Texas Crop Profile

PEPPERS

Texas A&M AgriLife Extension

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Basic Commodity Information, 1998-99 Average

Bell Peppers

State Rank: 7th

Acres Planted: 1,550

Acres Harvested: 1,450

Yield: .... 15,000 lbs. per acre

Cash Value: $5,766,000

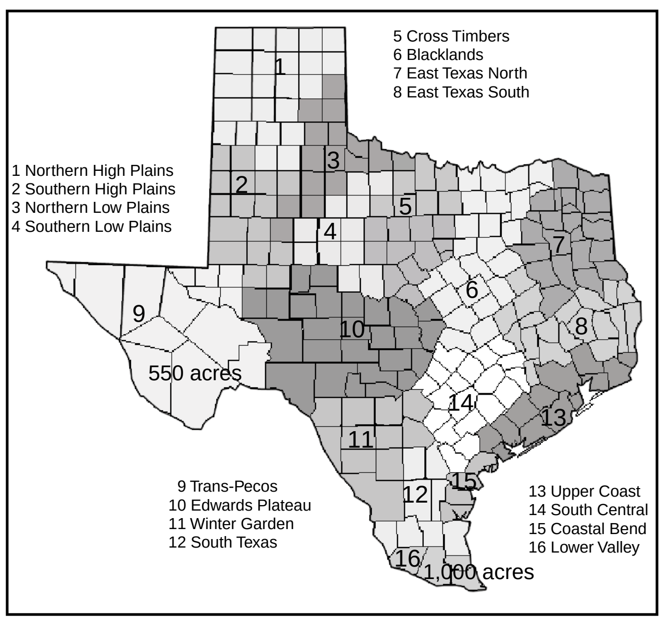
Yearly Production Costs: .... $2,767 per acre

Non-Bell Peppers

There are an estimated 9,000 acres of commercial non-bell peppers produced in Texas. This includes about 3,500 acres of long green chilies, 1,200 acres of jalapeños, and 1,600 acres of paprika. Long green chili yields are 15,000 to 20,000 pounds per acre; jalapeños, 10,000 to 25,000 pounds; and paprika 1,000 to 2,500 dry weight pounds per acre. In 1999, jalapeños sold for 18 cents to 20 cents per pound. Average variable production costs for jalapeños are $700 to $950 per acre with hybrid seed and $350 to $450 per acre with “open pollinated” (OP) seed. Hybrid varieties yield about 10 percent more than OP seed. Paprika variable production costs are about $350 to $450 per acre.

Commodity Destination

All of the Texas bell peppers are sold to fresh market handlers. About three-fourths of the non-bell pepper types go to processing that includes dehydration, canning or salsa, and processing for cosmetic dye and other uses. The remaining one-fourth of non-bell pepper types are destined for the fresh market. Most of the jalapeños are processed. All of paprika production is dehydrated.



Texas Bell Pepper Production: Number of acres planted by production region, 1997-98 average.

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Production Regions

Sixty-five (65) percent of the commercial bell peppers produced in Texas are grown in the Lower Valley and the remainder are produced in the Trans-Pecos. More than 50 percent of non-bell peppers are produced in the Trans-Pecos and nearly 40 percent are produced in the High Plains. A few are grown in the Edwards Plateau, the Winter Garden and the Lower Valley. In addition, there is some production of bells and non-bell peppers scattered throughout other parts of the state, particularly in the East Texas, South Central and the Coastal Bend areas. Much of this production goes to farmers' markets, road side sales and home consumption. Some small-scale pepper growers produce a variety of peppers for the cosmetic dye market.

Cultural Practices

Soil preference: Bell peppers prefer well-drained, fine, sandy loam soils with a pH of 6.0 to 7.5. They will tolerate heavier soils, however.

Irrigation: Peppers have a high water demand, about 25 to 35 inches per acre per season; a uniform moisture supply throughout the growing season is ideal. The critical water demand periods are at planting and at bloom set.

Irrigation plays a significant roll in Texas pepper production, but the method of applying water varies across the state. On the High Plains, a large majority of the peppers are irrigated with low energy precision application (LEPA) modified center pivot sprinkler systems. Standard center pivot sprinkler systems are also used, while a few acres are furrow irrigated. In the Trans-Pecos and the Lower Valley, furrow is the predominant irrigation method and center pivot sprinkler irrigation is the second most popular method. Drip irrigation is used to a limited extent in both the High Plains and the Lower Valley. Furrow, sprinkler and drip are all used in pepper production in the Edwards Plateau. Roll-out pipe is used on much of the furrow irrigated acres, particularly in the Lower Valley.

Salt content of irrigation water will influence yields and, in Texas, irrigation water varies widely in salinity. In the Fort Hancock area, the river water is quite salty and yields of dry red chili are around 3,000 pounds per acre. Up river in the El Paso area the river water is less salty and yields are around 4,500 pounds per acre.

In the Dell City area of the Trans-Pecos, well water is used for irrigation. Pepper fields are irrigated about every 5 to 10 days with 10 to 11 irrigations per season.

Eight to 12 1-inch irrigations are applied to peppers grown in the High Plains. This is not always sufficient, however.

Land preparation: Some growers practice minimum tillage. However, traditional preplant field activities for most growers include shredding, discing, plowing and cultivating to remove stubble, residue, and weeds and loosen up the soil (sometimes ripping, chiseling or deep breaking is necessary to break up a hard pan); listing to prepare the seed bed; fertilizing; and irrigating. In the Lower Valley some growers using drip irrigation install the drip tape during field preparation. Preplant pesticides (insecticides, fungicides and/or herbicides) are sometimes applied. Field leveling is sometimes necessary.

Some growers in the High Plains will plant cover crops. Windbreaks are recommended for all vegetable crops in the High Plains. These will help increase yields by protecting the crop from wind damage and in field moisture retention. About two rows of windbreaks are planted between every eight to 16 rows of peppers. Recommended crops for windbreaks include elbow rye, NK G1990 sorghum (headless), oats, and winter wheat. The no-head sorghum can get 10 to 12 feet high. Onion yields have been shown to increase by 50 percent to 100 percent with windbreaks. Currently, only about 10 percent to 25 percent of growers use windbreaks.

Planting: Statewide, 80 to 90 percent of the peppers are direct seeded but transplanting is growing in popularity because transplants permit earlier harvest. Seeders used range from simple drill to precision seeders. Seeds are planted in preplant irrigated fields or in dry soil irrigated immediately after planting. Transplanting is done by hand or with mechanical transplanters. Peppers are generally planted on 40-inch rows.

The optimum time to direct seed bell peppers in the spring is when the soil temperature exceeds 60 to 65 degrees F. Transplanting should be done after the average last frost free date. For fall planting, it is recommended to direct seed or transplant peppers about 120 days and 90 to 100 days, respectively, prior to the average first frost date. Regular seeding rate is 2 to 4 pounds per acre. With precision planting the seeding rate is 0.25 to 0.5 pounds per acre. Seeds are planted 1/2 to 3/4 inch deep. Seedlings may be thinned 35 to 40 days after emergence to approximately 30,000 plants per acre or 6 to 12 inches apart (jalapeños 10 inches apart and bell peppers 12 inches apart). A thinning crew, which also weeds the field in the process, costs $50 to $60 per acre.

In the High Plains, growers direct seed peppers around the last of April and first of May. Transplant peppers are set in May. Peppers are planted in March in the Trans-Pecos and the beginning of April in the Edwards Plateau. There are two growing seasons—spring and fall—in the Lower Valley. The spring pepper crop is planted January to March and the fall crop from June to August.

Varieties: Recommended varieties include bell peppers—Jupiter, Capistrano, Supersweet 840, Valiant, CamelotX3R, Pip, Taurus, and MVR Aladdin; jalapeño peppers—TAM Mild-1, TAM Veracruz, Jalapeño-M, Hy Mitla, Hy Jalapa, Hy Grande, Hy Delicias and PS 204589.

Optimum growing conditions: The pepper is a warm season crop that grows best in hot days of 80 degrees to 90 degrees F and cool nights of 65 degrees to 70 degrees F. Peppers do poorly in temperatures of 40 degrees to 60 degrees F. Best temperatures for fruit setting are 65 to 80 degrees F. Very little fruit set will occur at temperatures above 90 degrees F. Excessively high temperatures will reduce fruit size.

Fertility/fertilization: Generally, growers apply 100 to 200 pounds of nitrogen, 20 to 100 pounds of phosphorus, and 10 to 30 pounds of potassium per acre. Some growers will apply two to three nitrogen side dressings during the growing season. Also, some growers use fertilizer applications to apply supplemental nutrients.

Preharvest activities: Post-plant preharvest field activities include cultivating, hand thinning and hoeing, pesticide applications and irrigation. Immediately after planting some growers will use an implement to break up the soil crust. Growers cultivate two to seven times when the pepper plants are small. Once the plants are about 12 inches tall the stems become stiff and the rows begin to close up and the peppers could be damaged by late cultivation. Pepper fields are hoed by hand one to three times in the season.

Harvest: Direct-seeded bell peppers are harvested 110 to 120 days after planting and transplanted bell peppers at 75 to 85 days. Bell peppers are harvested in the mature green stage when pods are 3 to 3 1/2 inches in diameter.

High Plains peppers are harvested from July to December depending on planting method (direct-seeded or transplanted), the type of pepper and the intended use. Paprika, for example, may not be harvested until November or the first freeze. Peppers that will be used in chili powder or in cosmetics are allowed to mature and dry on the vine before harvesting. In the Trans-Pecos, fresh long green chilies are harvested in July or August and harvest continues until the first frost in late October to mid-November. Red chili (long green chili allowed to mature until it turns red and dries up) is harvested beginning the first week of October until January. In the Edwards Plateau, fresh peppers are harvested all summer. The Lower Valley spring pepper crop is harvested from April to May and the fall crop harvest begins in October and sometimes carries into January.

In the High Plains, 80 to 85 percent of jalapeños are machine harvested with a one-row modified cotton harvester. Currently they are harvested only one time but efforts are being made to develop zone harvesting methods for multiple harvests. In zone harvesting the bottom of plant is picked in the first harvest and subsequent harvests move on up the plant.

All paprika is machine harvested using a cotton stripper. It all goes to processing (dehydration) and is transported in a cotton module transport truck. Paprika yields around 1,000 to 2,500 pounds dry weight per acre and often sells for 65 to 70 cents per pound, depending on color.

Most of the peppers in Texas are contract grown. Because of contract requirements, most of the long green chiles on the High Plains are hand harvested, usually in two to three pickings. In Far West Texas, it is popular to roast long green chilies and sell them along roadsides.

Bell peppers are mostly hand-harvested two to three times and shipped in boxes to fresh markets in Texas.

Miscellaneous Notes

Pepper production in Texas has declined over the last several years. One reason is because Texas has been losing market to Mexico where production costs are lower. The processing companies that formerly contracted with many Texas growers have reduced their Texas contracts drastically because of Mexico's competitiveness.

Some chili peppers are called long greens and some are red chili peppers. Both come from the same plant. The difference is in maturity. Long greens are harvested green and fresh while red chili peppers are allowed to remain on the plant until they turn red. Depending on their intended use, some are not harvested until they dry to less than 15 percent moisture.

Peppers belong to the genus *Capsicum*. Christopher Columbus discovered this "New World" spice in his 1492 voyage. Peppers are a rich source of vitamins C and A. Their uses include spice, consumption as vegetables, use as condiments, medicinal uses, coloring agents in the food and cosmetic industries, and uses in landscape and floral design. The extractable oleoresin in peppers is an ingredient in numerous commercial products, such as repellents and liniments. Peppers also play a part in rituals, magic and folklore.

Gulamic acid (AuxiGro®) is a newly registered agrochemical that acts as a plant growth regulator. It enhances crop growth and yield. It is registered on bell peppers and other vegetables but not on non-bell peppers. The extent of its use among Texas growers is unknown.

Better disease and insect resistance and possibly better colors, spicy heat control and processing features for many species of peppers are likely to result from a recent discovery by Dr. Marla Binzel, a molecular biologist for the Texas Agricultural Experiment Station in El Paso. Dr. Binzel discovered an efficient way to insert genes for the desired traits in peppers. This practice has become almost routine with some plants but remained difficult for others, including peppers. An example of what might be done with this discovery is to remove a gene that causes an undesired trait and reinsert it backwards to result in a desired trait.

Scientists are discovering natural chemicals in fruits and vegetables called phytonutrients. Dr. Kevin Crosby, a melon and pepper breeder at the Texas A&M Agricultural Research and Extension Center at Weslaco, says peppers have very high levels of phytonutrients. Phytonutrients prevent diseases like diabetes and some cancers as well as inhibit tumors, reduce heart disease and act against kidney disease. Some may boost the human immune system to help fight off communicable diseases. Plant breeders are now collaborating with medical scientists to develop new varieties of fruits and vegetables with additional and higher levels of phytonutrients.

Pest Information

1. **Sucking insects:** aphids, sweet potato whitefly (*Bemisia tabaci*), thrips western flower (*Frankliniella occidentalis)*, onion (*Thrips tabaci*), spider mites, broad mites, leaf hoppers, stink bugs
2. S**oil insects:** cutworms [black cutworm (*Agrotis ipsilon*), variegated cutworm (*Peridroma saucia*), and granulate cutworm (*Feltia subterranea*)]; white grubs (*Phyllophaga* spp.); wireworms
3. **Chewing insects:** pepper weevil (*Anthonomus eugenii*), serpentine leaf miner (*Liriomyza brassicae*), flea beetle, beet armyworm (*Spodoptera exigua*).
4. **Bacterial diseases:** bacterial leaf spot (*Xanthomonas campestris pv. vesicatoria*)

5. **Fungal diseases:** damping off (Rhizoctonia, Pythium spp.), phytophthora (*Phytophthora capsici*), southern blight (*Sclerotium rolfsii*), powdery mildew (*Leveilluia taurica*), alternaria

6. **Viral diseases:** tobacco erch virus, tobacco mosaic virus, pepper mottle, potato virus Y, tomato spotted wilt, curly top, cucumber mosaic virus

7. **Nematodes**

8. **Broadleaf weeds:** pigweed (*Amaranthus* spp.), purslane (*Portulaca oleracea*), lamb's-quarters (*Chenopodium album*), sunflower (*Helianthus annuus*), morningglory (*Ipomoea* spp.), nightshade (*Solanum* spp.), field bindweed (*Convolvulus arvensis*), woolly leaf bursage (*Ambrosia grayi*), cocklebur (*Xanthium strumarium*), devil's-claw (*Proboscidea louisianica*), flower-of-an-hour (*Hibiscus trionum L.*), ironweed (*Vernonia* spp.), kochia (*Kochia scoparia*), tumbleweed (*Salsola iberica*)

9. **Grasses and sedges:** johnsongrass (*Sorghum halepense*), bermudagrass (*Cynodon dactylon*), Texas panicum (*Panicum texanum*), nutsedge (*Cyperus* spp.)

Sucking insects

Aphids, sweet potato whitefly (*Bemisia tabaci*), **thrips** (western flower *Frankliniella occidentalis*, onion *Thrips tabaci*), **spider mites, broad mites, leaf hoppers, stink bugs**

Frequency of occurrence: *Aphids* are an annual threat to pepper fields in the Lower Valley and sporadically in other Texas pepper growing areas; they also are more of a problem with bell than non-bell peppers. *Aphid* populations often increase under humid conditions. The green peach aphid is the most common aphid affecting peppers.

Whiteflies occur annually with varying degrees of severity in the Lower Valley and the High Plains. *Thrips* are present in many pepper fields in the state annually but severity varies from year to year.

Broad mites and *stink bugs* are said to occur annually in the Lower Valley with severity increasing late in hot, dry weather. *Spider mites* are present every year in Lower Valley and Trans-Pecos pepper fields. *Leafhoppers* appear annually in the Lower Valley and occasionally in the Trans-Pecos.

Damage caused: *Aphids* suck plant sap, causing stunting and leaf curling, and secrete undesirable honeydew deposits. They can also transmit viruses that are damaging to the pepper plant. *Sweet potato whitefly* nymphs and adults feed by sucking plant juices. Heavy feeding gives the pepper plants a mottled appearance and often causes them to turn yellow and die. Like aphids, sticky honeydew excreted by whiteflies often glazes leaves and supports the development of black soot.

Thrips puncture pepper plants, rasp the surface and suck juice. This causes the formation of whitish blotches that first appear as dashes. Severely attacked plants develop a gray or silver appearance and may become distorted. Damage may be found first in the leaf sheaths and stem or on the undersides of a bent leaf where the insects always are most abundant.

Spider mites pierce leaf tissues and suck sap in larval, nymphal and adult stages. Attacked plants begin to lose color, fading from green to yellow and eventually turning reddish. *Broad mites* are reported to feed primarily on the lower leaf surface and tend to concentrate on the young foliage or flower buds. Affected pepper leaves develop a bronzed appearance on the lower side of the leaf, the leaf generally curls or cups downward and can appear elongated or narrow. Latter stages of damage include thickened and brittle leaves, russeted and distorted pods, and death of the apical meristem (growth points).

Leafhopper feeding causes curling, stunting and dwarfing, accompanied by a yellowing, browning or blighting of foliage. Injection of saliva into the phloem during feeding results in a physiological disturbance that produces diseaselike symptoms. Stink bug nymphs and adults suck sap from pods, buds, blossoms and seeds. They remove the liquid contents of developing seeds, making them flat and shriveled. *Aphids, whiteflies, thrips* and *leafhoppers* also transmit viruses that can be highly damaging to pepper plants.

Percent acres affected: An estimated 60 percent of Texas pepper acreage is affected by *thrips*, 20 percent by *aphids*, 15 percent by *whiteflies*, 7 percent by *broad mites*, 2 percent by *stink bugs*, and 1 percent by *spider mites*. No estimate of percentage of acres affected by *leafhoppers* is available.

Pest life cycles: *Aphids* are small, slow-moving, pear-shaped, soft-bodied insects often called plant lice. Most species give birth to living young and build up populations very rapidly. Overlapping generations of the *sweet potato whitefly* occur in the Lower Valley during spring, summer and fall. Adults emerge, mate and begin depositing elongated, yellow eggs, attaching them to the host plant by a short stalk. Just before hatching, *whitefly* eggs darken. The nymphal period lasts about 1 month.

The minute eggs of *thrips* are inserted into leaves or stems, and generally hatch in 2 to 10 days. The larval stage lasts from 5 to 30 days. Adult females can reproduce regularly without mating with the rarely found males. All life cycle stages are present during warmer months but during colder months only adults and larvae can be found. It is probable that five to eight generations occur per year, but more may occur in the warmer parts of the state.

Adult *spider mites* feed, spin webs and lay eggs on the underside of the infected leaves. They can reproduce very rapidly during hot, dry weather.

The life cycle of *broad mites* is as short as 4 to 5 days in warm weather and 7 to10 days in cold weather. Average egg deposition is four eggs per day per female. *Broad mites* are characterized by carrying "pupae" on their backs. They reproduce best with mild temperatures (77 degrees F) and high humidity and will generally not survive harsh winters unless in a greenhouse. Populations generally build up rapidly but will crash with a lack of suitable food source, unfavorable climatic conditions or an increase in natural enemies. Dispersal occurs by contamination of field equipment or personnel, by males carrying female mites, through wind dispersal, by crawling from plant to plant, or by attaching themselves to other insects such as the *sweet potato whitefly*.

Leafhopper females deposit slender, white eggs into stems and larger veins of plant leaves. Hatching occurs in 6 to 9 days and nymphs molt four times before becoming adults. Shortly after adults appear, mating takes place and eggs are laid. Several generations overlap each season. Both adults and nymphs are very active and can run backwards or sideways as rapidly as they move forward.

Stink bugs deposit beautifully colored, ornamental, barrel-shaped eggs in clusters, usually on the underside of foliage. Development from egg to adult averages 4 to 6 weeks. Depending on climatic conditions, one to three or perhaps four generations occur per year. They overwinter as adults in places sheltered from cold weather.

Timing of control: Some pepper growers apply insecticides for *aphid* and/or *thrips* control early in the season. However, many treat for *aphids* and/or *thrips* only after scouting reveals damaging numbers of these insect pests. This usually occurs before fruit set or after first flowering. When infestations are severe, insecticides are applied frequently (sometimes every week). In the High Plains, *thrips* build up in wheat in the winter and later move into onion, pepper and other crop fields, generally in May and June. *Thrips* usually are not a problem later in the year.

Fields are treated for *whiteflies* from preplant to harvest. Insecticide applications for *spider mite* and *broad mite* control begin when the mites are first observed (usually before fruit set) and continue throughout the season. Prevention applications are made for *leafhopper* control and/or when *leafhoppers* first appear at blossom. Applications for *stink bug* control are made before fruit set.

Yield losses: Estimated pepper yield loss, if *leafhoppers* are present and not controlled, is 100 percent. It is 60 percent for *broad mites*, 30 percent for *stink bugs*, 20 percent for *aphids*, 15 percent for *thrips*, 15 percent for *spider mites*, and 5 percent for *whiteflies*.

Regional differences: *Aphids* can be a problem in pepper fields in the High Plains, the Trans-Pecos and the Lower Valley. *Whiteflies* are a small problem in the High Plains and a major problem in the Lower Valley. *Thrips* are found in pepper fields in all major pepper growing areas of the state. *Spider mites, broad mites* and *stink bugs* infest pepper fields in the Lower Valley only.

Leafhoppers are reported in pepper fields in the High Plains and the Lower Valley. There are fewer insect problems in the Trans-Pecos than in the other major pepper growing areas of the state. Because there are few insect problems, most growers in the Fort Hancock area of the Trans-Pecos do not apply insecticides. Growers in the Dell City area rarely have a treatable insect problem.

Cultural control practices: Avoid planting peppers in fields with a history of insect problems. Destroy stubble and residue and control weeds and other alternative host plants. Use a 3- to 4-year crop rotation, plant early in the season, scout for insects, and keep plants well-watered to avoid stress. Some growers use plastic mulch and some believe the reflection from white plastic discourages insects. Avoid planting next to Conservation Reserve Program (CRP) acreage because it may help reduce whitefly populations.

Biological control practices: Heavy reliance on biological control is impractical because peppers have a low tolerance to insects. There are some aphid-resistant varieties of peppers and research is underway to develop more resistant varieties. Growers should avoid killing beneficial insects by using less harmful materials and only spraying when pest populations reach damaging levels. Beneficial insects include predatory mites, lady bugs and lacewings (larvae and adults). Some growers use pyrethrins and bacillus thuringiensis (Bt) and some have tried azadirachtin, an insect growth regulator derived from the neem tree.

Other issues: Some insecticides are approved for bell peppers but not for non-bell peppers. Most insecticides applied in pepper fields are ground applied.

Alternative chemicals: Lindane is good for control of aphids and thrips. Methamidophos (24C) (Monitor®) also controls thrips and can be used for green peach aphid control. Malathion and oxydemeton-methyl (Metasystox-R®) are also registered for aphid control and naled (Dibrom®) is registered for aphid and mite control.

IPM management: There are complex Integrated Pest Management (IPM) problems in peppers. Many growers scout their fields to check for severity of insect populations and spray only when populations reach damaging levels. Bt and tebufenozide (Confirm®) are pest-specific and kill only the pest without creating any more problems. Methomyl (Lannate®) and esfenvalerate (Asana®) are

Table 1: Chemicals for Control of Sucking Insects.*

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.	Efficacy
Methomyl (Lannate® LV)	30	foliar	1.25 pt	Apply as needed based on scouting; generally from bloom to harvest	2	poor to good
Target insects	aphids, beet armyworms, leaf miners, pepper weevil, broad mites, spider mites, thrips, wireworms, cutworms					
Acephate[1] (Orthene® 75S)	45	foliar	0.66 lb	Apply as needed based on scouting; generally from bloom to harvest	2	good to excellent
Target insects	aphids, beet armyworms, pepper weevil, broad mites, flea beetles, thrips, leaf miners					
Dimethoate (Dimethoate 4E)	15	foliar	0.66 pt	Apply as needed based on scouting; generally from bloom to harvest	2	NA
Target insects	aphids, leaf miners					
Imidacloprid (Admire® 2F)	5	soil	16-32 oz	Apply at planting	1	good to excellent
Target insects	aphids, whiteflies, flea beetles					
Disulfoton (Di-Syston®)	35	soil/foliar	4.5 lb-20G; 2 lb-8; 6.7-13.3 lb-15G	20G and 15G apply in the furrow in the soil at planting; 8 apply on the foliage as a preventative	1	good
Target insects	aphids, broad mites, flea beetles, pepper weevil					
Dicofol (Kelthane MF)	7	foliar	0.75 to 1.5 pt of 4E	Apply as needed based on scouting; generally from bloom to harvest	2	good
Target insects	broad mites, aphids, whiteflies, pepper weevil					

*Also see Table 3: Chemicals for Control of Chewing Insects.
Note: Many of these insecticides are rotated throughout the season to prevent resistance.
[1]Registered for bell peppers only.
NA—Information is not available.

moderate on beneficial insects and can cause secondary pest problems. Esfenvalerate (Asana®) can be used at a low rate to kill worms at 3 to 4 days of age. This is less harmful to beneficial insects and it will leave some aphids for the beneficial insects to feed on and survive. Oxamyl (Vydate®) is harder on beneficials and is used in rescue situations where aphid infestation is severe. It is a broad spectrum product that helps control leaf miners and pepper weevils. Carbaryl (Sevin®) is fairly hard on beneficial insects and is not used later in the season when more beneficial insects are present. Cyromazine (Trigard®), dicofol (Kelthane®), avermectrin (Agrimek®), bacillus thuringiensis (Bt), and cyfluthrin (Baythroid®) are also important insecticides in a pepper IPM program.

Use in resistance management: Some growers alternate between methomyl (Lannate®) and esfenvalerate (Asana®) to help prevent pest resistance. Resistance is more of a problem in the Lower Valley than in the other primary pepper growing areas of the state because insects are abundant in the Lower Valley. In the Lower Valley, some growers rotate cyromazine (Trigard®) with avermectrin (Agrimek®) to reduce chances of resistance and may use Bt for specific targets.

Soil insects

Cutworms [**black cutworm** (*Agrotis ipsilon*), **variegated cutworm** (*Peridroma saucia*), and **granulate cutworm** (*Feltia subterranea*)]; **white grubs** (*Phyllophaga* spp.); **wireworms**

Frequency of occurrence: Most pepper fields have some soil insect problems every year. The severity varies from year to year. Soil insects are more likely to be present in crops that follow cotton, wheat, grass turf or CRP land.

Damage caused: *Black cutworms* are widespread. They are nocturnal and feed on a large number of grasses and weeds, as well as many vegetable crops. They are solitary surface feeders that cut off plants at or slightly above the soil level. A single larva may destroy a number of seedlings in one night. *Variegated cutworm* eggs are deposited singly or in small batches on low leaves or stems. There may be four or more generations in a year and they overwinter as larvae or pupae. *Granulate cutworms* attack many different vegetable crops, cutting plants off at or slightly below ground level, feeding on roots and underground stems. Since they remain in the soil, control is difficult.

As many as 100 species of *white grubs* may cause damage to vegetables. Grubs feed on roots and other underground plant parts. Most severe infestations occur in crops following grass.

Wireworms attack virtually every vegetable crop. Damaged planted seeds and plant roots result in poor stands or complete crop loss. Larvae will also bore into large roots, stems and tubers, reducing yields and quality. Growing the same crop on the same land year after year tends to increase wireworm populations.

Percent acres affected: An estimated 15 percent of state pepper acreage is affected by some type of soil insect.

Pest life cycles: *Black cutworms* overwinter as larvae or pupae. Eggs are deposited singly or in small batches on low leaves or stems and there may be four or more generations in a year. *Granulate cutworms* are subterranean in habit, may overwinter as larvae and complete up to four generations per year. *Variegated cutworm* eggs are deposited in batches on low stems and leaves. There may be three or four generations in a year following overwintering as pupae. The larvae are often found on the soil surface, beneath leaves and other debris.

The life cycle of the *white grub* varies from 1 to 3 years depending on the species. *White grubs* are an annual pest. Eggs are deposited in the soil. Larvae migrate up and down through the soil profile with the season. Adults emerge from the soil during the spring, then mate and lay eggs.

Wireworms may be found at all times of the year. Adults lay eggs in the soil and a generation is completed in 1 to 6 years, depending upon the species.

Timing of control: Apply insecticides preplant to control soil insects.

Yield losses: Soil insects in pepper fields will cause an estimated 6 percent yield loss if not controlled.

Regional differences: Soil insects are more of a problem in the Lower Valley than in other pepper growing areas of the state.

Cultural control practices: Avoid planting peppers in fields with a history of insect problems. Destroy stubble and residue and control weeds and other alternative host plants. Rotate crops every 3 to 4 years. Plant early in the season, scout for insects, and keep plants well-watered to avoid stress.

Biological control practices: Heavy reliance on biological control is impractical because peppers have a low tolerance to insects. Growers should avoid killing beneficial insects by using less harmful materials and only spraying when populations reach damaging levels. Beneficial insects include predatory mites, lady bugs and lacewings (larvae and adults). Some growers use pyrethrins and Bt and some have tried azadirachtin insect growth regulator.

Alternative chemicals: Lindane is also registered for cutworm and wireworm control.

Table 2: Chemicals for Control of Soil Insects.*

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.
Diazinon	12	soil	14G 14-28 lb, 50W 4-8 lb	Preplant incorporated	1
Target insects	cutworms, wireworms, white grubs, leaf miners				

*Also see Tables 1 and 3: Chemicals for Control of Sucking Insects and Chemicals for Control of Chewing Insects.

Chewing insects

Pepper weevil (*Anthonomus eugenii*), **serpentine leaf miner** (*Liriomyza brassicae*), **flea beetle, beet armyworm** (*Spodoptera exigua*)

Frequency of occurrence: *Leaf miners, flea beetles* and *beet armyworms* are present annually in pepper fields but severity varies from year to year and region to region. *Pepper weevil* occurs annually in the Lower Valley.

Damage caused: *Pepper weevil* tunnels damage the seed mass in the center of pepper pods. *Serpentine leaf miner* maggots eat leaf tissue between the upper and lower surfaces, leaving slender, white winding trails through the leaf's interior. Peppers are weakened greatly. Plant foliage infested with *flea beetles* has numerous, very small, rounded or irregular holes eaten through or into the leaf, so that leaves look as though they have been peppered with fine shot. When these small holes are numerous, leaves may wilt and turn brown, killing or stunting the plant. *Beet armyworm* larvae may defoliate plants. Many processors will reject the whole load if they find even one worm present.

Percent acres affected: An estimated 60 percent of Texas pepper acreage is affected by *beet armyworms*, 46 percent by *leaf miners*, 44 percent by *flea beetles*, and 7 percent by *pepper weevil* (70 percent in the Lower Valley).

Pest life cycles: *Pepper weevil* adults lay eggs in buds or young pods. Young larvae feed and develop in young pods where they pupate. In the Lower Valley, there may be five to eight generations that appear to be continuous. Ten to 20 generations of *serpentine leaf miners* occur in a year. Fewer generations per year occur in northern Texas where the growing season is shorter. Adults deposit small eggs into leaf tissue. Under optimum conditions, eggs hatch in 4 days, larvae feed in the leaf tissue 14 days, pupate in the soil, remain there 5 days and then emerge as adults. The life cycle, under optimum conditions, is completed in 23 days.

Flea beetle adults hibernate in the soil or in crop remnants. They become active in spring, feeding on host plants as new growth appears. Eggs are laid on or in soil near the plant base. They hatch in about a week and larvae feed on plant roots or tubers for 2 to 3 weeks, followed by pupation and adult emergence. Life cycle from egg to adult may be completed in 6 weeks or less. One to four generations develop each year depending on species. Adult feeding may extend over 2 months.

In South Texas, *beet armyworms* may be found in all stages (egg to adult) throughout the year. They overwinter in the adult stage in colder areas. Their life cycle takes 24 to 36 days to complete and there may be four generations per year. They lay about 500 to 600 eggs, deposited in irregular masses of about 80 eggs and covered with scales or hairs from the adult's body. The eggs hatch in 2 to 5 days and the larvae feed for about 3 weeks before pupating in the soil.

Timing of control: Insecticide applications are made for *pepper weevil* control when they are most active, from bloom to harvest. Severe infestations require insecticide applications every 3 to 5 days. Populations are generally more pronounced in the spring crop than in the fall crop. *Leaf miners* may reach threshold early, requiring insecticide applications from near the beginning to the end of the season. Insecticide applications for *flea beetle* control are made preplant, at planting, and/or at seedling stage. *Beet armyworms* will first appear in corn fields, then cotton fields and later in pepper fields about midseason. When populations are high, insecticides are applied frequently from mid- to late season.

Yield losses: Estimated yield loss from pepper weevil when not controlled is 80 percent. *Leaf miners* may cause an estimated 33 percent yield loss or more if not controlled and *flea beetles*, 25 percent. Damage from *beet armyworms* is estimated at 20 percent but some processors will reject the whole load if one worm is found, effectively resulting in a 100 percent loss.

Regional differences: *Pepper weevils* are only a problem in the Lower Valley. *Leaf miners* are a major problem in the Lower Valley, a moderate problem in the Trans-Pecos and a minor problem in the High Plains. *Flea beetles* are a major problem in the High Plains and the Edwards Plateau and a moderate problem in the Lower Valley. *Beet armyworms* are a major problem in the High Plains and a moderate problem in the Trans-Pecos and the Lower Valley.

Cultural control practices: Avoid planting peppers in fields with a history of insect problems. Destroy stubble and residue and control weeds and other alternative host plants, rotate crops every 3 to 4 years, plant early in the season, scout for insects, and keep plants well-watered to avoid stress. To minimize occurrence of *beet armyworms*, do not plant peppers in ground recently in grass and avoid using broad spectrum insecticides to control *beet armyworms* and *leaf miners*. When the field is overtaken with *pepper weevil* it is best to plow down and destroy the crop immediately.

Biological control practices: Heavy reliance on biological control is impractical because peppers have a low tolerance to insects. Growers should only spray when the insect pest populations reach harmful levels and should use materials that minimize damage to beneficial insects. Beneficial insects include predatory mites, lady bugs and lacewings (larvae and adults). Some growers use pyrethrins and Bt and some have tried azadirach-tin insect growth regulator. Also, some growers release trichogramma wasps to control *beet armyworms*. One grower estimates 30 percent to 40 percent control of *beet armyworms* by the use of wasps. This control method is less expensive than using insecticides but also is less effective. Some *leaf miner* resistant pepper varieties are available.

Other issues: Other worms similar to beet armyworms, such as yellowstriped armyworms, fall armyworms, corn ear worms, bud worms and boll worms, also infest pepper fields. Beet armyworms appear to be the most prevalent, however. Pepper fields may be infested with one or more species of worms. References to beet armyworms apply to these other worms as well. The area affected and yield loss estimates given here for beet armyworms refers to all worms in this category. *Cabbage loopers* are present in some pepper fields in the Trans-Pecos but they cause little damage.

Alternative chemicals: Other insecticides registered for control of chewing insects include: chlorpyrifos (24C) (Lorsban®) and cryolite (Kryocide®) for *pepper weevil* control; azinphos methyl (Guthion® and Sniper®), methamidophos (Monitor®), and naled (Dibrom®) for control of *leaf miners* and *flea beetles*; malathion for *flea beetle* control; methoxychlor (Marlate®) for control of *flea beetles* and *beet armyworms*; and lindane for control of *leaf miners, flea beetles*, and *beet armyworms*. Thiamethoxam (Actara®) could be used to control *pepper weevil* if it were registered. Given the zero tolerance policy of some pepper processors, there is a need for an effective insecticide to control *beet armyworms* that can be used close to harvest time. Registration for tebufenozide (Confirm®), which currently has a Section 18 approval, is needed despite its high cost.

Table 3: Chemicals for Control of Chewing Insects.*						
Pesticide	**% A Trt.**	**Type of Appl.**	**Typical Rate/A**	**Timing**	**# of Appl.**	**Efficacy**
Carbaryl (Sevin®)	50	foliar	4L 1.5 pt, 50W 1.5 lb, 80W 1 lb	At seedling stage or as needed based on scouting	2	poor to good
Target insects	flea beetles, stink bugs, leaf hoppers					
Oxamyl (Vydate®L)	10	foliar	2-4 pt	At seedling stage or as needed based on scouting	2	good to excellent
Target insects	pepper weevil, leaf miners, aphids					
Permethrin (Ambush®, Pounce®)	25	foliar	25WP 6.4-12.8 oz	At seedling stage or as needed based on scouting	2	good
Target insects	pepper weevil, flea beetles, beet armyworms, leaf miners, aphids, white flies					
Esfenvalerate (Asana® XL)	30	foliar	8 fl oz	At seedling stage or as needed based on scouting	2	good to excellent
Target insects	pepper weevil, beet armyworms, flea beetles, aphids, thrip					
Cyromazine (Trigard®)	10	foliar	WSP 0.167 lb	At seedling stage or as needed based on scouting	2	good to excellent
Target insects	leaf miners					
Abamectin (Agri-Mek® 0.15EC)	8	foliar	0.75 pt	Mites - at first appearance Leaf miners - when adults are first observed	2	good to excellent
Target insects	leaf miners, broad mites, spider mites, aphids					
Endosulfan (Thiodan®)	6	foliar	3EC 0.66-1.33 qt	At seedling stage or as needed based on scouting	1.5	Good
Target insects	pepper weevil, leaf miners, aphids, broad mites					
Bacillus thuringiensis (Biobit® HP)	10	foliar	0.5-1 lb	At seedling stage or as needed based on scouting	2	poor to good
Target insects	beet armyworms, corn earworms					
Tebufenozide (Confirm®)[1]	30	foliar	8-16 fl oz	From bloom to harvest	2	good to excellent
Target insects	beet armyworms					
Spinosad (SpinTor® 2SC)[2]	NA	foliar	beet armyworms 6-8 fl oz, leaf miners 4-8 fl oz	At seedling stage or as needed based on scouting. Application should be timed to coincide with peak egg hatch in species without overlapping generations.	NA	NA
Target insects	beet armyworms, leaf miners, thrips					
Cyfluthrin (Bathroid®)	NA	foliar	2EC 1.6-2.8 fl oz	At seedling stage or as needed based on scouting	NA	good
Target insects	pepper weevil					

*Also see Table 1: Chemicals for Control of Sucking Insects.

Note: Growers alternate the use of several of these insecticides throughout the season to prevent pest resistance.

[1]One pint of Latron CS-7 per 100 gallons of spray mixture or a similar spreader-binder is recommended to maximize coverage and distribution of the spray material.

[2]Control of leaf miners and thrips may be improved by addition of an adjuvant to the spray mixture.

NA-Information is not available.

IPM management: There are complex IPM problems in peppers. Many growers scout their fields to check for severity of insect populations and spray only when populations reach damaging levels. Bt and tebufenozide (Confirm®) are pest-specific and only kill the pest without creating any more problems. Methomyl (Lannate®) and esfenvalerate (Asana®) are moderate on beneficial insects. Esfenvalerate (Asana®) can be used at a low rate to kill worms at 3 to 4 days of age. This is less harmful to beneficial insects and it will leave some aphids as food for the beneficial insects. Oxamyl (Vydate®) is harder on beneficials and is used in rescue situations where aphid infestation is severe. Carbaryl (Sevin®) is fairly hard on beneficial insects and is not used later in the season when more beneficial insects are present. Cyromazine (Trigard®), dicofol (Kelthane®), avermectrin

(Agrimek®), bacillus thuringiensis (Bt) and cyfluthrin (Baythroid) are also important insecticides in a pepper IPM program.

Use in resistance management: Resistance is more of a problem in the Lower Valley than in the other primary pepper growing areas of the state because insects are abundant. Some growers use Bt for specific targets to reduce chances of resistance. Spraying for pepper weevil can cause outbreaks of leaf miners and beat armyworms but rotating with oxamyl (Vydate®), permethrin (Ambush®) and chlorpyrifos (Lorsban®) for pepper weevil control can help prevent large outbreaks of leaf miners.

Bacterial Diseases

Bacterial leaf spot (*Xanthomonas campestris pv. vesicatoria*)

Frequency of occurrence: *Bacterial leaf spot* is present annually in some pepper fields and less often in others. It is more likely to appear and is more severe in wet years. In the Lower Valley, it is seen more in the fall crop than the spring crop.

Damage caused: *Bacterial leaf spot* causes small, yellowish green to brown spots to develop on both foliage and fruit. Under weather conditions favorable to the disease, the spots become numerous and sometimes grow together into large spots. Infected leaves turn yellow and fall off.

Percent acres affected: An estimated 50 percent of the state pepper acreage is affected by *bacterial leaf spot*.

Pest life cycle: *Bacterial leaf spot* is primarily seed-borne. Infected seed serves as a source of infection to emerging seedlings. It starts in certain areas of the field and spreads from plant to plant when the leaves get wet. Splashing from rains or sprinkler irrigation can spread the organism from diseased to healthy plants in the field. The pathogen can survive for a few months on infected crop residue.

Timing of control: It is best to apply control for *bacterial leaf spot* before it is brought on by wet weather or overhead sprinkler irrigation. Growers should keep an eye on the weather conditions and start treatment before a wet spell if at all possible. Otherwise, treatment should be made when the disease is first observed. Some growers treat weekly with copper when dews and light rains occur or when using overhead sprinkler irrigation. Treatment is usually made when growers are irrigating heavily and plants are heavy with foliage.

Yield losses: An estimated 60 percent yield loss can occur when *bacterial leaf spot* is present in the pepper field and not controlled.

Regional differences: *Bacterial leaf spot* can be a serious problem in all of the major pepper production regions of the state.

Cultural control practices: A key to *bacterial leaf spot* prevention is the use of disease-free seed. Center pivot with LEPA drag hoses help avoid spread of the disease and furrow irrigation is preferable to overhead sprinkler irrigation. Proper crop rotation and site selection are also significant factors in preventing disease. Avoid fields with a history of disease problems and destroy crop residues and weeds before planting.

Table 4: Chemicals for Control of Bacterial Disease.

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.	Efficacy
Copper (Kocide® 101)	50	foliar	2-3 lb	Before a wet spell, when there is wet weather, when disease is observed; repeat every 5-10 days as needed.	2	good
Target diseases	bacterial leaf spot					
Copper + Sulfur (Basicop® WP)	5	foliar	2-4 lb	Apply early leaf stage; repeat at 10-14-day intervals as needed, or immediately after rain.	1	fair, about 70%control
Target diseases	powdery mildew, bacterial leaf spot					

Note: Ground applications are more effective than air applications.

Biological control practices: Genetic resistance to *bacterial leaf spot* may be available in certain types of peppers, however, most of the common green pepper types are susceptible.

Alternative chemicals: Since there are so few chemicals available to control pepper diseases and bacterial leaf spot resistance to coppers has been documented, some growers have expressed an urgent need for more fungicide labels to more effectively and economically control pepper diseases, especially bacterial leaf spot. They believe it would be very helpful to have a systemic fungicide available.

Maneb (Manex® F) and mefenoxam + copper (Ridomil Gold Copper®) are registered to control bacterial leaf spot. Trifloxystrobin (Flint®) and acibenzolar-s-methyl (Actigard®) are not labeled for peppers but may be effective for bacterial leaf spot control. Actigard gives good control against bacterial leaf spot on tomatoes but may stunt or have other possible negative effects on peppers. Actigard® activates the plants' systemic acquired resistance.

IPM management: Scouting is the key element in IPM management for bacterial diseases. It is important to watch the weather for signs of rain and dew. When wet weather is about to occur or occurs and when symptoms of bacterial diseases are noticed, growers can treat with copper. Copper is not toxic and, therefore, is a good IPM pesticide.

Fungal Diseases

Phytophthora blight (*Phytophthora capsici*), **damping off** (*Rhizoctonia, Pythium* spp.), **southern blight** (*Sclerotium rolfsii*), **powdery mildew** (*Leveilluia taurica*), **alternaria**

Frequency of occurrence: *Phytophthora blight* is present annually in some pepper fields in the state. It is more prevalent in wet years and can be bad if the peppers are over-irrigated. *Phytophthora blight* is more likely to develop when heavy rains of 2 to 3 inches occur at a time but less likely to occur when rains are light at 1/2 inch. *Phytophthora blight* can be present in both bell and non-bell peppers. It is more common in the fall crop than the spring crop in the Lower Valley.

Damping off may occur annually in many pepper fields and every 2 to 3 years in others. It normally occurs after rain and when the soil stays cool and damp during the time the plants are starting to grow. *Southern blight* occurs annually in the Lower Valley. *Powdery mildew*, which is only a problem in non-bell peppers, may occur annually in some fields. Occurrence of *alternaria* is sporadic.

Damage caused: Plants with *phytophthora blight* may be girdled at the base, which causes sudden wilting and death of the plant. Diseased parts of the stem show a dark green, water-soaked band extending from the soil line to several inches up the stem. This band later turns brown and the plant dies. When peppers are furrow irrigated, sometimes a single infected row is observed in the field. This is because the fungus is carried by water down the furrow from a diseased plant, causing infection and death of several plants in the same row.

Damping off causes small, emerging seedlings to wilt and die soon after emergence. Root systems of surviving plants are damaged, resulting in stunted plants and poor yield.

Southern blight attacks the stem of the plant at or near the soil line, causing the plant to wilt and die. A white, cottony growth is observed on the surface of the stem. Later, pink to brown bodies resembling radish seed appear in the fungal growth.

Percent acres affected: An estimated 20 percent of Texas pepper acreage is affected by *phytophthora blight* and 10 percent by *powdery mildew*. Less than 10 percent is affected by *damping off* and *southern blight*.

Pest life cycle: *Phytophthora blight* is caused by a fungus that lives in the soil and may be carried in seed. Infection usually takes place at the soil line.

Timing of control: Apply control for *powdery mildew* before it occurs. It can be brought on by wet weather or even overhead sprinkler irrigation. It usually appears about midseason before the first harvest but is severe enough to require treatment only about 1 out of every 5 years.

Yield loss: Estimated yield loss is around 20 percent when *powdery mildew* is present in the pepper field. It is about 15 percent with *phytophthora* or *damping off* and less than 5 percent with *southern blight*.

Regional differences: *Phytophthora blight* is more common in the Lower Valley and the Trans-Pecos than in other pepper production areas of the state. *Damping off* is more common in the High Plains. *Southern blight* is more common in the Lower Valley. *Powdery mildew* is a minor problem in the High Plains and the Lower Valley. *Alterneria* occurs in the Lower Valley.

Cultural control practices: Planting fungicide-treated seed on a raised bed and avoiding excessive moisture in the plant bed are the best means of controlling *phytophthora blight*. Proper crop rotation is important in disease prevention. *Damping off* develops in cool soil, so avoid over irrigation or water logging and use windbreaks to help prevent it. Crop rotation and deep plowing are means of controlling *southern blight*. Soil fungicides may be helpful where *southern blight* has been a problem in the past.

Biological control practices: There are some resistant cultivars available.

Chemical controls: Planting treated seed is the primary chemical control practice used by growers to control these fungi diseases. Captan and thiram are used for seed treatment. Mefenoxam (Ridomil Gold®) is registered for control of *damping off* and quintozene (Terraclor®) for *southern blight* control but there is little evidence of grower use of these products. Sulfur and benomyl are used for *powdery mildew* control.

Alternative chemicals: Propamocarb hydrochloride (Tattoo®) and dimethomorph (Acrobat®) could be used for *phytophthora blight* control but they are not registered for use in peppers. Azoxystrobin (Quadris®) and B.s. QST 713 strain (Serenade®) are not labeled for peppers but may be effective for *powdery mildew* control. Myclobutanil (Nova 40 W) has Section 18 approval for *powdery mildew* control.

Table 5: Chemicals for Control of Fungal Diseases.

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.	Efficacy
Sulfur (Sulfur® 90W)	10	foliar	3-5 lb	Apply early leaf stage; repeat at 10-14-day intervals as needed, or immediately after rain.	4	fair, about 70% control
Target diseases	powdery mildew					

Note: Ground applications are more effective than air applications.

Viruses

Tobacco erch virus, tobacco mosaic virus, pepper mottle, potato virus Y, tomato spotted wilt, curly top, cucumber mosaic virus

Frequency of occurrence: Viruses occur annually in many pepper fields of the state but they vary in strain and severity from field to field and year to year.

Damage caused: Young leaves of affected plants show a greenish-yellow mottle and may be curved and irregular in shape. Under severe infection, leaves curl upward and are bunched, very small and discolored. This results in stunted plants with a bunched appearance. Fruits are small, abnormal in shape and of poor quality. Severe infection can result in the complete failure of the crop.

Percent acres affected: An estimated 35 percent of statewide pepper acreage is affected by viruses.

Pest life cycles: Several viruses are known to attack peppers. Often plants are infected by a combination of viruses rather than by a single strain. Viruses overwinter in perennial weeds and are transmitted by aphids from the weeds to healthy plants in the fields. Environmental conditions favoring aphid multiplication and migration into the field will result in severe outbreaks of virus diseases.

Timing of control: There are no effective chemical controls.

Yield losses: Estimated yield loss is around 45 percent when viruses are present.

Regional differences: Viruses are a major problem in the Lower Valley, a moderate problem in the High Plains and a small problem in Trans-Pecos.

Cultural control practices: Keep fields clean of weeds around the edges and turn rows and control insects to help reduce the spread of viruses. When pepper plants are infected with viruses early in the season the damage is more severe than when larger plants are infected later in the season. Therefore, early control of vectors such as aphids and thrips is important.

Biological control practices: Resistant pepper varieties are now available in limited supply. County Extension agents are good sources of information on currently used varieties.

Chemical controls: There are no chemical controls for viruses.

Nematodes

Root knot nematode (*Meloidogyne* spp.) (Root knot nematode is the most common type of nematode, and the only type discussed here.)

Frequency of Occurrence: Nematodes are present annually in some pepper fields. They occur in hot spots in the field and are not spread evenly across the field.

Damage Caused: Above-ground symptoms are similar to many other root diseases or environmental factors that limit water and nutrient uptake. Symptoms consist of wilting during periods of moisture stress, stunted plants, chlorotic or pale green leaves, and reduced yields. Most characteristic symptoms, however, are those that occur on underground plant parts. Infected roots swell at the point of infection and form knots or galls. Several infections may occur along the same area, resulting in large fleshy galls. The appearance of galls will depend in part upon the host and the nematode species involved. Infected roots are retarded in growth and lack fine feeder roots. Rotting of roots may develop late in the season and, as a result, the pepper fruit will be smaller. Fields with nematode problems have plants of uneven height because nematode-damaged plants are stunted while healthy plants are taller. This makes the field uneven and difficult to harvest with a mechanical harvester.

Percent acres affected: An estimated 10 percent of statewide pepper acreage is affected by nematodes. Nematodes are more likely to be a problem in sandier soils.

Pest life cycle: The average life cycle of nematodes is 25 days. The infectious stage of the root knot nematode is the second stage larva that occurs free in the soil (the larva has already molted once in the egg). The second stage larva penetrates the plant at or near the root tip and become sedentary. An enzyme is released that causes the plant cells surrounding the head region to enlarge, forming giant cells that serve as a source of nourishment for the parasite. Female nematodes swell until they become pear-shaped or oval. During this time, the nematode undergoes two more molts. Females begin laying eggs around 20 days after penetration of the host, laying an average of approximately 30 eggs per day for 2 weeks. Populations will build up rapidly when environmental conditions are favorable.

Timing of control: If a soil test for nematodes is positive, nematicides should be applied 3 weeks to 1 month before planting seed or setting transplants.

Yield losses: Nematodes may cause an estimated 50 percent yield loss within the area of the field in which they are present.

Regional differences: Nematodes can be found in all pepper-producing areas of the state.

Cultural control practices: Select planting sites free of nematode infestations. The soil should be tested for nematode presence months before planting to give growers sufficient time to fumigate or select another site if nematodes are present. Growers should follow a 3- or 4-year crop rotation program with resistant crops. Most cereal crops are fairly resistant. Although impractical in some instances, dry summer fallow with cultivation every 3 to 4 weeks is an effective method of reducing nematode populations.

Alternative chemicals: Oxamyl (Vydate®) and other nematicides are sometimes used. They do not kill plants like dichloropropene does.

Table 6: Chemicals for Control of Nematodes.

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.
Dichloropropene chloropicrin (Telone C)	5	soil injected	10-15 gal.	3 weeks to 1 month before planting	1
Target pests	nematodes				

Note: Dichloropropene kills every living thing, including plants.

Broadleaf Weeds

Pigweed (*Amaranthus* spp.), **purslane** (*Portulaca oleracea*), **lamb's-quarters** (*Chenopodium album*), **sunflower** (*Helianthus annuus*), **morningglory** (*Ipomoea* spp.), **nightshade** (*Solanum* spp.), **field bindweed** (*Convolvulus arvensis*), **woolly leaf bursage** (*Ambrosia grayi*), **cocklebur** (*Xanthium strumarium*), **devil's-claw** (*Proboscidea louisianica*), **flower-of-an-hour** (*Hibiscus trionum L.*), **ironweed** (*Vernonia* spp.), **kochia** (*Kochia scoparia*), **tumbleweed** (*Salsola iberica*)

Frequency of occurrence: Weeds are an annual problem in peppers and are more abundant in wet years. Most weeds occur yearly but not in all areas of the state.

Damage caused: Weeds reduce yields by competing with pepper plants for space, sunlight, water and nutrients. Weeds interfere with harvest and act as alternate hosts for diseases, nematodes and insects. As an example, *pigweed* can get 6 to 7 feet tall and can cause almost a total crop loss by bogging down mechanical harvesters. The perennial *field bindweed* also presents a problem with the mechanical harvester. The vinelike *field bindweed* is often found in pockets in the field where it can grow over the pepper plants and choke them out.

Percent acres affected: The estimated percent pepper acreage affected statewide by the individual weeds is *pigweed*, 70; *purslane*, 40; *sunflower*, 20; *tumbleweed*, 15; *morningglory*, 12; *lamb's-quarters*, 11; *cocklebur*, 7; *devil's-claw*, 7; *nightshade*, 4; *field bindweed*, 4; *flower-of-an-hour*, 4; and **woolly leaf bursage**, 3 percent. No estimate was available for *ironweed* and *kochia*.

Pest life cycles: *Pigweed, purslane, sunflower, cocklebur, devil's-claw* and *tumbleweed* are native annual warm season weeds; *lamb's-quarters, flower-of-an-hour* and *kochia* are introduced annual warm season weeds; *ironweed* and *woolly leaf bursage* are native perennial warm seasos weeds; *field bindweed* is an introduced perennial warm season weed; and *morningglory* and *nightshade* are native (introduced) annual (perennial) warm season weeds.

Timing of control: Herbicide applications can be made preplant, post-plant when weeds are young, and in spot treatments as needed throughout the growing season.

Yield losses: The following estimated yield loss percentages are caused by weeds if not controlled: *morningglory*, 60 percent; *pigweed*, 55; *nightshade*, 50; *flower-of-an-hour*, 50; *woolly leaf bursage*, 50; *purslane*, 40; *sunflower*, 30; *tumbleweed*, 25; *lamb's-quarters*, 20; *ironweed*, 18; *cocklebur*, 5; and *devil's-claw*, 5 percent.

Regional differences: *Pigweed, lamb's-quarters, purslane, morningglory* and *sunflower* invade pepper fields in the High Plains and the Lower Valley. *Purslane* is the biggest weed problem for Lower Valley pepper growers. *Nightshade, cocklebur, devil's-claw, flower-of-an-hour, tumbleweed, woolly leaf bursage* and *field bindweed* are more common in High Plains pepper fields than in the other areas. *Ironweed* and *kochia* are more common in the Trans-Pecos.

Cultural control practices: It is important to select sites without a history of *morningglory*, *nutsedge* and *field bindweed*. Peppers should be planted on the best land possible and rotated every 4 years–1 year peppers and 3 years a legume or grain crop but not cotton. Many major weeds are common to both peppers and cotton, but are easier to control in cotton because of its larger canopy. These weeds can become a problem when peppers are planted after cotton. Peppers are generally hand-hoed at least once during the season. Some growers will cultivate before the pepper plants get too tall and stiff. Weed problems are minimal with drip irrigation compared to furrow irrigation. Some bell pepper growers use plastic mulch but it is generally not cost effective on non-bell peppers. Some growers plant a small thin nurse crop to protect the seeds from being blown away and just before the pepper plants come up they spray glyphosate, fluazifop-p-butyl (Fusilade® DX), or sethoxydim (Poast®) to kill the nurse crop.

Many growers use a shielded or hooded sprayer to apply glyphosate (Roundup®) or trifluralin (Treflan®) during the growing season. The hood or shield covers the furrow and pushes the pepper plant out of the spray path. In some fields with a history of weed problems, growers apply glyphosate in the winter. According to one of the primary pepper growers in the Lower Valley it is very difficult to economically control *purslane*.

Alternative herbicides: Trifluralin is registered for preplant applications in transplanted peppers but not direct seeded peppers. However, an effort is underway to get trifluralin cleared for preplant use in direct seeded peppers. Pyrithiobac (Staple®) is used in cotton and gives good control of late *pigweed* and other weeds and would possibly be good for use in peppers. Oxyfluorfen (Goal®) is cleared for use on peppers in New Mexico but not in Texas.

Use in resistance management: Pigweed is beginning to show some resistance to trifluralin. Growers can rotate with paraquat (Gramoxone Extra®) if the weeds are showing resistance to glyphosate (Roundup®).

Table 7: Chemicals for Control of Broadleaf Weeds.

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.	Efficacy
Trifluralin (Treflan® 4EC)	35	soil & side dress	1 pt	Transplants - preplant incorporate. Direct seeded - pre-emergence, or layby when the pepper plants are about 4 inches tall.	1	good
Target weeds pigweed and all broadleaf and grass weeds						
Bensulide (Prefar® 4E)	20	soil	4-6 qt	Preplant incorporated or preemergence	1	poor to good
Target weeds pigweed, lamb's-quarters, other broadleaf weeds, some grass weeds						
Napromamide (Devrinol® 2E)	40	soil	0.5-1 gal	Preplant incorporated or preemergence	1	poor to good
Target weeds pigweed, other broadleaf weeds, some grass weeds						
Glyphosate (Roundup® 4WS)	65	weed foliage, hooded sprayer	0.75-3 pt annuals, 1-10 pt perennials, 2% solution spot treat	Apply preplant, preemergence, layby with hooded sprayer, and spot treatment as needed during growing season. Avoid contact with pepper plants.	1	good to excellent
Target weeds all weeds, broadleaves and grasses						
Paraquat (Gramoxone Extra® 2.5L)	15	weed foliage	1.25 pt	Apply preplant or preemergence, for burn down just before emergence, best on smaller weeds 1-6 inches tall.	1	good to excellent
Target weeds all weeds, broadleaves and grasses						
Clomazone (Command® 4EC)	15	soil	0.5-2 pt	Apply preplant or preemergence	1	NA
Target weeds	many weeds, broadleaves, grasses					

NA-Information is not available.

Grasses and Sedges

Johnsongrass (*Sorghum halepense*), **bermudagrass** (*Cynodon dactylon*), **Texas panicum** (*Panicum texanum*), and **nutsedge** (*Cyperus* spp.)

Frequency of occurrence: Grasses and sedges occur annually in fields where they have been present in the past. *Yellow nutsedge* is more common than *purple nutsedge*. *Nutsedge* is not widespread but it can be a problem because it responds well to irrigation.

Damage caused: Grass and sedge weeds, like broadleaf weeds, reduce yields by competing with the pepper plants for space, sun, water and nutrients. They also interfere with harvest and act as alternate hosts for diseases, nematodes and insects. *Johnsongrass* causes a serious problem with mechanical harvesting.

Percent acres affected: An estimated 23 percent of Texas pepper acreage is affected by *nutsedge*, 20 percent by *johnsongrass*, 15 percent by *bermudagrass*, and 10 percent by *Texas panicum*.

Pest life cycles: *Yellow nutsedge* is a native perennial warm season weed; *purple nutsedge*, *bermudagrass*, and *johnsongrass* are introduced perennial warm season weeds; and *Texas panicum* is a native annual warm season weed.

Timing of control: Growers apply herbicides for grass and sedge control before planting, after planting when the weeds are small, and with spot treatments as needed throughout the season.

Yield losses: If not controlled *nutsedge* (yellow or purple) can cause an estimated 40 percent loss in yield; *johnsongrass*, 35 percent; *Texas panicum*, 30 percent; and *bermudagrass*, 5 percent.

Regional differences: *Bermudagrass* is a problem in the Lower Valley and the Trans-Pecos. It is a small problem in some areas of the Trans-Pecos while in other areas it is the biggest weed problem and difficult to control. *Johnsongrass* and *nutsedge* are moderate problems in the High Plains and the Lower Valley. *Texas panicum* is a moderate problem in the Lower Valley and a small problem in the High Plains.

Cultural control practices: Site selection and proper crop rotation are important weed control practices. If possible, growers should avoid planting peppers in fields that have a history of *nutsedge* problems. Nutsedge is not a big problem in cotton because of canopy shading and less irrigation, but it may be a problem in peppers that follow cotton.

Table 8: Chemicals for Control of Grasses and Sedges.

Pesticide	% A Trt.	Type of Appl.	Typical Rate/A	Timing	# of Appl.	Efficacy
Sethoxydim (Poast® 1.5EC)	15	foliar	0.5-1.5 pt	Postemergence, early season, when pepper plants are about 6" tall, as needed.	1	good to excellent[1]
Target weeds	bermudagrass, johnsongrass, Texas panicum					
Fluazifop-p-butyl (Fusilade® DX)	5	foliar	0.375-1.5 pt	Postemergence, early season, apply to actively growing grasses	1	NA
Target weeds	bermudagrass, johnsongrass, Texas panicum					
Metolachlor[2] (Dual Magnum®)	5	soil, foliar, or layby	0.5-1 pt	Transplanted - pre-transplant surface broadcast or broadcast within 48 hours after transplanting. Direct seeded - apply layby at the 8-leaf stage when pepper plants are about 4" tall	1	fair to good
Target weeds	nutsedge and broadleaf weeds					

[1]Efficacy reports were good to excellent in the High Plains but the only efficacy report from the Trans-Pecos gave sethoxydim a poor rating saying that it just retards the weeds.

[2]Metolachlor is registered for use on bell peppers but the registration on non-bell peppers is pending. However, it currently has a 24(c) Special Local Need Registration which includes non-bell peppers. The higher rates are recommended for silt and clay soils and the lower rates for coarse, sandy soils.

NA - Information is not available.

Growers control weeds with cultivation early in the season when the pepper plants are small. Cultivation can damage the pepper crop when the plants are taller because the stems are stiff and the cultivator may cause them to break. Most growers hire a crew to hand-hoe the peppers at least once in the growing season. Some hand-hoe more often and some use plastic mulch. Plastic mulch is generally not cost effective with non-bell pepper types.

Alternative chemicals: Pyrigthiobac (Staple®) may be good for *nutsedge* control but it is not labeled for peppers and it is low on the U.S.D.A.'s Interregional Research Project # 4 (IR-4) list for pursuing pesticide labels.

FQPA, Statistic, Economic and Efficacy Summary

Organophosphates, carbamates, organochlorines and pesticides on the Environmental Protection Agency's B2 carcinogen list are said to be the most risky pesticides and those which EPA intends to evaluate first under the Food Quality Protection Act (FQPA). Therefore, uses of these pesticides may be in the greatest jeopardy of being withdrawn or reduced. In this publication, these pesticides are referred to as FQPA target pesticides. One-third (11 of 33) of the pesticides listed in this crop profile that are used in Texas pepper production are FQPA target pesticides. Eight are insecticides (methomyl, acephate, dimethoate, dicofol, carbaryl, oxamyl, and diazinon), two are fungicides (benomyl and dichloropropene), and one is a herbicide (bensulide).

An average of 6.1 insecticide applications are applied to Texas pepper fields per crop season from a tool bag of 18 different chemicals, eight of which are FQPA target pesticides. Fungicide applications average 1.6 per season from five different chemical products, two being FQPA target pesticides. An average of 2.2 herbicide applications are made with one of the nine different products being an FQPA target pesticide. Insecticide applications provide an estimated overall 83 percent control of target pests, fungicides control 57 percent, and herbicides control 83 percent.

Overall estimated yield loss attributed to insect damage given the presence of insects and no control is 64 percent, it is 57 percent from diseases and 100 percent from weeds. Estimated cost of insecticide insect control (product plus application cost) is $105 per acre; fungicide disease control cost is $22 per acre and herbicide weed control cost is $50 per acre. Therefore, total estimated cost of pesticide control is $177 per acre. Assuming an estimated average crop value of $2,590 per acre for peppers produced in Texas, estimated pesticide pest control costs are 6.8 percent of the total crop value.

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