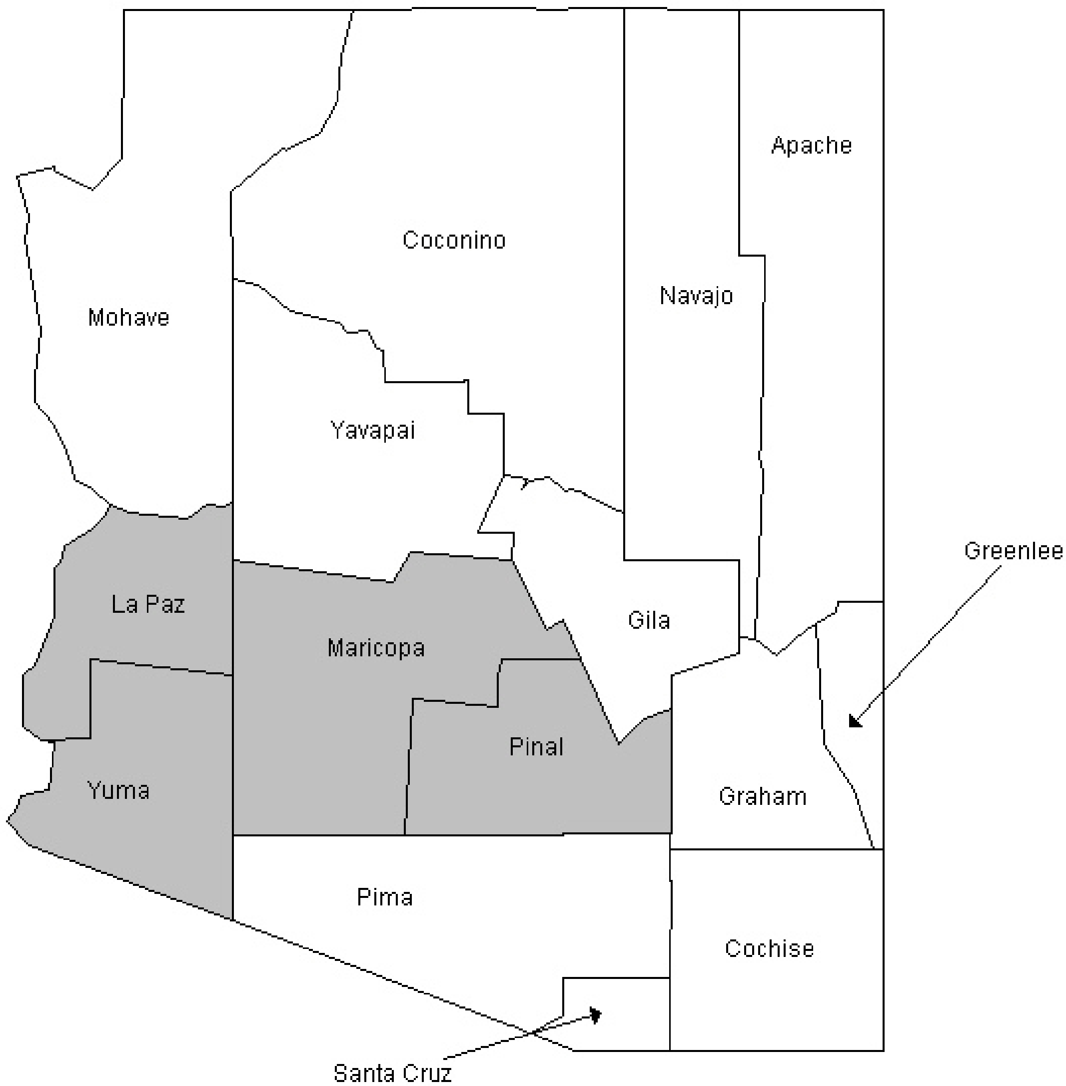
Crop Profile for Spinach in Arizona

Prepared: November, 2001

Family: Chenopodiaceae
Scientific name: *Spinacia oleracea* L.
Edible portions: leaves; consumed raw or cooked.
Use: fresh, frozen or canned vegetable, potherb.

General Production Information



- In 1997, Arizona produced 6% of the nations spinach, ranking 4th in the United States[2, 3].
- And average of 1808 acres of spinach was harvested in Arizona between 1995 and 1999[2]. The acreage of spinach grown in Arizona, however, is increasing significantly. In 1999 there were 2,900 acres of spinach grown in Arizona[2].
- An average of 945,304 cartons of spinach were produced yearly between 1995 and 1999[2].
- Spinach production had an average yearly value of average value of 9.1 million dollars between 1995 and 1999[2].
- The majority of spinach is produced in Yuma and Maricopa Counties. Spinach is also grown

Pinal and LaPaz Counties.

- Yuma County is responsible for the majority of Arizona's baby spinach production but produces very little fresh bunching spinach.
- Land preparation and growing expenses for spinach are approximately $1.86/carton[4].
- Harvest and post harvest expenses for spinach are approximately $4.01/carton[4].

Cultural Practices

General Information[7, 8, 9]: In Arizona, spinach is grown during the fall and winter. Planting of spinach starts the beginning of October and continues until the middle of February. During the spinach growing season, temperatures during the months of production range from 30°F to 90°F. Long days and prolonged hot temperatures induce bolting. Most production in Arizona is done on soils ranging from clay loam to sandy loam with a pH of 7.5-8.0.

Cultivars/Varieties[6]: In Yuma and Maricopa County the most popular varieties of spinach grown are; 'Rushmore' and 'Bossa Nova'. Bossa Nova is chosen for its slow growth that enables it to be more bolt tolerant during the warm weather. This variety is also resistant to races 1-3 of blue mold. Rushmore is popular because of its resistance to races 1-5 of blue mold. In Maricopa County, the varieties 'Polka' and 'Unipack 151' are also grown. Polka is high yielding and has a uniform, erect structure. This variety is also fast maturing. Unipack 151 is a savoy variety of spinach that is slow maturing and high yielding. This variety is also desirable for its uniform petiole length and leaf shape. Polka is resistant to races 1-3 of blue mold; Unipack 151 is resistant to races 1-3 and 4 of blue mold. Baby leaf spinach is also grown in Arizona. The previously described varieties are also used for growing baby leaf spinach; they are merely harvested earlier.

Production Practices[5, 7, 8]: A typical method for preparing a field for spinach production is as follows. Prior to planting, the field is deeply tilled, disked and land planed, the beds are formed and the field is pre-irrigated. A preplant incorporated herbicide may be before the beds are formed. If a pre-plant fungicide, such as mefenoxam, is utilized it is usually applied after bed formation but prior to planting.

Bunching spinach is directly seeded ¼ to ½ an inch deep into beds with 40" or 80" centers. Forty inch beds have 4 rows per bed; 80" beds have 6 to 8 rows per bed. Plants are spaced 3" apart within a row. Sprinkler irrigation is often used to establish seedlings. Baby spinach is often grown on beds with 80" to 84" centers and more closely spaced than bunching spinach with 10 to 12 rows per bed.

The field is cultivated two to three times during production. Side dressing fertilizer is added two or three times, increasing the amount of cultivation. Furrow irrigation is used to provide a consistent water source. The soil must be well drained for optimal spinach production. Spinach has a deep taproot; however, the majority of its root system is located in the top two to four inches of the soil. For this reason, cultivation must be kept shallow to avoid root injury. As well, this increases the need for soil moisture in the top portion of the soil bed.

Harvesting Procedures: Spinach is ready for harvest 37 to 70 days after planting[5]. Harvesting starts the beginning of December and can continue through to the middle of April[7, 8]. Spinach may be harvested at any time during development; yield and market value often predict when it is harvested.

Fresh bunching spinach is harvested by hand, being cut just above the soil surface[7]. When used for processing or fresh packaged, spinach leaves may be harvested individually, leaving the rest of the plant to continue producing[7]. The spinach may be recut 1-3 additional times. Leaf spinach is used in value-added salad packages. Some baby spinach is mechanically harvested but most is harvested by hand. Bunching spinach is washed, tied into bunches of 1 or 2 plants and packed 12 or 24 bunches per wax cardboard carton[10]. Spinach may be packaged in cello packs. Cello packs for food service are packed four 2½lb packs per carton[11]. For retail use there are twelve 10 oz cello packs per carton[11]. Spinach for processing is shipped in bulk to packinghouses in bushel baskets or plastic totes[10].

In order to meet Arizona standards, all spinach must be free of serious damage. No more than 5%, in any lot, can have decay[13]No more than 10% can fail to meet Arizona standards[12] All fresh and processed spinach must meet the same standards in Arizona.

Insect Pests

(7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22)

Coleoptera

Striped Flea Beetle (*Phyllotreta striolata*)

Potato Flea Beetle (*Epitrix cucumeris*)

Western Black Flea Beetle (*Phyllotreta pusilla*)

Western Striped Flea Beetle (*Phyllotreta ramosa*)

The color of flea beetles varies between species, but all species have a hard body and large hind legs. When flea beetles are disturbed, their large hind legs allow them to jump great distances.

In Arizona, flea beetles are particularly damaging to spinach because the feed on the marketable portion of the crop. The female flea beetle lays her eggs in the soil and on leaves of the spinach plant. Depending on the species, the larvae feed on the leaves or the roots of spinach. The adult beetles will also feed on the spinach plant, chewing small holes and pits into the underside of leaves. These insects are the most damaging during stand establishment. Even a small population can stunt or kill a stand of seedlings. Damage to the leaves of spinach will render the plant unmarketable.

Sampling and Treatment Thresholds: Flea beetles often migrate from surrounding production areas and Sudan grass. Fields should be monitored weekly for flea beetles and damage. The following are the University of Arizona's recommended treatment thresholds. Prior to head formation, treatment should occur when there is 1 beetle per 50 plants[17]. Once the head has formed, spinach should be treated when populations reach 1 flea beetle per 25 spinach plants[17].

Biological Control: There are no natural predators or parasites that can effectively control flea beetle populations.

Chemical Control: Methomyl, diazinon and pyrethroids such as lambdacyhalothrin, permethrin and cypermethrin are all commonly used treatments for the control of flea beetles. Methomyl is foliar applied; diazinon and pyrethroids can be foliar applied or chemigated. Diazinon and pyrethroids applied by chemigation have the added benefit of targeting crickets and grasshoppers.

Cultural Control: It is important to control volunteer plants and weeds, in and around the field, which could act as a host for flea beetles. Crop rotation is important; however, flea beetles have a wide range of hosts so not all crops are suitable for rotation. Spinach fields should be disked immediately following final harvest. It is important that Sudan grass is plowed under within a week of the final harvest, as this crop often harbors flea beetles.

Post-Harvest Control: There are no effective methods for the post-harvest control of flea beetles.

Alternative Control: Some growers use rotenone dust and pyrethrins to control flea beetles. Alternative control of these pests, however, is very difficult.

Darkling Beetle (*Blapstinus* sp.)

Rove Beetle (*Staphylinids* sp.)

Darkling beetles are dull black-brown in color. They are often confused with predaceous ground beetles, which are also black-brown but are shiny and lack clubbed antennae. It should be noted that the predaceous ground beetle is a beneficial because it feeds on lepidopterous larvae and other insects.

Rove beetles are a ¼" in length, or smaller, have a shiny, dark black-brown body and very short elytra that cover the wings. These beetles are frequently confused with winged ants and termites.

Darkling and rove beetles are most damaging during seedling establishment, digging planted seeds out of the soil. They will also feed on spinach seedlings, girdling plants at the soil surface. Sometimes these beetles feed on the leaves of older plants. Shippers will not accept leaves that have been damaged by beetle feeding.

Sampling and Treatment Thresholds: Nighttime is the best time to monitor a field for darkling beetles; this is when they are the most active. During the day they tend to hide in the soil or debris. These beetles often migrate from nearby cotton and alfalfa fields or weedy areas. Experts at the University of Arizona recommend treating a field when beetle populations are high or there is a threat of migration into the field[17].

Biological Control: There are no effective methods of biologically controlling rove and darkling beetles available.

Chemical Control: Placing baits around the perimeter of the field will also provide some control when beetles migrate into the field. Methomyl, diazinon and pyrethroids such as permethrin and cypermethrin are all frequently used for the control of rove beetle and darkling beetle populations. Diazinon and pyrethroids can be chemigated through the sprinkler system or foliar applied. These chemistries will also help control cricket, grasshopper and lepidopterous larvae populations.

Cultural Control: It is important to control weeds in the field, and surrounding the field, that can act as hosts for darkling and rove beetles. Ditches filled with water around the field's perimeter can deter beetle migration into the field. Fields should be deeply plowed to reduce soil organic matter and beetle reproduction.

Post-Harvest Control: There are no post-harvest control methods for rove beetles or darkling beetles.

Alternative Control: Some growers use rotenone or need oil to control darkling and rove beetles.

Orthoptera

Cricket (*Gryllus* sp.)

Crickets are rarely a problem in Arizona but dense populations are capable of causing significant damage. Crickets are ½ to 1" in length, and brown-black in color. Most cricket feeding occurs at night; during the day crickets hide in the soil, weeds, ditches and under irrigation pipes. Crickets attack spinach seedlings as they emerge from the soil. If cricket populations are high enough, they can completely decimate an entire crop.

Crickets build up in cotton fields, Sudan grass and desert flora and move into spinach fields at the end of the summer. Fields that use over-head sprinkler irrigation create an ideal environment for crickets because female crickets lay their eggs in damp soil.

Sampling and Treatment Thresholds: Crickets are difficult to monitor for during the day, as they tend to hide. One can check underneath irrigation pipes; however, a visual inspection of damage is usually sufficient to give an estimate of cricket activity. Fields planted near cotton or Sudan grass should be closely monitored. The University of Arizona recommends that a field should be treated when cricket damage is high or there is a threat of cricket migration into the field[18].

Biological Control: There are no effective methods for biologically controlling cricket populations.

Chemical Control: Baits such as, permethrin and carbaryl, can be used to control cricket populations. Baits are usually placed at the field borders to target crickets migrating into the field. Methomyl, diazinon and pyrethroids such as cypermethrin and permethrin are often used to control cricket populations. These insecticides can be ground applied or applied by chemigation. Spraying, rather than using baits, has the added benefit of targeting lepidopterous pests.

Cultural Control: Fields should be disked immediately following harvest; this will help control cricket populations.

Post-Harvest Control: There are no effective methods for the post-harvest control of crickets.

Alternative Control: Some growers use rotenone to control cricket populations.

Spur-Throated Grasshopper (*Schistocerca* sp.)

Desert (Migratory) Grasshopper (*Melanoplus sanguinipes*)

In Arizona, grasshoppers are usually not a threat to spinach stands. Occasionally, sometimes after a heavy rain, the grasshopper population can 'explode'. In these years grasshoppers move from the desert into produce fields and can decimate entire crops. Due to their ability to fly, it is difficult to prevent the migration of grasshoppers into a field. There have been such outbreaks in previous years in Arizona; however, they are rare. Grasshoppers are foliage feeders and will chew holes into leaves. In most years, grasshopper populations are so small their damage is insignificant.

Sampling and Treatment Thresholds: University of Arizona experts suggest that fields should be treated as soon as grasshoppers begin to cause damage to the crop[18].

Biological Control: A predaceous protozoon, *Nosema locustae*, can be used to control grasshopper populations.

Chemical Control: If grasshopper populations are large, chemical control is usually the only option. Chemical control of these insects can be difficult. Pyrethroids, such as lambdacyhalothrin, have been used in the past with some success.

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

Post-Harvest Control: There are no effective methods for the post-harvest control of grasshoppers.

Alternative Control: Some growers use rotenone to control grasshopper populations.

Diptera

Heart maggot (syn. crown maggot)

The heart maggot has not yet been defined or studied in Arizona, but can be an important pest of spinach that is cut and allowed to grow back for additional harvests. Heart maggots have been noted in the field by pest control advisors and are thought to be the seed corn maggot (*Delia platura*) or closely related.

Maggots are the larva stage of the fly. The adult fly of the crown maggot is gray and approximately 1/3 the size of a housefly. After the first cut of spinach, larvae populate the crown and feed at the growing point and developing leaves. These maggots do not feed on the spinach's roots, only in the crown of the plant. Bacterial rot of the tissue may also occur. Emergent leaves are damaged and are riddled with holes from maggot feeding. The leaf tissue will eventually turn black. The first growth of spinach does not appear to be affected by maggot feeding, only the subsequent growths of the spinach plant. Often feeding is so severe, the entire crop is ruined and the leaves are unmarketable.

Heart maggots often appear in January or February after an increase in temperature.

Sampling and Treatment Thresholds: University of Arizona experts recommend that spinach should be treated when the adult flies are migrating into the field[18].

Biological Control: There are no effective methods of biologically controlling heart maggots.

Chemical Control: Pyrethroids will provide moderate control of heart maggots. Diazinon will provide some control if applied by chemigation. Spinach should be treated when flies are migrating into the field; larvae are more difficult to control once they are in the heart of the plant.

Cultural Control: Maintaining a sanitary field might help reduce maggot populations; however, it will not prevent adult flies from migrating into the field.

Post-Harvest Control: There are no effective methods for the post-harvest control of maggots.

Alternative Control: There are no alternative control methods for heart maggots.

Leafminers (*Liriomyza* sp.)

Adult leafminers are small, shiny, black flies with a yellow triangular marking on the thorax. The adult female leafminer oviposits her eggs within the leaf tissue. Male and female flies feed at these puncture sites. The larvae hatch inside the leaf tissue, nd feed on the mesophyll tissue. They do not emerge until they pupate. Leafminers usually pupate in the soil, although sometimes they will pupate on the leaf surface. When conditions are favorable, leafminers can complete a life cycle as quickly as 3 weeks.

As larvae feed on the mesophyll tissue, they create extensive tunneling within the leaf. The width of these tunnels increases as the larvae grow. These mines cause direct damage by decreasing photosynthesis, as well; the puncture wounds provide an entryway for pathogenic infection. The disfiguration of the leaves renders the spinach unmarketable. Leafminers will pupate between the spinach leaves, contaminating the plant. These bodies may also die and rot, providing a medium for the growth of pathogens. Leafminers are a more frequent pest of baby spinach than in bunching or processing spinach. If large populations leafminers occurred in a field their damage on bunching or processing spinach would be more significant.

Sampling and Treatment Thresholds: It is important that the crop is monitored regularly for leaf mines, larvae and adult flies. The cotyledons and first true leaves are the first to be mined. Mining is more visible on the undersurface of the leaf; thus both leaf surfaces must be viewed. Presence of leafminer parasites and parasitized mines should also be determined. Yellow sticky traps are a good method for measuring leafminer migration into a field, as well as, determining which species are present. It is important to accurately identify which species are present, because insecticide resistance has been documented for *Liriomyza trifolii*. According to University of Arizona guidelines, spinach should be treated prior to head formation when populations have reached 1 active mine per leaf[17]. After head formation, treatment should occur when populations reach 1 mine per leaf per 25 spinach plants[17].

Biological Control: *Diglyphus* and *Chrysocharis* genera of parasitic wasp are sometimes utilized to control leafminer populations. Insecticides used to control noxious pests should be used with care because they can eliminate parasitic wasps causing a leafminer outbreak.

Chemical Control: Diazinon and pyrethroids such as permethrin are commonly used chemistries to control *L. sativae* adults. Permethrin is ineffective against leafminer larvae. Neither diazinon nor permethrin are effective against *L. trifolii*. Spinosad is used for the control of the adults and larvae of both *L. sativae* and *L. trifolii*. Spinosad is the only chemistry available that effectively controls *L. trifolii*. Insecticide resistance has been noted in *L. trifolii* populations, thus there is a need for a diversity of insecticides to allow resistance management.

Cultural Control: It is best to avoid planting near cotton, alfalfa and other host fields, because leafminers will migrate from these fields into the spinach field. A field that has a leafminer infestation should be disked immediately following harvest.

Post-Harvest Control: There are no effective methods for the post-harvest control of leafminers.

Alternative Control: Some growers use insecticidal soaps to control leafminer populations.

Lepidoptera

Lepidopterous complex = loopers and beet armyworm

Black Cutworm (*Agrotis ipsilon*)

Variegated Cutworm (*Peridroma saucia*)

Granulate Cutworm (*Agrotis subterranea*)

The threat of cutworms in Arizona is sporadic, and appears to vary in response to environmental conditions. The adult moth has gray-brown forewings with irregular markings; the hindwings are lighter in color. The female moth lays her eggs on the leaves and stem near the soil surface.

Cutworm populations are heaviest during the fall. Newly hatched larvae feed on the leaves temporarily, but then drop to the soil surface and burrow underground. The larvae emerge at night and feed on the spinach plants. Seedlings are the most significantly impacted by cutworm attack. The cutworm attacks spinach by cutting the stem at, or just below the soil surface. A single cutworm is capable of damaging several plants in one evening and a large population can destroy an entire spinach stand. When cutworms have been active, one might observe several wilted or cut off plants in a row. A stand that has recently been thinned is especially sensitive to cutworm attack. Cutworms frequently occur in fields that were previously planted with alfalfa or pasture.

Sampling and Treatment Thresholds: Prior to planting, the field, field borders and adjoining fields should be monitored for cutworms. Pheromone traps can be used to monitor the presence of cutworms in a field. Once seedlings have emerged, fields should be scouted twice a week. If an area of several wilted or cut off plants is discovered, the surrounding soil should be dug into and searched for cutworms. Cutworms are nocturnal; therefore it is easiest to scout for them on the soil surface during the evening. Cutworms are often not noticed until crop damage has become severe. University of Arizona experts recommend that a field should be treated as soon as soon as stand loss begins[17].

Biological Control: There are some natural enemies of the cutworm; however, they do not provide adequate control.

Chemical Control: Baits can be used to control cutworms but are more effective when used prior to spinach emergence. These baits should be placed in the areas where cutworms have been found in previous years. Cutworms often occur at the field borders or in isolated areas within the field. Sometimes spot and edge treatments are sufficient to control cutworm populations. Spinosad, methomyl and pyrethroids such as permethrin and cypermethrin are the most frequently used methods for controlling cutworm populations. These larvae, however, are often controlled when the crop is sprayed for stand-establishment pests. Cutworms usually do not get an opportunity to establish a population.

Cultural Control: Fields that are in close proximity to alfalfa fields are especially prone to cutworm infestation, and should be carefully monitored. Cutworms tend to reoccur in the same area of a field and in the same fields. It is important to control weeds, that can act as hosts to cutworms, in the field and surrounding the field. The field should be plowed a minimum of two weeks prior to planting, in order to kill cutworms, hosts and food sources.

Post-Harvest Control: There are no effective methods for the post-harvest control of cutworms.

Alternative Control: Some growers use *Bacillus thuringiensis* (Bt) for the control of cutworms. It is best to spray Bt in the dark because it is UV light and heat sensitive. Spraying at night will give the longest period of efficacy.

Saltmarsh Caterpillar (*Estigmene acrea*)

The adult saltmarsh caterpillar moth has white forewings that are covered with black spots; the hindwings are yellow. The female moth lays groups of 20 or more eggs on the leaf surface. The young larvae are yellow-brown in color and covered in long, dark black and red hairs. Older larvae sometimes develop yellow stripes down the sides of their bodies. These caterpillars are sometimes referred to as ‘wooly bear caterpillars’.

Saltmarsh caterpillar populations are heaviest in the fall. These larvae are more common in cotton, alfalfa, bean and sugarbeet fields but the larvae will migrate from surrounding host fields. The saltmarsh caterpillars feed on seedlings and can skeletonize older plants. The larvae often feed in groups on older plants. If populations are high, they can decimate an entire seedling stand.

Sampling and Treatment Thresholds: According to University of Arizona experts, fields should be treated at the first signs of damage[18].

Biological Control: There are no effective methods for the biological control of saltmarsh caterpillars.

Chemical Control: Field edges should be sprayed when saltmarsh caterpillars begin to migrate into the spinach field. Methomyl, spinosad, tebufenozide and pyrethroids such as permethrin and cypermethrin are the most commonly used treatments for controlling saltmarsh caterpillars. Tebufenozide, methomyl and pyrethroids are all contact insecticides that are foliar applied. Spinosad is a contact herbicide but also has translaminar activity.

Cultural Control: The simplest way to control saltmarsh caterpillars is to prevent their migration into a field. Monitoring any surrounding cotton and alfalfa fields prior to spinach emergence will help assess the degree of risk for the crop. Saltmarsh caterpillars do not like to cross physical barriers. A six-inch high aluminum foil strip or irrigation pipes that the larvae cannot crawl under will provide a suitable barrier to the field. These barriers can also be used to herd the larvae into cups of oil. A ditch of water containing oil or detergent that surrounds the perimeter of the field can also be used as a barrier.

Post-Harvest Control: There are no effective methods for the post-harvest control of saltmarsh caterpillars.

Alternative Control: *Bacillus thuringiensis* may be used to control saltmarsh caterpillars. One important consideration when using *B. thuringiensis*, is its tendency to break down when exposed to UV light and heat. Usually it is sprayed at night to allow the longest period of efficacy.

Diamondback Moth (*Plutella xylostella*)

The adult diamondback moth is small, slender and gray-brown in color. The name ‘diamondback’ is derived from the appearance of three diamonds when the male species folds its wings. The female moth lays small eggs on the underside of the leaf. Typically the eggs are laid separately, but occasionally can be found in small groups of two or three. The larvae are about a 1/3 of an inch long, pale yellow-green and covered with fine bristles. A v-shape is formed by the spreading prolegs on the last segment of the caterpillar. When startled, the larvae will writhe around or quickly drop from the leaf on a silken line. Diamondback moth populations peak in March and April and again in June and August. If conditions are favorable, this moth can have four to six generations a year.

Diamondback moth larvae attack all stages of plant growth but their damage is most significant during the seedling stage and at harvest. Diamondback moths are occasionally found in spinach grown in Arizona. Larvae attack the growing points on young plants, stunting growth and decreasing yield. The larvae chew small holes, mostly on the underside of mature leaves, on mature plants. The larvae of the diamondback moth penetrate spinach heads, damaging the head as well as contaminating it.

Sampling and Treatment Thresholds: Fields should be monitored during; the seedling stage, crop thinning and prior to heading. Fields should also be checked if an adjacent field has recently been harvested or been disked, as the larvae will migrate from such fields. The University of Arizona recommends that prior to head formation; spinach should be treated when there is 1 larva per 50 plants[17]. Once the spinach head has formed, the crop can tolerate 1 larvae per 100 plants[17]. All other larvae in the lepidopterous complex should be included in this count.

Biological Control: The ichneumonid wasp (*Diadegma insularis*) will commonly parasitize *Plutella* cocoons. *Trichogramma pretiosum* is a less common parasite that attacks diamondback moth eggs. Lacewing larvae and ladybug larvae (syn: ant lions) can also be used to control small diamondback larvae. Care must be used when spraying insecticides as they can harm populations of beneficial insects. These beneficial insects usually do not provide complete control of diamondback moth populations.

Chemical Control: Methomyl, thiodicarb, spinosad and pyrethroids such as permethrin and cypermethrin are the most frequently utilized chemistries for the control of diamondback moths. *Plutella* resistance to insecticides has been reported and is a concern in spinach production.

Cultural Control: Fields should be disked immediately following harvest in order to kill larvae and pupae and prevent moth migration to adjacent crops.

Post-Harvest Control: There are no effective methods for the post-harvest control of diamondback moths.

Alternative Control: *Bacillus thuringiensis* (Bt) can be used to control diamondback moth larvae. A consideration when using *B. thuringiensis*, is its tendency to break down when exposed to UV light and heat. Spraying at night will allow the longest period of efficacy. Diatomaceous earth can be used to control diamondback larvae. Neem oil soap, neem emulsion, and rotenone are less effective choices for the control of larvae.

Cabbage Looper (*Trichoplusia ni*)

Alfalfa Looper (*Autographa californica*)

Loopers are a major pest in the central and southwestern deserts of Arizona. They are present all year, but their populations are highest in the fall when vegetables are grown. Loopers can cause extensive damage to spinach grown in Arizona.

Cabbage loopers and alfalfa loopers are very similar in appearance, which makes it difficult to differentiate between the two species. The front wings of the adult looper are mottled gray-brown in color with a silver figure eight in the middle of the wing; the hindwings are yellow. The female moth lays dome-shaped eggs solitarily on the lower surface of older leaves. The larvae are bright green with a white stripe running along both sides of its body. The looper moves by arching its back in a characteristic looping motion, which is also the source of its name. Loopers can have from 3 to 5 generations in one year.

Loopers will attack all stages of plant growth. These larvae feed on the lower leaf surface, chewing ragged holes into the leaf. Some loopers will burrow into the spinach head from below. Excessive feeding on seedlings can stunt growth or even kill plants. Spinach leaves that have been damaged by looper feeding or that are contaminated with larvae or larvae frass are unmarketable.

Sampling and Treatment Thresholds: Once spinach has germinated, fields should be monitored twice a week. The lower leaf surface should be checked for larvae and eggs, especially on damaged leaves. When populations are noted to be increasing, fields should be monitored more frequently. Pheromone traps are useful for measuring the migration of moths into crop fields. The presence of parasitized and virus-killed loopers should also be noted. The following are the University of Arizona's suggested treatment thresholds. Prior to head formation, spinach should be treated when populations have reached 1 larva per 50 plants[17]. After head formation, spinach can tolerate 1 larva per 100 plants[17]. All other larvae in the lepidoptera complex should be included in this count.

Biological Control: There are several species of parasitic wasps, as well as, the tachinid fly (*Voria ruralis*) that will aid in the control of the looper. Care must be taken with insecticide treatment, as it can decrease populations of these beneficial insects. Nuclear polyhedrosis virus is a naturally occurring virus that can assist in the control of loopers when conditions are favorable.

Chemical Control: Spinosad, tebufenozide and pyrethroids such as permethrin and cypermethrin are routinely used to control looper populations. All are foliar-applied insecticides. Spinosad, permethrin and tebufenozide provide good control of loopers. Spinosid and tebufenozide are more effective on hatching larvae. Neither chemistry will provide good control of the adult moths. Thiodicarb provides moderately good control of loopers, often this chemistry is tank-mixed with permethrin to provide control of the lepidopterous complex. Tebufenozide and pyrethroids are contact insecticide; spinosad is a contact insecticide that also has translaminar activity. Thiodicarb is an insect stomach poison.

Cultural Control: Weeds growing within the field or surrounding the field must be controlled because they can act as hosts for loopers and other lepidopterous insects. Weeds on ditch banks and adjacent fields should be monitored for eggs and larvae during seeding. Fields ought to be plowed under immediately following harvest to kill larvae and remove any host material.

Post-Harvest Control: There are no methods for the post-harvest control of loopers.

Alternative Control: *Bacillus thuringiensis* can be used to control looper populations, but is the most effective if applied when eggs are hatching and larvae small. One concern when applying *B. thuringiensis* is its tendency to break down when exposed to UV light and heat. Spraying at night will allow the longest period of efficacy. This microbial insecticide will control other lepidopterous insects, with the exception of beet armyworms, and will not affect beneficial predators and parasites. Diatomaceous earth, neem oil soap, neem emulsion and rotenone are other methods for the alternative control of cabbage loopers.

Beet Armyworm (*Spodoptera exigua*)

The forewings of the adult moth are gray-brown in color with a pale spot on the mid-front margin; the hindwings are white with a dark anterior margin. The female moth lays clumps of light green eggs on the lower leaf surface. The eggs are covered with white scales from the female moth’s body, giving the eggs a cottony appearance. The eggs darken prior to hatching. The emergent larvae are olive green and are nearly hairless, which distinguishes them from other lepidopterous larvae. The larvae have a broad stripe on each side of the body and light-colored stripes on the back. A black dot is located above the second true leg and a white dot at the center of each spiracle. The mature larvae pupate in the soil.

Armyworm populations are heaviest during the fall and the larvae attack all stages of plant growth. Young larvae feed in groups near their hatching site. As the beet armyworm feeds, it spins a web over its feeding site. Mature armyworms become more migratory and move to new plants. Many armyworms die while traveling between plants. Armyworms can skeletonize leaves and will feed on the midrib and leaf margins. The armyworm will sometimes bore into a spinach plant from the bottom and feed on newly formed leaves at the plant’s growing point. A single armyworm can attack several plants and can consume entire seedlings. Spinach heads that have been damaged by armyworm feeding are unmarketable.

Beet armyworm populations are the most active during the months of July through November. In the fall, beet armyworms often migrate from surrounding cotton and alfalfa fields to vegetable crops. Armyworms also feed on weeds including; redroot pigweed (*Amaranthus* sp.), lambsquarters (*Chenopodium album*) and nettleleaf goosefoot (*Chenopodium murale*).

Sampling and Treatment Thresholds: Weeds surrounding the field should be examined for larvae and eggs prior to crop emergence. If population levels are high in surrounding weeds, the crop should be monitored very carefully following emergence. Pheromone traps can be used to check for the presence of beet armyworms in a field. After germination, fields should be monitored twice a week. Experts at the University of Arizona recommend that spinach should be treated prior to head formation when populations reach 1 larva per 50 plants[17]. Once the head has formed, spinach can tolerate 1 larva per 100 plants[17]. Loopers should be included in this count.

Biological Control: There are viral pathogens, parasitic wasps and predators that attack the beet armyworm. These biological agents, however, are unable to completely control armyworm populations. Caution must be used when spraying insecticides as they can harm beneficial insects.

Chemical Control: Spinosad, tebufenozide and pyrethroids such as permethrin and cypermethrin are the most commonly used insecticides for the control of armyworms. Spinosad and tebufenozide will control of armyworms, but neither are effective against adult moths. Complete coverage of spinach is essential for effective control. Permethrin provides moderate control of armyworms. Pyrethroids, spinosad and tebufenozide are all contact insecticides; spinosad also had translaminar activity. The best time to spray with an insecticide is when the larvae are hatching; this allows maximum control of the population. This also provides the opportunity to determine the degree of predator activity and dispersal deaths. Insecticides are more effective when applied at dusk or dawn when the armyworms are the most active. It is important to practice sound resistance management practices by alternating chemistries.

Cultural Control: Weeds growing within and surrounding the field should be controlled, as armyworms can build up in these areas. When seeding, it is important to monitor weeds along the field's borders and on ditch banks for eggs and larvae. Armyworms will also migrate from surrounding cotton and alfalfa fields. Fields should be disked immediately following harvest to kill any larvae that are pupating in the soil.

Post-Harvest Control: There are no effective methods for the post-harvest control of beet armyworms.

Alternative Control: Some growers use diatomaceous earth, neem oil soap, neem emulsion and rotenone for the control of beet armyworms. *Bacillus thuringiensis* is registered for controlling beet armyworms but does not provide adequate control.

Corn Earworm (Bollworm) (*Helicoverpa zea*)

Tobacco Budworm (*Heliothis virescens*)

The tobacco budworm and corn earworm occur throughout Arizona but are most prevalent in central and western parts of the state. The adult corn earworm moth has mottled gray-brown forewings; the hindwings are white with dark spots. The forewings of the tobacco budworm moth are light olive-green with three thin, dark bands; the hindwings are white with a red-brown border. The female moth lays white eggs separately on the plant's leaves. Twenty-four hours after they are laid, the eggs develop a dark band around the top and prior to hatching the eggs darken in color. The larvae of these two species vary in color and develop stripes down the length of their body. It is difficult to differentiate between the larvae of these two species until they are older. Older larvae can be distinguished by comparing the spines at the base of the abdominal tubercles and by the presence of a tooth in the mandible.

Budworm and earworm populations peak during the fall. These larvae are currently only an occasional pest of spinach. The larvae of these two species are cannibalistic, eating larvae of their own species and of other lepidopterous species, thus they tend to feed alone. Budworms and earworms are capable of killing entire stands of seedlings. In older plants, the larvae chew holes into the leaves and also attack the growing point of the plant, often killing the growing tip. Damage to the spinach head will result in an unmarketable plant.

Sampling and Treatment Thresholds: Field monitoring should begin immediately following seed germination. Pheromone traps can be used to monitor for the presence of tobacco budworms and corn earworms. Earworms and budworms migrate from corn and cotton fields, thus it is important to carefully monitor field edges that border these fields. If eggs are discovered, it should be determined if they have hatched, are about to hatch or have been parasitized. The spinach should be checked for larvae and feeding damage. It is important to correctly identify which larvae is present, as resistance in tobacco budworms has been reported. The University of Arizona recommends that prior to spinach head formation, the crop requires treatment when populations reach 1 larva per 50 plants[17]. After head formation the crop can tolerate 1 larvae per 100 plants[17]. All other larvae in the lepidopterous complex should be included in this count.

Biological Control: Some parasites and predators of earworms and budworms include; *Trichogramma* sp. (egg parasite), *Hyposoter exiguae* (larval parasite), *Orius* sp. (minute pirate bug) and *Geocoris* sp. (bigeyed bugs). These enemies are often able to reduce earworm and budworm populations. Care must be taken with insecticide treatment, as it can decrease the populations of these beneficial insects. Nuclear polyhedrosis virus, a naturally occurring pathogen, also helps control populations.

Chemical Control: Insecticide treatment is more effective at peak hatching, when larvae are still young. Eggs darken just prior to hatching, which gives a good indication when to prepare to spray. This also allows the opportunity to check for the presence of predators and parasites. The best time to treat for tobacco budworms and corn earworms is mid-afternoon, this is when the larvae are the most active. Spinosad, and pyrethroids such as permethrin and cypermethrin are often used for controlling earworms and budworms.

Cultural Control: Fields that are planted next to cotton fields require close monitoring. Delaying planting until after cotton defoliation will decrease larvae migration into spinach fields, however due to market demands it is not always possible to delay planting. Fields should disked under following harvest to kill any larvae pupating in the soil.

Post-Harvest Control: There are no methods for the post-harvest control of corn earworms or tobacco budworms.

Alternative Control: Methods for the alternative control of budworms and earworms include; diatomaceous earth, neem oil soap, neem emulsion and rotenone.

Imported Cabbageworm (*Pieris rapae*)

The imported cabbageworm is not a common pest in Arizona, but damage caused by this pest has been recorded. The adult cabbageworm moth, called the cabbage butterfly, is white-yellow in color and has black spots on the upper surface of its wings. The female moth lays rocket-shaped eggs on the lower leaf surface. The larvae are green in color with a faint yellow or orange stripe down its back and broken stripes down the sides of its body. The larvae's body is covered with numerous hairs giving the larvae a velvety appearance.

The imported cabbageworm chews large, irregular holes into the leaves. When young plants are attacked, the larvae can stunt or kill the plants. Older plants can tolerate more larvae feeding than the young plants can. The larvae feed for 2 to 3 weeks and then attach themselves to the stem or leaf on the plant or a near by object to pupate. The presence of the larvae and larvae frass within the spinach head and damage to the head will render the plant unmarketable.

Sampling and Treatment Thresholds: The field should be randomly checked for areas of damaged plants. Cabbage loopers, however, cause the same sort of damage as the cabbageworm. Thus it is important to also check for eggs, larvae and moths to positively identify the larvae species causing the damage. The University of Arizona recommends that prior to head formation, spinach should be treated when there is 1 larva per 50 plants[17]. Once the spinach head has formed, the crop can tolerate 1 larvae per 100 plants[17]. All other larvae in the lepidopterous complex should be included in this count.

Biological Control: There are many natural enemies to the imported cabbageworm including; *Pteromalus puparum*, *Apanteles glomeratus*, *Microplitis plutell*a and the tachinid fly (*Voria ruralis*). There are also some viral and bacterial diseases that will attack cabbageworms. Insecticides should be sprayed with caution as they can harm beneficial insects.

Chemical Control: Spinosad and pyrethroids such as permethrin and cypermethrin are often used for controlling imported cabbageworms.

Cultural Control: Weeds growing within the field and surrounding the field can act as hosts to cabbageworms and thus must be controlled. Fields should be plowed after harvest to eliminate any larvae that may be pupating in the soil. Sanitation of equipment is important to prevent the contamination of uninfected fields.

Post-Harvest Control: There are no methods available for the post-harvest control of imported cabbageworms.

Alternative Control: *Bacillus thuringiensis* (Bt) can be used to control cabbageworms and will not harm beneficial predaceous and parasitic insects. Bt is most effective when sprayed on young larvae. One concern when spraying Bt is its tendency to break down when exposed to UV light and heat. Spraying at night will allow for a longer period of efficacy.

1999 Insecticide Usage to Control Lepidoptera Larvae on Arizona Grown Spinach

Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	(# of reports) By Air	AW***	CE	CW	DM	ICW	L
Bacillus thuringiensis	0.05	0.39	1.05	277.4	10%	19	14	16	0	0	0	0	9
Cypermethrin	0.05	0.09	0.10	89.4	3%	4	2	2	0	1	1	0	3
Diazinon (**OP**)	0.25	2.17	4.00	116.8	4%	12	6	6	0	0	0	0	2
Endosulfan	0.75	0.77	1.00	4	0%	1	1	1	0	0	0	0	1
Imidacloprid	0.16	0.08	0.38	244.9	8%	32	5	9	0	0	1	0	8
Methomyl (**carbamate**)	0.45	0.72	0.90	753.1	26%	58	26	34	0	1	0	0	18
Permethrin	0.05	0.17	0.10	1440.5	50%	157	55	81	2	1	3	0	37
Piperonyl butoxide	0.038	0.60	0.46	2.5	0%	1	1	0	0	0	0	0	1
Pyrethrins	0.01	0.01	0.01	212.8	7%	24	14	12	0	0	0	0	13
Rotenone	0.00	0.01	0.01	22	1%	8	3	0	0	0	0	0	0
Spinosad	0.023	0.08	0.156	966.33	33%	83	50	58	1	0	4	1	29
Sulfur	2.40	2.40	8.00	3	0%	2	0	2	0	0	0	0	

Thiodicarb (**carbamate, B1/B2**)	0.40	0.58	1.00	22.8	1%	2	1	2	0	0	0	0	1

AW - Armyworm
CE - Corn Earworm
CW - Cutworm
DM - Diamondback Moth
ICW - Imported Cabbageworm
L - Looper
OP - organophosphate

*Application rates are pounds of active ingredient per acre. Average rate is an average of field level rates from the ADA 1080 reports using a NAS conversion table to determine the pounds of AI in pesticide products. Maximum and Minimum rates come from product labels.

**the number of reports is the number of unique 1080 forms received with indicated AI. 1080s with multiple AIs are counted for each AI. Acres for multiple AI mixes are separately counted for each AI. % of acres treated is AI acre total divided by planted acres. Only previous year's planted acres is available.

***Up to four target pests are recorded and multiple AI applications are common. No mechanism in the 1080 forms presently exists to link specific AIs to specific target pests. For this reason, all AI/pest counts do not necessarily reflect intended efficacy.

Homoptera

APHIDS (syn: plant lice)

Green Peach Aphid (*Myzus persicae*)

Potato Aphid (*Macrosiphum euphorbiae*)

Green peach aphids are the most common species of aphid found on spinach; potato aphids are occasionally observed. Green peach aphids are light green, red or pink in color. They are found feeding on the lower surface of mature leaves and will quickly colonize younger leaves as the population increases. Potato aphids have a similar appearance to green peach aphids but are larger and form small colonies on the lower surface of new leaves.

Aphid populations peak during the months of November and December and again during February and March. Populations consist entirely of asexual reproducing females that produce live young; this allows the population to increase rapidly. When conditions are ideal, aphids have as many as 21 generations in one year. When populations become too large or food is scarce, aphids produce winged offspring that migrate to new hosts.

Aphids are an important pest that can severely damage a spinach crop. Aphid feeding can cause distorting and curling of spinach leaves and will deplete the plant’s phloem sap. Extreme aphid feeding can deplete enough phloem sap to reduce the plant’s vigor or even kill the plant. In addition, as an aphid feeds it excretes phloem sap ("honeydew") onto the plant’s surface. This provides an ideal environment for sooty mold infection, which inhibits photosynthesis. Another concern are the viruses that green peach aphids can transmit such as the cucumber mosaic virus. Aphids are also damaging as a contaminant. The presence of aphids in spinach or aphid damage to the leaves will make the plant unmarketable.

Sampling and Treatment Thresholds: To control aphid infestations, it is essential to monitor fields frequently and prevent the growth of large populations. These pests migrate into crop fields and reproduce rapidly, quickly infecting a crop. Beginning in January, fields should be monitored no less than twice a week. Yellow waterpan traps are useful for measuring aphid movement into the field. Aphids usually appear first at the upwind field border and those borders that are adjacent to fields of cruciferous weeds and crops. In infested fields, aphids tend to occur in clusters within the field, thus it is important to randomly sample the field. According to University of Arizona guidelines, spinach should be treated prior to spinach head formation when populations reach 1 aphid per 10 plants[17]. After head formation, spinach should be treated when aphid colonization begins[17].

Biological Control: Parasitoids and predators that attack aphids are available; however, they are usually unable to completely control aphid populations. Lady beetle larvae (syn: ant lions), lacewing larvae, syriphid fly larvae, aphid parasites are some of the insects used to control aphids. These beneficial insects, however, can also become contaminants of spinach heads. Spraying of insecticides should be performed with caution as it can eliminate beneficial insects.

Chemical Control: A pre-plant application of imidacloprid is the most common method used to control aphids. This insecticide has the benefit of long-term residual control. However, this prophylactic approach to control is expensive and is applied with the assumption that the crop will receive aphid pressure. Many growers choose to wait and apply a foliar insecticide. When foliar insecticides are used, the timing of application is critical. Endosulfan, dimethoate and imidacloprid are the most frequently utilized foliar-applied treatments. The initial treatment should occur once aphids begin to migrate into a crop field. To ensure that the harvested spinach is not contaminated with aphids, it might be necessary to use repeated applications. Aphids are often difficult to treat in spinach because of its low-growing form and crumpled leaves. If aphids only occur at the field borders or in isolated areas, border or spot applications may be sufficient to control populations. There is a heavy dependence on imidacloprid but it is still important to alternate chemistries for good resistance management.

Cultural Control: Aphids tend to build up in weeds, particularly cruciferous weeds and sowthistle (*Sonchus asper*), therefore it is important to control weeds in the field and surrounding the field. Fields should be plowed under immediately following harvest, to eliminate any crop refuse that could host aphids.

Post-Harvest Control: There are no methods for the post-harvest control of aphids.

Alternative Control: Some growers use; insecticidal soaps, neem oil soap, neem emulsion, pyrethrins, rotenone dust, plant growth activators, elemental sulfur, garlic spray and diatomaceous earth to control aphid populations.

WHITEFLIES

Sweetpotato Whitefly (*Bemisia tabaci*)

Silverleaf Whitefly (*Bemisia argentifolii*)

Historically, whiteflies have not been a primary pest of spinach but have been a concern because of their ability to spread viral pathogens. More recently, whiteflies have become a primary pest feeding on the plant's phloem and are capable of destroying an entire crop.

The adult whitefly is 1/16" in length and has a white powder covering its body and wings. The female whitefly lays small, oval, yellow eggs on the undersurface of young leaves. The eggs darken in color prior to hatching. The immature whitefly (nymph) travels about the plant until it finds a desirable minor vein to feed from. The nymph does not move from this vein until it is ready to pupate. Whiteflies can have numerous generations in one year.

Whitefly infestations are usually the heaviest during the fall. Spinach, however, is usually planted when whitefly populations have begun to decline. Colonization of the crop can begin immediately following germination, beginning with whiteflies feeding on the cotyledons. Whiteflies migrate from cotton, melon and squash fields, as well as, from weed hosts. Spinach planted downwind from these plants is particularly susceptible. Whitefly feeding removes essential salts, vitamins and amino acids required by the spinach plant for proper growth. This feeding results in reduced plant vigor and can delay harvest if not controlled at an early stage. As with aphids, the phloem sap that whiteflies excrete onto the spinach's surface creates an ideal environment for sooty mold infection. Whiteflies can contaminate the harvested spinach head, making it unmarketable. Whiteflies are also a vector for many plant viruses.

Sampling and Treatment Thresholds: The best way to prevent a whitefly infestation is to inhibit initial colonization. Whitefly counts should be performed early in the morning when the insects are the least active. Once whiteflies become active they are difficult to count. During the mid-morning, fields should be monitored for swarms of migrating whiteflies. The University of Arizona recommends if a soil-applied insecticide is not used, the crop should be treated when populations reach 5 adults per leaf[17].

Biological Control: Parasitoid wasps (*Eretmocerus* sp.) can be used to control whitefly populations, however they only parasitize immature whiteflies. Lacewing larvae and ladybug larvae (syn: ant lions) are also used for the control of whiteflies. These insects are very sensitive to pyrethroids and other insecticides, thus it is important to determine the severity of pest pressure and the activity of beneficial insects before spraying.

Chemical Control: If the crop is planted when whitefly populations are at their greatest a soil-applied prophylactic insecticide, such as imidacloprid, is often applied. If spinach is planted after whitefly populations have declined, foliar-applied insecticides can be used as necessary. Imidacloprid, endosulfan, and dimethoate are the most commonly used foliar insecticides. Tank-mixing insecticides helps control whiteflies, as well as, preventing the development of insecticide resistance. When spraying it is important to achieve complete crop coverage, this will provide the best control of whiteflies. There is a strong dependence on imidacloprid to control whiteflies; this creates concerns of product resistance. As well, whitefly resistance to organophosphates and pyrethroids has been noted in the past, thus resistance management is important.

Cultural Control: Whitefly populations are most active in early September and tend to migrate from defoliated and harvested cotton. Delaying planting until populations have begun to decrease and temperatures are lower will help manage whitefly infestation. Delaying planting, however, is not always a feasible option due to market windows. Whiteflies build up in weeds, especially cheeseweed (*Malva parviflora*), thus it is important to control weeds in the field and surrounding the field. Crop debris should be plowed under immediately following harvest to prevent whitefly build up and migration to other fields.

Post-Harvest Control: There are no methods for the post-harvest control of whiteflies.

Alternative Control: Some growers use; neem oil soap, neem emulsion, pyrethrins, insecticidal soaps, rotenone, elemental sulfur, garlic spray and diatomaceous earth to control whiteflies.

Thysanoptera

THRIPS

Western Flower Thrips (*Frankliniella occidentalis)*

Onion Thrips (*Thrips tabaci*)

Thrips are present all year, but their populations increase in the early fall and late spring. In Yuma County, thrips are an important pest of baby spinach; Maricopa county is less affected by thrips. Thrips spread from mustard, alfalfa, onion and wheat fields, surrounding weedy areas and unirrigated pastures.

Thrips are small (1/20-1/25 in.), slender and pale yellow-brown in color. The two species are similar in appearance, which can make it difficult to distinguish between them. It is important, however, to identify which species of thrips is present because western flower thrips are more difficult to control. Consulting a specialist is best if one is unsure. Female thrips lay small, white, bean-shaped eggs within the plant tissue. The hatched nymphs are similar in appearance to the adults, but smaller in size and lack wings. Thrips will pupate in the soil, or leaf litter, below the plant.

Thrips feeding wrinkles and deforms leaves, damages heads and stunts growth. Feeding can also cause brown scaring. Extreme damage causes leaves to dry and fall off the plant. Black dust, the thrips feces, on the leaves distinguishes this damage from windburn or sand burn. Shippers will not accept damaged leaves or the presence of thrips in harvested spinach.

Sampling and Treatment Thresholds: Sticky traps are a good way to monitor the migration of thrips into a field. When inspecting for thrips, the folded plant tissue must be carefully examined, as this is where thrips prefer to hide. It is estimated that for every 3 to 5 thrips observed there are three times as many that are undiscovered. The following are the University of Arizona's suggested treatment thresholds. Prior to head formation, spinach should be treated when populations reach 1 thrips per 10 plants[17]. After head formation, the crop should be treated when the population reaches 1 thrips per 25 plants[17].

Biological Control: Lacewing larvae, ladybug larvae (syn: ant lions) and the minute pirate bug can be used to provide control of thrips. Insecticides must be sprayed with care as they can harm these beneficial insects.

Chemical Control: Treatment should begin when thrips populations are still low and when tissue scarring begins. For more effective control, applications should be made during the afternoon because this is when thrips are the most active. Studies have shown that even the most effective insecticides do not decrease thrips populations, they are merely able to maintain the population size. This is important to consider when an application date is being chosen. The number of applications a crop stand requires will vary according to the residual effect of the chemical and the rate of thrips movement into the crop field. The size of the plant and the temperature will also effect the degree of control. The more mature a plant is the more folds and crevices it has for thrips to hide in and avoid insecticide contact.

Pyrethroids such as permethrin and cypermethrin will not control thrips nymphs but will suppress the adults. Pyrethroids should only be used in a tank mix to prevent chemistry tolerance in thrips. Dimethoate, spinosad and methomyl will provide control nymphs but not adults. Currently there are no insecticides that can provide complete control of thrips. For this reason, a pyrethroid is commonly tank mixed with dimethoate, spinosad or methomyl to provide control of all thrips stages.

Cultural Control: Cultural practices do not effectively control thrips because thrips will rapidly migrate from surrounding vegetation.

Post-Harvest Control: There are no methods for the post-harvest control of thrips.

Alternative Control: Some growers use pyrethrins and elemental sulfur to control thrips.

OTHER CONTAMINANTS ('Trash Bugs')

False Chinch Bug (*Nysius raphanus*) (Hemiptera)

Lygus Bug (*Lygus hesperus*) (Hemiptera)

Three-Cornered Alfalfa Hopper (*Sissistilus festinus*) (Homoptera)

Potato Leafhopper (*Empoasca fabae*) (Homoptera)

The false chinch bug is gray-brown with a narrow, 1/8" long body and protruding eyes. False chinch bugs tend to build up in cruciferous weeds.

The lygus bug varies in color from pale green to yellow-brown with red-brown or black markings. This insect is ¼" long and has a flat back with a triangular marking in the center. These insects are commonly found in cotton, safflower and alfalfa fields, as well as, on weed hosts.

The three-cornered alfalfa hopper is approximately a ¼" long, light-green wedge-shaped body. The potato hopper has an elongated body and varies from light green to light brown in color. Both species have well-developed hind legs, allowing them to move quickly. These pests are common in alfalfa and legume fields as well as weed hosts. Leafhoppers are not commonly found in spinach fields.

These contaminants normally do not cause direct damage to spinach, they are more of concern as a contaminant of the spinach head. Populations of these insects often increase when the growing season experiences high rainfall and desert vegetation and weeds flourish. These insects also build up when spinach is planted near alfalfa.

Sampling and Treatment Thresholds: The following are the University of Arizona's suggested treatment thresholds. Before the formation of the spinach head, a stand does not require treatment until populations reach 10 contaminant insects per 50 plants[17]. Once the head is formed, spinach should be treated when populations reach 1 contaminant insect per 25 plants[17].

Biological Control: There are no methods for the biological control of contaminant insects.

Chemical Control: Since these insects generally do not cause physical damage to spinach, chemical control is not normally required until head formation begins. Growers typically spray as close to harvest as possible to ensure the spinach is not contaminated. Dimethoate, methomyl, diazinon and pyrethroids such as permethrin and cypermethrin are the most commonly used insecticides for controlling contaminant insects.

Cultural Control: It is important to control weeds that can harbor contaminants, in the field and surrounding the field. Alfalfa should not be cut until the spinach field has been harvested, this will prevent insect migration into the spinach field.

Post-Harvest Control: There are no methods for the post-harvest control of contaminant insects.

Alternative Control: Some growers use neem oil, garlic spray, rotenone and pyrethrins to control contaminant insects.

Other Insect Pests: Bulb mites (*Rhizoglyphus* sp.), webworms (various species) and wireworms (various species) are occasionally found in spinach crops. Bulb mites are found on baby spinach crops. Mites can distort leaves and stunt plant growth. There are no effective methods for controlling mites in spinach crops. Webworms chew holes in spinach leaves, but these pests are usually controlled when spraying for other lepidoptera larvae. Wireworms are rarely found in spinach fields. These pests feed on the roots and sometimes on the planted seed.

1999 Insecticide Usage on Spinach Grown in Arizona

Active Ingredient	Label Min.*	Ave. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	(# of reports)					
							By Air	SE***	Aph.	Lep.	Thp.	WF
WESTERN												
Allium sativum	n/a	0.10	n/a	1	0%	1	1	0	1	0	0	0
Bacillus thuringiensis	0.05	0.42	1.05	212.5	12%	15	11	0	2	19	0	0
Cypermethrin	0.05	0.08	0.10	55.8	3%	1	0	0	0	2	0	0
Diazinon (**OP**)	0.25	1.64	4.00	266.9	15%	23	3	14	9	7	0	0
Imidacloprid	0.16	0.16	0.38	445.56	25%	59	3	2	54	29	0	0
Methomyl (**carbamate**)	0.45	0.71	0.90	448.5	25%	41	11	0	19	43	0	0
Permethrin	0.05	0.17	0.10	1534.7	85%	174	56	17	32	162	2	0
Piperonyl butoxide	0.038	0.60	0.46	2.5	0%	1	1	0	1	1	0	0
Pyrethrins	0.05	0.02	0.31	34.1	2%	10	4	0	9	10	0	0
Rotenone	0.00044	0.01	0.00088	22	1%	8	3	0	8	8	0	0

Spinosad	0.023	0.07	0.156	904.13	50%	73	44	1	3	90	2	0
Sulfur	2.40	2.40	8.00	3	0%	2	0	0	0	2	0	0
CENTRAL												
Bacillus thuringiensis	0.05	0.15	1.05	94	9%	5	4	1	1	7	0	0
Cypermethrin	0.05	0.09	0.10	33.6	3%	3	2	0	2	5	1	0
Diazinon (**OP**)	0.25	0.47	4.00	211.1	19%	9	9	9	0	7	0	1
Endosulfan	0.75	0.64	1.00	29	3%	2	2	1	0	2	0	0
Imidacloprid	0.16	0.05	0.38	233.3	21%	14	13	3	14	4	0	0
Methomyl (**carbamate**)	0.45	0.73	0.90	328.6	30%	18	16	12	0	27	0	1
Permethrin	0.05	0.16	0.10	444.8	41%	21	18	17	3	24	0	0
Pyrethrins	0.05	0.01	0.31	178.7	16%	14	10	10	3	23	1	1
Spinosad	0.023	0.10	0.156	106.1	10%	11	7	5	3	20	1	0
Thiodicarb (**carbamate, B1/B2**)	0.40	0.58	1.00	22.8	2%	2	1	1	0	3	0	0

SE - Stand Establishment
Aph - Aphids
Lep - Lepidoptera Larvae
Thp. - Thrips
WF - Whiteflies
OP - organophosphate

*Application rates are pounds of active ingredient per acre. Average rate is an average of field level rates from the ADA 1080 reports using a NAS conversion table to determine the pounds of active ingredient (AI) in pesticide products. Maximum and minimum rates come from product labels.

**The number of reports is the number of unique 1080 forms received with indicated AI. 1080s with multiple AIs are counted as an individual report for each AI. Acres for multiple AI mixes are separately counted for each AI. % of acres treated is AI acre total divided by total planted acres. Only previous year's planted acres is available.

***Up to four target pests are recorded and multiple AI applications are common. No mechanism in the 1080 forms presently exists to link specific AIs to specific target pests. For this reason, all AI/pest counts do not necessarily reflect intended efficacy.

Diseases

FUNGAL DISEASES

(5, 7, 8, 13, 23, 24, 25, 26, 27, 28)

Damping-off (*Pythium* sp., *Rhizoctonia solani*)

In Arizona, damping-off is occasionally observed in spinach fields. Damping-off is a soil borne fungus that attacks germinated seedlings during or after emergence. Cool, wet weather promotes infection by most *Pythium* species, where as cool to moderate weather promotes *Rhizoctonia* infection. Fields that have poor drainage, compacted soil and/or high green organic matter are the most susceptible to damping-off. The damping-off fungi will not affect plants that have reached the three to four-leaf stage.

Rhizoctonia damage usually occurs at soil level, leaving lesions in the stem tissue. The tissue becomes dark and withered, the weak support causes the seedling to collapse and die. *Pythium* infects the lower stem of spinach and causes a black-greasy rot of the tissue. *Pythium* can also attack the seedling's roots, causing them to turn brown and rotten.

Biological Control: *Gliocladium virens* GL-21 is labelled for the control of *Pythium* and *Rhizoctonia* induced damping-off. *G. virens* is a fungus that antagonizes *Pythium* and *Rhizoctonia*. In the greenhouse *G. virens* provides good control of damping-off; in the field the control that *G. virens* provides is variable.

Chemical Control: Metam sodium and metam-potassium are fumigants registered for use on damping off; however, these methods are costly and generally not considered a viable option. Mefenoxam is the only other chemical method available for controlling *Pythium*-induced damping-off. This fungicide works best when used as a preventative treatment, being applied before disease becomes apparent. Usually mefenoxam is applied in a band over the seed row, either pre-plant incorporated or preemergence. There are also no registered seed treatments in Arizona for controlling damping-off. Most growers, however, do not treat for damping-off, as this disease is not currently a large threat to spinach in Arizona.

Cultural Control: All residues from the previous crop should be plowed under and completely decomposed before planting spinach. It is best to plant when the soil is warm, as this will speed germination and allow the crop to quickly reach a resistant stage of growth. Overhead and sprinkler irrigation are the best methods for promoting rapid germination. It is very important to manage water application and avoid over saturating the field. Fields should be properly drained and low spots should be eliminated to avoid water accumulation. When directly seeding it is important not to plant too deep as this will slow emergence, increasing the seedling's susceptibility to damping-off. It is important to avoid stressing the crop, as this will make it more susceptible to damping-off.

Post-Harvest Control: There are no effective post-harvest measures for the control of damping-off.

Alternative Control: Some growers spread compost on the soil to control pathogens.

Blue Mold (syn: downy mildew) (*Peronospora effusa*)

Of the potential fungal diseases, blue mold poses the largest threat to the production of spinach in Arizona. This disease only occurs occasionally in Arizona, but when it does occur it has a large effect on spinach production and is difficult to control.

Blue mold thrives in cool, humid weather, such as that which is typical of the winter growing season in western Arizona. This weather promotes spore formation and spore dispersal, as well as, plant infection. When conditions are favorable, the pathogen can spread rapidly. *P. effusa* can survive with crop debris and infected seed. The fungus also produces resting spores, which can survive in the soil or crop residue until the following season. *P. effusa* is spread by; wind, rain, equipment and infected seed.

Spinach can be particularly susceptible to infection due to its low growing structure that allows for the build up of humidity beneath the plant. Plant infection begins with chlorotic lesions on the upper leaf surface. Fungi, bearing masses of purple-gray spores, develop on the lower leaf surface beneath these lesions. Leaves develop a creamy yellow color and become wrinkled; some leaves may blacken and eventually die. Blue mold can decimate large numbers of seedlings. Severe infections of mature spinach can result in decreased photosynthesis, stunted plants and reduced yield. Blue mold is a systemic disease that will spread throughout the plant. Damage to the leaves will also cause the plant to be susceptible to secondary infections. More importantly, any leaves that are damaged or discolored are unmarketable.

Biological Control: There are no biological methods for controlling blue mold.

Chemical Control: Mefenoxam, fosetyl-aluminum and copper-based fungicides are the most commonly used methods for chemically controlling blue mold. Mefenoxam and fosetyl-aluminum are systemic treatments; copper fungicides is a protectant. Blue mold is best controlled when treatment is used as a preventative measure, rather than waiting for the onset of disease symptoms. If there is heavy rain, one can anticipate blue mold. If environmental conditions remain favorable for disease development, multiple applications may be required. It is important to alternate fungicides or apply fungicide mixtures to ensure proper resistance management.

Cultural Control: An effective method to control blue mold is to plant resistant varieties of spinach and certified disease-free seed. Seed that is not disease-free can be treated with hot water; however, this will reduce the germination percentage of the seed. Weeds can act as a host for blue mold and must be controlled. Crop rotation will help control blue mold in a field by allowing different cultural practices and the use of different products. Overhead irrigation should be avoided, as this aids in the spread of *P. effusa*. Fields should be plowed under following harvest to promote the decomposition of infected plant debris.

Post-Harvest Control: There are no methods for the post-harvest control of blue mold.

Alternative Control: Some growers use milk and hydrogen peroxide to control blue mold. Spreading compost on the soil is also used for the control pathogens. *Bacillus subtilis* has also been used to reduce downy mildew.

BACTERIAL DISEASES

(5, 7, 23, 25, 26, 27)

Bacterial Soft Rot (*Erwinia* sp.)

In Arizona, bacterial soft rot is occasionally reported to occur on spinach. Bacterial soft rot rarely occurs in the field, but can be a problem if the field experiences flooding. Bacterial soft rot is a more common occurrence during the post-harvest storage. Infection is likely to occur in spinach that is stored at warm temperatures, or heat if is allowed to accumulate in the storage containers. High humidity also promotes infection. This disease is capable of destroying an entire lot of spinach.

Open wounds on the plant provide an entry for the bacterium. Plants that were infected with blue mold or that have experienced freezing or insect damage are particularly susceptible to bacterial soft rot. The initial sign of infection is the appearance of small water soaked spots on the leaves. Once inside the spinach plant, the bacterium spreads rapidly. *E. carotovora* dissolves the middle lamella that holds cells together and causes the inner contents of the cell shrink. The water soaked areas increase in size and eventually cartons of stored spinach can become slimy masses. The infected portions of plant may develop a brown color.

Machinery, insects, rain, irrigation and humans are all capable of spreading *Erwinia*.

Biological Control: There are no available methods for the biological control of bacterial soft rot.

Chemical Control: There are no methods for the direct chemical control of *Erwinia*; however, insecticides can help control the insects that damage spinach leaving it susceptible to bacterial infection.

Cultural Control: Crops should be cultivated carefully, to prevent damage to the plant that could provide an entryway for bacterial infection. It is important to control weeds in and around the field that could act as a host to *Erwinia*.

Post-Harvest Control: Spinach must be handled carefully to avoid bruising or wounding that will leave the plant susceptible to infection. Plants should be thoroughly washed and kept in cold storage, typically 40 °F. The center of cartons should be precooled as this area can remain warm for as long as 24 hours and allow bacterial growth. It is important to keep the storage facility and containers free of soft rot bacteria by immediately destroying any infected plants and maintaining a clean and facility.

Alternative Control: Some growers spread compost on the soil to control pathogens in the field. There are no alternative control methods that can be utilized during post-harvest storage.

1999 Fungicide Usage on Spinach Grown in Arizona

Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	(# of reports) By Air	Unspecified Fungus	Downy Mildew***	*Pythium*
WESTERN										
Ampelomyces	n/a	0.00	n/a	15.5	1%	2	2	0	2	0
Fosetyl-Al	1.60	2.70	4.00	505.1	28%	68	12	45	23	0
Mancozeb (**B1/B2**)	1.50	4.27	2.40	3.75	0%	1	0	1	0	0
Mefenoxam	0.25	0.33	0.13	567.2	31%	91	0	63	0	14
Metam-sodium (**B1/B2**)	63.30	156.51	324.94	52	3%	5	0	0	0	0
Neem Oil	0.005	1.24	0.043	209.9	12%	16	14	0	2	0
Sulfur	2.25	2.40	12.80	3	0%	2	0	0	0	0
CENTRAL										
Fosetyl-Al	1.60	2.43	4.00	3	0%	1	1	0	1	0

*Application rates are pounds of active ingredient per acre. Average rate is an average of field level rates from the ADA 1080 reports using a NAS conversion table to determine the pounds of AI in pesticide products. Maximum and Minimum rates come from product labels.

**the number of reports is the number of unique 1080 forms received with indicated AI. 1080s with multiple AIs are counted for each AI. Acres for multiple AI mixes are separately counted for each AI. % of acres treated is AI acre total divided by planted acres. Only previous year's planted acres is available.

***Up to four target pests are recorded and multiple AI applications are common. No mechanism in the 1080 forms presently exists to link specific AIs to specific target pests. For this reason, all AI/pest counts do not necessarily reflect intended efficacy.

VIRAL DISEASES

(5, 24, 27, 29)

In Arizona, the cucumber mosaic virus and curly top virus affect spinach production. Cucumber mosaic virus is a systemic virus that is transmitted by green peach aphids and mechanical inoculation. The leaves of plants infected by the cucumber mosaic virus become mottled with chlorotic spots. As the disease progresses the entire leaf will turn yellow and wrinkle. Infected plants may exhibit reduced vigor and may die. Long days and intense sunlight increases the viral disease. Curly top virus is spread by leafhoppers. This disease causes vein clearing on immature leaves and as the disease progresses the leaf margins curl. The disease can stunt mature plants; younger plants may die. When any viral disease disfigures spinach leaves, the leaves are unmarketable.

Biological Control: There are no biological methods for directly controlling viruses; however, biological methods can be utilized to control virus vectors e.g. aphids. Controlling virus vectors, however, is not very effective because it only requires a few insects to spread viral diseases.

Chemical Control: Viruses cannot be chemically controlled. The insects that spread viruses, however, can be controlled e.g. aphids. This method of control, however, is inefficient because it only requires a few insects to spread viral disease.

Cultural Control: Planting only disease-free seed and resistant cultivars will help control viral infections. Controlling weeds that can serve as hosts for viral diseases is crucial. It is also important to avoid stressing the plant, i.e.) supply an adequate amount of water and fertilization. All plant residues should be plowed into the soil and promote their decomposition.

Post-Harvest Control: There are no available methods for the post-harvest control of viruses.

Alternative Control: There are no available methods for the alternative control of viruses.

Vertebrates

(13, 14)

Birds can be very destructive of crops. Horned larks, blackbirds, starlings, cowbirds, grackles, crowned sparrows, house sparrows and house finches frequently eat planted seeds and seedlings. Frightening devices (visual and acoustical), trapping, poisoned baits and roost control can be used to control birds. Pocket gophers can be destructive to spinach crops by eating and damaging the roots when they dig their burrows. The mounds that gophers produce while digging their burrows can be damaging to agricultural equipment and can disrupt irrigation furrows. Some methods for controlling gophers include controlling food sources (weeds), fumigation, flooding, trapping and poisoning. Ground squirrels are known to damage irrigation ditches and canals as well as feed on spinach seedlings. These pests can be controlled by fumigation, trapping and poisoning. It is best to poison squirrels in their burrows to prevent the poisoning of predatory birds. There are several species of mice that can be pests of vegetable crops; they can be controlled by weed control, repellents and occasionally with poisoning. Wood rats sometimes pose a threat to the crop and can be controlled by exclusion, repellents, trapping, shooting, toxic baits. Raptors, kestrels and burrowing owls are all helpful for the control of rodent populations. Rabbits that infest fields can cause economic damage. Rabbits are be controlled by habitat manipulation, exclusion, trapping, predators (dogs, coyotes, bobcats, eagles, hawks etc), repellents and poisons. In Arizona, cottontails are classified as a small game species and state laws must be observed to take this species. Jackrabbits are classified as nongame species, but a hunting license or depredation permit is required to take the species. Elk, whitetail deer and mule deer can cause severe grazing damage to vegetable crops. Deer and elk, however, are classified as game species and require special permits to remove them. Fencing can be used for deer control; frightening devices and repellents provide some control. Feral horses and burros also cause damage to spinach, but are protected by Arizona State laws.

Weeds

(5, 13, 14, 30)

Weeds are a threat to the cultivation of any crop. They compete with the crop for sunlight, water and nutrients. Control of weeds is fundamental for pest management because weeds may host a variety of diseases and pests that can be transmitted to spinach. Spinach has difficulty competing with weeds; thus, it is best if weeds are controlled prior to spinach seedling emergence. Weeds present at harvest can contaminate harvested spinach, especially when harvested mechanically. Due to the low-growing form of spinach, any weeds present at harvest will slow down the harvesting crew who will be forced to search through the weeds for the desired crop. It is essential that weeds are destroyed before they flower and produce seed. One plant can produce 1000s of seeds.

The summer broadleaf weeds most commonly found in Arizona between the months of August and October are pigweed (*Amaranthus* sp.), purslane (*Portulaca oleracea*), lambsquarters (*Chenopodium album*) and groundcherry (*Physalis wrightii*). Common summer grasses include; barnyardgrass (*Echinochloa crusgalli*), cupgrass (*Eriochloa* sp.), junglerice (*Echinochloa colonum*) and sprangletop (*Leptochloa* sp.). The winter broadleaf weeds most commonly found in Arizona between the months of November and March are black mustard (*Brassica nigra*), wild radish *(Raphanus sativus*), shepherdspurse *(Capsella bursa-pastoris*), London rocket (*Sisymbrium i*rio), cheeseweed (*Malva parviflora*), sowthistle (*Sonchus oleraceus*), prickly lettuce (*Lactuca serriola*), knotweed (*Polygonum* sp.), annual yellow sweet clover (*Melilotus indicus*) and nettleleaf goosefoot (*Chenopodium murale*). Common winter grasses include; canarygrass (*Phalaris minor*), annual blue grass (*Poa annua*), wild oats (*Avena fatua*) and wild barley (*Hordeum* sp.).

Sampling and Treatment Thresholds: A yearly record should be kept detailing what weed species are observed in each field. This is important because herbicides usually work best on germinating weeds. To choose the appropriate herbicide, one must know what weeds are present before they have actually germinated.

Biological Control: There are no effective methods available for the biological control of weeds.

Chemical Control: Chemical control of weeds is difficult as some weeds are in the same family as spinach (Chenopodiaceae). There are few chemistries available for controlling weeds in spinach fields and the herbicides that are available often cause damage to spinach rendering it unmarketable. It is challenging to adequately control weeds while ensuring crop safety. Many growers choose to control weeds culturally because of the lack of an effective and safe herbicide for spinach.

There are non-selective herbicides, such as glyphosate, which can be used prior to spinach emergence to eliminate weeds in the field. These herbicides will kill any contacted plants and cannot be utilized once spinach has emerged.

Oxyfluorfen is a preemergence broadleaf herbicide registered for use in spinach fields. This herbicide, however, is not practical because it must be used 120 days prior to planting spinach. Oxyfluorfen has little soil residual, thus it will not control weeds once the spinach has been planted. Metolachlor, a preemergence grass herbicide, is temporarily available in Arizona from 09/08/00 to 05/15/01 with an emergency exemption, Section 18. Metolachlor, however, can cause discoloration and distortion of leaves and occasional plant death. Diethatyl-ethyl was a preemergence herbicide often used in spinach fields but its tolerance was removed and it is no longer available for use in Arizona.

Sethoxydim is the only available postemergence herbicide for use on fresh spinach. This herbicide has good grass control but has no efficacy against broadleaf weeds. Phenmedipham is a postemergence broadleaf weed herbicide; however, it is only registered for use on spinach grown for processing or seed. Ro-neet is a preemergence herbicide for the control of various grass, broadleaf and perennial weeds. This herbicide, however, was not registered in Arizona due to the lack of necessary ground water studies. The lack of registered postemergence herbicides limits the ability to effectively control weeds in spinach fields.

Herbicides can cause injury to spinach if not applied carefully and correctly. Injury may result from; spray drift, residue in the soil from a previous crop, accidental double application to a row, using the wrong herbicide or using a rate that is too high. Herbicide injury can cause leaf spotting or yellowing that can be misidentified as pathogen injury or nutrient deficiency. Soil, water or plant tissue test can be used to identify herbicide injury.

<u>Cultural Control</u>: Spinach should be encouraged to grow quickly and establish the stand, which will allow increase the ability of spinach to out compete any weeds present in the field. Precise planting, a regular water supply and appropriate fertilization will help increase the ability of endive and escarole to compete with weeds.

Purchasing seed that is guaranteed to be weed-free will help prevent the introduction of new weed species into a field. It is also important to maintain field sanitation by always cleaning equipment used in one field before it is used in another and ensuring that any manure that is used is weed seed free. Contaminated irrigation water from canals, reservoirs and sumps can also spread weed seed. Irrigation ditches, field borders and any other uncropped area should be maintained weed-free. A properly leveled field is important to prevent the build up water in isolated areas, especially when utilizing furrow irrigation. Water build up promotes the germination of weeds that are favored by wet conditions.

Delaying planting until the time when summer weeds are declining but before winter weeds begin to germinate will decrease the amount of weed competition. owever, due to market demands this control method is not always feasible.

Another method used to control weeds is to till the field, form beds and irrigate prior to planting. This will encourage the germination of the weed seeds. The field can then be sprayed with a nonselective herbicide or rotary hoed to eliminate the weeds. After the weeds have been destroyed, the spinach is planted. Disking will eliminate germinated weeds but will also expose new weed seed that may germinate and cause a second flush of weeds.

Cultivation and hoeing can be used to control weeds in a planted field but should be done with care due to the shallow root system of spinach. Rows and beds must be carefully planted and the cultivation equipment must be carefully aligned. Hand weeding can also be used to eliminate weeds within the field, but is very costly. Fields should be disked after harvest to eliminate any weeds present and to prevent the weeds from flowering and spreading seed.

Rotating crops will allow the use of herbicides that are more effective for the control of weeds. Crop rotation also promotes different cultural practices and planting times that will aid in weed control.

<u>Post-Harvest Control</u>: There are no methods for the post-harvest control of weeds.

<u>Alternative Control</u>: There are no alternative methods available for controlling weeds

1999 Herbicide Usage on Spinach Grown in Arizona

				Total	% of		(# of reports)			
							By Air	Broadleaf***	Unspecified	Sedge

Reports**	Acres Treated	# of Acres	Max.*	Rate*	Min.*	I

WESTERN										
Diethatyl-ethyl	3.00	2.60	4.00	422.2	23%	93	0	0	90	0
Glyphosate	0.25	1.50	5.00	1	0%	1	0	0	0	1
Metolachlor	0.48	0.54	0.63	703.2	39%	56	0	2	54	0
Sethoxydim	0.10	0.28	0.24	43.1	2%	3	3	0	3	0
CENTRAL										
Trifluralin	0.50	0.09	0.75	66	6%	1	1	0	0	0

Note: Unspecified typically refers to weeds that were treated at the germination stage or seedling stage with a general weed control.

*Application rates are pounds of active ingredient per acre. Average rate is an average of field level rates from the ADA 1080 reports using a NAS conversion table to determine the pounds of AI in pesticide products. Maximum and Minimum rates come from product labels.

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ARIZONA PESTICIDE USE REPORTING

The state of Arizona mandates that records must be kept on all pesticide applications. Submission to the Arizona Department of Agriculture (ADA) of these pesticide use reports (form 1080) is mandated for all commercially applied pesticides, pesticides included on the Department of Environmental Quality Groundwater Protection List (GWPL) and section 18 pesticides.

Commercial applicators licensed through the state must submit Arizona

Department of Agriculture Form 1080 Pesticide Use Reports for all applications. The use of commercial applicators varies across crops. Aerial application is always performed by commercial applicators.

The GWPL is a list of active ingredients determined by the Department of Environmental Quality to potentially threaten Arizona groundwater resources. Enforcement of this list is difficult. Strictly speaking, only specific types of soil application of GWPL active ingredients must be reported. Inclusion on the GWPL should indicate a higher level of reporting but without further research no useful distinctions can be drawn.

Section 18 active ingredients should have 100% reporting. There was an active section 18 for metolachlor in Arizona for spinach in the 1999 growing season.

Voluntary reporting does take place. Anecdotal evidence indicates some producers submit records for all applications.

Reported pesticide usage provides a solid lower bound of acres treated and a mean application rate of reported applications. Relative magnitude of reported acres is useful for rough comparison but could reflect a bias among commercial applicators or differing reporting rates as a result of inclusion on the GWPL. Finally, while the quality of data from the ADA 1080 forms has improved dramatically in recent years, there is still the possibility of errors.

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