Texas Spinach Pest Management Strategic Plan

August 2007

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Executive Summary

A Pest Management Strategic Plan was developed for spinach grown in Texas during a workshop held on August 14, 2007 in Batesville, Texas. Participants included Extension personnel involved in the spinach industry, private growers, shippers, members of the Wintergarden Spinach Producers Board, IR-4 representatives, and corporate spinach production specialists. General information was provided to the group on the basis for PMSP development. Participants discussed major pests of spinach and the methods employed to manage those pests. The major focus of discussion centered upon the critical needs, or priorities, for research, regulatory, and education.

During the workshop it became clear that there are certain priorities that are critical to the sustainability and profitability of the spinach industry in Texas. **Regulatory** priorities that were of special concern to workshop participants included the necessity for finding a replacement for diazinon. Currently, diazinon is the only tool available to spinach growers to effectively control soil pests such as wireworms, grubs and fire ants. The inevitable loss of this tool due to reregistration will severely deplete the tools available to battle these critical pests. Another regulatory priority also concerns fire ants. The Texas spinach industry strongly supports product label changes that would allow the use of various fire ant bait products to be applied to fields commonly planted or rotated to spinach.

Workshop participants similarly identified **research** needs that are deemed critical to the viability of the Texas spinach industry. Among the most important of these include the need for a registered fungicide that can be applied to both fresh and processing spinach. The impetus behind this critical need is based on the production circumstances commonly encountered in spinach production. Due to a variety of factors, sometimes spinach that is planted with the intent to be delivered in the fresh market must in fact be used as processing material. Factors such as planting dates, climatic conditions, and marketing forces that are beyond the control of the producer may dictate that fresh market spinach instead be harvested and marketed for the processing market. As a result, the availability of an effective fungicide that is labeled for both fresh market and processing spinach would allow producers much greater flexibility and utilization of their investment.

Educational priorities were also a very important part of the discussion during the workshop. The availability of educational literature to growers that addresses vital information such as plant-back restrictions for various herbicides was deemed a critical need. Spinach growers in Texas commonly rotate the crop with various grain crops such as corn, grain sorghum, and wheat. While the number of registered herbicides available to spinach growers may be low, the number of herbicides labeled and used in corn, sorghum, and wheat is vast. This poses a challenge to spinach growers in that this large number of herbicides encompasses a variety of chemistries, modes of action, and persistence in the soil. For this reason spinach growers are in desperate need of educational materials that will clearly delineate the plant-back or rotational restrictions between commonly used herbicides and spinach.

Regulatory, Research, and Educational Priorities for Spinach

Regulatory Priorities

- Must have replacement for diazinon – critical for early season control of fire ant, wireworm, and grubs
- Need to amend fire ant bait labels to allow use in fields – application may need to be at destruction of previous crop - primarily corn – perhaps a bare ground treatment
- The development of glyphosate-tolerant sugarbeets is causing the loss of older products such as Spin-Aid and Nortron which are still important products for spinach growers
- Need to decrease harvest interval of Ridomil Gold from 21 d to 14 or 15 d
- Reduce PHI for Dual Magnum (24c) – primarily for fresh market

Research Priorities

- Need better herbicides to control troublesome broadleaf weeds such as purslane, Virginia copperleaf, London rocket, lambsquarter, shepherd's purse, and wild carrot – these weeds have become more prominent since the loss of Bladex and Lasso
- Need to evaluate alternative weed control chemistries for pre-plant incorporated, preemergence, and postemergence weed control
- Need research on disease management of Phytopthora rot
- Need fungicide that can be used on both fresh and processed spinach
- There is a distinct need for fungicides with alternate chemistry to the strobilurins
- Need more research on disease management tools for organic spinach production
- Need more research on weed management tools for organic spinach production
- Need research on disease management of black smutty rot – this disease is not only a processing problem – what effect does crop rotation have?

Education/Extension Priorities

- Need a handout listing plant-back restrictions for herbicides, particularly the sulfonylureas
- Need to maintain and preserve IPM agent and Extension Specialist positions working in vegetable production
- Need Extension publication on organic vegetable production; this publication should coincide with the National Organic Production (NOP) guidelines
  for example: address uncomposted N sources, lack of standardized labeling for organic products

List of Attendees at Spinach Pest Management Strategic Plan Meeting

August 14, 2007

Wintergarden Coop, Batesville, TX

Participant	Affiliation
Allen Mize	Del Monte Foods
Aaron Phillips	Del Monte Foods
Devin Kerstetter	Del Monte Foods
Edward Ritchie III	Tiro Tres Farms
Charlie Ritchie Jr.	Tiro Tres Farms
Kenneth White	Extension Agent – Retired
Mark Matocha	Texas AgriLife Extension Service

Background

The purpose of the Pest Management Strategic Plan is to assist growers and regulatory agencies to insure profitability in crop production by providing cost-effective pest management tools. Attendees of this workshop helped identify priorities and needs for spinach production in Texas. These priorities and needs have been categorized into research, regulatory, and extension.

The information in this plan will assist growers, researchers, extension personnel, and regulators to better understand the needs and priorities of spinach production in Texas. Also included in this document is specific information about the major pests associated with spinach and the current tools available for their control.

The development of a Pest Management Strategic Plan (PMSP) is a method of setting pest management priorities for a commodity and demonstrating stakeholder involvement in the process. The USDA's Office of Pest Management Policy (OPMP) developed the PMSP as a planning and priority setting process to facilitate a transition to alternative pest management practices when one or more pesticides used to manage pests on a crop are lost as a result of regulatory review. Land Grant University research and extension specialists or commodity organizations, often with the assistance of personnel from the USDA OPMP, facilitate the development of PMSPs. Growers, commodity representatives, land-grant specialists, food processors, crop consultants, and other stakeholders are generally involved in the process.

Ideally, a PMSP outlines the current state of pest management for a commodity at the state, regional, or national level and presents a prioritized list of needs for research, regulatory activity, and extension education to facilitate the transition to alternative pest management practices. The plans take a crop phenology and pest-by-pest approach to identifying and assessing the current management practices applied to an area. The stakeholders involved in the PMSP process also identify and prioritize their pest management research, regulatory and extension needs.

Pest Management

Pest management strategies have always been dependent on the knowledge that certain chemical intervention methods of pest control would be available as the need arose. A part of basic pest management research involves specific pesticide controls. Known chemicals would provide a specific level of control for each given pest as discovered through research. When pest counts reached treatable levels, known pesticides would provide a level of control for a certain period of time.

As different pesticides come on the market, research is needed to determine the level and duration of control that could be expected for each respective chemical. Additional research is needed to determine effects on non-target organisms. Chemical control agents have varying effects and these influences on natural controls ultimately impact pest management strategies.

The purpose of a pest management program is to achieve satisfactory long-range pest control through an integration of techniques that will maximize net profit to growers in a social, environmental and ultimately ecosystem compatible manner. A general understanding of a respective pest/host/crop interaction and the subsequent identification of pests and beneficials and definition of pest status would be important considerations in the early developmental phases of a sound pest management program. This objective is approached through the "integration" of various PM tools, generally with emphasis on preventive methods and preservation of natural control agents. Ideally, this objective is achieved with minimum chemical intervention. The integrated components include: regulatory, quarantines, cultural control, biological control, chemical control and education.

Regulatory

As noted, a pest management program or strategy first line of defense is often some form of chemical pest control. Regulations through label changes or product cancellation can limit or alter the availability of certain pest management tools and potentially have serious impact on the prevailing pest management strategy. The contemporary approach to pesticide regulation is for the regulatory community to pay very close attention to pest control needs in the field and thus insure as regulations are developed critical pest managements needs are not overlooked. This approach to pesticide regulation necessitates a very thorough understanding by the regulatory community of day to day field level pest problems. Communication between regulators, producers, commodity groups and research and agricultural education organizations are extremely important.

Worker Activities

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.

Hand hoeing is occasionally used as a weed control method in spinach and these workers are in contact with the crop. Spinach grown for processing is mechanically harvested. Therefore, workers generally do not come into direct contact with the crop. Fresh market spinach may be hand harvested in which case workers manually cut and pack plant material in the field. Consultants scout spinach for the presence and subsequent abundance of harmful pests. Field scouting begins at planting and continues weekly through harvest and is accomplished by individuals walking through fields examining plants at random for pests.

Production Information

Texas ranks fourth in the U.S. in the production of spinach. In 2006, Texas spinach producers harvested approximately 3,800 acres of spinach. This represented 2,200 acres of fresh market spinach and approximately 1,600 acres of spinach for processing. The majority of spinach production in Texas is concentrated in the Wintergarden area with limited production in the Lower Rio Grande Valley and the Plains Region.

Cultural Practices

Spinach prefers well-drained clay loam soils but will tolerate a wide range of loamy soils with pH range of 6.5 to 8.0. The optimum growing conditions are cool and dry weather with temperatures ranges of 65 to 75 degrees F daytime and 40 to 45 degrees F nighttime. Spinach will withstand freezing temperatures down to the lower 20s F.

Commercial spinach in Texas is direct seeded into soil with a temperature of less than 100 degrees F in the seed zone and/or day time air temperature is less than 95 degrees F. The seeding rate for processing spinach is 12-16 pounds per acre with the higher rate generally used when planting in high temperature soil. Plant spacing for processing spinach is 6 to 8 plants per foot of seed row, normally 2 to 4 seed rows per 40-inch raised bed. On 80-inch raised beds the population is adjusted to 4-6 plants per foot of seed row with a range of 12-21 seed rows per raised bed.

Fresh market spinach in Texas may be planted as 2 to 4 seed rows per 40-inch raised bed to provide 3 to 6 plants per foot. However, in order to produce baby leaf spinach, some Texas growers plant 15 to 30 seed rows per 80-inch wide bed with 1-to-2 inches in-row spacing. This planting method may result in seeding rates of 2 million seeds per acre.

Fertility practices usually followed include a generalized rate of 140-90-80. For nitrogen fertility, 80 to 100 pounds N is normally applied preplant plus 60 pounds side-dressed or injected into irrigation water after each cutting. Tissue analysis is generally used to determine supplemental N rates. For phosphorus fertility, 75 to 100 pounds is banded 2 inches below seed at planting. Higher rates of P_2O_5 may be used if recommended by soil testing. Potassium is not normally required in most spinach production areas of Texas.

Spinach has a low-moderate demand for irrigation. Generally 10 to 15 inches of water is required for proper plant growth and development. If soil moisture is low, irrigation is usually provided after each harvest cutting. Overhead sprinkler irrigation is not advised due to increased incidence of foliar diseases associated with this irrigation method.

Raised beds are recommended because spinach cannot tolerate waterlogged soil.

It is essential that the crop be destroyed immediately upon crop termination and that a 3 to 5 year rotation be observed to reduce white rust inoculum levels and help control white rust.

Insect Pests

Insect pests can cause significant yield and quality reduction in spinach. Serious pests include aphids, flea beetles, leafminers, beet armyworms, cabbage loopers, and grasshoppers. Cultural practices generally have little to moderate effect on insect populations. Because spinach is a high value crop with a low threshold for damage, beneficial insects are generally not as important in spinach as they are in some other crops. In Texas spinach production, by the time the beneficial insects bring pests under control the damage may have already been done.

Resistance management is a critical component of spinach insect management. Extension specialists and consultants recommend implementing an integrated pest management system. Since biological control is not as advantageous in spinach production as in other crops, other aspects of IPM become even more important. Activities such as scouting and rotation of insecticide mode of action are important elements of insect management in Texas spinach.

Aphids

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. 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.

To avoid destroying beneficial insect populations, delay insecticide applications for aphids. If aphid numbers increase dramatically due to early-season insecticide use, very little control will be obtained from insecticide application.

Controls

Cultural: When possible, prevent overlapping of spinach planting dates.

Biological: There are several natural enemies including syrphid flies, lacewings, and the predaceous midge, minute pirate bugs, bigeyed bugs, lady beetles (the adults and larvae of which both consume aphids), soldier beetles, and parasitic wasps like *Diaeretiella rapae.*

Chemical Controls:

Common name	Trade name	MOA Group
• Imidacloprid	(Admire, Provado)	4A
• Diazinon		1B

- Dimethoate		1B
- Acetamiprid	(Assail)	4A
- Pymetrozine	(Fulfill)	9B

Flea beetle

Damage Caused: Adult flea beetles cause the most damage by feeding on foliage, cotyledons, and stems. As flea beetles feed, they create shallow pits and small rounded, irregular, holes (usually less than 1/8th inch) in the leaves, resulting in a “shot hole” appearance. The damage is unique and similar for nearly all species. A heavy flea beetle attack can result in wilted or stunted plants. Heavily damaged leaves may completely dry out and die.

Controls

Cultural: Trap crops, such as mustard, may have some benefit.

Biological: The braconid wasp, *Microcotonus vittage* Muesebeck, parasitizes and kills the adult flea beetle.

Chemical controls:

- Bifenthrin	(Capture)	3
- Zeta-cypermethrin	(Mustang)	3
- Carbaryl	(Sevin)	1A

Leafminer

Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days eggs hatch and larvae feed between the upper and lower surface of the leaves, making distinctive winding, whitish tunnels or mines that are often the first clue that leafminers are present. Larvae emerge from the mines and pupate on the leaf surface or, more commonly, in cracks in the soil. Many generations occur each year and the entire life cycle can be completed in less than 3 weeks when the weather is warm.

Damage Caused: The larvae feed between the lower and upper leaf surfaces. Loss of foliage from heavy infestations may retard plant growth and reduce yield.

Controls

Cultural: Avoid planting adjacent to infested fields.

Biological: Parasitic wasps may offer some control of leafminers. Other parasites attack leafminers, but because leafminers feed within the leaf, they are protected from most predators.

Chemical controls:

- Cyromazine (Trigard) 17
- Spinosad (Spintor) 5

Beet Armyworm

Beet armyworms lay their eggs in distinctive cottony masses on leaf surfaces. Newly hatched beet armyworms are small, green worms that often feed in groups. Older beet armyworms vary in color, but usually have many fine, wavy, light-colored stripes down the back and a broader stripe down each side. The body appears hairless.

Damage Caused: Beet armyworms feed primarily on the buds and terminal growth of the spinach plant.

Controls

Cultural: Destroy fields immediately after harvest. Destroy or prevent weeds along field borders.

Biological: Many natural enemies attack these caterpillars. Among the most common parasites are wasps such as *Chelonus insulari*, and the tachinid fly, *Lespesia archippivora*.

Chemical controls:

- *Bacillus thuringensis* 11B2
- Methoxyfenozide (Intrepid) 18A
- Methomyl (Lannate) 1A
- Thiodicarb (Larvin) 1A
- Spinosad (Spintor) 5

- Indoxacarb (Avaunt) 22
- Chlorantraniliprole (Coragen) 28

Cabbage Looper

Cabbage loopers usually have a narrow, white stripe along each side and several narrow lines down the back. Eggs are dome-shaped and laid on the undersurfaces of older leaves.

Damage Caused: Cabbage looper feeding injury scarify the leaves and older larvae eat irregular shaped holes of various sizes. Loopers feed in the crown of the spinach plant and can severely stunt or kill seedlings. The potential for damage and contamination continue right up until harvest.

Controls

Cultural: Destroy fields immediately after harvest. Destroy or prevent weeds along field borders.

Biological: Many natural enemies attack loopers. Among the most common parasites are wasps such as *Chelonus insulari*, and the tachinid fly, *Lespesia archippivora*.

Chemical controls:

- *Bacillus thuringensis* 11B2
- Zeta-cypermethrin (Mustang) 3
- Permethrin 3
- Spinosad (Spintor) 5
- Indoxacarb (Avaunt) 22
- Chlorantraniliprole (Coragen) 28

Grasshopper – (Processing Spinach Only)

Damage Caused: These insects are particularly troublesome in processing spinach as a result of their unshakable presence. Although grasshoppers do not cause feeding damage on the leaves, they are a major contamination problem during harvest. Grasshoppers are a major problem especially when spinach is harvested at night or in cold weather because they tend to hold on tightly to harvest plants and will be shake off.

Controls

Cultural: If grasshopper populations are decimating a field, replanting is often the only option.

Biological: Birds such as crows, cat birds, bluebirds, mockingbirds, and sparrows are natural predators of grasshoppers. However, the presence of these vertebrates dramatically increases risk of microbial contamination and therefore are not encouraged in or around spinach fields.

Chemical controls:

- Zeta-cypermethrin (Mustang) 3
- Permethrin 3
- Methomyl (Lannate) 1A
- Malathion (Fyfanon) 1B
- Bifenthrin (Capture) 3 (Not preferred due to 40 d PHI)
- Carbaryl (Sevin) 1A (Not preferred due to 14 d PHI)

Efficacy ratings for insect management tools are listed in Table 1.

Toxicity ratings of insecticides to beneficial insects are listed in Table 4.

Diseases

Diseases can cause significant yield and quality reduction in spinach. Serious disease pests include white rust, pythium, downy mildew, cercospora leaf spot, viruses, and nematodes. Cultural practices can have a significant impact on the occurrence and severity of diseases in spinach.

Resistance management is a critical component of spinach disease management. Extension specialists and consultants recommend implementing an integrated pest management system. Cultural practices such as crop rotation are essential tools within a spinach integrated disease management system. Additionally, activities such as scouting and rotation of fungicide mode of action are also important elements of disease management in Texas spinach.

White rust

Frequency of Occurrence: White rust is an annual problem in spinach and is considered the most damaging Texas spinach disease. Losses are due primarily to reduction in quality and increased costs resulting from increased sorting time, and rejection of loads when the level of white rust is too high.

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. The disease appears as a small yellowish spot on the upper surface of the leaves. As these lesions develop, glassy white pustules form which eventually release spores. Tissue next to the pustules may turn brown. An entire leaf may become infected and die.

Controls

Cultural: Destroy fields (disking or plowing) immediately after harvest. This practice will reduce potential for white rust to increase within the field. Also, a three to five year rotation program with an unrelated crop is essential to reduce inoculum levels and help reduce white rust. There are some spinach varieties that have moderate resistance to white rust and may be used based on production requirements.

Biological: None.

Chemical controls:

Common name	Trade name	MOA Group
• Fixed copper		M
• Mefenoxam	(Ridomil Gold)	4

- Mefenoxam/Cu hydroxide (Ridomil Gold/Copper) 4 + M
- Azoxystrobin (Amistar) 11
- Pyraclostrobin (Cabrio) 11

Damping-off (Pythium)

Damage Caused: Pre-emergence damping off results in a brown, gelatinous rotting within the seed coat. Radicles and cotyledons may become brown and soft after germination, but fail to emerge. Water-soaked, greasy lesions may also form on hypocotyls and roots after emergence when infected with *Pythium* spp., causing plants to collapse and wither.

Controls

Cultural: Plant spinach in well-drained soils. Manage irrigation to avoid saturated conditions.

Biological: None.

Chemical controls:

- Mefenoxam (Ridomil Gold) 4

Downy mildew (blue mold)

Frequency of Occurrence: Downy mildew causes the greatest disease in cool, wet weather which are frequently the conditions experienced during typical spinach growing conditions in Texas. When ideal conditions are present, the disease can spread rapidly and significant yield loss can be incurred. Lesions occur primarily on the undersurface of leaves and when sporangia develop they have a bluish hue, giving rise to the name blue mold.

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.

Controls

Cultural: A three to five year rotation is recommended to reduce inoculums levels. There is some

Biological: None.

Chemical controls:

- Azoxystrobin (Amistar) 11
- Fosetyl-Al (Aliette) 21 (Not preferred- phytotoxicity)
- Mefenoxam/Cu hydroxide (Ridomil Gold/Copper) 4 + M
- Pyraclostrobin (Cabrio) 11

Cercospora leaf spot

Frequency of Occurrence: Leaf spots are primary pests, generally occurring annually in Texas spinach. Heavily influenced by environmental conditions, the causal organism, *Cercospora beticola*, produces conidiophores of varying sizes from stomata.

Damage caused: Cercospora leaf spot causes 3-5 mm lesions on older spinach leaves. Initial symptoms are small, water-soaked areas on both old and young leaves. These areas develop into yellow or necrotic lesions. 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.

Controls

Cultural: Reduce inoculum carryover through tillage and crop rotation.

Biological: None.

Chemical controls:

- Azoxystrobin (Amistar) 11
- Pyraclostrobin (Cabrio) 11

Viruses

Viral diseases including cucumber mosaic virus, beet curly top, beet western yellows (Spread by aphids and leafhoppers). Viruses are not usually major diseases in Texas, however, the only control that can be obtained is by controlling the insect vectors that transmit the disease(s).

Controls

Cultural: None.

Biological: None.

Chemical control: None.

Nematodes

Damage caused: Nematodes are not usually a major problem in spinach, but if soil populations levels are high they can be severe. Plants are stunted; in cases of severe early infection, death will occur. The root system of infected plants is characterized by large galls covered with numerous rootlets.

Controls

Cultural: Rotate with crops that are nonhosts.

Biological: None.

Chemical control:

- Potassium N-methyldithiocarbamate (K-Pam)
- Dichloropropene and chloropicrin (Telone C-17)
- 1,3-Dichloropropene (Telone II)

Efficacy ratings for disease control tools are listed in Table 2.

Weeds

Weeds compete with spinach for moisture, nutrients and sunlight which results in reduced yield. Weeds present at harvest can also lower grade by contaminating processed material. Due to optimal planting dates and climatic conditions in Texas, spinach production is plagued by both warm and cool-season weeds. Warm-season weeds are generally a problem the first few weeks after early fall-planted spinach has been established. As the growing season progresses, the warm-season weeds generally complete their life cycle while cool-season weeds begin to emerge and cause problems for spinach producers.

Dual Magnum has been available to Texas spinach growers as a Section 24(c) registration. Users must complete a Waiver of Liability and Indemnification Certificate before being allowed to purchase and use the product.

Annual grasses

Annual grasses commonly found in Texas spinach include: rescue grass, cheat, annual bluegrass, and foxtail. Rescue grass, cheat, and annual bluegrass are cool-season annual grassy weeds while foxtails are warm-season weeds.

Controls

Cultural: Crop rotation with crops that allow effective weed control programs can minimize weed problems in spinach. Cultivation and hand hoeing are also weed control options.

Biological: None.

Chemical control: Preemergence or Pre-plant incorporated

Common name	Trade name	MOA Group
• s-metolachlor – 24(c)	(Dual Magnum)	15
• Cycloate	(Ro-Neet)	8

Perennial grasses

Perennial grasses commonly found in Texas spinach include: johnsongrass. Johnsongrass is a warm-season grassy weed that persists in fields due to its ability to produce large, fleshy rhizomes that can regenerate new shoots from beneath the soil surface.

Controls

Cultural: Crop rotation with crops that allow effective weed control programs can minimize weed problems in spinach. Cultivation and hand hoeing are also weed control options.

Biological: None.

Chemical control: Postemergence

• Clethodim	(Select)	1
• Sethoxydim	(Poast)	1

Annual and Perennial Broadleaf Weeds

Broadleaf weeds commonly found in Texas spinach include: henbit, London rocket, wild carrot, purslane, copperleaf, lambsquarter, curly dock, and Texas thistle. Henbit, wild carrot and London rocket are cool-season annual broadleaf weeds that can germinate and grow very rapidly once daylight and temperature conditions become optimal. Purslane, copperleaf, and lambsquarter are warm-season annual broadleaf weeds that typically plague spinach growers early in the fall or in the spring. Curly dock and Texas thistle are perennial broadleaf weeds that can grow in both cool and warm-seasons and are difficult to control due to their ability to regenerate from taproots.

Controls

Cultural: Crop rotation with crops that allow effective weed control programs can minimize weed problems in spinach. Cultivation and hand hoeing are also weed control options.

Biological: None.

Chemical control: Preemergence or Pre-plant incorporated

Common name	Trade name	MOA Group
• s-metolachlor – 24(c)	(Dual Magnum)	15

Chemical control: Postemergence

Common name	Trade name	MOA Group
• Phenmedipham	(Spin-Aid)	5
• Clopyralid	(Stinger)	4

Efficacy ratings for weed control tools are listed in Table 3.

Table 1. Efficacy ratings for insect management tools used in Texas spinach production.

Pests	Aphids	Flea beetle	Leafminer	Beet Armyworm	Cabbage Looper	Grasshopper (processing only)
Registered products						
Acetamiprid (Assail®)	F					
Bifenthrin (Capture®)		G				F
Bacillus thuringensis				F	F	
Carbaryl (Sevin®)		G				G
Chlorantraniliprole (Coragen®)				E	E	
Cyromazine (Trigard®)			G			
Diazinon	F					
Dimethoate	G					
Imidacloprid (Admire®)	G					
Indoxacarb (Avaunt®)				G	G	
Malathion (Fyfanon®)						G
Methomyl (Lannate®)				G		G
Methoxyfenozide (Intrepid®)				G		
Permethrin					G	F
Pymetrozine (Fulfill®)	E					
Spinosad (Spintor®)			F	F	F-G	
Thiodicarb (Larvin®)				F		
Zeta-cypermethrin (Mustang®)		G			F	F
Non-chemical methods						
Crop rotation						
Sanitation				P		
Biologicals	P		P			
Host plant resistance						
Cultivation						

Rating scale

E = excellent
G = good
F = fair
P = poor

Table 2. Efficacy ratings for disease management tools used in Texas spinach production.

Diseases	White rust	Pythium (damping off)	Downy mildew	Cercospora leaf spot	Viruses	Nematodes
Registered products						
Azoxystrobin (Amistar®)	F-G		F-G	E		
1,3-dichloropropene + Chloropicrin (Telone C-17®)						G
1,3-dichloropropene (Telone II®)						F
Fixed copper	F		F			
Fosetyl-Al (Aliette®)			F			
Mefenoxam (Ridomil Gold®)	G	G				
Mefenoxam/Cu hydroxide (Ridomil Gold/Copper®)	G		G			
Potassium N-methyldithiocarbam. (K-Pam®)						G
Pyraclostrobin (Cabrio®)	G		G	G-E		
Non-chemical methods						
Crop rotation	F			F		
Sanitation					F	
Biologicals						
Host plant resistance	P		P			
Cultivation						

Rating scale

E = excellent
G = good
F = fair
P = poor

Table 3. Efficacy ratings for weed management tools used in Texas spinach production.

Pests	rescue grass	cheat	Annual bluegrass	foxtail	johnsongrass	henbit	London rocket	wild carrot	purslane	copperleaf	lambsquarter	curly dock	Texas thistle
Registered products													
Clethodim (Select®)	E	E	E	E	G								
Clopyralid (Stinger®)						G	E	G	G	G	E	G	F
Cycloate (Ro-Neet®)	P	F	G	G		F	G		F	F	F		
s-metolachlor (Dual Magnum®)*	F	G	E	G		E	G-E	G	G-E	G	G		
Phenmedipham (Spin-Aid®)						G	G				G		
Sethoxydim (Poast®)	E	E	E	E	G								
Non-chemical methods													
Crop rotation					F								
Sanitation													
Biologicals													
Host plant resistance													
Cultivation	P	F	P	P	P	P	P	P	P	P	F	F	F

* Dual Magnum has been available to Texas spinach growers under a Section 24(c) registration.

Rating scale
E = excellent
G = good
F = fair
P = poor

Table 4. Toxicity to beneficials of registered insecticides used in Texas spinach.

Toxicity	General predators	Predatory mites	Parasites	Honey bees
Registered products				
Acetamiprid (Assail®)	-	-	M	L
Bifenthrin (Capture®)	H	L-H	-	H
Bacillus thuringensis	L	L	L	L
Carbaryl (Sevin®)	H	H	-	H
Chlorantraniliprole (Coragen®)	-	-	-	L
Cyromazine (Trigard®)	L	L	L	L
Diazinon	L	L	L	L
Dimethoate	H	H	H	H
Imidacloprid (Admire®)	L	-	L	M
Indoxacarb (Avaunt®)	-	-	-	M
Malathion (Fyfanon®)	H	H	H	H
Methomyl (Lannate®)	H	H	H	M
Methoxyfenozide (Intrepid®)	L	L	L	L
Permethrin	H	L	H	H
Pymetrozine (Fulfill®)	L	L	L	M
Spinosad (Spintor®)	L-M	L	L-M	L
Thiodicarb (Larvin®)	L	L	L	L-M
Zeta-cypermethrin (Mustang®)	M	L	M	H

Rating scale

H = high
M = medium
L = low
- = unknown

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