COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

IPM-13

KENTUCKY PEPPER

INTEGRATED CROP MANAGEMENT

GROWER MANUAL

Prepared by

Terry Jones; Extension Horticulturist
Ric Bessin; Extension Entomologist
John Strang; Extension Horticulturist
Brent Rowell; Extension Vegetable Specialist
Dave Spalding; Extension Associate

January, 2000

TABLE OF CONTENTS

INTRODUCTION

Peppers are grown in Kentucky for both the fresh and processing markets. Bell peppers are one of the leading vegetable crops grown in Kentucky in terms of total acreage and dollar returns. Yields of 15 tons or greater per acre (1,000-30 pound boxes) of bell peppers have been achieved with good production practices and favorable weather conditions. A daily average temperature near 75°F is ideal for pepper growth and development. Peppers grow well in a wide range of soil types but grow best in light, fertile well drained soil. The following information was prepared to help you achieve maximum returns from your crop.

Consult Horticulture Crop Enterprise Cost and Return Estimates (ID-99) for fresh market and processing pepper budgets.

FIELD SELECTION & CROP ROTATION

Well drained, rolling or flat upland soil is most desirable for peppers. Avoid low, bottom land areas along creek banks where air drainage may be poor in order to reduce foliar disease problems. Bacterial leaf spot disease is very serious under conditions of high humidity and warm temperatures.

Light textured soils with a south facing orientation will warm up faster in the spring allowing earlier fruit production when the price is higher. Select fields that are free of hard pans and excess weed seed accumulations.

Crop rotations help reduce weed problems, as well as diseases such as bacterial leaf spot, phytophthora root rot and verticillium wilt (see Table 1). Corn is a good rotational crop for peppers because herbicides available for use in corn control nightshade and field bindweed. Also, corn is not a host for pepper viruses. Alfalfa is also a good choice for a rotational crop because its frequent cutting cycle reduces many weeds and available herbicides eliminate most other weed problems. Other crops considered to be useful rotational crops with peppers include grasses, cereals, cole crops and beans.

Peppers should not follow tobacco, tomatoes, potatoes or eggplant in a rotation since they are in the same family as peppers (Solanaceae) and serious disease and or insect problems may result. In addition, similar herbicides are used in their production, resulting in similar uncontrolled weeds. If tobacco is grown in the rotation it should be planted the year following peppers.

Table 1 . Rotation for Peppers From Various Crop Groups

Crop Group	Probability of Disease overlap
Pepper, Tomato, Tobacco	Very High
Pumpkin, Melon, Cucumber	High
Cabbage, Broccoli, Cauliflower	Medium
Soybean, Alfalfa, Peas	Medium
Corn, Wheat, Grasses	Very Rare

Avoid fields where herbicide carry-over may be a problem (Table 2). Many herbicides like scepter or atrazine are used in Kentucky soybean and corn fields and can carryover and cause serious injury to peppers, especially following dry years.

Growers should also attempt to locate pepper plantings as far away from tobacco plantings as possible because of the danger of aphid movement and virus disease spread from tobacco to peppers.

Table 2. Rotational Restrictions for Peppers Following Soybean and Corn Herbicides

Soybean Herbicides	(In months)
Canopy	18-B*
Classic	B
Command	NR
Dual	12*
Lexone or Sencor	12*
Lorox	4*
Prowl	AH
Pursuit	16*
Reflex	18*
Salute	12*
Scepter	18*
Squadron	18*
Tri-Scept	18*
Status or Blazer	AH
Treflan	NR**
Turbo	12*
Corn Herbicides	
AAtrex and others	SY
Accent	10***
Becon	18*
Bicep	24*
Bladex	AH
Peak	18*
Princep	SY

* *The rotational restrictions are in months after application.*

** *Read label for additional restrictions due to soil pH, application rate, etc.*

*** *18 months with a soil pH of greater than or equal to 6.5.*

B = *A field bioassay is required before planting the crop; consult label.*

NR = *No rotational requirement*

AH = *After harvest - can be planted in fall or spring following application.*

SY = *The crop cannot be planted until the second year after application (cannot be planted the year following application).*

Fields where tobacco or a legume crop was grown the previous year may also present a problem if the organic matter and carryover nitrogen level is high. Some excellent pepper crops have been grown on tobacco fields, but care should be taken to reduce the initial nitrogen application on such fields.

Peppers may follow crops such as wheat, soybeans, cabbage, sweet corn, cantaloupes or cucumbers in the rotation. If peppers are to follow crucifers or cucurbits any potential weed problems should be noted since these crops often use the same herbicides as peppers.

SOIL PREPARATION AND FERTILIZATION

Peppers do extremely well following fescue sod when the sod is plowed at least a month prior to planting. Pepper root systems have an effective rooting depth of 12 to 18 inches with one-half the roots in the top 6 inches. Hard pans, plow pans, compacted soils, high water tables, and tight soils will restrict root development and total yield. Excessive tillage tends to compact the soil. Subsoiling to a depth of 16 to 18in. can improve air and water drainage and allows for the development of a more extensive root system. Use an insecticide in the setter water for cutworm control especially on sod ground or grassy sites. A well prepared plant bed free from clods that may hold weed seeds is very important. Herbicides will be much more effective if the soil is moist, well prepared and free of clods.

Soil preparation and fertilization of the pepper crop varies depending on the crop production system used. Regardless of the system used, the field should be fall plowed if erosion is not a problem or plowed in the spring as early as possible to

a depth of 8 to 10 inches. Take a soil sample and have it tested for pH, phosphorus, potassium, calcium, and magnesium. Soil tests can be sent off through the local County Extension Office for analysis.

Potassium and especially phosphorus are likely to accumulate in most Kentucky soils following several years of heavy applications for vegetable crops or tobacco. Soil pH influences plant growth and availability of nutrients in the soil and is often low in tobacco fields. Have your soil tested the fall prior to planting so that any needed lime can be applied and will have time to react. Calcium has limited mobility in the soil, so broadcast and incorporate needed lime to a depth of six inches in the fall if possible, particularly on sod ground.

A pH range of 6.5 to 7.0 is best for peppers and liming may be required if soil pH falls below 6.0. Soil test results should show at least 1,500 pounds of calcium and 100 pounds of magnesium prior to transplanting. If magnesium levels are low (less than 100 lbs / acre) and lime is needed, use dolomitic limestone. If the soil pH is satisfactory but the magnesium level is low, Epsom Salts ($MgSO_4$) or magnesium oxide or some other source of magnesium may be used.

Soils known to be high in residual nitrogen should be avoided to prevent peppers from producing excessive foliage at the expense of fruit. Consider the previous crop when deciding how much nitrogen to apply; there will probably be some residual nitrogen following a crop which received heavy doses of nitrogen fertilizer during the previous season. Simple, hand-held electronic meters are now available which growers can use to quickly determine the nitrate nitrogen status of soils and plants. These Cardy meters can be used to determine residual nitrate levels in soils prior to planting as well as to measure nitrate levels in plant sap in order to assess the efficiency of fertigation.

Nitrate is the form of nitrogen which is most readily available for use by crops. Soils also contain varying amounts of ammonium forms of nitrogen which bacteria convert to nitrate forms over time. Nitrate ion meters like the Cardy do not measure ammonium nitrogen and therefore may underestimate some of the nitrogen becoming available to plants during the course of the growing season.

For bare ground plantings on soils known to be relatively poor, apply 50 pounds of nitrogen per acre preplant. Apply one-half at plowing and one-half just prior to transplanting and disk into the soil. On more fertile soils, apply 25 to 30 pounds of nitrogen per acre prior to transplanting.

For processing bell pepper production where plastic mulch is not used, sidedressing or banding additional nitrogen to either side of the plant when the first fruit begin setting is essential for good yields. Apply 30 pounds of nitrogen per acre at the first sidedressing. A second sidedressing of 30 pounds of nitrogen two weeks later should also be made. Nitrogen fertilizer placed up against the plant stem can burn and injure the plant. *Caution should also be exercised that too much nitrogen not be put on before pepper pods (1-1 1/2"diameter) have set on the plant or the plant may grow vegetatively rather than set fruit*. Pepper plants must, however, obtain sufficient size and foliage before bloom and

fruit set in order to prevent sunscald. Fruit set on small plants will stunt plant growth and such plants will fail to develop the size needed to produce a profitable crop.

For fresh market bell pepper production on most medium-textured soils where raised beds, plastic mulch and drip irrigation are being used, we recommend that all of the phosphorus, all the potassium, and 30 to 50 percent of the nitrogen requirement be applied prior to bedding and laying plastic. The fertigated portion of the total nitrogen requirement can be divided into equal amounts (remaining nitrogen requirement divided by the number of weeks until final harvest) and injected weekly as in Table 3. (based on 14,500 plants per acre). Growers with very sandy soils should also consider applying 50 to 60 percent of their potassium requirement in weekly increments through the drip system in addition to nitrogen. For typical nutrient needs of a pepper crop see Table 4.

COVER CROPS

Winter cover crops help protect the soil from water and wind erosion. When incorporated into the soil as "green manure," cover crops contribute organic matter to the soil.

Cover crops help protect the soil from water and soil erosion. When incorporated as green manure crops they contribute organic matter to the soil. Organic matter improves soil structure and reduces compaction and crusting. Organic matter also increases water filtration, decreases leaching and releases nutrients to the plants. Cover crops should be plowed under at least one month before transplanting the pepper crop.

The planting of cover crops and subsequent incorporation of the green manure into the soil enhances pepper production. Pepper growers frequently plant wheat, oats, rye or ryegrass as winter cover crops. If these non-nitrogen fixing cover crops are to be incorporated as green

Table 3. Fertigation Recommendations for Bell Peppers.

Total fertigated N requirement*	Actual N/week (lbs/acre)	Ammonium nitrate (lbs/acre/week)	Ammonium nitrate (lbs. /1000 plants/ wk.)	Calcium nitrate (lbs /acre/week)	Calcium nitrate (lbs/1000 plants/wk.)
75 lbs. / acre	6 lbs 4 oz	19	1 lb 5 oz	40	3
100 lbs. / acre	8 lbs 5oz	25	1 lb 11oz	54	4

**Fertigation can begin 14 days after transplanting and assumes 50 lbs N/acre was applied preplant and starter fertilizer was used.*

Based on a total season N recommendation of 125 lbs actual N/acre with 50 lbs N/acre applied preplant and the remaining N (125 - 50 = 75 lbs.) divided into equal amounts to be fertigated on a weekly basis (75 lbs ÷ 12 weeks = 6 lbs 4 oz N per week). The dose for 1000 plants is based on a plant population of 14,500 plants/acre (i.e., double rows on 6 ft. centers with plants 12 in. apart in the rows). Either the moderate (75 lb) or high (100 lb) N rate can be selected below. For seasons extending beyond 12 weeks a maintenance dose of 1 to 1.5 lbs N/week is adequate.

Table 4. Pounds of The Major Nutrients Used by a 22,500 lb. Pepper Crop.

	N	P	K
Fruit	45	6	50
Plant	95	6	90
Total	140	12	140

manure, provide them with adequate nitrogen during their growth. This increases the quantity of organic matter produced and provides a carbon:nitrogen (C:N) ratio less likely to "tie up" or immobilize nitrogen during decomposition. As a general rule, when non-leguminous organic matter having a C:N ratio exceeding 30 to 1 is incorporated, a supplemental nitrogen application (usually 20 to 30 pounds of nitrogen per acre) prior to incorporation is recommended. The exact rate required will depend on the C:N ratio, soil type and amount of any residual nitrogen in the soil. Plow green manure crops under as deep as possible with a moldboard plow at least three weeks prior to transplanting peppers.

Addition of organic matter:

✔ *improves soil structure (helps to reduce compaction and crusting),*

✔ *increases water infiltration,*

✔ *decreases water and wind erosion,*

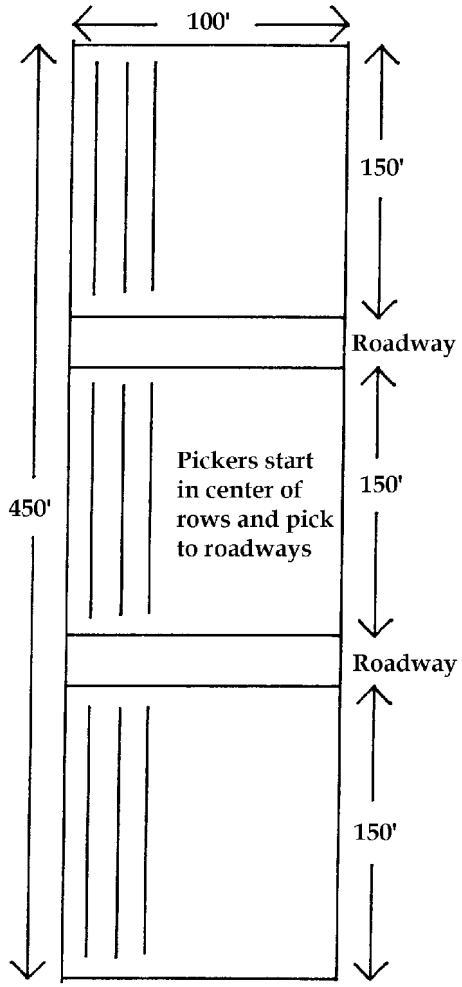
✔ *increases the soil's ability to resist leaching of many plant nutrients, and*

✔ *releases plant nutrients during decomposition.*

FIELD LAYOUT

Good field layout can significantly reduce harvest labor time. Often more time is spent carrying peppers out of the field than is spent picking them, especially if drive rows are not left to facilitate spraying and harvest. Lay fields out so that there are drive rows approximately every 8 rows and roadways across the field at 150 foot intervals. This conserves time in harvesting and loading the fruit onto wagons or trucks (Figure 1). Pickers can start at the middle of each 150 foot long row and work back to the drive rows.

Figure 1. Field Layout for Hand Harvesting.



Arranging field with cross roads as shown reduces the time required to carry out harvested peppers.

Table 5. Bell Pepper Varieties

Variety	Days to maturity	Comments
*Bacterial Leaf Spot Resistant**		
Boynton Bell	70-75	Race 1,2,3 resistant; best overall in 1995-97 trials under epidemic leaf spot conditions. Green to red.
Summer Sweet 890	70-75	Race 1,2,3 resistant. Green to red.
Enterprise	70-75	Race 1,2,3 resistant. Green to red. Also acceptable for processing.
Yorktown	70-75	Race 1,2,3 resistant. Green to red.
Aladdin X3R	70-75	Race 1,2,3 resistant. Green to yellow; can be marketed as green.
Lexington	72	Race 1,2,3 resistant. Virus tolerant (TMV, PVY) Green to red. Fruit large, dark green. Plant relatively tall.
Wizard X3R	73-75	Race 1,2,3 resistant, TMV. Green to red, blocky; attractive. Not as tolerant to bacterial leaf spot as some other varieties.
Phytophthora resistant/tolerant		
Paladin	70-75	Not resistant to bacterial leaf spot; high yielding and attractive in disease free trial.
Not Resistant to Bacterial Leaf Spot		
North Star	60-65	Medium large fruit. TMV tolerant. Green to red.
Merlin	65-70	Excellent shape. Consistently high yields in diverse environments, large fruit. TMV tolerant. Green to red. Also acceptable for processing.
King Arthur	65-70	Very large fruit. Virus tolerant (TMV, PVY, TEV). Green to red. Also acceptable for processing. Fruit appearance variable.
Specialty Bell		
Ivory	65-70	Precocious yellow. Medium sized fruit. White to deep yellow.
Early Sunsation	70	For trial; Race 1,2,3 resistant. Maintains firmness in mature stage. Widely grown in the industry. Green to yellow.
Ledoro		Very large yellow fruit
Oriole	74	Light orange.
Mandarin	68-72	Dark orange; elongated fruit; excellent color. Susceptible to alternaria.
Valencia	72	Dark orange, very good color, TMV tolerant.
Lilac	68	Lavender to red.
Purple Pepper	60	Dark purple to red; large fruit
Purple Beauty	70	Green to dark purple to red. Large fruit.

**Many varieties with resistance to at least 3 races of the pathogen are commercially available; a number of these have been tested for several years by the University of Kentucky. Those recommended have performed well under both epidemic and disease-free conditions. We recommend that they be used where bacterial leaf spot is a problem. Check with the processing company before growing these for processing. See the Disease Control section for more information on management of this important disease. TMV=Tobacco mosaic virus; PVY=Potato virus Y; TEV=Tobacco etch virus.*

TRANSPLANTS

Profits are increased by full stands of stocky, disease-free plants. Plants can either be homegrown or bought from a reliable source. For maximum yields, transplants should never have fruits, flowers, or flower buds before transplanting. An ideal transplant is young (8 to 12 inches tall with a stem approximately 3/8 to 1/4 inch in diameter), does not exhibit rapid vegetative growth, and is slightly hardened at transplanting time. Rapid growth following transplanting helps assure a well-established plant before fruit development. Transplants should be set as soon as possible after removing from containers. If pepper plants are held for several days before transplanting, keep them cool (around 55°- 65°F if possible) and do not allow the roots to dry out.

A certification label should accompany all out-of-state grown plants, and should be requested by growers. To be assured of good quality plants, growers may want to grow their own or buy plug plants from reputable greenhouse sources.

Certified Plants

Many pepper plants are grown in Florida, South Georgia, Alabama and North Carolina and shipped north for transplanting. Transplant producing areas have certification laws and inspection systems directed toward producing high quality, disease-free plants.

Before buying, observe the following precautions:

✔ ***Buy plants carrying a certification label from the state in which grown.*** *Growers should request certified plants when they order. Copies of the invoice should be kept in case problems arise at shipment.*

✔ ***Determine plant producer's reputation by asking for references from other growers who have used his/her plants three or more years.***

✔ ***Accept shipment only if plants are of the correct size, variety, count and in good condition.*** *Observe plants closely to be sure they have good terminal buds and root systems.*

✔ ***Accept only pest-free plants that have a large root system.*** *Generally, the larger the root system, the greater the yields.*

✔ ***Observe plants for overheating symptoms.*** *It is to the grower's advantage to buy seed of the desired variety and send it to the plant producer for growing. This reduces potential mislabeling of desired varieties.* ***Avoid purchasing plants that have been clipped since this increases the chance of disease.***

Greenhouse Grown Plants

High quality plants are produced through top management, and many growers grow their own plants. Light, temperature, humidity, moisture, fertilizer and the potting mix must be properly managed so that disease organisms, insects and weeds are controlled. Greenhouse grown plants require 6-8 weeks from seeding to transplant size.

Greenhouse container-grown plants are recommended for planting with plastic mulch and trickle irrigation. Plants grown in 72-cell trays are considered economical to grow while of sufficient size to produce large and vigorous transplants. Seed should be treated with bleach (Chlorox) by

the grower to help reduce seed transmission of bacterial leaf spot (see seed treatment procedure under "Bacterial Spot" in the Disease Control section in Commercial Vegetable Crop Recommendations, ID-36). Bacterial leaf spot remains a serious risk to pepper plantings in many parts of the state and growers in areas prone to bacterial spot problems should use resistant varieties.

Advantages realized from locally grown transplants include:

✔ *Plants of the desired variety.*

✔ *Plants that are ready for setting during optimum soil and weather conditions.*

✔ *Plants that produce a uniform stand (higher survival rate), early growth and higher yield, especially for plug or container grown plants when compared to bare root transplants.*

✔ *Greater control of diseases and insects.*

✔ *Better control of root system size.*

✔ *Higher early yields if plants are container grown.*

✔ *Better control of hardened plants for early, spring planting. Container grown plants resume growth faster than bareroot plants.*

Size of Transplant Container

Research at Kentucky and other universities has shown that plants grown in 2 1/2 to 3-inch containers produce a larger root system, bloom earlier and have higher early marketable yields than plants grown in small containers (for fresh market). Growers often use smaller plug plants for processing pepper production. Returns from higher early yields often offset the additional cost of plant production. Total yields may not differ between plants grown in various container sizes. In one Kentucky study the gross early return / acre for using 1 1/2" plugs was two times that for plugs that were only 13/16" in diameter.

Greenhouse grown plug plants must be hardened off before setting into the field. Plants are moved outside the greenhouse to expose them to higher light intensities and usually no fertilizer is applied the week prior to setting.

TRANSPLANTING

Peppers are a warm season crop and should be planted only after danger of frosts and freezing has passed. For the central, north central and eastern parts of Kentucky the average planting date should be May 7 to 15. For the southern and more western counties, transplanting can usually start around May 5. It is better to delay planting a few days than to be too early and expose plants to prolonged cold temperatures. Optimum soil temperatures for pepper growth are between 65°F and 80°F. Peppers grow best if nighttime soil temperatures average 60°F or higher. Raised plant beds with black plastic mulch warm up quickly in the spring and enhance earlier growth.

When setting plants, roots should be placed three inches to four inches deep. At transplanting, apply an appropriate fertilizer starter solution. After transplanting (especially within the first two weeks) it is very important that soil moisture be maintained so that plant roots can become well established.

Peppers for Processing

Tobacco transplanters work very well for conventional bare root, bare ground pepper production. Peppers grown for processing are usually transplanted 16 inches apart in rows 36 to 42 inches apart. This will require between 9,957 and 11,616 plants per acre. If pimento peppers are grown, space plants 18 to 22 inches apart in rows 40 to 42 inches apart (7,500 plants per acre). Although processing peppers have traditionally been grown on bare ground in Kentucky, several growers in recent years have doubled their profits by using higher plant populations, hybrid varieties, black plastic mulch, and drip irrigation.

Row spacing and plants / acre are shown in Table 6. Optimal plant population / acre depends upon plant growth habit, plant size at maturity, vigor, soil fertility, and availability of irrigation. Adequate populations for the many different cultivars range from 6,000-15,000 plants / acre. Bell peppers are fairly compact and row spacing of 36-42 inches with 12-16 inches between plants are common. For other kinds of peppers which produce larger plants, the population should be decreased accordingly.

Given the higher cost of the raised bed / plasticulture production system, processors have not objected to growers selling a portion of the crop as fresh greens. Yields can be dramatically increased with plastic and drip irrigation, especially in a dry season. Growers are advised to check with the processing company, however, as the benefits of mulch and drip irrigation will not be as great with open-pollinated varieties normally supplied by the processor. Techniques (including double row spacings) for using this system with processing peppers are the same as those described below for fresh market peppers.

Fresh Market Plasticulture Pepper Production

Planting hybrid bell pepper plants on 6 to 8 inch raised beds covered with black plastic mulch using drip irrigation has resulted in high yields of excellent quality peppers for fresh market sales. A bed shaper / plastic layer and a setter that will transplant through plastic are essential for this production system. Two rows of peppers spaced 15 inches apart are planted on each bed; plants are spaced 12 inches apart within each row. The beds are usually six feet from center to center (14,500 plants per acre).

Since a portion of the fertilizer will be applied though the drip irrigation system (fertigation), uniform watering will ensure that plants receive adequate nutrients. While the consequences of underwatering (and therefore underfertilizing) are obvious, many growers overlook the fact that overwatering will leach nutrients out of the root zone. Growers using trickle irrigation and plastic mulch should carefully monitor soil moisture using inexpensive tensiometers. Check them daily. Don't assume that because it has rained there will be water in the root zone under plastic! For more details on how to set up a trickle irrigation system with fertilizer injection, contact your county Extension agent or irrigation supply representative.

Excellent weed control is critical when plant population is increased because of difficulty in cultivating between rows and with "weeds in the row" which require hand removal. Never allow herbicides to collect on the black plastic as pepper plant injury usually results.

Starter Fertilizers

Research has shown that pepper plants respond to starter fertilizers high in phosphorus if placed around the plant roots at transplanting. Phosphorus is important in promoting rapid root growth and early plant development. Starter fertilizers can be purchased in both the granular and liquid form. Use 3 pounds of a granular fertilizer such as 10-52-17, 12-48-8, 8-52-16 or similar analysis for every 50 gallons of water and apply about 1 cup of solution around each plant when transplanting. You will need to use about 1 gallon of a liquid starter such as 7-14-7 or 6-18-6 per 50 gallons of water to get a comparable amount of phosphorus around the plant roots.

You will usually need from 11 to 12 fifty gallon tanks of starter water to transplant an acre (33-36 pounds of granular starter fertilizer).

Table 6. Pepper Plant Population/Acre With Different Row and Plant Spacings.

Row Width (in)	Plant Spacing (in)	Plants / Acre
34	12	15,376
34	14	13,188
34	16	11,531
36	12	14,520
36	14	12,445
36	16	10,890
42	12	12,445
42	14	10,667
42	16	9,334
DR*	12	14,520

DR = Double Row - Rows 12" apart with plants 12" apart in row with 6 feet between beds on center.

IRRIGATION

A uniform soil moisture supply throughout the growing season is essential to produce consistent yields of quality fruit. Irrigation increases pepper yields from 20 to 60 percent and eliminates disastrous crop losses resulting from severe drought. Long dry periods will cause plants to abort flowers and produce small fruit. Drought injured plants are usually slow to recover. Moisture stress in peppers also causes fruit drop, sunscalding and blossom end rot. Soil moisture should be maintained between 65 and 80 percent of field capacity. Soil at 100% field capacity is saturated and too wet for prolonged growth of the plants. Use tensiometers to determine when to irrigate. Transplanting, flowering and fruit development are the most critical stages where a lack of water will severely reduce production.

DRIP IRRIGATION

Drip irrigation with black plastic mulch has become essential for profitable pepper production. One of the major advantages of drip irrigation is its water use efficiency. Vegetables always require some irrigation. Using drip irrigation results in water savings of 60% compared to sprinkler irrigation. Weeds are also less of a problem since only the rows are watered and the middles remain dry. Studies have also shown significant yield increases with drip irrigation and plastic mulch when compared with sprinkler irrigated peppers. The most dramatic yield increases have been attained by using drip irrigation, plastic mulch and supplementing nutrients by injecting fertilizers into the drip system (fertigation).

Drip tubing may be installed on the soil surface or buried two to three inches deep.

When used in conjunction with plastic mulch, the tubing is installed at the same time the plastic mulch is laid. Usually one line of tubing is installed on each bed. If two rows of peppers are planted on a bed and they are not more than 12 inches apart, then both rows can be watered from the same drip line. A field with beds spaced five feet center to center will require 8,712 feet of tubing per acre (one tube per bed). The tubing is available in various wall thicknesses ranging from three mils to 25 mils. Most growers use thin wall tubing (8-10 mils) and replace it every year. Heavier wall tubing can be rolled up at the end of the season and reused; however, take care in removing it from the field and store in a shelter. Labor costs for removing, storing, and reinstalling irrigation tubing are often prohibitive.

Excellent results have been achieved by injecting at least half of the nitrogen through the drip system. This allows plant nutrients to be supplied to the field as needed. This method also eliminates the need for heavy fertilizer applications early in the season which tend to leach beyond the reach of root systems or cause salt toxicity problems. Only water soluble formulations can be injected through drip systems. Nitrogen formulations tend to be more water soluble and consequently, are easily injected. Nitrogen also tends to leach quicker and needs to be supplemented during the growing season. Drip systems should be thoroughly flushed with fresh water following each fertilizer injection.

Surface water used in a drip irrigation system should be well filtered to remove any particulate matter which might plug the tubing. The water should be tested for minerals which could precipitate and cause plugging problems.

Tensiometers or soil moisture blocks to measure soil moisture levels can be purchased and placed in the soil. When using tensiometers, on silt loam soils maintain the soil moisture below 40 centibars at the 12 in. depth. Do not apply too much water, especially beneath black plastic mulch.

SPRAYING EQUIPMENT

Sprayers are used for applying insecticides, fungicides, herbicides and foliar fertilizers. Basically, there are two types of sprayers: boom and air blast. Boom sprayers are most often recommended for pepper growers. Boom sprayers with the aid of drop nozzles provide better coverage of the plant canopy than air blast sprayers. Boom sprayers get their name from the arrangement of the conduit that carries the spray liquid to the nozzles. Booms or long arms on the sprayer extend across a given width to cover a particular swath as the sprayer passes over the field. Each component is important for efficient and effective application.

Most materials applied by a sprayer are a mixture or suspension. Uniform application demands a uniform tank mix. Most boom sprayers have a tank agitator to maintain uniform mixing of the spray materials. The agitation (mixing) may be produced by jet agitators, volume boosters (sometimes referred to as hydraulic agitators) or mechanical agitators. These can be purchased separately and installed on sprayers. Make sure an agitator is on every sprayer. Some growers make the mistake of not operating the agitator when moving from field to field or when stopping for a few minutes. Always agitate

continuously when using pesticides that tend to settle out. If pesticides are not uniformly mixed, inadequate control and/or plant injury may result.

PUMPS

Before selecting a pump, factors such as intended use, cost, service, operating speeds, flow rate, pressure and wear should be considered. For spraying peppers, a diaphragm pump is recommended because of serviceability and pressures required. A typical pump should be able to apply 60-80 gal/acre at 100-150 psi.

Factors to consider in selecting the proper pump for a sprayer are:

✔ *Capacity - The pump should be of proper capacity or size to supply boom output and to provide for agitation. The boom output, depending upon the number and size of nozzles, plus 20-30 percent for pump wear is recommended. Capacities of pumps are given in gallons per minute or per hour.*

✔ *Pressure - The pump must produce the desired operating pressure for the spraying job to be done. Pressures are indicated as pounds per square inch (psi).*

✔ *Resistance to corrosion and wear - The pump must be able to handle the chemical spray materials without excessive corrosion or wear. Use care in selecting a pump if wettable powders are to be used. These materials will enhance pump wear.*

NOZZLES

Nozzle tips are the most neglected and abused part of the sprayer. Since clogging can occur when spraying, clean and test the nozzle tips and strainers before each application. When applying chemicals, be sure to maintain proper ground speed, operating pressure, spray height, etc. This will ensure adequate placement of the recommended amounts of pesticides to the plant canopy.

Rapid nozzle wear is a common problem. Nozzles are made of different types of materials. To reduce the rate of wear, ceramic or stainless steel nozzles should be used. Use a flat fan type nozzle to apply broadcast herbicides. Flat fan nozzles produce an elliptical pattern, where the edges are light and heavy in the center. These should be spaced on the boom for 30 - 40 percent overlap. When it becomes necessary to band apply herbicides, use an even fan or flood nozzle. These nozzles produce a uniform pattern across the area sprayed. The fan nozzles should be operated at 20-40 psi. Flood nozzles are designed to operate at lower pressures of 5 - 15 psi. The capacity of both type nozzles should be 15-20 gpa.

When applying insecticides and fungicides, use solid or hollow cone type nozzles. The two patterns that are developed by solid or hollow cone nozzles can be produced by different tip configurations.

Nozzle Arrangements

When applying insecticides or fungicides, you must completely cover both sides of all leaves with spray material. When pepper plants are small (up to 12 inches) one or two nozzles over the top is sufficient. Then, as the plant starts to bush or branch, add drop nozzles. This directs spray material from all directions into the pepper canopy. As the plant increases in

height, add another nozzle for every eight to 10 inches of growth. In all spray configurations, the nozzle tips should be approximately 6-10 inches from the foliage.

Properly selected nozzles should be able to apply 25-125 gallons per acre operating at 90-200 psi. Actual capacity and pressure required will vary depending on the crop's stage of development. In most cases, more than one size nozzle will be needed to carry out a season spray program. Generally, ground speed should be between 2-4 miles per hour. Calibrate pepper sprayers often. *Calibration should be conducted every eight to 10 hours of operation to ensure proper pesticide application.*

WEED MANAGEMENT

Weeds reduce pepper yields by competing for light, water, and nutrients; delaying maturity; and by reducing harvest efficiency. Peppers are a warm season crop that need a long growing season, but they are very poor competitors with weeds early in the season. Weeds interfere with harvest and produce seeds that are troublesome in rotational crops. Effective weed management in peppers begins with proper field selection and identification of potential weed problems. It involves cultivation, proper land preparation, sanitation, and proper selection of herbicides. When combined with good cultural practices, available herbicides can control many of the weed species found in pepper fields. Herbicide choice depends upon the weed species present and the cultural practices followed by the grower.

Many major weed problems can be reduced by avoiding fields that are severely infested with weeds such as nightshade, field bindweed, nutsedge, and pigweed which compete effectively with peppers. Avoid moving weed seed into fields on equipment. When equipment has been used in a weedy field, clean it before entering other fields. Deep plowing (9 to 10 inches) with a moldboard plow before disking and bed preparation can bury nutsedge tubers deep enough to prevent their emergence.

HERBICIDES

Preemergence herbicides are applied to the soil before weeds emerge. They are effective against germinating weed seeds and usually give residual control. Apply preemergent herbicides just before planting. Some are mechanically incorporated into the soil. If weeds have already emerged, a postemergent treatment may also be necessary. Preemergent herbicides are effective against germinating seeds, not dry seeds. Do not apply these materials to wet soils, however, as compaction can occur.

Postemergence herbicides are sprayed onto the foliage of the weeds after they have emerged. They are absorbed by the weeds and translocated to the site of action; thus they work best when sprayed on unstressed plants. Herbicides work best if they are applied when soil moisture is adequate for plant growth.

In pepper production, many growers apply glyphosate (Roundup) or paraquat (Gramoxone Extra) between the plastic rows after weed seedlings emerge. Preemergent herbicides may also be tank mixed with glyphosate or paraquat after weed emergence to provide control of weed seeds that may germinate latter.

Cultural practices

The use of black plastic mulch inhibits weed growth on pepper beds. However, weeds will emerge at the base of the pepper plant where it is inserted into the plastic. These must be removed by hand early in the season.

If black plastic mulch is used be sure to control weeds that grow between the plastic strips. Tilling between the strips is difficult because of plastic tearing.

Herbicide use

If fields are infested with perennial weeds such as Johnsongrass or Bermudagrass, they should be treated with Roundup the year before planting to reduce weed problems during the pepper growing season. Roundup is very effective in killing the roots of these perennial weeds and does not result in residual carry-over, but it will not control weeds from seed. All herbicides should be applied at the times and rates given on the label. Some may be applied before setting while others must be applied after setting. Chemicals that can be applied before planting are usually effective in controlling grasses and a few broadleaf weeds, but they do not give total season control of Johnsongrass, bermudagrass, barnyardgrass, ragweed, lambsquarters, nutsedge or morningglories.

Annual grasses are usually controlled in peppers by preplant or post-plant preemergent herbicides incorporated 2"-3" deep. Barnyard and crabgrass may become a problem after an incorporated herbicide has lost its effectiveness. Layby applications where annual grasses are prevalent are effective.

Herbicides are no more effective than the techniques used to apply them. Sprayer calibration is of prime importance when applying materials at uniform rates. It is extremely important that efforts be made to apply herbicides at uniform rates over the entire area to be treated. This includes using identical nozzle tips, good agitation, correct pressure and speed. Post-emergent herbicides may require a surfactant.

Rainfall or irrigation within 4-5 days of herbicide application is necessary for some chemicals to be effective.

There are no foliar-applied herbicides that selectively control broadleaf weeds in peppers; however, sethoxydim (Poast) can be applied to control most annual and perennial grasses during the season. Poast has good selectivity on peppers, but may cause some phytotoxic symptoms if the temperatures are above 85° to 90°F. For Poast to work well, the grass should be growing vigorously. Napropamide (Devrinol) can be applied over the top of transplants immediately before a rain or sprinkler irrigated into the soil. Metalachlor (Dual) may be applied prior to setting or up to 48 hrs after setting peppers. Both clomazone (Command) and trifluralin (Treflan) are applied and incorporated before transplanting

Where black plastic mulch is used, Dual and shielded Gramoxone Extra sprays have worked well between the beds for weed control.

On bare ground plantings the best preemergence weed control is obtained by applying two herbicides such as Treflan and Command, Treflan and Dual, or Treflan and Devrinol. This provides a broader spectrum of weed control.

For weed control recommendations,

refer to the current issue of ID-36 Commercial Vegetable Crop Recommendations, available through your local county Extension office.

MONITORING

To plan a weed management program, it is essential to know which weed species are present and the relative abundance of each. Conduct weed surveys of each field at least twice a year: the first after planting but before weeding and the second just before harvest. Records from previous crops will indicate what weeds escaped control and will likely infest the pepper crop. Also examine fence rows and ditch banks, as these are other sources for weed invasion. Pay special attention to where perennial weeds occur so that follow-up control measures can be taken.

Weeds compete for water, fertilizer and sunlight as well as harbor insects and diseases. They greatly reduce harvesting efficiency thereby increasing costs.

Pigweed, lambsquarters, morning glory and weeds of the nightshade family cause the most common weed problems in peppers. Growers should survey the weeds in the field before planting and check the Guide to relative response of weeds to herbicides chart in the front of ID 36, Commercial Vegetable Crop Recommendations to see if these weeds can be effectively controlled with recommended herbicides. Remember that major variations in soil type within a field make application of herbicides difficult because the rates must be adjusted. Rotation helps prevent difficult weed problems because the changes in planting times, cultural practices and herbicides help eliminate those conditions favoring a particular weed. Sweet corn is a valuable rotation crop for peppers because several herbicides are available for corn that will control morning glory and weeds in the nightshade family. Cucurbits (cucumbers, cantaloupes, etc.) do not provide a good rotation because they use many of the same herbicides used with peppers. To plan a weed management program you must know what weeds are present. Do not apply granular treflan with your fertilizer as this often leads to uneven distribution and very poor weed control.

CULTIVATION

Herbicides seldom provide complete control of all weeds when applied, so some cultivation and hand hoeing is needed in most pepper crops. Remember the old saying, "one years seeding results in seven years weeding." Cultivate while weeds are small in order to keep cultivation shallow. Cultivation after fruit set (if necessary) should be shallow. Root pruning by cultivation slows plant development, reduces yield and promotes blossom drop and blossom end rot. Even a small stand of weed seedlings can deplete the soil moisture in the upper soil layer.

SANITATION

Rogue out or spot treat small infestations of troublesome perennials. Clean fence rows to prevent weed spread into the field. Glyphosate and gramoxone herbicides are valuable tools in eliminating emerged weed seedlings and perennial weed problems.

INSECT MANAGEMENT

Pepper production in Kentucky is plagued by moderate levels of insect pests. This includes European corn borer and beet armyworm that attack the fruit (direct pests) as well as insects attacking the foliage such as aphids and flea beetles (indirect pests). Occasionally, corn earworms and yellowstriped armyworm can attack pepper fruits, but this is less common. However, as with most insects encountered in the Midwest, populations of individual pests vary from year to year and location to location reinforcing the need to routinely monitor pepper fields.

EUROPEAN CORN BORER

European corn borer can cause severe damage to peppers in commercial fields throughout Kentucky. Feeding by corn borer larvae can cause several problems, the most serious of which is direct damage to the fruit and premature drop of small fruit. Borer entrance holes in larger fruit allow water to enter, resulting in fruit rot. When rotting begins, borers often leave and move to infest new fruit. In this way, one larva can damage several fruit. In addition, plants may break due to tunneling by the borers in the stems.

European corn borer larvae are flesh-colored with inconspicuous, light brown stripes down the body. They are about l-inch long when full-grown. Adult female moths are pale yellow-brown with irregular, wavy, dark bands across the wings. Males are distinctly darker with olive brown markings on the wings. The moths are good fliers, and are active on calm nights.

European corn borer moths tend to congregate in tall grassy areas around field margins, these are called action sites. Females fly into fields at night to lay their eggs. Weather conditions during egg laying can greatly affect the severity of corn borer problems. Calm warm nights are most favorable for moth activity while few eggs are laid on windy, stormy nights.

European corn borer eggs are laid in masses of 15 to 30 eggs per mass. Eggs are round and flattened and overlap each other like fish scales. Often they are placed on the underside of the pepper leaf near the midrib. Age of the egg mass is indicated by its color: freshly laid eggs are white, then cream. When a distinct black spot, the head of the larva, can be seen in the egg, it will hatch within 24 hours.

Newly hatched larvae, about 1/16 inch long, leave the mass and crawl toward the developing fruit. They do little feeding on pepper leaves. Within 2 to 24 hours after hatch, young larvae reach the calyx of the pepper fruit. Once under the calyx, they are protected from insecticides and natural enemies.

There are two to three generations of this pest each year. The first appears in late May through early June. This first generation does not attack peppers, so producers do not need to use an insecticide at this time. This generation attacks corn and other weeds. The second generation develops from late July through August. A partial third generation may occur in some years in early September. The second and third, or midsummer generations, are most likely to cause problems for commercial pepper producers.

Management

Abundance of European corn borers varies from year to year. Inspection of pepper leaves for corn borer egg masses and young larvae is impractical and ineffective. Growers are encouraged to use pheromone traps and/or black light traps to determine if corn borer moths are active and when treatments should be applied to control small larvae before they enter the pepper fruit. ***If corn borers are caught in traps, then begin looking in grassy areas near your field. If moths are found in these action sites and the plants have fruit, then a spray is justified.***

European corn borer is difficult to control because of the short interval between egg hatch and larval tunneling of the fruit. An insecticide must be applied before larvae have entered the fruit or stems and spray coverage must be thorough. Over reliance on pyrethroid insecticides (Ambush, Asana, Baythroid, and Pounce) can lead to the rapid buildup of aphids on pepper foliage through the reduction of natural enemies. While pyrethoid insecticides can provide effective corn borer control, they should be used in rotation with other classes of insecticides to prevent aphid outbreaks.

Try to avoid insecticide spray applications during the bloom period to prevent unnecessary bee kills. If treatment is necessary, then spray in the early morning or late evening when bees are not active. A dry spray deposit is less dangerous to foraging bees.

Corn Borer Model

A degree day model that predicts the occurrence of the corn borer life stages is available at the University of Kentucky. It is recommended that these predictions be used in combination with field scouting of moth activity in action sites or pheromone trapping in order to make management decisions. These predictions will alert you to when it is necessary to monitor pheromone traps closely and scout fields.

Current degree day accumulations are available for European corn borer, as well as other insects for many locations in the state through the Agricultural Weather Center maintained by the UK Department of Agricultural Engineering. Up-to-date European corn borer estimates are available through the World Wide Web using the following address "http://wwwagwx.ca.uky.edu/." See ENTFACT 106 for a explanation of how to use the degree day estimates (Appendix 3).

BEET ARMYWORM

The beet armyworm is a major pest in the southwestern and southern US attacking alfalfa, beans, beets, cole crops, corn, lettuce, onion, peppers, potatoes, peas, and tomatoes. It is an occasional invader of vegetable crops in the Ohio River Valley. Although it cannot overwinter here, it is a significant pest for vegetable growers because of its wide host range and resistance to most insecticides. Producers of fall vegetable crops need to watch out for this pest during August and September. This insect is killed by the first hard frosts in the fall.

The beet armyworm is a light-green to black larva with four pairs of abdominal prolegs and a dark head. There are many fine, white wavy lines along the back and a broader stripe along each side. There is usually a distinctive dark spot on each side just above the second pair of true legs. Female moths lay masses of up to 80 eggs underneath a covering of cottony-white

scales, as many as 600 eggs over a 3 to 7-day period. These eggs hatch in 2 to 3 days and the larvae first feed together in a group near the egg cluster. As they grow, they gradually move away from the egg masses. Many small larvae die during this wandering stage and the behavior tends to spread out the infestation. Beet armyworm is quite mobile, one larvae may attack several plants in a row. Older larvae may feed on fruit as well as leaves. After they complete their feeding, the 1-1/4" inch larvae pupate in the soil in a loose cocoon containing soil particles and leaf fragments. The life cycle takes about a month to complete.

Beet armyworm feeding on young tender growth can be very damaging to small transplants. Often a fine webbing is produced by smaller larvae near these feeding sites. Older plants can become rapidly defoliated. Vegetable growers should pay particular attention to fall plantings of beans, tomatoes, crucifers, other truck crops.

Management

Regular scouting of fields to detect the first indications of a beet armyworm infestation is critical. Growers in Kentucky and southern Indiana should scout their fields weekly and watch for small beet armyworm larvae feeding in groups on young leaves. ***If beet armyworm larvae are found, a spray is justified.*** Sprays containing *Bacillus thuringiensis* var *azawai* are effective when used at higher labeled rates against young larvae.

Beet armyworm has few effective parasites or predators which can effectively reduce its numbers. Broad-spectrum insecticides are needed when large number of larvae are present. If a complex of insect pests including beet armyworm are present, treat them as beet armyworm when selecting an insecticide. SpinTor (spinosad) is a new class of chemistry that can provide high levels of control of beet armyworm. Cyfluthrin (Baythroid) and methomyl (Lannate) are also recommended for beet armyworm control, but they provide only moderate control, at best, of severe infestations.

Timing of insecticide applications is very important. Once larvae are 1/2 inch or longer, they become very difficult to kill with insecticides. So treatment must be targeted against young larvae. Only with frequent field surveys can these pests be detected and controlled effectively. Coverage is also an important consideration. Because insecticides can provide only moderate levels of control, it is important to deliver the proper dose to the pest. Drop nozzles, high pressure (200 psi), hollow cone nozzles, reducing sprayer speed (2 to 2.5 mph), and a high volume spray will allow for thorough coverage of these vegetable crops.

APHIDS

Several aphids species may be commonly found infesting peppers during most of the growing season. The most common aphid on peppers is the green peach aphid. Large numbers of aphids can affect pepper production in two ways. Honeydew produced by aphids can leave a sticky film on the surface of the fruit and cause the development of sooty mold fungi. Various species of aphids can also transmit viruses, notably potato virus Y, that can reduce yields. Aphid infestations may begin in the greenhouse on pepper transplants.

As aphid colonies begin to form on the

leaves, development occurs rapidly. Aphids reproduce without mating and individual generations may be completed within one week during the summer. Winged adult aphids develop periodically and disperse from fields following periods of overcrowding. Colonies are found on the undersides of leaves, usually in the lower canopy.

Management

Some insecticides used for other pepper insect pests can contribute to rapid increases of aphids. Natural enemies such as lady beetles, green lacewings, and damsel bugs usually control aphid populations adequately. ***Broad spectrum insecticides, particularly pyrethroid insecticides, can deplete these natural enemies and allow aphid populations to develop unchecked.*** Insecticides should only be applied for other insects when necessary, as determined by trap catches and scouting, and care should be taken to select insecticides that do not favor secondary aphid problems.

DISEASE MANAGEMENT

DISEASES & CONTROL STRATEGIES

In the early 1980's Kentucky produced over 8,000 acres of bell peppers each year for 5 processing companies and several fresh market cooperatives but due to bacterial leaf spot, the acreage declined dramatically. Consequently bacterial leaf spot is considered to be the most serious disease in pepper production in Kentucky and surrounding states (Table 7). Today there is one bell pepper processor contracting in Kentucky and fresh market bell pepper acreage, through the use of leaf spot resistant cultivars, is just beginning to recover.

Table 7. Importance of Pepper Diseases By State

Disease	KY	OH	IN	TN
Anthracnose	3	2	-	2
Bacterial spot	1	1	1	1
Phytophthora	5	2	2	4
S. rolfsii	6	-	-	3
Cercospora	7	-	-	7
Poty-viruses	2	-	-	6
TSWV	4	4	3	5

- = not important
 # ranked, 1 = most serious problem

ANTHRACNOSE, CERCOSPORA LEAF SPOT, AND ALTERNARIA FRUIT ROT

Anthracnose occurs as sunken spots on ripe fruit, accompanied by pinkish spore masses during wet conditions; infection occurs on both green and ripe fruit. Anthracnose and Alternaria Fruit Rot frequently develop on injured or over-ripe fruit. Protecting fruit from the effects of bacterial leaf spot and sunscald and harvesting carefully will reduce problems from these fruit diseases. Cercospora leaf spot develops as large circular to oblong spots usually with a white to gray center during prolonged periods of hot, wet weather. Alternaria develops as a black mass of spores on damaged areas of the fruits. Use disease-free seed and or transplants. Rotate for 3 to 4 years to crops not related to pepper (see Table 1), controlling solanaceous weeds during the rotation. Plow down crop residues immediately after harvest. Weekly fungicide sprays with Maneb 80 at 1.5 to 3.0 lbs / A are effective if sprays start prior to or at the time when first symptoms appear and are maintained past bloom to control anthracnose and the fruit phases of these diseases. Copper fungicides are also labeled, but have limited value on these diseases. For more complete

recommendations, see ID-36 Commercial Vegetable Crop Recommendations available at your County Extension Office.

BACTERIAL SOFT ROT OF FRUIT

Bacterial soft rot causes a very soft slimy rot with a strong odor. The bacteria causing it are commonly present on the fruit surface and enter the fruit through wounds, especially those caused by European corn bores. Control insect pests (especially corn borers) and spotting diseases to minimize wounding. If wash water is used in packing operations, it should contain 25 ppm of available chlorine. A number of chlorine sources are available, but for most small operations in Kentucky the most available option is to use household bleach (those containing 5.25% sodium hypochlorite) at the rate of 1 tablespoon of bleach per 8 gallons of water or 1 pt/264 gallons of water. To keep the chlorine available, it is important that the initial water pH be 6.0 to 7.5, that the water remain clean and is changed often, and that the water is near the temperature of the fruit (no colder than 10°F below that of the harvested fruit). If the wash water is too cold, the wash water will be pulled into the fruit and promote disease development.

BACTERIAL LEAF SPOT

Bacterial leaf spot occurs as water-soaked, black to tan, irregular shaped spots on the leaf (see figures), especially the margins, and on fruits as raised spots. Defoliation of infected leaves can be extensive, greatly impacting fruit quality. This disease can be a limiting factor in pepper production in Kentucky and chemical controls have been marginal under strong disease pressure. Fortunately, major improvements in control options have recently become available in the form of resistant varieties. Bacterial Leaf Spot can result in severe damage to pepper crops. It has been one of the most serious and costly problems affecting peppers in Kentucky, causing thousands of dollars worth of damage. The successful grower must understand and appreciate this disease's potential, to successfully grow peppers. Bacterial leaf spot is favored by warm, wet weather and its spread is aided by driving rain or wind-blown soil and debris.

✔ *Use Resistant Varieties:* Based on studies done in Kentucky, resistant varieties should be used for both fresh market and processing where possible. See the pepper variety table (Table 5.) for a listing of several recommended resistant cultivars. Other control options will continue to be recommended because susceptible pepper varieties will continue to be released . These control options are also necessary to manage strains of the bacterium that may not be controlled by resistant varieties.

✔ *Seed-borne Disease:* The bacterium causing this disease is seed-borne, transplant-borne, and over winters on site and nearby in weeds such as nightshade, horse nettle and ground cherry and residues. Bacterial leaf spot remains viable on plant residues as long as there is any residue left. The bacteria may survive as latent epiphytes (living without causing an infection) on the leaves of "healthy" plants. Once it is introduced into the planting and under prolonged wet conditions, control is limited because of the rapid rate of reproduction and limitation of available chemicals. ***Therefore, control is centered around preventing introduction of the bacterium rather than eradication of it once present!***

✔ Use crop rotations of 2 to 3 years, excluding peppers, eggplant, tomatoes, and tobacco from the total rotation, also

excluding small grains in the rotation the season before peppers are to be planted. Control broadleaf weeds during the rotation and around the field borders. Disk all crop residues into the soil promptly after harvest to encourage more rapid decline of the bacterium and plow cover crops very early in the spring to minimize carry-over.

✔ Do not work plantings while wet. Spraying plants while wet with high pressure may encourage spread by blowing bacteria about the field.

✔ Use Disease-free seed and transplants: Plant disease-free seed whenever possible and treat them before planting with household bleach (2 pts household bleach to 1 gallon of water per lb of seed, washing for 40 minutes with continuous agitation). Air dry, dust seed with Thiram 65 W at 1 tsp / lb of seed, and sow promptly to control damping off. While in the seedbeds and starting with the first true leaf stage, make frequent applications (3 to 5 days) of the antibiotic Streptomycin 17% at 200 ppm or 2 teaspoons / gallon of water. *(Note:* streptomycin is labeled only *for use prior* to *transplanting and is not labeled for use in the field and should not be used in the field.)* Also, note that streptomycin is not specifically labeled for greenhouse use, so use fixed coppers in greenhouse transplant production, but do not expect the high degree of control available with streptomycin.

✔ If transplants are purchased from off the farm, obtain only certified disease-free transplants and assume that you probably have still purchased some low level of infection. Plant them into soil with recommended rates of N and K, but at the high end of the scale. Losses from bacterial spot are greatest when peppers become deficient in N or K and the disease can be minimized by maintaining high fertility, being careful not to get the plants into an overly vegetative state or fruit set will be seriously reduced.

✔ *Foliar Sprays:* Sprays made early in the season before symptoms are evident are the most valuable at keeping population of the bacteria low. Start sprays immediately after transplanting with fixed copper (1.0 lb of active ingredient) plus Maneb 80 at 1.5 lbs / A and continue at 7-day intervals during wet weather to reduce buildup and spread of the bacterium in the field (see labels for rates). *After mixing Maneb and fixed copper in the spray tank, let it sit for 30 minutes with agitation. During this period a new chemical compound will be formed that is more effective at controlling bacterial spot than either of the two individual materials.* Note the copper material can be applied more frequently, but maneb is labeled for no closer than 7-day intervals, plus note that maneb has a 7-day preharvest interval while coppers have zero.

Table 8. Bacterial Leaf Spot - Coppers & Maneb			
Material	Rate of Material to Use / A	Minimum Days To:	
		Harvest	Reentry
Copper (Kocide 101)	2.5 lb	0	2
Kocide DF	2.5 lb	0	2
Copper-Count N	3 qt	0	2
Kocide 606	2 qt	0	2
Champ Flowable	2 qt	0	2
basic copper sulfate	3 lb	0	1
maneb 4F	2.5 pt	7	1
maneb 80 WP	1.5 lb	7	1
maneb 75 DF	1.5 lb	7	1

SCLEROTINIA STEM BLIGHT

Sclerotinia Stem Blight is caused by a fungus living in the soil and attacking the base of the pepper plants. The disease is favored when organic matter plowed under is not completely broken down before planting. Sclerotinia is characterized by white cottony growth on the stem and small hard black seed like structures (sclerotia) which form in the pepper stems. Good site selection and good field preparation will help control this disease. Crop rotation must also be used.

PHYTOPHTHORA BLIGHT

Pathogens: *Phytophthora capsici, P. parasitica*
This disease can cause serious losses, but for some reason has caused limited problems in Kentucky. This could rapidly change with changes in production, especially water management.

Symptoms:

Above ground symptoms of Phytophthora root and crown rot include rapid wilting and death of affected pepper plants. Phytophthora blight occurs as a rapid wilting and death of plants, especially in wet areas of the field. Fruit rot occurs as a water-soaked, dark rot usually surrounded by a halo of lighter color. Close examination of the roots and stems of affected plants is necessary to confirm the cause of disease. The disease can develop at any plant growth stage. Tap roots and smaller lateral roots show water soaked, very dark brown discoloration. Stem lesions are first dark green and watersoaked, then dry and turn brown. Factors that influence the development of root and crown rot in peppers in a given season include varietal susceptibility, amount and frequency of irrigation, and soil compaction and drainage. The fungus survives in the soil for several years and is similar to tobacco black shank. The black shank fungus can also cause a fruit rot of peppers.

Cultural Control:

The disease can be effectively prevented by a program integrating crop rotations of 2 years that exclude susceptible plants, irrigation management, and clean seed and transplants. In heavy soils that are poorly drained, root and crown rot may be reduced by carefully managed drip irrigation. Practices that reduce or alleviate soil compaction may improve control; for example, growing plants on raised beds. One variety is available which has performed well in Kentucky trials and has resistance to Phytophthora (but which is not resistant to bacterial leaf spot--See cultivar Table 5.

Chemical Control:

Fungicides are sometimes used in fields with histories of root rot or problems with drainage. Soil drainage is critical to control; avoid wet fields, and plant on raised beds in well drained soils. Rotate to non-solanaceous crops and non-cucurbit crops for 3 to 4 years to reduce disease potential. If planting into fields with a history of disease, make a preplant incorporated application of Ridomil Gold EC at 1 pt/A before transplanting, plus additional applications at 30 and 60 days after transplanting, directing the spray as a band on either side of the plant. The copper/maneb sprays used for bacterial spot control should also reduce Phytophthora fruit infections, but will not control the root and stem phases of this disease. Ridomil Gold/Copper 70W at 2.5 lbs/A as a foliar spray at 10-14 day intervals is also an option for preventing the stem and fruit phases.

SOUTHERN STEM BLIGHT

Sclerotium rolfsii

This disease can be a problem where rotation includes soybeans, tomatoes or other susceptible crops. The fungus attacks the stem near or at the soil line and forms white mold on the stem. Later small round brown bodies (sclerotia) appear in the mold. Infected plants wilt and die slowly. This disease is often found in lots of transplants, so set clean plants. Avoid fields with a history of this disease and rotate problem fields with sod crops. *Sclerotium rolfsii* has a wide host range and is common in Kentucky on tobacco, soybeans, peppers, and tomatoes. Deep plow to bury sclerotia and crop debris. Incorporate cover crops early to ensure they are well rotted before transplanting into the site. Maintain good weed and grass control through preventive means because the fungus can attack dying weeds then move onto pepper transplants. The fungicide PCNB (Terrachlor 75 WP) at 3 to 5 lbs/ 100 gallons in the transplant water is an aid to control, but better results are obtained if the material is sprayed into the transplant furrow using 10 lbs/ 100 gallons over 14,500 ft of row. It is important to maintain agitation [see label].

TOMATO SPOTTED WILT AND IMPATIENS NECROTIC SPOT VIRUSES

These viruses are carried by thrips and can cause serious losses in transplant production or when introduced in the transplants. Ensure that transplants are from fields or greenhouses certified to be free of TSWV. **Local transplant producers should take steps to reduce the spread of TSWV and INSV by following recommended thrip control and not producing pepper transplants in houses where ornamentals are being produced or sold.** Rogue out infected plants as soon as they are found and maintain a thrip control program. Avoid using transplants from sources containing these viruses.

PEPPER VIRUS COMPLEX

This is the name given to several virus diseases that attack peppers in Kentucky. Viruses are the second most important disease problem (Table 7) on Kentucky peppers because of the production of tobacco. At least four viruses are responsible, tobacco mosaic (TMV), tobacco etch virus (TEV), cucumber mosaic virus (CMV) and potato virus (PVY). All except TMV are transmitted primarily by aphids. On occasion, tomato spotted wilt virus (TSWV) which is transmitted by the adult thrip has been found. Aphids carry these viruses to pepper fields from perennial weeds growing nearby. Plants infected early in their life may be stunted, have deformed leaves with mosaic or mottling patterns, and produce small, discolored, misshaped fruit (see figures). Plants

infected later in the season are not as badly stunted. Pepper viruses may also cause flower drop in pepper which also contributes to lower yields.

Pepper Virus Complex Control:

1) Plant peppers in and surrounded by fields used for row crops "barrier crops". Six rows of corn around a pepper planting will reduce virus transmission to the peppers by 80% and delay the time of aphid infection and development. Peppers planted near woods, fence rows, hay, or pastures may be exposed to virus-carrying aphids from nearby weedy perennial hosts. Partial isolation from infected aphids can be accomplished by locating fields between plantings of corn or other non-host, field crops where the weeds are killed before peppers are transplanted. Do not grow peppers within 150 ft of virus susceptible tobacco. Controlling aphids in tobacco located near peppers, especially at the times of tobacco topping and harvest, may help to reduce movement of aphids and viruses to peppers.

2) Plant peppers as early as possible. Virus diseases normally show up in early summer. Since aphids feeding for only a short time will introduce viruses into the plant, aphid controls are not effective.

3) Control weeds, especially those in the nightshade family, in and around the pepper fields.

4) Use virus resistant pepper and tobacco cultivars (Table 9) whenever possible. Observations from recent surveys indicate that growing tobacco varieties resistant to the aphid-borne virus complex may be helpful in reducing these diseases in peppers, probably because the pathogen level in the nearby plant community is greatly reduced.

5) Maintain aphid control in peppers. In problem fields, with a high value fresh market crop, spraying weekly with stylet oils can be helpful (using 3 qt / 100 gallons) [see labels and follow the labeled protocol strictly], but the value of this treatment has not been evaluated in Kentucky. Reflective mulches show promise in reducing the incidence or delaying the onset of these diseases in some tests.

NEMATODES

Root knot nematodes, *Meloidogyne incognita, M. hapla,* and *M. arenaria* cause economic damage to peppers when present. They are usually a problem in sandy soils such as those in a river bottom. Nematodes cause physical damage to root systems and open up wounds that allow disease to become established. Nematode infested plants are generally stunted with pale green to light yellow foliage. Soils infested with root knot nematodes should either be treated with chemicals (fumigated) or avoided.

Table 9.	1999 Burley Tobacco Varieties: Disease Resistance, Relative Yield Scores, and Maturity							
Variety	Black Shank		Virus Complex	Black Root Rot	TMV	Fusarium	Relative Yield Score[1]	Maturity
	Race 0	Race 1						
ms KY 14 x L8	10	0	S	M	R	M	7	early
KY 8959	1	1	R	H	S	-	7	late
KY 907	2	2	R	H	R	-	8	med-late
KY 908	4	4	R	H	R	-	2	med-early
KY 910	10*	5*	R	H	R	-	2*	med-early
NC BH 129	1	1	S	H	R	S	7	med-early
NC 2**	2	2	R	H	R	S	3	medium
NC 3**	2	2	R	H	R	S	7	med-late
TN 86	4	4	R	H	S	S	7	late
TN 90	4	4	R	H	R	-	6	med-late
TN 97	5*	5*	R	H	R	-	7*	med-late
Hybrid 403	0	0	S	M	R	M	9	medium
N-126	0	0	S	M	R	-	7	medium
NBH 98	2*	2*	S	M*	R	-	4*	medium
R 610	4	4	S	M	-	-	5	medium

[1] = Relative yield scores are based on growth under disease free conditions.
* = Based on a limited number of field tests and subject to change.
** Resistant to root knot nematode (*Meloidogyne incognita*, Races 1 and 3).
- Resistance not rated for this disease.

PHYSIOLOGICAL PROBLEMS

FLOWER DROP AND ABORTION

Flower drop is an indication of pepper plant stress at the time of flowering. This may be a response to temperature stress (greater than 90°F or less than 50°F), water stress, root pruning (cultivation), shading or excess fruit load. Stink bug and pepper viruses will also cause flower drop. Pepper cultivars differ greatly in their ability to withstand stress.

FRUIT SET

Very little fruit set occurs when temperatures are above 90°F during the day or below 60°F at night. Fruit that set at temperatures above 85°F are usually small and deformed. Best fruit set occurs when temperatures are between 65°F and 80°F. In general hybrid pepper cultivars have better tolerance to heat stress than open-pollinated cultivars.

BLOSSOM END ROT

Blossom end rot (BER) usually occurs on fruit 1/3 to 2/3 mature size as a small water soaked spot at or near the blossom end (bottom of the pepper.) The water soaked spot enlarges and becomes dry, sunken, flattened, brown or black and papery or leathery.

BER is caused by inadequate calcium availability in the fruit tissues during periods of rapid growth. The lack of adequate calcium can be due to low levels in soil, but is most often caused by poor calcium uptake and movement associated with uneven soil moisture and/or plant root damage. Excessive levels of potassium (K^+) and the over use of ammonium fertilizers may aggravate this problem. The most effective control is to maintain uniform soil moisture conditions throughout the growing season and not damage roots during cultivation or fertilization. Be especially careful of soil moisture conditions when using raised beds which can dry more quickly. *Foliar calcium sprays are not considered an effective treatment, but proper soil calcium levels should be maintained.*

B E R Control (Prevention)

✔ *Grow pepper crop on well drained soils, avoid water logged fields. Plant on raised beds to ensure good drainage.*

✔ *Apply fertilizer according to soil test. Maintain adequate calcium and avoid excessive ammonium nitrogen applications, highly soluble (K) potassium, (Mg) magnesium or (Na) sodium salts.*

✔ *Cultivate shallowly especially after fruit set or in dry weather.*

✔ *Maintain uniform soil moisture throughout the growing season, especially as fruit develops. Use plastic mulch and trickle irrigation to help reduce moisture fluctuations on peppers for fresh market.*

SUNSCALD

Sunscald is a noninfectious problem caused by exposure of pepper fruit to direct sunlight and high temperatures. This is a common problem on plants having premature foliage loss (usually from disease, cultivation damage, or hail). Nitrogen deficiency after fruit set delays plant canopy development and increases sunscald problems. Plants which grew poorly when small and then set fruit are very prone to sunscald. Symptoms include an irregular light colored scalded area which appears on any fruit surface directly exposed to the sun. Affected areas become sunken, wrinkled and creamy white as fruit ages. Sunscald areas dry out and become paper thin.

Sunscald Control (Prevention)

✔ *Select pepper cultivars which develop adequate foliage cover.*

✔ *Control diseases and insects.*

✔ *Provided adequate nutrient levels (fertilizer, water).*

✔ *Use good cultural practices to reduce the incidence of sunscald, (proper plant spacing, double rows, black plastic, irrigation). Some growers will stake and tie plants to prevent them from falling over in storms and sunscalding the fruit.*

COMMON PEPPER NUTRIENT DEFICIENCIES

LOW SOIL pH

If the soil pH is too low a number of nutrients can be limiting or present at toxic levels. Under these conditions plants may be stunted and yellowish white in color due to manganese and aluminum toxicity.

NITROGEN

Nitrogen deficient pepper plants are pale green or yellowish. The plants will

tend to be stunted. Older leaves will gradually die and drop from the plant as nitrogen is removed from these and moved to the young leaves.

POTASSIUM

Deficient plants show yellowing of leaf margins which rapidly die leaving leaves with brown dead edges. A lack of potassium affects the oldest leaves first and the upper part of the plant may be normal in appearance.

PHOSPHORUS

The leaves on phosphorus deficient plants are small and dark green. Phosphorus deficiency is more common early in the season when soils are cold and phosphorus is not readily taken up.

MAGNESIUM

Magnesium deficiency is common on pepper plants. Yellowing of the leaves is apparent in the interveinal areas and veins remain green. The oldest leaves are affected first. Sometimes magnesium deficiency occurs when excessive applications of potassium have been made. It may also show up under extremely hot dry weather.

Apply magnesium as dolomitic lime if the pH is low or as magnesium oxide when dolomitic lime is not available or a soil pH change is not needed.

SCOUTING AND SPRAY PROGRAM RATIONAL

It is strongly recommended that growers plant bacterial leaf spot resistant varieties, particularly if there is a history of this disease in the area. Even though these varieties are resistant to the three strains of this disease that are most common in Kentucky, it is important to keep up a spray program to discourage the development of other strains, there are 10 in total now nationwide, of bacterial leaf spot. If other strains become widely established in the state, the resistant varieties will no longer be useful.

As soon as the pepper plants are transplanted to the field, apply two sprays of fixed copper and Maneb 7-10 days apart to clean up the plants. This will keep the epiphytic population from building up on the plants by acting as a bacterial leaf spot suppressant. Watch the weather and continue with a fixed copper Maneb spray program on a 10-14 day interval if it is dry. If the weather is wet, use a 7 day spray interval. These sprays are to keep the bacterial leaf spot population down, as well as to control other diseases. Do not wait until you see bacterial leaf spot before trying to control it. This disease works too fast and once it becomes well established under favorable weather conditions these spray materials will not be able to control it.

To manage insect pests, walk the fields regularly to monitor for beet armyworm, yellowstriped armyworm, hornworms, and corn earworm. Use pheromone trap catches to begin sprays for second generation corn borer or alerts from your county Cooperative Extension Service based on the computer model. Most sprays should target European corn borer unless beet armyworm is present, but that is uncommon.

PEPPER HARVEST

FRESH MARKET PEPPERS

Fresh market peppers require 70-80 days from transplanting to the first harvest. First harvest usually occurs the last week of June in southern and western Kentucky, early July in central Kentucky and July 5-10 in northern Kentucky. Begin harvesting in the center of each 150 ft long row and pick down the row to the roadways. When harvesting for fresh market, pick at the mature green stage and handle carefully. Fresh market green peppers are normally harvested when they attain full size but before they lose their dark green color. Mature green peppers ready for harvest will be firm to the touch and stems and calyxes should be fresh and green. Fruit with soft, pliable thin walls and a pale green color are too immature to harvest. Harvest before any visible chocolate or red coloration or yellowing is apparent. Discard any peppers that are small, misshapen, diseased or damaged by insects, hail, sunscald or other means to avoid handling these a second time during grading.

Do not pick into plastic bags, because peppers will heat up and quickly decay. Hard and rough picking containers may cause skin breakage or punctures and should be avoided. Take care in dumping operations to avoid bruising and punctures. Pack only clean, undamaged, insect and disease-free peppers.

Good harvest management is needed to pack high quality peppers. Employees must be trained and supervised to avoid pepper damage. Pepper plants have brittle stems that break easily during harvest. Workers must use care during harvest to reduce plant damage. Good pickers snap the fruit from the plant with a backward twist. Some retailers prefer to have peppers cut from the plant with a sharp knife or pair of shears, because the wound heals much faster and there is less loss to decay.

Picking buckets should be cleaned and sanitized before each day's harvest to prevent accumulated disease organisms from infecting sound peppers. Rinse buckets with water to remove debris then wash them in a sanitizing solution consisting of 3.5 ounces of 5.25 percent sodium hypochlorite (household bleach) mixed in 7.5 gallons of water.

Wet peppers should not be harvested, because surface moisture increases field heat accumulation in the load and increases disease development. Physical damage occurs during bulk bin loading as peppers drop onto hard wooden bottoms. Many split as they strike the surface, while others are bruised. It has been demonstrated that pepper loss during field loading can significantly be reduced by padding bin bottoms. Placement of insulated carpeting in the bins reduced splitting and bruising and resulted in a 40 percent decrease in loss. Used carpeting is available to most growers, and its installation would improve the quality and quantity of field harvested peppers.

Protect peppers from direct sunlight while holding them in the field. Sunscald develops quickly on exposed peppers in loaded bulk bins. Trucks loaded with these bins should be parked under shade if there is any delay (such as a noon meal break) in moving them to the packing shed. Field packed boxes of peppers should not be held on flat bed trailers in the heat after loading. It helps to cover the peppers to reduce heat buildup from sun exposure.

A study of the effect of delayed cooling on field packed peppers has shown that shelf life can be reduced by one-half if peppers are allowed to set in full sunlight for two hours after harvest.

Washing, grading & packing

Proper washing, grading, and packing of fresh market bell peppers is critical to marketing success. Roughly 2/3 of pepper production costs are involved in harvesting, cooling, packing and storage. For small operations a small grading line can be used very successfully to wash and grade the fruit. Fruit are gently rolled from the transporting containers and picked up by a conveyor belt. The peppers are then carried beneath high pressure water nozzles, brushed and are often rolled over sponge donuts to dry them somewhat.

Fruit should never be washed by dunking them in water for a period of time or left sitting in water, because the cut stem will take up water leading to decay and reduced shelf life. *See the Bacterial Soft Rot of Fruit section on the importance of water temperature and the use of chlorine during the washing operation.* Fresh market peppers are generally not waxed or oiled. Next the peppers are deposited on a rotating grading table. At this point the fruit are visually sized, graded and any cull fruit are removed.

Peppers are graded into "U.S. Fancy" (not less than 3 inches in diameter and not less than 3 1/2 inches long) and U.S. No. 1 (not less than 2 1/2 inches in diameter or length). All grades must have similar varietal characteristics, be firm, fairly well shaped, and free from damage caused by freezing injury, hail, scars, sunburn, disease, insects, mechanical or other means. Free copies of USDA standards for grades of peppers and other fruit and vegetables are available on the internet at: http://www.ams.usda.gov/standards/vegfm.htm or can be obtained free of charge by writing: USDA, Agricultural Marketing Service, Fruit and Vegetable Division, Standardization Section, P.O. Box 96456, Room 2049-S, Washington, D.C. 20090-6456. Peppers are usually packed in 30 lb 1 1/9 bushel waxed corrugated boxes. Fruit size is designated as extra large, large, medium or small. Most buyers prefer the extra large or 55-60 count pepper size (Table 10). Medium sized fruit are usually moved through local markets and it is difficult to move small peppers.

Table 10. Pepper Box Counts

Size	Count/box
Extra large	55-65
Large	65-75
Medium	75-90
Small	90-100

PROCESSING MARKET PEPPERS

Processing bell pepper harvest usually begins in early to mid-August. They are picked when red ripe. A sound ripe pepper will remain in good condition for 7 to 10 days after becoming fully ripe. Processing companies want only fully red ripe peppers and do not want green or chocolate colored fruit. Green peppers can not be ripened to a satisfactory red color after they are removed from the plant. Before harvesting for the first time, measure off 50 feet of row. If you can pick one half bushel or more of red ripe peppers from this 50 feet of row the field is ready to harvest.

Red processing bell peppers must be sound, fully ripe and at least 2 1/2 inches

in diameter. An average acre of processing peppers will need to be harvested 3-5 times between mid-August and station closing (usually early October). Each harvest will require 12-18 hours of labor/acre depending on field size, layout, yield, labor management, amount of weeds, and method and frequency of harvest. Without access roads considerable time is spent or wasted carrying peppers out of the field.

STORAGE

Cool peppers to 45-50°F by putting them in the cooler as soon as possible after harvest; cool rooms with forced air equipment will greatly speed the process and extend shelf life. Once fruit are precooled, hold them at 45-50°F with a relative humidity of 90-95%. Peppers suffer chilling injury when stored at temperatures below 40°F. Symptoms of chilling injury are browning at the calyx end and surface pitting. At 35°F fruit will develop surface pitting after several days. Chilling injury usually does not show up until the pepper temperature is increased, usually at the market.

Do not store peppers with tomatoes, cantaloupes, apples or other produce that gives off ethylene gas. Ethylene will cause the loss of the green chlorophyll pigment.

BELL PEPPER PRODUCTION SUMMARY

To be successful perform all of these steps in a timely manner.

✔ *Determine your market. (See ID-134 Marketing Options for Commercial Vegetable Growers). This is the first priority. Keep the buyers informed of delivery times and amounts. Use packages suitable to the buyers needs.*

✔ *Select a variety that meets the demands of your particular market and growing conditions.*

✔ *Topped transplants from the south are a disease risk for both fresh and processing markets and should be avoided if at all possible.*

✔ *Take necessary steps to assure that disease-free plants are grown and planted.*

✔ *Select a site with medium-textured soils which provides good root penetration and moisture holding capacity and has good air drainage.*

✔ *Apply lime, phosphorus, potassium and minor elements according to soil test recommendations. Avoid excessive nitrogen applications which result in increased production costs and delayed fruiting.*

✔ *Apply nitrogen according to the recommended fertigation schedule.*

✔ *Take necessary precautions to avoid frost injury to early plantings.*

✔ *Space plants according to the variety and market. Good weed control is critical to establishment of a good crown set of large peppers. Fruit size tends to be slightly smaller on fruit set on the branch tips.*

✔ *Irrigate if soil moisture levels are low based on soil tensiometer readings.*

✔ *Monitor pests and control them using proven methods, equipment and timely applications.*

✔ *Harvest at the stage of maturity and size that your market requires. Handle peppers carefully and move them promptly to cooling facilities at their intended destination. No one wants small, immature, or damaged peppers.*

✔ *Take necessary steps to improve production efficiency and reduce expenses. Records on costs*

and returns are critical for improvement of your operation. See ID 99 ***Horticulture Crop Enterprise Cost and Return Estimates*** *for a sample budget.*

Appendix 1

PEPPER INTEGRATED PEST MANAGEMENT FORM

COOPERATOR:		**SCOUT:**	**FIELD #:**
ADDRESS:			
CITY:	**ZIP:**	**VARIETY:**	**ACRES:**
COUNTY:	**PHONE:**		**DATE PLANTED:**

SOIL CONDITIONS	**WEATHER**	**TIME/DATE:**
WET MOIST DRY **LOOSE HARD LIGHT CRUST**	**COOL WARM HOT** **SUNNY CLOUDY RAINY** **CALM LIGHT STRONG WIND**	**GROWTH STAGE:**

INSECTS/DISEASES:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTAL**	**AVG**	**% INFESTATION**

PHEROMONE TRAP INFORMATION

LURE TYPE	**# MOTHS LAST VISIT**	**# MOTHS THIS VISIT**	**TOTAL FOR 2 WEEKS (LAST + THIS VISIT)**	**DATE LURES CHANGED**
EUROPEAN CORN BORER				
BEET ARMYWORM				

PESTICIDES APPLIED	**RATE/ACRE**	**DATE APPLIED**
FERTILIZER APPLIED	**RATE/ACRE**	**DATE/APPLIED**

COMMENTS:

WEEDS:
PREDOMINANT SPECIES

Appendix 2

ACTIVITIES BY MONTH FOR PRODUCTION OF RED BELL PEPPERS FOR PROCESSING

	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.
Land prep-plow	X						
Spread fertilizer	X						
Land prep-disc	X						
Disc herbicides		X					
Transplant with starter solution		X					
Cultivate / weed control		X	X				
Irrigation / fertigation		X	X	X	X		
Spray insecticide as needed using IPM		X	X	X	X		
Spray fungicide		X	X	X			
Harvesting and hauling					X	X	X
Labor hours per acre	2.0	10.5	8.5	9.0	37.0	53	20

PREDICTING EUROPEAN CORN BORER DEVELOPMENT

The European corn borer is a serious pest of corn and peppers in Kentucky. Corn borers overwinter as full-grown larvae in corn stubble. With the return of warm weather in the spring, development is resumed and the larvae pupate. Temperature plays a major role in determining the rate of corn borer development. The European corn borer has a 50° to 85°F temperature range at which it is most comfortable. Below 50°it will now develop, and above 85°F development will slow dramatically. The rate of development of European corn borer can be predicted using this relationship. Dr. Grayson Brown at the University of Kentucky developed a degree day model which accurately predicts the occurrence of the different corn borer life stages. It is recommended that these predictions be used in combination with field scouting or pheromone trapping in order to make management decisions. These predictions will alert you to when it is necessary to monitor pheromone traps closely and scout fields for corn borers.

A degree day for European corn borer is one of degree above 50°F over a 24-hour period. For example, if the average temperature for a 24-hour period was 70°F, then 20 degree days would have accumulated (70 - 50 = 20) on that day. These accumulations can be used to predict when corn borers will pupate, emerge as adults, lay eggs, and hatch as larvae. With European corn borer, begin accumulating degree days January 1 of each year. Accumulated degree day totals can be compared with the values in the tables below that correspond to various corn borer life history stages. Tables are available for the first and second generation, in some years a third generation may also occur. Values for the third generation are not available. Values corresponding to initiation indicate when the earliest individuals of that stage may appear. For example, a degree day value of 750 would indicate that nearly 100% of adults have emerged from pupae, of which slightly more than 50% have flown, egg laying has begun, but is less than 25% complete, and that the earliest first instar larvae may be present. This example illustrates the need to compare the accumulated degree day total with values in several columns of the table. During the growing season there is usually a mixture of different stages in a field. Because corn borers emerge at different times, not all corn borers will be in the same stage at any particular time.

Current degree day accumulations are available for European corn borer as well as other insects for many locations in the state through the Agricultural Weather Center maintained by the UK Department of Agricultural Engineering. Up-to-date European corn borer estimates are available through the World Wide Web using the following address "http://wwwagwx.ca.uky.edu/."

European Corn Borer Life History Stages

First Generation

Percentage	Adult Flight	Egg	1st Instar	3rd Instar	5th Instar
Initiation	550	610	750	1140	1420
25%	690	790	920	1220	1490
50%	740	850	960	1250	1520
75%	790	900	1000	1280	1550
Peak	900	990	1090	1350	1620

Second Generation

Percentage	Adult Flight	Egg	1st Instar	3rd Instar	5th Instar
Initiation	1660	1740	1860	2140	2370
25%	1880	2020	2160	2420	2800
50%	1950	2110	2250	2500	2930
75%	2030	2190	2330	2580	3060
Peak	2190	2360	2490	2720	3500