Crop Profile for Endive & Escarole in Arizona

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Escarole

Endive

Family: Asteraceae (Compositae)

Scientific name: *Cichorium endivia* L. ssp. *endivia*

Edible portions: leaves, consumed raw

Use: fresh vegetable, potherb

General Production Information

- In 1997, Arizona was accounted for 3.6% of the nation's endive production and 19% of the nation's escarole production[3].
- An average of 270 acres of endive and 211 acres of escarole was produced between 1994/1995 and 1998/1999 growing seasons[2].
- An average of 92,787 cartons/year of endive and 97,988 cartons of escarole was produced between the 1994/1995 and 1998/1999 growing seasons[2].
- The average yearly wholesale value of endive production between 1996/1997 and 1998/1999 growing seasons was approximately $897,250. The average yearly wholesale value of escarole production in between the growing seasons of 1996/1997 and 1998/1999 was approximately $952,400. These values are from the Los Angeles, CA terminal prices, as these figures are not currently available for endive or escarole in Arizona[4].
- Land preparation and growing expenses for endive and escarole are approximately $3.25/carton[5].
- Harvest and post harvest expenses for endive and escarole are approximately $2.77/carton[5].
- Endive and escarole are produced in Maricopa and Yuma counties.

Cultural Practices

General Information[7, 10]: In the state of Arizona, endive and escarole are grown during the fall and winter. Planting begins the beginning of September and is usually completed by October. Temperatures during the endive and escarole growing season can range between 30 °F to 90 °F. Prolonged low temperature, long days or environmental stresses will induce bolting of endive and escarole. In Arizona, endive and escarole are mostly grown on soils that range from a dry loam to a sandy loam with a pH of 7.5-8.0.

Cultivars/Varieties[9]: In Arizona, the most commonly grown varieties of endive are ‘Lorca’ and ‘Salad King’. Salad King is an old standard that has been grown for many years. The outside leaves will blanch slightly but the inner leaves remain green. Lorca is popular because also have slight blanching properties. Blanched endive leaves are yellow-green in color and are desired for packaged salads because they add to the color diversity of the mix.

‘Fullheart’ and ‘Salanca’ are the most commonly grown varieties of Escarole. Fullheart is a public variety, and has been grown for many years. Salanca has also been grown for many years.

Production Practices[10, 11]: 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 applied prior to bed formation. If a pre-plant fungicide, such as mefenoxam, is utilized it is usually applied after bed formation but prior to planting.

Most endive and escarole is directly seeded but a small percentage may be transplanted. Seeds are planted at a depth of ¼ to ½ an inch in beds with 40" centers. There are two rows per bed, and plants are spaced 8" apart within the row. Sprinkler irrigation may be used to promote seed germination.

The field is cultivated two or three times during production. A side dressing of fertilizer is also added two or three times, as required. Both drip and furrow irrigation are used for endive and escarole Production in Arizona.

Harvesting Procedures: Endive and escarole require, from the time of planting, 3 to 3 ½ months to reach maturity[1]. Harvesting begins in early December and is usually completed by the middle of March[10]. The leaves are harvested by hand and are trimmed, washed and tied into bunches in the field. Two dozen bunches are packed into wax cardboard boxes and then sent to coolers[12]. Endive and escarole are vacuumed cooled to remove heat from the boxes and cool the heads to the core. The USDA recommends storing endive and escarole at 32 ºF with a relative humidity of 95-100%[8]. In order to meet Arizona standards, endive and escarole must be fresh, well trimmed, fairly well blanched, free of decay and free of serious damage[13]. All endive and all escarole that is packed must have similar varietal characteristics. No more than 5%, by count, can have decay. No more than 10%, by count, can have other defects. No more than 15%, by count, can fail to meet Arizona standards[13].

Insects and Mites

(10, 11, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25)

Hymenoptera

Harvester Ant (*Pogomyrmex rugosus*)

Ants are not a frequent pest of Arizona crops; however, when they do occur in a field they can be insidious. The harvester ant is primarily a pest during stand establishment. They eat seedlings and will carry the planted seeds and seedlings back to their nest. When there are ants in a field, typically there is no vegetation surrounding the anthill. Ants generally do not cause damage to mature endive or escarole plants. Ants are also a pest to people working within the field by swarming and biting workers.

Sampling and Treatment Thresholds: University of Arizona experts suggest that a field should be treated at the first signs of damage[22].

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

Chemical Control: Hydramethylnon is often used to control harvester ant populations, by placing it around the anthill. Worker ants will carry the poisoned bait back to their nest and distribute it to the other ants and the queen. Hydramethylnon, however, can only be used on bare ground, outside borders and ditch banks. Carbaryl baits can be used to control ant populations within the crop field.

Cultural Control: Surrounding the field with a water-filled ditch can help control ant migration into the field. This method, however, is of little value if the ants are already in the field.

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

Alternative Control: Rotenone is an alternative method used by some growers to control ant populations. Another method is to pour boiling water that contains a citrus extract down the anthill to kill populations inside.

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 destructive during stand establishment. The female flea beetle lays her eggs in the soil, on leaves, or within holes and crevices within the endive or escarole head. Depending on the species, the larvae feed on the leaves or the roots. The adult beetles will also feed on endive and escarole, 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. Mature plants, however, are more tolerant of feeding and rarely suffer severe damage. If the leaves of endive or escarole are damaged, however, the head is 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. Experts at the University of Arizona recommend treating prior to head formation when there is 1 beetle per 50 plants[21]. After head formation, treatment should occur when there is 1 beetle per 25 plants[21].

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 and permethrin, are the most commonly utilized 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 also targeting crickets, grasshoppers and lepidopterous larvae.

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. Fields should be disked under immediately following the final harvest to kill any larvae pupating in the soil. It is also 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 beneficial because it feeds on caterpillars and other insects.

Rove beetles are a ¼" in length with a shiny, elongated 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. Rove beetles tend to dig up planted seeds out of the soil. Darkling beetles feed on emerging seedlings and girdle plants at the soil surface. Sometimes these beetles feed on the leaves of older plants. Darkling and rove beetles, however, are normally not a threat to mature plants unless their populations are high.

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. The beetles often migrate from nearby cotton and alfalfa fields or weedy areas. According to University of Arizona guidelines, endive and escarole should be treated when beetle populations are high or there is a threat of migration into the field. A plant that has 5 to 6 leaves is usually not at risk for beetle attack[21].

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

Chemical Control: Methomyl, diazinon and pyrethroids such as permethrin are routinely used treatments for the control of rove beetle and darkling beetle populations. Diazinon and pyrethroids can be chemigated through the sprinkler system or foliar applied. These two active ingredients 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 and neem oil to control darkling and rove beetles.

Orthoptera

Cricket (*Gryllus* sp.)

Crickets are rarely a problem in Arizona but dense populations are capable of destroying an entire crop. Crickets are ½" to 1" in length, and brown-black in color. Most feeding occurs at night; during the day crickets hide in the soil, weeds, ditches and under irrigation pipes. Crickets attack endive and escarole seedlings as they emerge from the soil.

Cricket populations build up in cotton fields, Sudan grass and desert flora and then move from these fields into endive and escarole fields at the end of the summer. Fields that use over-head sprinkler irrigation encourage inhabitance by creating 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. Experts at the University of Arizona recommend that a field should be treated when cricket damage is high or there is a threat of cricket migration into the field[22].

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 permethrin are the most commonly utilized treatments for controlling cricket populations. These insecticides can be ground applied or applied by chemigation. Spraying, rather than using baits, has the added benefit of also 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 endive or escarole. Occasionally, 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. Often the grasshoppers are merely seeking shade in the field.

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[22].

Biological Control: A predaceous protozoon, *Nosema locustae*, can be used to help 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 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

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, feed on the mesophyll tissue and do not emerge until they pupate. Leafminers usually pupate in the soil, although sometimes they will pupate between the leaves of the head. These larvae often die and rot within the head, providing a substrate for pathogen infection. 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. Leafminers are usually considered to be a secondary pest. The leaves of endive and escarole must be completely free of damage as this is the consumed portion of the crop. If a head is damaged by leafmining, or contaminated by leafminer pupae, the plant is unmarketable. Most leafminer damage, however, occurs at the seedling stage on the cotyledons.

Sampling and Treatment Thresholds: It is important that the crop is monitored regularly for leaf mines, larvae and adult flies. The cotyledons and the 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*. University of Arizona guidelines recommend that prior to head formation, endive and escarole should be treated when populations have reached 1 active mine per leaf[21]. After head formation, treatment should occur when populations reach 1 mine per leaf per 25 plants[21].

Biological Control: *Diglyphus*, *Opius* 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 both *L. sativae* and *L. trifolii*. Spinosad is the only chemistry available that provides control for *L. trifolii*. Insecticide resistance has been noted in *L. trifolii* populations, thus there is a need for a diversity of insecticides to allow for resistance management.

Cultural Control: It is best to avoid planting near cotton, alfalfa and melon fields, as leafminers will migrate from these fields into an endive or escarole 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 = saltmarsh caterpillars, loopers, beet armyworm, corn earworm and tobacco budworm.

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 such as warm temperatures. The adult moth has gray-brown forewings with irregular markings; the hind wings 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 and frequently occur in fields that were previously planted with alfalfa or pasture. Seedlings are the most susceptible to cutworm attack. 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 endive and escarole. The cutworm attacks the plant 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 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. If endive or escarole are contaminated by cutworms or damaged by cutworm feeding, the head is unmarketable.

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 for 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. According to University of Arizona guidelines a field should be treated as soon as soon as stand loss begins[21].

Biological Control: There are some natural enemies to 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 seedling 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 and pyrethroids are the most routinely used chemistries for controlling cutworm populations. The 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 areas of a field and in the same fields. It is important to control weeds, in the field and surrounding the field, which could act as hosts to cutworms. 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 hind wings 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 are covered in long, dark black and red hairs. Older larvae may also 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 sugarbeets but will migrate from surrounding host fields into endive and escarole fields. The saltmarsh caterpillars feed on seedlings and can skeletonize older plants. On older plants, the larvae often feed in groups. If populations are high, they can decimate an entire seedling stand.

Sampling and Treatment Thresholds: Counts of saltmarsh caterpillars should be included with the total Lepidoptera count.

According to University of Arizona experts, fields should be treated at the first signs of damage[21].

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

Chemical Control: Methomyl, spinosad, tebufenozide and pyrethroids are the most commonly utilized treatments for controlling saltmarsh caterpillars. Methomyl and pyrethroids are contact insecticides that are foliar applied. Spinosad is a translaminar insecticide that must be consumed or tread upon to kill the larvae. Tebufenozide is an insect stomach poison that must be consumed to be effective.

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 seedling emergence will help assess the degree of risk for the crop. Saltmarsh caterpillars do not like to cross physical barriers. A 6" high aluminum foil strip or irrigation pipes that the larvae cannot crawl under will provide a 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. Barriers work well to exclude saltmarsh caterpillars from the field, but will have no useful value if the larvae have already infested the field.

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

Alternative Control: *Bacillus thuringiensis*
(Bt) may be used to control saltmarsh caterpillars. An important consideration when using Bt 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.

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 winter vegetables are planted.

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 hind wings are yellow. The female moth lays dome-shaped eggs solitarily on the lower surface of mature 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 and can cause extensive damage to endive and escarole. The larvae feed on the lower leaf surface, chewing ragged holes into the leaf. Often loopers will bore into the base of the head and feed within the head and on the growing tip. Excessive feeding on seedlings can stunt growth, prevent head formation or even kill plants. Endive or escarole that has been damaged by looper feeding or that is contaminated with larvae or larvae frass is unmarketable.

Sampling and Treatment Thresholds: Once endive and escarole have germinated or been transplanted, 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 University of Arizona recommends that prior to head formation endive and escarole should be treated when populations have reached 1 larva per 50 plants[21]. After head formation, plants can tolerate 1 larva per 100 plants[21]. All other lepidopterous larvae that are noted should be included in this total.

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. If conditions are favorable, nuclear polyhedrosis virus, a naturally occurring virus, can assist in the control of loopers.

Chemical Control: Spinosad, tebufenozide and pyrethroids, such as permethrin, are the most commonly utilized chemistries for controlling looper populations. All are foliar applied insecticides. Thiodicarb is often tank-mixed with permethrin to provide control of the lepidopterous complex.

Cultural Control: During seeding, weeds on ditch banks and adjacent fields should be monitored for eggs and larvae. Weeds growing within the field or surrounding the field should be controlled because they can act as hosts for loopers and other lepidopterous insects.

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 most effective if applied when larvae have just hatched. A 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.

Beet Armyworm (*Spodoptera exigua*)

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

The forewings of the adult moth are gray-brown with a pale spot on the mid-front margin; the hind wings 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 emergent larvae are olive green and are nearly hairless. There is a broad stripe on each side of the body and light-colored stripes on their back. A black dot is located above the second true leg and a white dot at the center of each spiracle. Mature larvae pupate in the soil.

Beet armyworms are a key pest that affects vegetable Production in Arizona. Armyworm populations are heaviest during the fall and will 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 will die while traveling between plants. Armyworm feeding can skeletonize leaves and consume entire seedlings. A single armyworm can attack several plants. Sometimes an armyworm bores from underneath into a head and feeding on the margins of newly formed leaves. Endive or escarole heads that have been damaged by armyworm feeding are unmarketable.

Sampling and Treatment Thresholds: Weeds surrounding the field should be monitored for larvae and eggs prior to crop emergence. If population levels are high in surrounding weeds, the crop should be closely monitored. Pheromone traps can be used to monitor for the presence of beet armyworms in a field. After germination, fields should be monitored twice a week. According to University of Arizona guidelines, prior to head formation endive and escarole should be treated when populations reach 1 larva per 50 plants[21]. Once the head has formed, endive and escarole can tolerate 1 larva per 100 plants[21]. All other lepidopterous larvae that are noted should be included in this total.

Biological Control: There are viral pathogens, parasitic wasps and predators that attack the beet armyworm. These beneficial insects, 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 are the most commonly used insecticides for the control of armyworms. 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. The eggs darken prior to hatching, which gives a good indication when to prepare to spray. 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 the field or surrounding the field should be removed, 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 larvae pupating in the soil.

Post-Harvest Control: There are no methods for the post harvest control of 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 hind wings are white with dark spots. The forewings of the tobacco budworm moth are light olive-green with three thin, dark bands; the hind wings 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 can be a variety of colors 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 attack all stages of plant growth and can be very destructive to endive and escarole stands. The larvae are cannibalistic, eating larvae of their own species and of other lepidopterous species, thus they tend to be feed alone. These larvae are capable of killing entire stands of seedlings. In older plants, the larvae chew holes into the leaves and the midrib. Sometimes the larvae will bore into the head and attack the growing point of the plant, often killing the growing tip. Once inside the head it is difficult to control larvae with pesticides. Often this damage is not noticed until endive and escarole are harvested. Damage to the head will result in an unmarketable plant.

<u>Sampling and Treatment Thresholds</u>: Field monitoring should begin immediately following 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. Endive and escarole should also be checked for larvae and feeding damage. It is important to correctly identify which species of larvae are present, as resistance in tobacco budworms has been reported. Experts at the University of Arizona recommend that endive and escarole should be treated before head formation when populations reach 1 larva per 50 plants[21]. After head formation the crop can tolerate 1 larva per 100 plants[21]. All other larvae in the lepidopterous complex should be included in this count.

<u>Biological Control</u>: 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 beneficial insects. Nuclear polyhedrosis virus, a naturally occurring pathogen, also helps control populations.

<u>Chemical Control</u>: 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 are often used for controlling earworms and budworms.

<u>Cultural Control</u>: Delaying planting until after cotton defoliation will decrease larvae migration into endive and escarole fields. However, due to market demands it is not always feasible to delay planting. Fields that are planted next to cotton fields require close monitoring. Fields should disked following harvest to kill any larvae pupating in the soil.

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

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

1999 Insecticide Usage for the control of Lepidoptera Larvae in Endive and Escarole Grown in Arizona

							(# of reports)				
Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	By Air	AW	CW	L	WU
Bacillus thuringiensis	0.05	0.37	1.05	53.5	19%	4	4	3	0	3	1
Imidacloprid	0.16	0.04	0.38	3	1%	2	0	2	0	0	0
Methomyl (**carbamate**)	0.45	0.79	0.90	168.9	60%	17	10	13	0	7	2

Permethrin	0.1	0.17	0.2	344.4	122%	27	18	18	1	19	5
Spinosad	0.023	0.08	0.156	225.55	80%	17	14	14	0	7	3
Tebufenozide	0.09	0.11	0.12	36.6	13%	2	2	2	0	2	0

AW armyworm

CW cutworm

L loopers

WU worm unknown

OP organophosphate

*Application rates are pounds of active ingredient (AI) 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 are 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*)
Lettuce Aphid (*Nasonovia ribisnigri*)
Plum Aphid (*Brachycaudus helichrysi*)

Aphids are one of the key pests of endive and escarole. There are two principal species of aphid that are pests to endive and escarole: green peach aphids and lettuce aphids. 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. Lettuce aphids can vary in color including; light green, yellow, orange or pink. The aphids have long, spindly legs and older aphids develop dark stripes on their abdomen and legs. Lettuce aphids are usually found feeding in the growing point; being hidden within the head makes lettuce aphids more difficult to control. The plum aphid ranges in color from green, yellow or brown. Plum aphids feed on the undersurface of the leaves.

Aphid populations peak during the months of November and December and again during February and March. Populations consist entirely of asexual reproducing females producing live young; this allows the population to increase rapidly. Under ideal conditions aphids have as many as 21 generations in one year. A single aphid can have as many as 100 offspring during its 30-day lifespan. When populations become too large or food is scarce, aphids produce winged offspring that can migrate to new hosts.

The majority of aphid damage occurs during the final heading stage. Extreme aphid feeding can deplete a plant of 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. Aphid feeding can cause the leaves to become deformed and the head to be distorted. Another concern are the viruses that green peach aphids can transmit such as; lettuce mosaic virus, beet western yellows and turnip mosaic virus. Lettuce aphids will transmit beet western yellows and cucumber mosaic virus, but not the lettuce mosaic virus. Aphids are most damaging, however, as a contaminant; their presence in an endive or escarole head will make the head 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. In infested fields, aphids tend to occur in clusters within the field, thus it is important to randomly sample the field. Experts at the University of Arizona recommend that prior to head formation, treatment should begin when populations reach 1 aphid per 10 plants[21]. After head formation, endive and escarole should be treated when aphid colonization begins[21].

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

Chemical Control: A pre-plant application of imidacloprid is the most common method used to control aphids. This insecticide has the added 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 will choose to wait and apply a foliar insecticide. When foliar insecticides are used, the timing of application is critical. Dimethoate and imidacloprid are the most frequently used foliar-applied treatments. The initial treatment should occur once aphids begin to migrate into a crop field. To ensure that the harvested endive or escarole is not contaminated with aphids, it might be necessary to use repeated applications. Aphids often hide within the head making insecticide contact difficult. If aphids only occur at the field borders or in isolated areas, border or spot applications may be sufficient to control populations. Insecticide chemistries should be alternated 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: Organic growers use; insecticidial soaps, neem oil soap, neem emulsion, pyrethrin, rotenone dust, plant growth activators, elemental sulfur, garlic spray and diatomaceous earth to control aphid populations.

WHITEFLIES

Sweet potato whitefly (*Bemisia tabaci*)
Silverleaf whitefly (*Bemisia argentifolii*)

Historically, whiteflies have not been a primary pest of endive or escarole 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 minute (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 will darken at the apex prior to hatching. The hatched whitefly (nymph) travels about the plant until it finds a desirable minor vein to feed from and 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. Whiteflies migrate from cotton, melon and squash fields, as well as, from weed hosts. Colonization of the crop can begin immediately following germination, beginning with whiteflies feeding on the cotyledons. Endive and/or escarole planted downwind from these crops is particularly susceptible. Whitefly feeding removes essential salts, vitamins and amino acids required by endive and escarole for proper growth. This feeding results in reduced plant vigor, leaf chlorosis, decreased head size and can delay harvest if not controlled at an early stage. As with aphids, the phloem sap that whiteflies excrete onto the leaf surface creates an ideal environment for sooty mold infection. Whiteflies also contaminate harvested endive and escarole, making it unmarketable. Still a concern is the whitefly's ability to transmit viruses.

Sampling and Treatment Thresholds: Monitoring should begin as soon as the seedlings emerge. 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. According to University of Arizona guidelines, if a soil-applied insecticide is not used, crops should be treated when populations reach 5 adults per leaf[21].

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 in August or September when populations are at their greatest imidacloprid, a soil-applied prophylactic insecticide, is often applied. If endive or escarole are planted after whitefly populations have declined, foliar-applied insecticides can be used as necessary. Imidacloprid 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 the most active in early September and tend to migrate from defoliated and harvested cotton. Whiteflies build up in weeds, especially cheeseweed (*Malva parviflora*), thus it is important to control weeds in the field and surrounding the field. Delaying planting until populations have begun to decrease and temperatures are lower will help to decrease whitefly infestation. However, delay of planting is not always a feasible option. 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, pyrethrin, insecticidial 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. Thrips spread from surrounding weedy areas, unirrigated pastures, mustard, alfalfa, onion and wheat fields.

Thrips species are minute (1/16 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 are 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 results in wrinkled and deformed leaves, damaged heads and stunted growth. Feeding can also cause brown scaring; extreme damage causes leaves to dry and fall off the plant. Black dust (thrips feces) on the leaves distinguishes this damage from windburn or sand burn. Thrips present in harvested endive and escarole are considered a contaminant. Although thrips can cause crop damage, they are also an important mite predator. In some instances, the beneficial control that thrips provide for mite populations is greater than the damage they cause the crop. Endive or escarole that have been damaged by thrips or that are contaminated by thrips are not marketable.

Sampling and Treatment Thresholds: Sticky traps are a good monitor of thrips migration into a field. When inspecting for thrips, the folded plant tissue of the endive and escarole heads must be carefully examined, as this is where thrips to hide. It is estimated that for every 3 to 5 thrips observed there are three times as many undiscovered. The University of Arizona recommends that prior to head formation, endive and escarole should be treated when populations reach 1 thrips per 10 plants[21]. After head formation, the crop should be treated when the population reaches 1 thrips per 25 plants[21].

Biological Control: Lacewing larvae, ladybug larvae (syn: ant lions) and the minute pirate bug are 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 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 for nymphs but not adults. Currently there are no insecticides that provide complete control of thrips.

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 (syn. "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 has 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 with a 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 and on weed hosts. Leafhoppers are not commonly found in endive or escarole fields.

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

Sampling and Treatment Thresholds: The University of Arizona suggests that before the formation of the head, a stand does not require treatment until populations reach 10 contaminant insects per 50 plants[21]. Once the head is formed, endive and escarole should be treated when populations reach 1 contaminant insect per 25 plants[21].

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 endive or escarole, chemical control is not normally required until head formation begins. Growers typically spray as close to harvest as the label will allow. Dimethoate, methomyl, diazinon and pyrethroids 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 endive and escarole field has been harvested, this will prevent insect migration into the 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.

1999 Insecticide Use on Endive and Escarole Grown in Arizona

Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	(# of reports) By Air	Aph.***	Con.	Lep.	SE	Thp.	W
WESTERN													
Azadirachtin	0.21	0.01	0.9	28	12%	2	2	1	0	0	1	2	0
Bacillus thuringiensis	0.05	0.37	1.05	53.5	23%	4	4	0	0	7	0	0	0
Diazinon (**OP**)	0.25	0.97	4	35.6	15%	21	1	1	1	0	20	0	1[illegible]
Imidacloprid	0.16	0.20	0.38	90	38%	27	5	7	1	2	15	5	2[illegible]
Methomyl (**carbamate**)	0.45	0.77	0.90	210.4	90%	20	13	3	0	22	1	4	1
Permethrin	0.1	0.17	0.2	420.4	180%	36	25	4	0	42	6	11	2
Spinosad	0.023	0.08	0.156	277.05	118%	23	20	2	0	24	2	7	1
Sulfur	2.4	1.89	8	23	10%	2	2	1	0	0	0	2	0
Tebufenozide	0.09	0.11	0.12	36.6	16%	2	2	0	0	4	0	0	0
CENTRAL													
Permethrin	0.1	0.11	0.2	32	65%	2	2	0	0	1	0	0	0

Aph. aphids

Con. contaminant = lygus, chinch bug, leaf hoppers, alfalfa hoppers

Lep. lepidoptera larvae

SE stand establishment insects = ants, crickets, flea beetles, darkling beetles, grasshoppers

Thp. Thrips

WF Whitefly

OP Organophosphate

*Application rates are pounds of active ingredient (AI) 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

(6, 10, 11, 14, 15, 17, 18, 20, 26, 29, 30)

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

In Arizona, damping-off is rarely observed in endive or escarole fields. Damping-off is a soilborne fungus that attacks germinated seedlings that have not yet emerged or have just emerged. 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.

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* can also attack the seedling’s roots, causing them to turn brown and rotten. Rhizoctonia also causes bottom rot in mature endive and escarole plants.

Biological Control: *Gliocladium virens* GL-21 is the only biological method available for controlling *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 that are registered for use on both *Pythium* and *Rhizoctonia* induced damping-off; however, these methods are very costly and generally not considered a viable option. Mefenoxam is registered for controlling *Pythium*-induced damping-off on endive fields but not on escarole. This fungicides work 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 no other chemistries registered in Arizona to treat *Rhizoctonia*-induced damping-off. There are no registered seed treatments in Arizona for controlling damping-off of endive or escarole. Most growers, however, do not treat for damping-off, as this disease is not currently a large threat to endive or escarole in Arizona.

Cultural Control: All residues from the previous crop should be plowed under and completely decomposed before planting endive or escarole. 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 or sprinkler irrigation are the best methods for promoting rapid germination. It is important to manage water 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. If transplants are used they should be inspected for healthy, white roots. 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.

Sclerotinia Drop (*Sclerotinia minor, Sclerotinia sclerotiorum*)

In Arizona, *Sclerotinia* is normally not a concern in endive or escarole. *Sclerotinia* thrives when the winter growing season is cool and wet. Sclerotinia drop is caused by two species of soil-borne fungi. *Sclerotinia minor*, which infects only the parts of the plant that are in contact with the ground. *Sclerotinia sclerotiorum* also infects the parts of the plant that are in contact with the soil, but in addition produces air-borne spores that can infect the upper leaves.

The fungus produces large, black sclerotia in the plant tissue and on the soil surface. The sclerotia can survive for a long time in the soil, especially when the weather is dry. The sclerotia of *S. minor* and *S. sclerotinia* are spread by contaminated equipment, soil and plant tissue. *S. sclerotiorum* also produces sexual spores that are spread by wind.

Sclerotia germinate on the soil and then infect the plant. Any plant stage can be infected, but more commonly infection occurs on mature endive and escarole plants. Infection usually takes place through damaged or necrotic tissue. Senescing lower leaves are the most common sites of initial infection. The fungus can also enter through the upper portion of the root, near the soil surface. The initial sign of infection is the wilting of lower leaves. As the disease spreads to the inner leaves, the outer leaves collapse and eventually the entire head will wilt and discolor. This is followed with the rotting decay of the head and root system. The lower leaf surfaces of infected leaves become covered with white mycelium.

Biological Control: There are no available methods for the biological control of *Sclerotinia*.

Chemical Control: Metam sodium and metam potassium are fumigants and are the only chemistries registered for use on *Sclerotinia*; however, these methods are very costly and generally not considered a viable option. There are no other chemistries available for controlling *Sclerotinia* in endive or escarole fields.

Cultural Control: Fields should be carefully irrigated to avoid over saturating the field; as wet conditions favor *Sclerotinia* development. Weeds must be controlled in the field and around the field to eliminate potential hosts for *Sclerotinia*. It also important to rotate to resistant crops, to prevent the transmission of S*clerotinia* to the next crop. Infected plant debris should be removed from the field. Following harvest, the field should be deeply plowed to bury the sclerotia a minimum of 10 inches and encourage their decay. This will not, however, prevent the introduction of the air-borne spores of *S. sclerotiorum*.

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

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

Downy Mildew (*Bremia lactucae*)

Downy mildew can occur in endive and escarole fields but its occurrence is rare. *Bremia lactucae* thrives in cool, humid weather, such as that typical of the winter growing season in western Arizona. This weather promotes spore formation and spore dispersal, as well as, plant infection. A wet leaf surface is required for spore germination. *B. lactucae* infects endive and escarole plants through their leaves and then grows between the leaf's cells. When conditions are favorable, the pathogen can spread rapidly. The fungus also produces resting spores, which can survive in the soil or crop residue until the following season. *Bremia lactucae* is spread by; wind, rain, infected seed and infected transplants.

Damage occurs on both leaf surfaces, beginning with chlorotic, yellow areas. These areas enlarge in size and eventually turn necrotic and translucent. Young leaves may dry and drop off, while older leaves generally remain on the plant and develop a papery texture. On the underside of infected leaves one will find the growth of gray-white fungi. Downy mildew can decimate large numbers of seedlings. Severe infections of mature endive or escarole can result in decreased photosynthesis, stunted plants and reduced yield. Damage to the stem and head makes the plant susceptible to secondary infections. Often downy mildew is not noticed until the head is cut open. Any damage to the endive or escarole head, results in an unmarketable product. Even minor damage can cause significant losses due to trimming of infected leaves. Damaged leaves can continue to decay on heads that are in transit.

Biological Control: There are no biological methods for controlling downy mildew.

Chemical Control: Fosetyl-aluminum and copper hydroxide are the most commonly used chemistries for the control of downy mildew. Fosetyl-aluminum is a systemic treatments; copper fungicides are protectants. Azoxystrobin is registered for use on endive but not escarole. Azoxystrobin has some translaminar activity. Mefenoxam is temporarily registered, by a special local needs '24C', for controlling downy mildew in endive fields but not in escarole. Downy mildew is best controlled when treatment is used as a preventative measure, rather than waiting for the onset of disease. If there is heavy rain and/or mild temperatures, one can anticipate downy mildew. 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: Weeds that can act as a host for downy mildew must be controlled. It is important to rotate to a crop that is not susceptible *B. lactucae* in the subsequent year. Overhead irrigation should be avoided, as this aids in the spread of *Bremia lactucae*. A well-drained field will also help reduce the risk of infection. 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 downy mildew.

Alternative Control: Some organic growers use milk and hydrogen peroxide to control downy mildew. Spreading compost on the soil is also used to control pathogens. *Bacillus subtilis* is also registered for the control of *Bremia.*

Powdery Mildew (*Erysiphe cichoracearum*)

Powdery mildew has been noted to occur in endive and escarole fields but is normally not a major threat to production. *Erysiphe cichoracearum*
thrives in dry, mild temperatures. The fungus prefers low levels of light, thus it tends to develop on lower leaves. The fungus produces wind-dispersed spores that are capable of traveling long distances. Disease development occurs on both leaf surfaces, beginning with small spots of white, powdery fungal growth. Often the older healthy leaves are the first to be infected. As disease progresses the leaves become covered with white, powdery spores. The leaves may become chlorotic and eventually brown; sometimes they become dried and curled. Powdery mildew infection stunts growth and reduces plant marketability.

Biological Control: There are no biological methods for controlling downy mildew.

Chemical Control: Potassium bicarbonate is registered for controlling powdery mildew in Arizona on both endive and escarole crops. Azoxystrobin is registered on endive for controlling powdery mildew but not on escarole. For the best protection, fungicides should be applied before disease onset. Azoxystrobin has some translaminar activity; potassium bicarbonate does not. For the best results with potassium bicarbonate, the fungicide should be applied frequently and good coverage is essential. Sulfur is often used to control powdery mildew, but is not registered for use on endive or escarole grown in Arizona.

Cultural Control: There are no methods for the cultural control of powdery mildew.

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

Alternative Control: Spreading compost on the soil is sometimes used to control pathogens.

Bottom Rot (*Rhizoctonia solani*)

Rhizoctonia is a soil-borne fungus that thrives in warm, wet weather. The fungus produces sclerotia that are capable of surviving in the soil for long periods of time. The sclerotia germinate in the soil and infect the endive or escarole plant through open stomata or damaged tissue. Infection begins in those leaves that are in contact with the soil and then moves to inner, healthy leaves. The initial sign of infection is the development of sunken, brown spots on the underside of the lower leaves. Infection can occur in the early seedling stages but advanced symptoms usually do no occur until the final heading stage. The brown spots increase in size; rotting the bottom portion of the endive or escarole plant. White-brown mycelia grow within these lesions. If not controlled, the endive or escarole head will eventually be covered in a brown, slimly rot and collapse. Sometimes, fungal infection is not noticed until the head is harvested. Damage caused by *Rhizoctonia* can leave the plant susceptible to *Erwinia* sp. (bacterial soft rot).

Biological Control: There are no biological methods for controlling bottom rot.

Chemical Control: Metam sodium and metam potassium are fumigants and the only chemistries registered for use on *Rhizoctonia*; however, these methods are very costly and generally not considered a viable option. There are no other methods available in Arizona for the chemical control of bottom rot.

Cultural Control: It is important not to overirrigate fields, as this will encourage *Rhizoctonia* infection. It is also best not to rotate from alfalfa into endive or escarole; as alfalfa tends to harbor *Rhizoctonia*. Deep plowing will bury sclerotia and promote their decay.

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

Alternative Control: Spreading compost on the soil is also used to control pathogens. Another method used by some growers is to apply large amounts of nutritional sulfur on the soil, to promote the vigor of the plant.

Gray mold (*Botrytis cinerea*)

Botrytis is a sporadic disease in Arizona and is normally not an economic threat to endive or escarole. The fungus is saprophytic, surviving on crop debris in the soil, weeds and numerous crop species. The fungus produces spores that are dispersed by wind. Cool weather with high rainfall and lots of dew periods promote infection and disease development.

Plant infection begins through damaged and dying leaves that are in contact with the soil. Once the fungus has infected these leaves, it easily moves to the healthy leaves. The initial sign of infection is the yellowing and wilting of the lower leaves. Brown, decaying lesions are also noted on the outer leaves. The disease progresses inwards to the younger leaves. If the disease progresses the head will eventually collapse into a watery, brown decay, which ultimately becomes covered with gray mycelium. Black sclerotia may also be found in infected tissue. Young seedlings can also be infected; the disease girdles the stem and causes the seedling to collapse, resembling symptoms of damping-off.

Plants that have been infected by *Botrytis* are susceptible to bacterial soft rot and other fungal Diseases.

Biological Control: There are no biological methods for controlling *Botrytis*.

Chemical Control: DCNA is the only chemistry registered to control Botrytis in endive and escarole fields in Arizona. DCNA is a contract fungicide.

Cultural Control: It is important not to over irrigate and to have good field drainage to prevent fungal infection. Sprinkler irrigation should be avoided as this provides a wet plant surface for fungal infection. Care must be taken while cultivating to not injure roots or the head that will leave an entryway for infection. Controlling disease and insects that will cause plant injury will prevent the occurrence of lesions of the leaves, through which the fungus can enter. Deeply plowing the field after harvest will help control *Botrytis*.

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

Alternative Control: Spreading compost on the soil is also used to control pathogens.

Bacterial Diseases

(6, 10, 11, 14, 15, 17, 18, 20, 26, 27, 28, 29)

Bacterial Soft Rot (*Erwinia* sp.)

Bacterial soft rot occurs in the field, but is more common during the post-harvest. Open wounds on the plant provide an entry for the bacterium. Plants that are already infected with downy mildew or black rot or plants that have experienced freezing or insect damage are particularly susceptible to bacterial soft rot. The first sign of infection is the appearance of brown spots on the midrib of the outer leaves. Once inside the endive, the bacterium spreads rapidly, dissolving the middle lamella of the cell. The entire head will become blackened and consumed with a slimy, wet rot. Bacterial soft rot is accompanied by a foul odor.

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 endive and escarole leaving them 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 hosts to *Erwinia*.

Post-Harvest Control: Endive should be handled carefully to avoid bruising or wounding the plant. Endive should be stored at low temperatures, typically 40 °F. It is important to keep the storage facility 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. There are no alternative control methods that can be utilized during post-harvest storage.

1999 Fungicide Usage on Endive and Escarole Grown in Arizona

							(# of reports)	
Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	By Air	Downy Mil
WESTERN								
Sulfur	2.4	1.89	8	23	10%	2	2	1
Maneb	1.12	1.60	1.5	2	1%	1	0	2

*Application rates are pounds of active ingredient (AI) 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

(15, 31)

Generally speaking, viral Diseases are not a common occurrence in endive or escarole grown during Arizona's winters. Cabbage mosaic and turnip mosaic viruses have been observed in endive and escarole stands but their occurrences are rare. These viral Diseases cause the leaves to develop a yellow/light green/dark green mottled appearance. Necrotic areas can also develop. When infection is severe and occurs early in plant development, it can decrease plant vigor. Green peach aphids and lettuce aphids are both capable of transmitting viral Diseases.

Biological Control: There are no biological control methods for directly controlling viruses, however biological methods can be utilized to control virus vectors, e.g. aphids and whiteflies. 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, whiteflies). This method of control, however, is not very effective because it only requires a few insects to spread viral disease.

Cultural Control: Only planting 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. This will eliminate the host, thus killing the virus.

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.

Vertebrate Pests

(15, 16)

Birds can be very destructive of crops. Horned larks, black birds, 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 endive and escarole 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 (roundtailed ground squirrel, rock squirrel, Harris ground squirrel) are known to damage irrigation ditches and canals, as well as, feed on endive and escarole seedlings. These pests can be controlled by fumigation, trapping and poisoning. It is best to poison squirrels in their burrows to prevent poisoning of predatory birds. There are several species of mice that can be pests of vegetable crops; they can be controlled by repellents and occasionally with poisoning. Wood rats occasionally 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 (black-tailed jackrabbits, desert cottontails) that infest fields and cause economic loss. Rabbits can 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 endive and escarole, but are also protected by Arizona State laws.

Abiotic Diseases

(15)

There are a number of Abiotic Diseases that endive and escarole can suffer from that can affect the crop yield and often have symptoms similar to those caused by pathogens or insect pests.

Brownheart is a disease that is caused by inadequate supply of calcium. This disease causes the browning of the margins on young leaves. A foliar spray of calcium can be used to help control brownheart. Heads that have been damaged by brownheart are susceptible to secondary infections such as bacterial soft rot.

Although both endive and escarole are relatively tolerant of cold temperatures, escarole is the more tolerant of the two. Despite this tolerance, the leaves of the head can experience cold injury. The outer leaves that are damaged, however, can be removed and have little effect on the crop value. The damage that occurs may render the plant susceptible to secondary infections.

Winds that are strong and carry sand can abrade the leaves and make them susceptible to secondary infections. When the leaves heal themselves, it results in thickened, discolored areas that can be misidentified as pathogen infection. Wind can also severely damage seedlings, pinching the stem and collapsing them.

High salt concentrations in the soil can also be injurious to endive and escarole. Symptoms include; stunted plants, thick dark leaves, yellowing or burning at the leaf margin and roots that are orange in color and rough in appearance. Salt may also inhibit seed germination.

Nutrient deficiencies can cause damage to endive and escarole crops. Nutrient deficiency damage often results in stunted plants, chlorosis and leaf spotting. Nitrogen, phosphorus and molybdenum are the most common element deficiencies to cause injury. Soil and plant tissue should be sampled regularly to determine if deficiencies are present. It is usually not possible, however, to replenish an element after the stand is established.

Weeds

(6, 15, 16, 20, 32, 33)

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 can host a variety of Diseases and insects that can be transmitted to endive and escarole. Weed control is the most important during the first 30 days of plant establishment, after this period endive and escarole are better able to compete with weeds. As well, the canopy created by the endive or escarole stand, shades the underlying soil and inhibits the germination of weed seeds. It is essential that weeds are destroyed before they flower and produce seed. One plant can produce 1000s of seeds.

The summer weeds are the weeds commonly found in Arizona between the months of August and October. Common summer broadleaf weeds include; 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 weeds are the weeds most commonly found in Arizona between the months of November and March. Common winter broadleaf weeds include; black mustard (*Brassica nigra*), wild radish *(Raphanus sativus*), shepherdspurse *(Capsella bursa-pastoris*), London rocket (*Sisymbrium irio*), 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 germinated.

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

Chemical Control: It is important to correctly identify the weed species, as different weeds have different chemical tolerances. Most postemergence herbicides do not have a wide range of weed control. Preemergence herbicides are more effective for the control of weeds in a radicchio crop field. It is challenging to adequately control weeds while ensuring crop safety. Another option is to use a non-selective herbicide such as glyphosate to eliminate weeds in the field prior to crop emergence.

Trifluralin, bensulide, oxyfluorfen and pronamide are the only registered preemergence grass herbicides in Arizona. Bensulide is usually sprayed behind the planter in a band over the seed row; however, it can also be broadcast spayed or chemigated. Irrigation is required to activate this chemistry; sprinkler irrigation is often utilized. This herbicide is effective against grass weeds and will also control some small-seeded broadleaf weeds. Trifluralin is usually sprayed prior to planting and must be mechanically incorporated. This herbicide is effective on grass weeds, and has efficacy against some small-seeded broadleaf weeds. Trifluralin usually gives better broadleaf weed control than bensulide. Pronamide can be used pre-plant, preemergence or post-emergent but most applications are band-applied over the seedbed either just before or immediately after planting. Pronamide controls grasses and also has some efficacy against small-seeded broadleaves. Oxyfluorfen is an effective preemergence broadleaf herbicide but has little effect on grasses. In addition, oxyfluorfen is only registered for use on a fallow field and the plant back restriction is 120 days, which makes this option impractical. Sethoxydim and fluazifop-p-butyl are the only available postemergence herbicide. These herbicides have good grass control but have no efficacy against broadleaf weeds. Pelargonic acid can be used for spot treatment on postemergence crops.

Herbicides can cause injury to endive and escarole 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>: Endive and escarole should be encouraged to grow quickly and establish the stand, which will allow increase their ability 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. This water build up will promote 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. However, 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 kill the weeds. After the weeds have been destroyed, the endive and escarole can be 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 must be done with care. Rows and beds must be carefully planted and the cultivation equipment must be carefully aligned. Hand hoeing can also be utilized. Fields should be disked after harvest to eliminate any weeds present and to prevent the weeds from flowering and spreading seed.

Crop rotation allow the use of different herbicides that are not registered on endive or escarole. 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 Use on Endive and Escarole Grown in Arizona

							(# of reports)	
Active Ingredient	Label Min.*	Avg. Rate*	Label Max.*	Total # of Acres	% of Acres Treated	# of Reports**	By Air	Unspecified
WESTERN								
Benefin	1.12	1.19	1.5	62.9	27%	1	0	1
Bensulide (**OP**)	5	3.55	6	112.25	48%	14	0	13
Pronamide	1	0.76	2	30	13%	20	0	20
Trifluralin	0.5	0.68	1	30	13%	2	0	2
CENTRAL								

Trifluralin	0.5	0.46	1	15	31%	1	0	1

OP = organophosphate

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 (AI) 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.

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 were no section 18s active in Arizona for endive or escarole 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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