	1 lb	21	
		phosphamidon (Dimecron) 8 EC	½ pt	8 oz	6	
	Pepper maggot	endosulfan (Thiodan)				On foliage when flies appear on yellow sticky traps. Repeat weekly as needed. Adult flies may be active from early June through July.
		2 EC	2 qt	1 lb	4	
		50 WP	2 lb	1 lb	4	
		malathion (various)				
		57 EC	2½ pt	1.5 lb	3	
		25 WP	6 lb	1.5 lb	3	
		dimethoate (Cygon, De-Fend)				
		2.67 EC	¾ to 1 pt	4 to 6 oz	0	
		4 EC	½ to 2/3 pt	4 to 6 oz	0	
		trichlorfon (Dylox, Proxol) 80 SP	20 oz	1 lb	21	
		acephate (Orthene) 75 S	1 to 1 1/3 lb	12 to 16 oz	7	Do not use on nonbell peppers.
	Pepper weevil	parathion (various) 4 E	½ pt	4 oz	15	Apply at 7-day intervals when infestation becomes evident. Do not use on nonbell peppers. Avoid bringing in plants with fruit pods from Florida.
		permethrin				
		(Pounce) 3.2 EC	4 to 8 oz	0.1 to 0.2 lb	3	
		25 WP	6 to 12 oz	0.1 to 0.2 lb	3	
		(Ambush) 2 EC	6 to 12 oz	0.1 to 0.2 lb	3	
		25 WP	6 to 12 oz	0.1 to 0.2 lb	3	

*Do not plant crops other than alfalfa, corn, peanuts, peppers, potatoes, rice, sorghum, strawberries, sugar beets, sugarcane, and tobacco within 18 months of last application. Soybeans and oats may be planted the following season. Sweet corn, tomatoes, cabbage, peas, and beans may be planted the following season provided the prior season's application did not exceed 13 lb/A of Furadan 10 G, 8.7 lb/A of Furadan 15 G or 2 pints of Furadan 4 F. Any other crop may be planted if it is not harvested or grazed.

Insect Control For Commercial Vegetable Producers (Continued)

Commodity	Insect	Insecticide and Formulation	Amount of Formulation Per Acre	Active Ingredient Per Acre	Minimum Interval (Days) Between Last Application and Harvest	Precautions and Remarks
PEPPER (continued)	Spider mite	dicofol (Kelthane)				On foliage as needed.
		35 WP	2 lb	12 oz	2	
		18.5 WP	4 lb	12 oz	2	
		18.5 EC	2 qt	12 oz	2	
		4 F	1 pt	0.5 lb	2	
		dimethoate (Cygon, De-Fend)				
		2.67 EC	¾ to 1 pt	4 to 6 oz	0	Dimethoate will help suppress mites.
		4 EC	½ to 2/3 pt	4 to 6 oz	0	
		naled (Dibrom)				
		8 EC	1 pt	1 lb	1	
	Wireworm	diazinon (Diazinon, Spectracide) 14 G	21 to 28 lb	3 to 4 lb	—	Broadcast on soil before planting and thoroughly work into upper 6 to 9 inches.

Chemical Weed Control in Vegetable Crops

Crop	Weed	Herbicide and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEPPERS (preplant and preemergence)	Most annual and perennial weeds	methyl bromide	various	240	Inject into the soil 4 to 6 inches deep and cover with tarp immediately. Soil moisture should be near field capacity and soil temperature should be at least 50°F at the treatment depth. Allow 2 weeks after application before seeding or transplanting. If plastic tarp is removed, disking prior to planting will facilitate aeration.
	Contact kill of all green foliage. Stale bed application.	paraquat (Gramoxone Super) 1.5 L	3 to 5 pt	0.6 to 1	Apply in 20 to 60 gal spray mix to emerged weeds before transplanting as a broadcast or band treatment over a pre-formed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Plant with a minimum of soil movement for best results. Use a nonionic surfactant at a rate of 8 to 32 oz per 100-gal spray mix.
	Annual and perennial grass and broadleaf weeds. Stale bed application.	glyphosate (Roundup) 4 L	1 to 5 qt	1 to 5	Apply to emerged weeds at least 3 days prior to seeding or transplanting. Consult the manufacturer's label for rates for specific weeds.
	Annual broadleaf weeds and grasses including nightshade	chloramben (Amiben) 10 G	30 to 40 lb	3 to 4	Use granular only. Apply after plants recover from transplanting up to 30 days after transplanting to weed-free soil.
	Annual grasses and small-seeded broadleaf weeds	napropamide (Devrinol) 50 WP 2 EC	2 to 4 lb 2 to 4 qt	1 to 2	Apply preplant and incorporate into the soil 1 to 2 inches as soon as possible with a rototiller or tandem disk. May also be applied overtop after transplanting. Shallow cultivations or irrigation will improve control. Can be used on direct-seeded and transplanted peppers. See replant precautions on label for small grains.
		trifluralin (Treflan) 4 EC	1 to 2 pt	0.5 to 1.0	Apply pretransplant and incorporate to a depth of 2 to 3 inches within 8 hours with a rototiller or tandem disk.
		diphenamid (Enide) 90 WP	3.3 to 5.5 lb	3 to 5	Apply broadcast over top of transplants within 30 days after transplanting to weed-free soil. Shallow cultivations will improve control.
		DCPA (Dacthal) 75 WP	10.75 to 13.5 lb	8 to 10	Delay application 4 to 6 weeks after tansplanting, but apply only to weed-free soil. Shallow cultivations will improve control.
PEPPERS (postemergence)	Contact kill of all green foliage.	paraquat (Gramoxone Super) 1.5 L	2.5 pt	0.5	Apply in 20 to 100 gal spray mix as a shielded spray to emerged weeds between rows of peppers. Use a nonionic surfactant at a rate of 8 oz per 100-gal spray mix.

PLATE 1

1 Pydrin injury

2 Fertilizer injury

3 Cygon injury

4 Enide injury

5 Mosaic symptoms

6 Green peach aphid

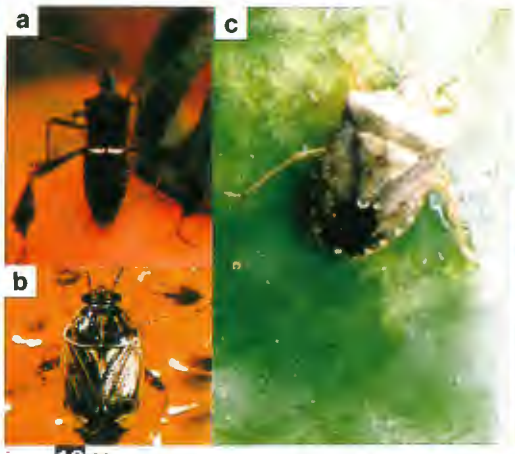
7 Spider mite

8 Wireworms

9 Flea beetles

10 Margined blister beetle

11 Pepper weevil



12 Hemiptera

13 Leaf miners

PLATE 1

1 **Pydrin injury** is expressed as a whitish bleaching of actively growing leaves. Plants stressed by high temperature, and high or low moisture often exhibit injury a few days after being sprayed. Most non-bell peppers are especially susceptible. There is a rate response. The injury is usually minor, and the plant outgrows the damage in 7-14 days. CONTROL: A new formulation of Pydrin, known as Asana, is available and plants exhibit less injury. Avoid high rates and repeated applications on stressed plants.

2 **Fertilizer injury** often occurs in the plant bed or with banded fertilizer. Symptoms include marginal foliar burning, yellowing and browning of leaves, browning of roots, and no growth. CONTROL: Avoid overfertilization by following soil and leaf tissue test reports. Irrigation helps leach excess fertilizer.

3 **Cygon injury** is expressed initially as marginal leaf rolling, and later as degrees of flecking on the leaves. There is a rate response. CONTROL: Avoid using on small, unhardened plants. Use the low rate on established plants.

4 **Enide injury** is fairly common. Initial symptoms are marginal burn and whitish blotches. Later a brown flecking between the veins appears. CONTROL: Use preplant herbicides where applicable. Be careful and select ideal weather conditions for applying herbicides. A shield on the spray boom is helpful.

5 **Mosaic symptoms** are common, and are often confused with mutations, nutrient deficiency, or chemical injury. CONTROL: Positive diagnosis is critical to control measures (see plate 3).

6 **Aphids.** Winged and wingless green peach aphids, *Myzus persicae* (Sulzer), occur on the undersides of leaves. Their feeding, secretions of honeydew, and the development of black sooty mold, affects leaves and fruit. More importantly, aphids play a role in spreading plant viruses. CONTROL: Early detection with yellow pans or sticky traps is important in timing sprays. Applying systemic insecticides will give 3-4 weeks control. Stylet oil and reflective film offer some delay in the spread of aphid-borne viruses.

7 **Twospotted spider mites**, *Tetranychus urticae* Koch. Mites suck plant juices causing yellow leaves and poor growth. Mites tend to build up around field margins during hot, dry weather. CONTROL: Scout fields and spray with a miticide/insecticide when infestations occur. Excessive and unnecessary sprays of certain carbamate and pyrethroid pesticides may cause mite populations to increase.

8 **Wireworms**, *Conoderus vespertinus* (F.), are associated with fields previously either in small grain or not in row crops. CONTROL: Avoid problem fields, bait with corn in 6-in. soil plugs, and use soil insecticides.

9 **Flea beetles**, *Epitrix hirtipennis* (Melsheimer), are primarily associated with recent transplants. Overwintering adults move to plants, causing small holes in leaves. CONTROL: Early detection and prompt insecticide sprays provide the best control.

10 **Margined blister beetles**, *Epicauta pestifera* Werner, sometimes feed voraciously on foliage in late summer. Damage to leaf margins is typical. CONTROL: Sprays for major worm species usually offer control.

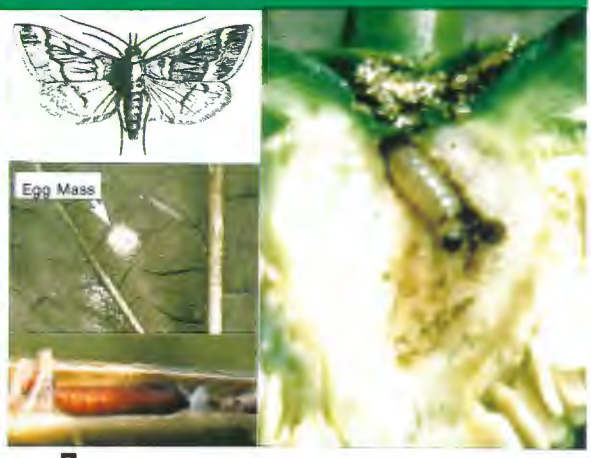
11 **Pepper weevils**, *Anthonomus eugenii* Cano, are introduced on transplants grown further south. Adults oviposit in fruit causing scars in dimples. Larvae feed in the seed cavity causing fruit to drop or become deformed. CONTROL: Avoid using transplants grown further south having flowers, buds, or small fruit. Inspection certificates and insect free transplants are encouraged. Weekly sprays of pyrethroid insecticides are suggested.

12 **Hemiptera and injury**. (a) Leaffooted bugs, *Leptoglossus phyllopus* (L.), (b) tarnished plant bugs, *Lygus lineolaris* (Palisot de Beauvois); and (c) stink bugs, *Euchistus* spp., probe and feed on buds and fruit causing aborted buds, or groups of white blotches on the fruit (halo). CONTROL: Control broadleaf weeds, check for insects, and spray with an insecticide.

13 **Vegetable leafminers**, *Liriomyza sativae* Blanchard, are common, but injury is usually confined to small greenhouse plants and recent transplants. CONTROL: Early detection and prompt sprays provide the best control.

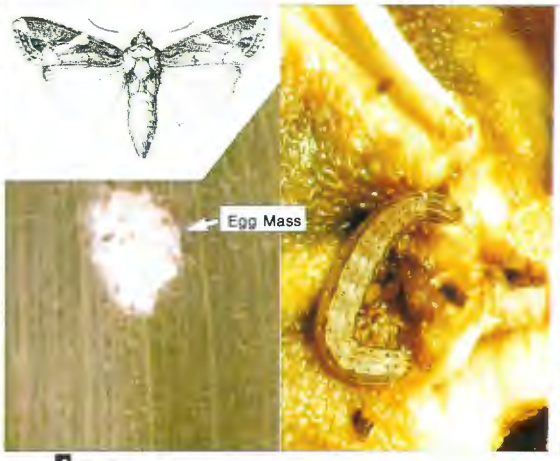
PLATE 2

1 Pepper maggot

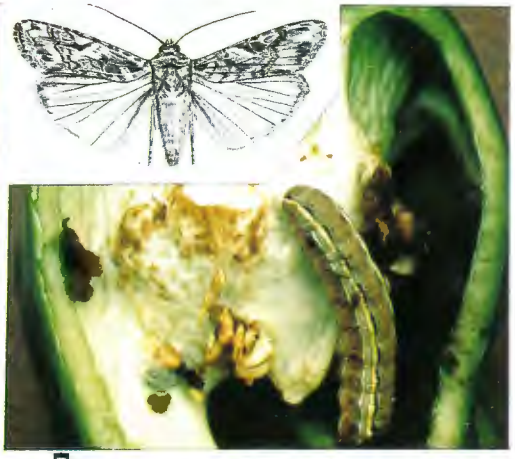


2 European corn borer

3 Black cutworm



4 Fall armyworm



5 Yellowstriped armyworm

6 Corn earworm

7 Cabbage looper

8 Beet armyworm

9 Tobacco hornworm

PLATE 2

1 **Pepper maggot**, *Zonosemata electa* (Say). Adult flies resemble house flies, but have black markings in the wings. Females oviposit in fruit which becomes dimpled or deformed. Although any type pepper may serve as host, cherry pepper is preferred. Infested fruit often turns red prematurely. CONTROL: Rotate fields in pepper. Early detection of adults with yellow sticky traps will help determine when to initiate sprays. Weekly sprays by air or with airblast sprayers, to fields and their margins, will control adult flies.

2 **European corn borer**, *Ostrinia nubilalis* (Hubner). Second and third generation corn borers are the most destructive. Egg mass resembles fish scales and appears on undersides of leaves. Young larvae feed on the surface, and within a day or two, tunnel into the fruit around the seed caps. Infested fruit often abort, decay, or may be harvested and end up in the market channels. CONTROL: Monitor adult flight periods with blacklight insect traps or sex phermone traps to determine when to initiate sprays. Spraying every 5-7 days may be needed as long as a significant moth flight period exists.

3 **Black cutworms**, *Agrotis ipsolon* (Hufnagel), occasionally cut plants at the soil line, reducing stands. Damage occurs during hot, humid weather and in the evening, and is usually confined near field margins or weeds. CONTROL: Moth collections in blacklight insect traps or sex phermone traps indicate cutworm activity and relative numbers. Use baits or spray drenches.

4 **Fall armyworms**, *Spodoptera frugiperda* (J.E. Smith), usually move into North Carolina before July 1. Egg mass contains moth scales and appears on leaves. Larval feeding on foliage may be extensive; however, damage to fruit is of more concern. CONTROL: Moth collections in blacklight insect traps or sex phermone traps indicate activity and relative numbers. Apply timely thorough sprays of certain insecticides.

5 **Yellowstriped armyworm**, *Spodoptera ornithogalli* (Guenee), is present year round in North Carolina. It may be found in plant houses, on plants, or inside fruit later in the season. CONTROL: Sprays for other worms also control this armyworm.

6 **Corn earworm**, *Heliothis zea* (Boddie). Adult moths are usually most abundant from late July through mid September. An entrance or exit hole on the shoulder of fruit is evidence that earworms have been present. Many larval color forms may be present. Other indicators are large excrement deposits, extensive feeding damage, or large worms. CONTROL: Moth collections in blacklight insect traps or sex phermone traps indicate earworm activity and relative numbers. Sprays every 5-7 days may be needed when populations are high.

7 **Cabbage looper**, *Trichoplusia ni* (Hubner). Larvae occasionally feed on fruit where damage is usually confined to the surface. CONTROL: Check blacklight insect traps and sex phermone traps for this migratory insect. Sprays for major worm species should give acceptable looper control.

8 **Beet armyworms**, *Spodoptera exigua* (Hubner), are late season pests that ravage foliage and later move into fruit. CONTROL: Blacklight insect traps indicate activity. Scout fields and spray when small larvae are seen.

9 **Tobacco hormworms**, *Manduca sexta* (L.), may be serious defoliators. CONTROL: Monitor blacklight insect traps for adult activity. Some control via mass trapping is possible. Check for stripped foliage or large droppings underneath plants. Sprays for major worm species usually control hornworm.

PLATE 3

1 Botrytis

2 Seedling damping-off

3 Bacterial, Phoma, and Cercospora leafspots

4 Southern blight

5 Phytophthora blight

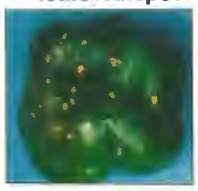
6 Mosaic

7 Bacterial leafspot

8 Bacterial leafspot

9 Bacterial leafspot

10 Bacterial leafspot



11 Bacterial leafs leafspot

12 Fruit rots

13 Phoma fruit rot

14 Blossom end rot

15 Bacterial soft rot

PLATE 3

1 **Seedling blight and damping-off** caused by the airborne fungus *Botrytis*. A brownish mold usually appears on dead tissue (see insert). CONTROL: Maintain air circulation and low humidity; spray during rainy periods.

2 **Seedling damping-off** caused by the soil-borne fungus *Pythium* often starts in small, round patches which enlarge outward. A white, cottony mold may occur on infected stems. CONTROL: Treat soil and use sanitation to avoid introducing the pathogen.

3 **Bacterial, Phoma, and Cercospora** leafspots. CONTROL: Seed treatment, sanitation, and sprays.

4 **Southern blight** caused by the soil-borne fungus *Sclerotium rolfsii* occurs in "hot-spots". Plants suddenly wilt and die. Stem bases and roots rot, and a white, stringy mold develops on infected areas and adjacent soil. Mustard-seed-like spores may be seen in the moldy growth. Blight usually appears when warm, wet weather follows a dry period. CONTROL: Deep turn plow with a moldboard plow; avoid problem fields; use fungicide in transplant water; fumigate then cover soil with plastic film.

5 **Phytophthora blight** caused by the soil-borne watermold *Phytophthora capsici*. Symptoms resemble southern blight, except no moldy growth occurs on infected tissues. It is associated with wet fields having high soluble salts. During rainy periods or with frequent overhead irrigation, large spots may appear on leaves, stems and fruit. It may also affect squash, tomato and eggplant. CONTROL: Avoid wet fields, high soil salts, and frequent irrigation; rotate with nonsusceptible crops; use soil and foliar fungicides.

6 **Mosaic** is caused by tobacco mosaic (TMV), tobacco etch (TEV), potato virus Y (PVY), tomato ringspot (TomRV), tobacco rattle virus (TRV), and others. They reduce the productive life of peppers, and are especially troublesome in tobacco producing areas. CONTROL: TMV, sanitation and resistant cultivars; TEV & PVY, aphid stylet oil sprays and reflective films; TomRV & TRV, nematode control.

7 **Seedlings with bacterial leafspot**, *Xanthomonas vesicatoria*. Expanded cotyledons usually drop off. Seedlings may be contaminated and not show symptoms until after transplanting. CONTROL: Keep all seed and plant lots separate from each other. Do not use plants from infected lots. Use nearby transplants with great caution: spray regularly with a bactericide; never handle when wet; never dip in water. Avoid overhead irrigation that results in splashing or misting.

8 **Early symptoms of bacterial spot**. Note crinkling and bunching of upper foliage, and lower leaf yellowing and fall. Initial field distribution is usually in "hot spots", a consequence of its seed-borne nature. CONTROL: Spray when one plant in the field shows symptoms. Control is poor during rainy periods.

9 **Late-season symptoms of bacterial spot**. Note defoliation. Fruit is often sunscalded and predisposed to rots. CONTROL: See number 8.

10 **Bacterial leafspot lesions** have irregular margins and vary in size. Leaf margins often have a black edge. When a spot is cut in water, and observed under magnification, a granular cloud of bacterial ooze can be seen leaving the cut surface (see insert).

11 **Fruit with bacterial leafspot** is unattractive and poorly shaped, will not hold after harvest, and has contaminated seed. CONTROL: In addition to field practices, maintain 50 ppm chlorine in seed extraction water.

12 **Fruit rots** caused by *Alternaria* and *Colletotrichum*. CONTROL: Crop rotation, sanitation, and fungicides.

13 **Phoma fruit rot** usually starts in tissues that are sunscald. CONTROL: Protect foliage from bacterial leafspot and stresses that cause leaf fall.

14 **Blossom end rot** caused by calcium deficiency usually occurs as a dry, firm rot on the blossom end of fruit. CONTROL: Maintain proper soil pH and avoid moisture stress. Spray foliage with dilute calcium nitrate to help avoid rot on new fruit.

15 **Bacterial soft rot** caused by *Erwinia* spp. is prevalent during hot, wet weather. It may be a serious postharvest problem. CONTROL: Spray during the growing season with a copper fungicide; keep fruit cool after picking; maintain 50 ppm chlorine in wash or rinse water.

TREATMENTS

Selection of Insecticides, Miticides, Fungicides and Nematicides and Minimum Days to Harvest[1,2]

Insect or Mite	7 Orthene	5 Diazinon	0 Cygon	1 Thiodan	3 Lannate	21 Furadan	7 Pydrin	3 Pounce	3 Ambush	0 Sevin[3]	15 Parathion	3 Malathion
Aphids	+ + +	+ +	+ + +	+	–	+	–	–	–	–	+ +	+ +
Cabbage looper	+ + +	–	–	+ +	+ + +	+	+ + +	+ + +	+ + +	+ +	+ +	+
Cutworms	+ +	+	–	+	+ +	–	+	+	+	+	+	–
European corn borer	+ + +	–	–	+	+	+ +	+ +	+ +	+ +	+ +	+	–
Corn earworm	+ + +	–	–	+	+	+ +	+ + +	+ + +	+ + +	+ +	+	–
Fall armyworm[4]	+ + +	–	–	+	+ + +	+	+	+	+	+	+	–
Flea beetles	+ +	+ +	–	+	+	+	+ +	+ +	+ +	+ +	+	+
Leafminer	–	+ +	+ +	+	–	+	–	–	–	–	–	+
Pepper maggot	+ +	–	+ +	+	–	–	+	+	+	–	+	+ +
Pepper weevil	+	–	–	–	–	–	+ +	+ +	+ +	+	+	+
Spider mites	–	+	+	–	–	–	–	–	–	–	+	+
Stink bugs[5]	+ + +	+	+	+	+ +	+	+ + +	+ + +	+ + +	+ +	+ +	+
Tobacco hornworm	+ + +	+	–	+ +	+ + +	+	+ + +	+ + +	+ + +	+ +	+ +	+
Wireworms	–	+ +	–	–	–	+	–	–	–	–	–	–

Disease	5 Maneb, Mancozeb	0 Copper (fixed)[6]	Streptomycin Sulfate[7]	7 Ridomil 2E	Stylet oil	PCNB	Chlorine Bleach	Telone II	Methyl Bromide	Vorlex	Vapam	Telone C-17	Vorlex 201
Anthracnose	+ +	+	–	–	–	–	–	–	–	–	–	–	–
Bacterial leafspot	–	+	+ +	–	–	–	+ +	–	–	–	–	–	–
Bacterial soft rot	–	+ +	+ +	–	–	–	+ +	–	–	–	–	–	–
Botrytis	–	–	–	–	–	–	–	–	–	–	–	–	–
Cercospora	+	+	–	–	–	–	–	–	–	–	–	–	–
Fruit rots (bacterial)	–	+	–	–	–	–	+ +	–	–	–	–	–	–
Fruit rots (fungal)	+ +	+	–	+ +	–	–	+	–	–	–	–	–	–
Damping-off[9]	–	–	–	+	–	+	–	–	+ +	+ +	+ +	+ +	+ +
Mosaic (aphid)[10]	–	–	–	–	+	–	–	–	–	–	–	–	–
Mosaic (TMV)	–	–	–	–	–	–	+ +	–	–	–	–	–	–
Phytophthora blight	+	+	–	+ +[8]	–	–	–	–	+ +	+ +	+	+ +	+ +
Root-knot (nematode)	–	–	–	–	–	–	–	+ + +	+ + +	+ +	+ +	+ +	+ +
Southern blight	–	–	–	–	–	+ +	–	–	+	+ +	+ +	+ +	+ +

[1]This information is provided only for background and is based on field observations. The use of trade names does not imply endorsement or criticism of similar products not mentioned. Actual selection and uses of pesticides must follow product labels. Tank mixes are probably more effective, as insects may develop resistance to a pesticide with repeated use. Alternate classes of insecticides where possible.

– do not use, not effective, or no information

+ partially effective

+ + + most effective or first choice

[2]Apply insecticides in late afternoon to minimize bee kills.

[3]Repeated use of Sevin may induce aphid problems.

[4]Also controls other armyworms.

[5]Also controls other true bugs.

[6]Tank mixes with maneb or mancozeb are more effective

[7]Use Streptomycin sulfate with copper on transplants in beds, not for field use.

[8]Fungus may develop resistance to fungicide; if so, switch fungicide.

[9]Use PCNB for Rhizoctonia), and Ridomil for Pythium) damping off.

[10]Stylet oil, aphicides, aluminim reflective mulch.

KNOW AND MANAGE PEPPER PESTS

MANAGEMENT PRACTICES FOR AVOIDING PEPPER PROBLEMS

Disease and insect pests threaten efficient pepper production by lowering yield, reducing fruit quality and making harvests unreliable. These risks can be reduced by using sound technology and wise management:

Keep records.

Select adapted cultivars, where available, with resistance to mosaic, other diseases and insects.

Select fertile, well drained fields and check annually for pH, nutrients, nematodes, southern stem blight, soil insects and weeds.

Use proven horticultural practices (e.g. crop rotation, plastic films, starter solutions, irrigation, cultivation, nutrition, weed management).

Use bleach-treated seed and certified containerized transplants; never dip plants in water; and avoid overhead irrigation in plant beds.

Keep seed and plant lots separate.

Practice sanitation.

Spray plants for bacterial spot prior to pulling.

Obtain pest-free plants and transplant on a raised bed after soil temperature exceeds 55°F.

Identify insects and diagnose all leafspots, rots and abnormalities promptly.

Monitor insect populations by trapping and scouting.

Spray at first appearance of disease and when insects warrant with a 250^{+} psi sprayer or a mist blower.

Harvest quality fruit, avoid injuries during handling and immediately remove field heat.

Use 50 ppm chlorine in wash and receiving water.

For more information see figure captions on this poster and Commercial Pepper Production Bulletin.

USEFUL RESOURCES AND REFERENCES

Professional, Advisory and Educational Services
County Agent
Agricultural Extension Service
County Seat
Office in Every County

Disease and Insect Identification
Plant Disease and Insect Clinic
Box 7616
North Carolina State University
Raleigh, N.C. 27695-7616

Nematode, Soil and Plant Analysis
Agronomic Division
N.C. Department of Agriculture
Raleigh, N.C. 27611

Production of Commercial Vegetable Transplants
AG-337, 16pp
N.C. Agricultural Extension Service
NCSU, Raleigh, N.C. 27695-7603

North Carolina Agricultural Chemical Manual
325pp., revised annually, $10.00
N.C. Agricultural Extension Service
NCSU, Raleigh, N.C. 27695-7603

Insect and Related Pests of Vegetables
AG-295, illus., 173pp., $7.00
N.C. Agricultural Extension Service
NCSU, Raleigh, N.C. 27695-7603

Commercial Pepper Production
AG-387, 16pp.
N.C. Agricultural Extension Service
NCSU, Raleigh, N.C. 27695-7603

This poster is published by the North Carolina Agricultural Extension Service in cooperation with the North Carolina Pickle Growers Association, Inc. to assist growers in cropping efficiency. For more information contact your County Agent.

AGRICULTURAL EXTENSION SERVICE

Prepared by:
Kenneth A. Sorensen, Extension Entomologist
Charles W. Averre, Extension Plant Pathologist
Nancy Leidy assisted.
Poster produced by Department of Agricultural Communications, North Carolina State University.