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Texas Crop Profile

SPINACH

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This profile on spinach production in Texas gives an overview of basic commodity information; discusses insect, disease and weed pests; and covers cultural and chemical control methods.

Basic Commodity Information—1996-98 Average

State Rank: ....Second in total U.S. production.
Percent U.S. Production: ....50 percent
Acres Planted: 10,000
Acres Harvested: 9,000
Cash Value: $11,000,000
Yearly Production Costs: ....$600 per acre

Commodity Destination

Seventy (70) percent of the crop is processed; 30 percent goes to fresh market.

Production Regions

The Winter Garden (southwest of San Antonio) produces the majority of the Texas crop. Other production areas are the Lower Rio Grande Valley (McAllen-Harlingen) and the Plains area surrounding Lubbock.

Cultural Practices

Spinach grows well under cool, dry conditions. Fresh market varieties such as Samish, Fall Green and Coho are direct seeded into well-drained loamy soils fertilized at a rate of approximately 120 pounds of nitrogen, 75 pounds phosphorus and 80 pounds potassium (N-P-K) per acre. Seeding is at 5 to 10 pounds per acre, spaced three to six plants per foot of row. About 70 percent of the Texas spinach is the smooth-leaf varieties suitable for processing; the remainder is the fresh market savoy (crinkled leaf varieties). Frequently, Texas spinach is irrigated, with low to moderate demand, after each cutting.

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Pest Information

Insects

Common insect pests include aphids, crown maggots, cucumber beetles, a variety of foliage feeders and several soil insects.

Aphids

Frequency of occurrence: In Texas, aphids are an occasional pest of spinach in 1 out of 4 years and will be a problem throughout the growing season. Much of the damage from aphids is contamination where insect parts are found in the finished product.

Damage caused: Aphids contaminate spinach by causing quality and yield reductions. Primary damage is from feeding in the crown of plants and from the production of honeydew that provides a medium for mold growth. Mold not only retards growth, but contaminates processed and fresh market spinach. Aphids also are vectors for beet western yellows and cucumber mosaic viruses.

Percent acres affected: Once in a typical 4-year period, approximately 80 percent of Texas spinach acreage will have aphid problems.

Pest life cycles: Aphids can overwinter in the egg stage, but adults often are a season long spinach problem. Aphids began life either by hatching from an egg, or by live birth from a stem mother. A life cycle can be completed in 4 to 5 days during warm weather but may stretch to longer periods if cooler temperatures prevail.

Timing of control: Aphid control measures are generally initiated in spinach when numbers reach one to two aphids per leaf. However, as harvest nears, a fewer number of aphids can be tolerated. When insecticides are needed, the choice of control options will be limited by the registered product's "preharvest interval." Parasites and predators play a important role in suppressing aphid populations.

Yield losses: Aphids damage spinach through yield and quality reduction. Heavy aphid infestations can cause load rejection at the processing facility and large numbers also can reduce tonnage. Too much leaf crinkling caused by aphid feeding may dictate that the harvested spinach be designated to product with a lower value.

Regional differences: Aphids generally attack spinach statewide.

Cultural control practices: Reducing weed populations, applying insecticides and planting alternative host plants near spinach fields can help reduce aphid levels.

Biological control practices: Parasitic wasps, syrphid flies and lady beetles are effective aphid parasites and predators. However, immature beneficial insects in spinach at harvest are considered a contaminant and subsequently are considered pests. Aphid diseases that may occur during wet weather can play a major role in reducing populations.

Other issues: Insect control in other crops can affect aphid numbers in spinach. Synthetic pyrethroid use can trigger an aphid buildup.

Table 1: Aphid Chemical Controls.

Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Imidacloprid (Provado®)	60	air	3.7 oz.	Apply when one to two aphids per leaf or 250 aphids per foot of row. Aphids in crown of plant can trigger treatment.	3
Use in IPM Programs:	Use of wrong chemical, such as pyrethroid, can cause aphid buildup.				

Table 2: Aphid Control Alternatives.

Alternative	Efficacy
Dimethoate (Dimethoate)	Tank mixed with Thiodan will help control thrips.
Endosulfan (Thiodan®)	Use of Thiodan early in spinach crop can prevent need for pyrethroids. Only useful prior to first cutting because of 21-day preharvest interval. Not as effective as Provado, but is more effective against Lepidopterous pests.

Crown maggots

Frequency of occurrence: About 30 percent of the Texas spinach acreage each year is affected with crown maggots.

Damage caused: Crown maggots attack the plant crown, preventing regrowth, and cause black smutty leaves, which reduces grade.

Percent acres affected: In any given year, approximately 30 percent of the Texas spinach acreage will be damaged by crown maggots.

Pest life cycles: Crown maggots are the immature stage of a fly. They are very similar to the seed corn maggot. Crown maggots are attracted to seedling crowns covered with soil splashed by rains and to decaying spinach residue left from the first cutting. This habitat attraction plus the short life cycle mean that subsequent generation immatures can easily invade second cutting spinach.

Timing of control: Treat immature crown maggots when there is an average of one larvae per 100 plants. It is possible to predict potential maggot outbreak by observing humidity and organic matter levels.

Yield losses: Crown maggot damage reduces yield of second cutting as much as 50 percent. Often, harvest must be early to prevent further crown maggot damage.

Regional differences: Crown maggots are a problem in the Texas Winter Garden and in the lower Rio Grande Valley.

Cultural control practices: Planting on raised beds to reduce soil splash during rains and reducing plant residue after the first and second cutting are helpful cultural control practices for crown maggots.

Biological control practices: Fire ants can help reduce crown maggot numbers but fire ants are affected by chemical applications directed at other pests.

Postharvest control practices: There are none.

Cucumber Beetles

Frequency of occurrence: Cucumber beetles are common in spinach fields but become a problem at harvest.

Damage caused: Beetle adults contaminate the processed and fresh market material and feeding damage lowers fresh market quality.

Percent acres affected: About 50 percent of the Texas spinach crop each year will be affected by the cucumber beetle.

Pest life cycles: Cucumber beetles are green oblong-oval *Coleoptera* that are about 5 mm long and have wings that are marked with 12 black spots. Females lay oval orange-yellow eggs in clusters of 25 to 50 on the undersides of leaves. The beetle larvae are about 10 mm long and have a yellow-white, somewhat wrinkled body with three pairs of brownish legs near the head. Pupae are white, tinged with yellow and 6 to 8 mm long.

Timing of control: Cucumber beetles must be controlled to prevent feeding damage and prior to harvest to prevent contamination of processed spinach.

Table 3: Chemical Controls for Crown Maggot.

Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Methomyl (Lannate®)	48	ground	1.5 pts.	Apply after first cutting, when maggots are found.	1
Use in IPM Programs:	Use of chemical should be avoided because of secondary pest outbreaks.				
Resistance Management:	Possible alternative to carbamate.				
Efficacy Issues:	Poor efficacy. Efficacy rating of 3 on a scale of 1 to 5 where 1 is excellent control.				

Table 4: Crown Maggot Control Alternatives.

Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Permethrin (Ambush®)	5	ground	12.8 oz.	Apply postemergence.	2
Efficacy Issues:	Poor efficacy. Efficacy rating of 4 on a scale of 1 to 5 where a 1 is excellent control.				

Table 5: Chemical Controls for Cucumber Beetle.					
Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Permethrin (Ambush®)	40	air	0.10 lb. a.i./acre	Usually only needed at first cutting.	1
Use in IPM Programs:	Use of pyrethroid can cause pest outbreak.				

Table 6: Cucumber Beetle Control Alternatives.	
Cypermethrin (Ammo®)	Highly efficacious. Efficacy rating of 1 on a scale of 1 to 5 where a 1 is excellent control.

Yield losses: Cucumber beetles cause no direct yield reduction but losses occur when spinach cannot be processed because of contamination.

Regional differences: Cucumber beetles are most often a problem in the Lower Rio Grande Valley and Winter Garden areas of Texas.

Cultural control practices: Prevent beetle movement from alternative hosts into the crop.

Biological control practices: Some control occurs from natural parasites and predators, but there are no practical biological controls.

Foliage Feeders

Frequency of occurrence: Foliage feeding insects are an annual problem.

Damage caused: These insects damage foliage by feeding, but more importantly they contaminate the crop at processing.

Percent acres affected: All (100 percent) of the Texas spinach crop each year is affected.

Pest life cycles: Foliage feeders are *Lepidopterous* insects that spend part of the life cycle as a larva or worm. Adults are winged and often are not found with the crop. Adults lay eggs that hatch into larvae, the feeding stage. Larvae pupate most often in the soil or occasionally on leaves before becoming adults. Most crop damage is done by immatures or larvae.

Timing of control: Harvest commonly occurs 30 days after planting, typically at 16-leaf stage. It is important to control larvae in early instars rather than the last instar because larger larvae are harder to kill.

Yield losses: Foliage feeders can reduce yields 20 percent, but a 100 percent loss is possible if the load is contaminated.

Regional differences: Foliage feeders are common across all regions. The lower Rio Grande Valley often may have more armyworms than other areas.

Cultural control practices: Trap crops and the elimination of alternative hosts near fields can help prevent pest outbreaks. Plants are mechanically shaken during harvest to dislodge any insects clinging to leaves. Timing of harvest with respect to cold fronts can substantially influence crop contamination from *Lepidopterous* larvae.

Biological control practices: Use *Bacillus thuringiensis* (Bt) materials aggressively.

Postharvest control practices: Good crop sanitation and washing plant material destined for fresh market or processing can help clean the commodity that is contaminated with insects and insect parts.

Other issues: Consumer demand for a high quality, noninsect contaminated food dictates the control philosophy.

Table 7: Chemical Controls for Foliage Feeding Insects.					
Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Methomyl (Lannate®)	70	air	2 pts. per acre	Apply postemergence.	1.5

Table 8: Alternative Controls for Foliage Feeding Insects.	
Alternative Efficacy	
Bt (Bacillus thuringiensis)	Marginal effectiveness against the fall armyworm and the beet armyworm. Slightly more effective against the cabbage looper (50 to 70 percent control).
Tebufenozide (Confirm®)	Effective against fall armyworm and beet armyworm but moderately effective against the cabbage looper.
Spinosad (Spintor®)	Works well against fall armyworm and beet armyworm but is slightly less effective against the cabbage looper.
Thiodicarb (Thiodicarb)	May be used as a primary material for fall armyworm control but is not as effective as methomyl. Good control against the cabbage looper.

Soil Insects

Frequency of occurrence: Soil insects are annual pests in Texas spinach. Since 1990, ants have also become annual pests. Other soil pests are cutworms, white grubs and wireworms.

Damage caused: Soil insects destroy young spinach plants, roots and stems

Percent acres affected: All (100 percent) of the Texas spinach crop is affected annually.

Pest life cycles: Pests will have several life cycles in 1 year. Their occurrence is most critical in stand establishment and in one-leaf and two-leaf plants.

Timing of control: It is important to make control applications at planting.

Yield losses: High yield loss can result if soil insects are not controlled. Losses can be in the range of 80 to 90 percent.

Regional differences: Soil insects are especially important in the Winter Garden area.

Cultural control practices: Crop rotation is an important pest management tool.

Biological control practices: After seedling stage, fire ants may be a possible biological control agent but this is not documented.

Postharvest control practices: Rotate crops.

Other issues: It is important to only suppress fire ants during crop emergence and establishment so surviving ants can provide a measure of aphid control later in the season.

Fungi

Blue mold (downy mildew)

Frequency of occurrence: This is a serious disease of spinach and a major limiting factor in Texas spinach production.

Damage caused: Blue mold reduces yield by infesting host leaves, affecting quality, retarding growth, and, under favorable environmental conditions, making the crop unsuitable for harvest.

Percent acres affected: Fifty (50) percent of the acreage is affected.

Pest life cycles: Multiple races of downy mildew are known to occur; races 3,4 and 5 currently are the most common. Downy mildew sporangia can germinate directly or release zoospores. Lesions appear on the host 6 to12 days after infection. Initial innoculum may develop from infected seed. Conditions that favor development are high humidity and a temperature of 60 degrees F to 80 degrees F.

Table 9: Chemical Controls for Soil Insects.

Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Diazinon (Diazinon)	95	ground	6 pts.	Important to apply at planting.	1
Use in IPM Programs:	Good for temporary control of fire ants. Need fire ants later in season to control aphids and other leaf feeding pests.				

Table 10: Alternative Soil Insect Control.

Alternative	Efficacy
Permethrin (Ambush®)	Good material for controlling soil insect pests such as cutworms, but not effective against the broad spectrum of spinach soil insect pests.

Table 11: Chemical Controls for Blue Mold.					
Pesticide	**% Acres Treated**	**Type of Appl.**	**Typical Rates**	**Timing**	**# of Appl.**
Mefenoxam (Ridomyl Gold®)	100	ground	10 lbs. per acre	Apply at planting	1
Use in IPM Programs:	Use in conjunction with resistant varieties, field site selection, sanitation and other fungicides.				
Resistance Management:	Must be used with other management practices to reduce risk of mefenoxam tolerance.				
Copper	50	air	0.5 to 1.0 lb. a.i. per acre	Apply mid and late season.	3
Use in IPM Programs:	Use on processed spinach only (visible residues unacceptable on fresh market spinach).				
Resistance Management:	Must be used with other management practices to reduce risk of mefenoxam tolerance.				

Table 12: Blue Mold Control Alternatives.	
Alternative	**Efficacy**
Better resistant varieties	Efficacious but need fungicide treatments.

Timing of control: It is important to apply fungicides prior to disease development and plant currently available resistant varieties of spinach.

Yield losses: Heavy yield losses can occur when susceptible varieties of spinach are not treated.

Regional differences: Blue mold is more important in humid wet conditions associated with rain and overhead irrigation.

Cultural control practices: Proper selection of genetically resistant varieties is the key to successful spinach production and can minimize pesticide use. Race-specific resistance is used mostly where white rust disease does not occur. Race-non-specific resistance (partial resistance) is used mostly in the Winter Garden where white rust is the most important disease.

Biological control practices: There are none available.

Postharvest control practices: Proper field sanitation after each harvest to remove infected older leaves from the plant can reduce innoculum available for subsequent pest outbreaks.

Other issues: Pathogen adaptation to race-specific resistant varieties has increased the need for chemical disease control.

Leaf spot (*anthracnose*)

Frequency of occurrence: Anthracnose is an annual problem.

Damage caused: Anthracnose causes spotting on spinach leaves, which reduces quality.

Percent acres affected: Approximately 10 percent of Texas spinach acreage is affected by anthracnose each year.

Pest life cycles: The spores depend upon infected seed and water to spread and cause infection. Warm and humid rainy weather at frequent intervals is necessary for disease development.

Timing of control: Apply fungicide prior to disease infection when favorable conditions prevail.

Yield losses: Anthracnose can cause yield losses up to 25 percent.

Regional differences: Anthracnose is more of a problem where prolonged leaf wetness and high humidity prevail.

Cultural control practices: Crop rotation and proper field sanitation are important cultural control practices.

Biological control practices: There are none available.

Postharvest control practices: Field sanitation is critical. Flip plowing can be a useful cultivation technique to bury infected crop debris.

Other issues: There are currently no registered alternative control compounds.

Table 13: Anthracnose Chemical Controls.					
Pesticide	**% Acres Treated**	**Type of Appl.**	**Typical Rates**	**Timing**	**# of Appl.**
Copper (Top Cop®)	10	air	2 qts. per acre	Apply after crop emergence in areas known to have leaf spot problems.	1
Use in IPM Programs:	None available.				
Resistance Management:	Resistant varieties could provide a margin of protection from leaf spot problems.				

Leaf spot (*Cercospora*)

Frequency of occurrence: Cercospora leaf spot is not a major pest of spinach statewide, but can be very damaging in local situations.

Damage caused: Cercospora leaf spot causes lesions (3 to 5 mm in size) on older spinach leaves. During periods of warm temperatures and high humidity or leaf wetness, tan necrotic spots on lower leaves will turn gray and lower quality or make the leaves unmarketable.

Percent acres affected: Approximately 50 percent of Texas spinach acreage is affected.

Pest life cycles: Heavily influenced by environmental conditions, the causal organism of cercospora leaf spot, *Cercospora beticola*, produces conidiophores of varying sizes from stomata. Carried by the wind, infected seed and splashed by rain, conidia enter host leaves and begin the disease cycle. Crop residue is a major source of disease innoculum.

Timing of control: Apply a foliar fungicide when favorable disease conditions exist. These conditions include warm temperatures, high humidity, leaf wetness and a field history of cercospora problems. Fresh market fields usually are not sprayed because visible evidence of copper remains on leaves.

Yield losses: A 5 percent cercospora infestation can eliminate the first spinach cutting in fall and early winter fresh market fields.

Regional differences: Cercospora leaf spot is more of a problem in South Texas and the Winter Garden than the Panhandle.

Cultural control practices: Crop rotation and residue destruction are major defenses against cercospora leaf spot. Late fall planting can lower risk.

Biological control practices: There are no known biological controls for cercospora leaf spot.

Postharvest control practices: There are no postharvest control practices for cercospora in spinach.

Other issues: There is no good foliar fungicide choice for use on crops intended for fresh markets. Currently, there are no registered alternative products available.

Table 14: Chemical Controls for Cercospora.					
Pesticide	**% Acres Treated**	**Type of Appl.**	**Typical Rates**	**Timing**	**# of Appl.**
Sulfur + copper (Top Cop® w/sulfur)	5	air/ground	2.5 lbs. per acre	Use as a field foliar application.	1
Copper (Kocide®)	1	air/ground	1 lb. to 2 lbs. per acre	Apply prior to disease development.	1
Use in IPM Programs:	Fungicides also help control white rust, blue mold and perhaps anthracnose.				
Resistance Management:	Cercospora has been know to develop fungicide resistance in other cropping situations.				
Efficacy Issues:	Copper cannot be used on fresh market spinach because fungicide residue is difficult to wash off.				

White rust

Frequency of occurrence: White rust is an annual problem in spinach and is considered the most damaging spinach disease.

Damage caused: Initial outbreaks of white rust often follow hard rains. Plants infected with the white rust fungus are weak and collapse quickly under warm, humid or wet conditions. Free moisture on a leaf surface is the key to rust spore germination and development

Percent acres affected: White rust is a problem in 100 percent of the Texas spinach acreage.

Pest life cycles: White rust disease development forms blister-like pustules primarily on the lower side of plant leaves. In advanced stages, white lesions form on the upper side of the leaf. Generally, however, the upper surface of the leaf will only be chlorotic. Optimum temperature for sporulation is 54 degrees F and development is most rapid at 72 degrees F or during periods of cool, humid nights and mild day temperatures.

Timing of control: Important treatment times are at planting and immediately after hard rains. Field selection for long rotations is also important.

Yield losses: Uncontrolled white rust can cause a total spinach crop failure.

Regional differences: White rust usually is more damaging in the Winter Garden and Lower Rio Grande Valley.

Cultural control practices: Long rotations, planting on beds and furrow irrigation are important cultural control practices. Early harvest may be necessary to preserve quality before the disease can advance.

Biological control practices: There are none currently available

Postharvest control practices: Plow down fields immediately after last harvest to reduce air borne and soil borne fungal spores.

Other issues: White rust is not a problem in the western United States, nor is it a problem outside the United States. It is a serious problem in the eastern and southern United States.

Table 15: Chemical Controls for White Rust.

Pesticide	% Acres Treated	Type of Appl.	Typical Rates	Timing	# of Appl.
Mefenoxam (Ridomyl Gold®)	100	soil (5G formulation)	10 to 20 lbs. formulation per acre	Apply at planting.	1
Use in IPM Programs:	Important to use in conjunction with spinach varieties known to be resistant to white rust.				
Resistance Management:	Using mefenoxam in combination with other control practices such as resistant varieties and cultural practices can lessen resistance development. Processing spinach can be treated with copper.				
Efficacy Issues:	Often requires follow-up foliar fungicide applications with foliar copper.				
Copper sulfate/sulfur (Top Cop®)	80	air	2 qts. per acre	Treat before disease becomes established.	
Efficacy Issues:	Efficacies enhanced by resistant varieties.				

Table 16: White Rust Control Alternatives.

Alternative	Efficacy
Copper hydroxide	Mefenoxam fungicide application at planting to reduce disease pressure makes foliar applications more effective.

Table 17: Chemical Controls of Annual Grasses.				
Pesticide	**% Acres Treated**	**Type of Appl.**	**Timing**	**# of Appl.**
Metolachlor (Dual®)	100	ground	Apply at planting	1
Use in IPM Programs:	Use where history of problem weeds occur.			
Resistance Management:	Generally not an issue. Rotate herbicide with rotational crops.			

Weeds

Annual Grasses

Frequency of occurrence: Annual grasses germinate during the warm fall and again in the spring when soils begin to warm.

Damage caused: Weeds reduce spinach yield by severe competition and can lower grade by contaminating processed material.

Percent acres affected: Weeds are a serious problem in 100 percent of Texas spinach.

Pest life cycles: Annual grasses germinate and grow when soils are warm. These weeds are stimulated by irrigation.

Timing of control: Preemergence herbicides are applied at planting after the preplant cultivation is completed.

Yield losses: Sixty (60) percent or more yield loss can occur in spinach if annual grasses are not controlled.

Regional differences: There are no regional influences.

Cultural control practices: Rotate fields when possible to summer annual crops where grass herbicides (i.e. trifluralin) can be used more effectively.

Biological control practices: No biological control options are available.

Postharvest control practices: Spot spray problem areas with herbicides like glyphosate.

Other issues: Grass weeds are severe contaminates in processed spinach. There are currently no alternative controls for annual grass control in Texas spinach

Winter annual broadleaf weeds

Frequency of occurrence: Winter annual broadleaf weeds are a constant problem in Texas spinach.

Damage caused: Reduced yield is caused by weed competition and grade reduction occurs when foreign plant parts contaminate the finished product.

Percent acres affected: All of the Texas spinach acreage has a problem with winter annual broadleaf weeds.

Pest life cycles: Winter annuals, such as mustard, germinate in the fall, grow throughout winter and go to seed in the spring.

Timing of control: Preplant and preemergence weed management are critical because the harvested product must be weed free.

Yield losses: Product contamination is an important consideration. Heavy weed competition can hamper or prevent stand establishment.

Regional differences: There can be as much as a month's difference in the onset of the growing season between north Texas and south Texas.

Cultural control practices: Cultivation is an important weed control tool. Off-season weed management helps reduce potential weed problems for the following growing season.

Biological control practices: There are no known biological control practices.

Postharvest control practices: Spinach sold for both fresh market and processing must be free from contamination by foreign matter.

Other issues: Dual, for the sixth year in 1999, had a Section 18 registration for use on spinach in Texas. There is no current Section 3 label. Users must complete a Waiver of Liability and Indemnification Certificate before being allowed to purchase and use the product. There are currently no alternative controls for winter annual broadleaf weeds.

Table 18: Winter Annual Broadleaf Chemical Controls.					
Pesticide	**% Acres Treated**	**Type of Appl.**	**Typical Rates**	**Timing**	**# of Appl.**
Metolachlor (Dual®)	90	ground	2 lbs. a.i. per acre in Winter Garden and 1 lb. in other approved areas	Application information varies per the Section 18 guidelines.	1
Use in IPM Programs:	Used to manage weeds in spinach. No currently registered alternative.				
Resistance Management:	Currently not aware of any resistance issues.				
Efficacy Issues:	In Winter Garden, rate varies depending on irrigation methods. One preemergence application at 1 lb. a.i. under sprinkler and 2 lbs. a.i. under furrow irrigation.				
Sethoxidim (Poast®)	15	ground	1.5 to 3.0 pts.	Avoid applications when temperatures exceed 90º F or when relative humidity exceeds 60 percent.	1
Use in IPM Programs:	Apply when susceptible weeds appear or begin to be a problem.				
Efficacy Issues:	Erratic control often occurs when weeds are stunted or stressed from drought, high temperatures, or low fertility				

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Produced by AgriLife Communications and Marketing, The Texas A&M University System
Texas AgriLife Extension publications can be found on the Web at: http://AgriLifebookstore.org

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas AgriLife Extension Service, The Texas A&M University System.
Revision