Crop Profile for Spinach in Texas

Prepared: July, 1999
Revised: May, 2003

General Production Information

State Rank: 2

Per Cent U.S. Production: 50%

Acres Planted: 10,000

Acres Harvested: 9,000

Cash Value: $11,000,000

Yearly Production Costs: $600/Acre

Production Regions: The Texas spinach growing regions are the Winter Garden (Southwest of San Antonio near Uvalde), the Lower Rio Grande Valley (McAllen-Harlingen) and the Pan Handle (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 120-75-80 pounds (N-P-K) per acre. Seeding is at 5-10 lbs. per acre, spaced 3-6 plants per foot of row. About 70 percent of the Texas spinach are the smooth-leaf varieties for processing, the remainder are the fresh market savoy or crinkled leaf varieties. Texas spinach is often watered with low to moderate irrigation demand often occurring after each cutting. A majority of the Texas crop is grown in the Winter Garden.

Worker Considerations: For labor considerations spinach, an annual crop, is grown from seed and harvested as leaves. Worker activities can be divided into two general categories: those operating equipment and those that come into direct contact with growing plants(field workers). The potential for
pesticide exposure would be greatest with the field worker group; i.e. hand harvesting and scouting (consultants). Equipment operators generally do not come in direct contact with a crop. The only spinach that is hand harvested is for fresh market where workers manually cut and pack plant material in the field. Consultants scout spinach for the presence and subsequent abundance of harmful pest. Field scouting begins at planting and continues weekly through harvest and is accomplished by individuals walking through fields examining plants at random for pests.

Commodity Destination(s):
Processing: 70%
Fresh Market: 30%

Insect Pests

Aphids

Frequency of Occurrence: Aphids are an occasional pest of Texas spinach, generally occurring in 1 out of 4 years and when they occur, are a potential pest throughout the growing season. Much of the damage is contamination of finished products.

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

Percent Acres Affected: Approximately 80% of the Texas Spinach acreage has aphid problems in a typical four year period.

Pest Life Cycles: Aphids can overwinter in the egg stage, but it is the adult that is a season long spinach problem. Aphids begin life either by hatching from an egg, or by live birth from a stem mother. A life cycle can be completed in 4-5 days during warm weather but may stretch to longer periods if cooler temperatures prevail.

Timing of Control: Aphid control measures are generally initiated when numbers reach 1-2 aphids per leaf. However, as harvest nears, fewer numbers of aphids can be tolerated. When insecticides are needed, the choice of control options will be limited by the registered products "pre-harvest interval". Parasites and predators play an 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 can also reduce tonnage. Too much leaf crinkling caused by aphid feeding may dictate that the harvested spinach be designated to a product with a lower value.

**Regional Differences:** Aphids generally attack spinach statewide.

**Cultural Control Practices:** Reducing weed populations, insecticide applications and alternative host plants near spinach fields can help reduce aphid levels.

**Biological Control Practices:** Parasitic wasp, syrphid flies and lady beetles are effective aphid parasites and predators. However, even beneficial insect immatures in spinach at harvest are considered a contaminant and then subsequently are considered pests. Aphid diseases can play a major role in reducing populations during wet weather.

**Other Issues:** Insect control in other crops can affect aphid numbers in spinach. Synthetic pyrethroid use can trigger an aphid build up.

**Aphid Chemical Controls:**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>%/A Treat.</th>
<th>Appl Type</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Imidacloprid</em> (Provado)</td>
<td>60</td>
<td>air</td>
<td>3.7 oz</td>
<td>About 1-2 aphids per leaf or 250 per foot of row. Aphids in crown of plant can trigger treatment.</td>
<td>3</td>
</tr>
</tbody>
</table>

**Use in IPM Programs:** Use of wrong chemical, such as pyrethroid, can cause aphid buildup.

**Aphid Alternatives:**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate (dimethoate)</td>
<td>Tank mix with thiodan will help control thrips.</td>
</tr>
<tr>
<td>Thiodan (endosulfan)</td>
<td>Use of thiodan early in spinach crop can prevent need for pyrethroids. Only useful prior to first cutting because of 21 day PHI. Not as effective as provado, but is more affective against Lepidopterous pest.</td>
</tr>
</tbody>
</table>
**Crown Maggots:**

**Frequency of Occurrence:** About 30% of the Texas spinach acreage each year is affected with crown maggots.

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

**Percent Acres Affected:** Approximately 30% of the Texas Spinach acreage will be damaged by crown maggots.

**Pest Life Cycles:** Crown maggots are the immature stage of a fly very similar to the seed corn maggot. Most seed corn maggot infestations begin when adults are attracted to seedling crowns that have been covered with soil splashed onto the plants by rain and to decaying first cutting spinach residue. Following this initial infestation a short life cycle allows the pest to develop large numbers that subsequently 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 crown maggot outbreak when high humidity is coupled with an abundance of organic matter.

**Yield Losses:** Crown maggot damage reduces as much as 50% of a second cutting in spinach. Further loss takes place when growers must harvest a crop early to prevent further crown maggot damage.

**Regional Differences:** Crown maggots are a problem in the Texas Winter Garden and the lower Rio Grand Valley.

**Cultural Control Practices:** Raised beds to reduce soil splash during rains and reducing plant residue after the first and second cuttings are helpful cultural control practices for crown maggots.

**Biological Control Practices:** Fire ants can help reduce crown maggot numbers but are often limited by chemical applications directed at other pests.

**Post-Harvest Control Practices:** None

**Crown Maggots Chemical Controls:**
### Crown Maggot Alternatives:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Methomyl</em> (Lannate)</td>
<td>48</td>
<td>ground</td>
<td>1.5 pints</td>
<td>After first cutting, when maggots are found.</td>
<td>1</td>
</tr>
</tbody>
</table>

**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 1-5 where 1 is excellent control.

### Cucumber Beetles

**Frequency of Occurrence:** Cucumber beetles are common in spinach fields, but only 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% of the Texas Spinach will be affected by the cucumber beetle.

**Pest Life Cycles:** Cucumber beetles are green, oblong Coleoptera that are about 5 mm long with 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 3 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.

**Yield Losses:** No direct yield reduction, but losses can result because of spinach that cannot be processed due to contamination.

**Regional Differences:** Aphids are most often a problem in the Lower Rio Grande Valley and Winter Garden areas of Texas.

**Cultural Control Practices:** Preventing beetle movement from alternative host by either removing this host material or controlling beetles on alternative host.

**Biological Control Practices:** There is some control from naturally occurring parasites and predators, but no practical biological controls.

### Cucumber Beetles Chemical Controls:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% Trt.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permethrin</td>
<td>40</td>
<td>air</td>
<td>.10 lb. ai/a</td>
<td>Usually only a problem in first cutting.</td>
<td>1</td>
</tr>
<tr>
<td><em>(Ambush)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use in IPM Programs: Use of a pyrethroid can cause a non-target pestout break.

**Cucumber Beetle Alternatives:**

<table>
<thead>
<tr>
<th>Cypermethrin</th>
<th>Highly efficacious. Efficacy rating of 1 on a scale of 1-5 where a 1 is excellent control.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(Ammo)</em></td>
<td></td>
</tr>
</tbody>
</table>
Foliage Pest

(Foliage pests include insects that actually feed on foliage and the presence of adults and immatures in the processed commodity)

**Frequency of Occurrence:** Foliage pest are an annual problem in Texas spinach.

**Damage Caused:** Aphids damage foliage, but more importantly, they contaminate crop at processing.

**Percent Acres Affected:** One hundred percent.

**Pest Life Cycles:** Foliage feeders are Lepidopterous insects that spend part of their life cycle as a larva or worm. Adults are winged and often not found directly associated with crop. Adults lay eggs that hatch into larvae, the feeding stage, which frequently pupate in the soil or occasionally on leaves before becoming adults. The damaging stage is most often immatures or larval stage.

**Timing of Control:** Thirty days after planting (6 leaf stage) is common treatment time for leaf feeding spinach pests. Spinach is typically harvested at 16 leaf stage. It is important to control larvae in early instars rather than later instars because larger larvae are harder to kill.

**Yield Losses:** Foliage pests can reduce yield 20% but can cause 100% loss if a load is contaminated

**Regional Differences:** Foliage feeders are common across 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 often 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 Bt materials aggressively

**Post-Harvest Control Practices:** Crop sanitation and washing plant material destined for fresh market or processing can help clean commodity contaminated with insects and insect parts.

**Other Issues:** Consumer demand for a high level non-insect contaminated food dictates control philosophy.

**Foliage Pest Chemical Controls:**
<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% Trt.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cypermethrin</td>
<td>35</td>
<td>air</td>
<td>2.5-5 oz</td>
<td>post emergence</td>
<td>1</td>
</tr>
<tr>
<td>(Ammo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>spinosad</td>
<td>95</td>
<td>air/ground</td>
<td>4-10 oz</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>methomyl</td>
<td>70</td>
<td>air</td>
<td>2 pints</td>
<td>post emergence, preferred</td>
<td>1.5</td>
</tr>
<tr>
<td>(Lannate)</td>
<td></td>
<td></td>
<td></td>
<td>material near harvest</td>
<td></td>
</tr>
</tbody>
</table>

**Foliage Feeders Alternatives:**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>Marginal effectiveness against the fall armyworm and the beet armyworm. Slightly more effective against the cabbage looper (50-70% control).</td>
</tr>
<tr>
<td>(Bacillus thuringensis)</td>
<td></td>
</tr>
<tr>
<td>tebufenozide</td>
<td>Affective against fall armyworm and beet armyworm but moderately affective against the cabbage looper.</td>
</tr>
<tr>
<td>(Confirm)</td>
<td></td>
</tr>
<tr>
<td>Spinosad</td>
<td>Works well against fall armyworm and beet armyworm but slightly less effective against the cabbage looper.</td>
</tr>
<tr>
<td>(Spintor)</td>
<td></td>
</tr>
<tr>
<td>thiodicarb</td>
<td>May be used as a primary material for fall armyworm control but not as effective as methomyl. Good control against the cabbage looper.</td>
</tr>
<tr>
<td>(Thiodicarb)</td>
<td></td>
</tr>
</tbody>
</table>

**Soil Insects**

**Frequency of Occurrence:** Soil insects are annual pests in Texas spinach. Ants have become annual pests since 1990; other soil pests are cutworms, white grubs and wireworms.
**Damage Caused:** Soil insects destroy young spinach plants, roots and stems.

**Percent Acres Affected:** One hundred percent

**Pest Life Cycles:** Many of the soil insects will have several life cycles in one year, but damage is most critical during stand establishment and at the crop's 1-2 leaf stage.

**Timing of Control:** Important to make control applications at planting.

**Yield Losses:** High yield loss if not controlled. Losses up to 80-90% range.

**Regional Differences:** Important in the Texas Winter Garden area.

**Cultural Control Practices:** Crop rotation is an important pest management tool.

**Biological Control Practices:** After seedling stage fire ants are a possible biological control agent, but this is not documented.

**Post-Harvest Control Practices:** Rotate crops

**Other Issues:** It is important to only suppress fire ants during crop emergence and establishment. This allows the ants to provide for critical early season aphid control.

### Soil Insects Chemical Controls:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A. Tret.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazinon</td>
<td>95</td>
<td>ground</td>
<td>6 pints</td>
<td>Apply at or just before planting incorporate.</td>
<td>1</td>
</tr>
<tr>
<td><em>(Diazinon)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use in IPM Programs:</td>
<td>Good for temporary control of fire ants. Need fire ants late in season to control aphids and other leaf inhabiting/feeding pest.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Use in IPM Programs:** Good for temporary control of fire ants. Need fire ants late in season to control aphids and other leaf inhabiting/feeding pest.

### Soil Insects Alternatives:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambush</td>
<td>Good material for controlling soil insect pest such as cutworms, but not affective against broad spectrum of spinach soil insect pest.</td>
</tr>
</tbody>
</table>

## Diseases

### Blue Mold (Downy Mildew)

**Frequency of Occurrence:** Downy mildew is a serious pest of spinach and a major limiting factor in Texas spinach production.

**Damage Caused:** Downy mildew reduces yield by infesting host leaves, a damage that affects quality, retards growth, and under favorable environmental conditions, makes crop unsuitable for harvest.

**Percent Acres Affected:** Fifty percent

**Pest Life Cycles:** Multiple races of downy mildew are known to occur with races 3, 4 and 5 currently the most common. Downy mildew sporangia germinate directly or release zoospores. Lesions appear on the host 6-12 days after infection. Initial innoculum may develop from infected seed. Favored conditions are 15-25 degrees centigrade and high humidity.

**Timing of Control:** It is important to apply fungicides prior to disease development and use currently available resistant varieties.

**Yield Losses:** On susceptible varieties heavy yield losses can occur when spinach is not treated.

**Regional Differences:** 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 Texas Winter Garden where white rust is the most important disease.

**Biological Control Practices:** None available.

**Post-Harvest 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 need for chemical disease control.

### Blue Mold Chemical Controls:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mefenoxam (Ridomyl Gold)</td>
<td>100</td>
<td>ground</td>
<td>10 lb.</td>
<td>At planting.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Use in IPM Programs:** Used in conjunction with resistant varieties, field site selection, sanitation and/or other fungicides.

**Use in Resistance Management:** Must be used with other management practices to reduce risk of mefenoxam tolerance.

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper</td>
<td>50</td>
<td>air</td>
<td>.5-1.0 lb ai/A</td>
<td>mid and late season</td>
<td>3</td>
</tr>
</tbody>
</table>

**Use in IPM Programs:** Used on processed spinach only (visible residues unacceptable on fresh market spinach)

**Use in Resistance Management:** Must be used with other management practices to reduce risk of mefenoxam tolerance.

### Blue Mold Control Alternatives:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better resistant varieties</td>
<td>Efficacious but need fungicide treatments.</td>
</tr>
</tbody>
</table>

### Leaf Spot (Anthracnose)

**Frequency of Occurrence:** Leaf spot is generally an annual problem in Texas spinach.

**Damage Caused:** Anthracnose fungi causes spotting on spinach leaves, reducing quality.

**Percent Acres Affected:** Approximately 10% of the Texas Spinach acreage is affected by anthracnose.
each year.

**Pest Life Cycles:** The spores depend upon infected seed and water for spread and 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:** Can cause yield losses up to 25%.

**Regional Differences:** More of a problem where prolonged leaf wetness and high humidity prevails.

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

**Biological Control Practices:** None available

**Post-Harvest Control Practices:** Field sanitation. Use of flip plowing can be a useful cultivation technique to bury infected crop debris.

**Leaf Spot Chemical Controls:**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper (top cop)</td>
<td>10</td>
<td>air</td>
<td>2 qts./acre.</td>
<td>Apply after crop emergence in area known to have leaf spot problems.</td>
<td>1</td>
</tr>
</tbody>
</table>

Use in IPM Programs: none available

Use in Resistance Management: Resistant varieties could provide a margin of protection from leaf spot problems.

**Anthracnose Leaf Spot Alternatives:**

There are currently no registered alternatives to the copper compounds.
Leaf spot (Cercospora)

**Frequency of Occurrence:** Cercospora leaf spot fungi is not a major state wide pest of Texas spinach but can be very damaging in local situations.

**Damage Caused:** Cercospora leaf spot causes 3-5 mm lesions 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:** Fifty percent of Texas spinach acreage is affected by cercospora leaf spot.

**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 began 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 are usually not sprayed due to visible evidence of copper on leaves.

**Yield Losses:** A 5% 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 also lower risk.

**Biological Control Practices:** There are no known biological controls for Cercospora leaf spot.

**Post-Harvest Control Practices:** There are no post-harvest control practices currently practiced for Cercospora in spinach.

**Other Issues:** While Cercospora leaf spot is not a major problem state wide in Texas spinach, in local situations it can be a serious pest due to no good foliar fungicide choice for fresh markets.
### Chemical Controls:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>sulfur + copper</td>
<td>5</td>
<td>air/ground</td>
<td>2.5 lb/A</td>
<td>Field foliar application.</td>
<td>1</td>
</tr>
<tr>
<td><em>(Top Cop w/sulfur)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>copper</td>
<td>1</td>
<td>air/ground</td>
<td>1-2 lbs</td>
<td>apply prior to disease development.</td>
<td>1</td>
</tr>
<tr>
<td><em>(Kocide)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Use in IPM Programs:
Fungicides also help control white rust, blue mold and perhaps anthracnose.

### Use in Resistance Management:
Cercospora has been known to develop fungicide resistance in other cropping situations.

### Efficacy Issues:
Copper can not be used on fresh market spinach because the fungicide residue is difficult to wash off.

### Cercospora Leaf Spot Alternatives:
There are currently no registered alternatives to the copper compounds.

### White Rust

**Frequency of Occurrence:** White rust fungi is an annual problem in spinach and is considered the most damaging Texas spinach disease.

**Damage Caused:** Initial outbreaks 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 one hundred 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 and in advanced stages will cause white lesions to form on the upper side of the leaf. Generally, however, the spinach upper surface will only be chlorotic. Optimum temperature for sporulation is 54° F. and development is most rapid at 72° 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:** Usually more damaging in the Winter Garden and Lower Rio Grande Valley areas of Texas.

**Cultural Control Practices:** Long rotations, planting on beds and furrow irrigation are important cultural control practices. Early harvest may be necessary to preserve quality prior to advancing disease development.

**Biological Control Practices:** Not available

**Post-Harvest Control Practices:** Plow down fields immediately after last harvest to reduce airborne and soil borne fungal spores.

**Other Issues:** White rust is not a problem in the Western States, nor outside the United States. It is a serious problem in the eastern and southern States.

**White Rust Chemical Controls:**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>mefenoxam</td>
<td>100</td>
<td>Soil (5G formulation)</td>
<td>10-20 lbs. formulation/acre</td>
<td>At planting.</td>
<td>1</td>
</tr>
<tr>
<td><em>(Ridomyl Gold)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use in IPM Programs: Important to use in conjunction with spinach varieties known to be resistant to white rust.
Use in 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 qt./acre Treat before disease becomes established.

Efficacy Issues: Efficacies enhanced by resistant varieties.

White Rust Alternatives:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Hydroxide</td>
<td>Mefenoxam fungicide application at planting to reduce disease pressure makes foliar applications more effective.</td>
</tr>
</tbody>
</table>

Weeds

Annual Grasses

Frequency of Occurrence: Annual grasses germinate during warm fall and again in the spring when soils warm up.

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

Percent Acres Affected: Weeds are a serious problem in one hundred percent of the Texas spinach.

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

Timing of Control: Pre-emergence herbicides are applied at planting after the preplant cultivation is completed.

Yield Losses: Sixty percent or more yield loss can occur in spinach if annual grasses are not controlled.
Regional Differences: Most of Texas commercial spinach is grown in the same area.

Cultural Control Practices: Rotate fields when possible to summer annual crops where grass herbicides can be used more effectively, i.e. trifluralin.

Biological Control Practices: No biological control options are available even though the potential probably exist.

Post-Harvest Control Practices: Spot spray problem areas with herbicides like glyphosate.

Other Issues: Grass weeds are severe contaminates in processed spinach.

Annual Grasses Chemical Controls:

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat.</th>
<th>Type of Appl.</th>
<th>Timing</th>
<th># of Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dual)</td>
<td>100</td>
<td>ground</td>
<td>at planting</td>
<td>1</td>
</tr>
</tbody>
</table>

Use in IPM Programs: Use where history of problem weeds occur.

Resistance Management: Generally not an issue. Rotate herbicide with rotational crops.

Annual Grasses Alternatives: There are currently no alternatives to Dual for annual grass control in Texas Spinach.

Winter Annual Broadleaf

Frequency of Occurrence: Winter annual broadleaf weeds are a consistent problem in Texas spinach.

Damage Caused: There is reduced yield caused by weed competition and grade penalties when foreign plant parts contaminating 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 and grow throughout winter
and go to seed in the spring.

**Timing of Control:** Preplant and pre-emergence weed management is critical because 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 difference in growing season onset from North Texas to South Texas.

**Cultural Control Practices:** Cultivation is an important weed control tool. Off season weed management helps reduce potential weed problems for a following growing season.

**Biological Control Practices:** No known biological control practices.

**Post-Harvest Control Practices:** Spinach sold for both fresh market and processing must be free from contamination by foreign matter.

**Other Issues:** Section 18 registration because there is no current section 3 label for winter annual broadleaf weeds in spinach. The Texas 2002 Dual/spinach Section 18 has been granted for nine consecutive years. Users must complete a Waiver of Liability and Indemnification Certificate before being allowed to purchase and use product.

**Winter Annual Broadleaf Chemical Controls:**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>% A Treat.</th>
<th>Type of Appl.</th>
<th>Typical Rates</th>
<th>Timing</th>
<th># of Appls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>metolachlor (Dual)</td>
<td>90</td>
<td>soil</td>
<td>2 lb. ai/acre in wintergarden and 1 lb. in other approved areas</td>
<td>Application information varies per the section 18 guidelines.</td>
<td>1</td>
</tr>
</tbody>
</table>

**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 Wintergarden area rate varies depending on irrigation methods. One pre-emergence application at 1 lb. ai under sprinkler and 2 lb. ai under furrow irrigation.

| **sethoxidim** (Poast) | 15 | ground | 1.5-3.0 pints | Avoid applications when temperatures exceed 90 F or when relative humidity exceeds 60% | 1 |

**Use in IPM Programs:** Apply when susceptible weeds appear or began to be a problem.

**Efficacy Issues:** Erratic control often occurs when weeds are stunted or stressed from drought, high temperatures, or low fertility.

**Winter Annual Broadleaf Alternatives:** There are currently no alternatives.

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