MARYLAND PEA PROFILE

Production Facts

- Maryland ranked 10th in national pea production in 1997, and accounted for 1.1% of total U.S. pea production (1).
- Maryland growers currently harvest about 2,000 acres of peas annually for processing and less than 310 acres for the fresh market (2, 3, 4, 5). This is down from about 3,100 acres harvested in 1996 (6).
- The average annual production cost for peas grown for processing in Maryland is about $251.27 per acre, or $678,429.00 total for 1997 (7).
- The average annual cash value of peas grown for processing harvested in Maryland in 1997 was $330.00 per acre or $891,000.00 total (7).
- The average annual cash value of fresh market peas grown in Maryland in 1997 was $1,129.00 per acre or $350,000.00 total (2, 8).
- IPM practices are used on 90-95 % of Maryland processing pea acres (4).

Production Regions

Nearly all commercial production of peas in Maryland is on the Eastern Shore, and is for processing. The availability of large fields and the proper soil type make the Eastern Shore ideal for large scale commercial production of peas (4). The majority of pea acreage for processing is in the Eastern Shore counties of Dorchester and Caroline, although about 400 acres are grown in north central Maryland (6, 3). Currently, about 2,000 acres are harvested annually for processing in Maryland by 3 major producers (3, 4, 5). This is a decline from 1996 estimates of about 3100 acres for processing (6). About 310 acres are harvested for the fresh market annually, about 55% on the Eastern Shore and 45% west of the Chesapeake Bay (2).

Production Methods

Peas are annual plants that thrive in cool weather and can tolerate frost. Peas perform best in fertile, well-drained, sandy to loamy soils which are fairly homogeneous (9, 10, 11). Fields with a mixture of soil types can result in asynchronous maturity of plants which leads to difficulties harvesting (11). Early plantings are made when the soil becomes tillable in the early spring, usually late February or early March, and planting may continue until the end of April (9). Peas are always direct-seeded (4). To assure good nutrient uptake, seeds on about 10 to 30% of Maryland acreage are inoculated with nitrogen-fixing bacteria at planting (4, 9, 10). About 60% of acres are planted with seeds that have been treated with a fungicide-insecticide combination. Insecticides used are either chlorpyrifos (Lorsban) or diazinon (4). Captan is the main fungicide seed treatment used (6). Often seeds come pre-treated from the seed company (4).

Seeding rates vary, depending upon the variety of peas (11). Generally, for processing peas, 250 to 275 pounds of seed per acre are planted in rows 6 to 7.5 inches apart, resulting in stands with 17 to 23 plants per yard and about 2 inch spacing between plants (6, 9). The resulting dense plant populations help increase crop competitiveness by creating a dense canopy and reducing weed growth. Early plantings of processing peas can be especially competitive against weeds and usually do not require herbicide applications (6). For fresh market peas, 80-120 pounds of seed per acre are planted in 30-inch rows. Growers use a press wheel drill or seeder to plant seed at a depth of no more than 1 inch, unless the soil is dry, in which case seed is placed below the moisture line (4, 9).

Peas are grown in rotation with other crops, to prevent the build up of soil pathogens that promote root rot. An ideal rotation is 7 years out of legumes (10). Most growers in Maryland practice at least a 3 year rotation out of peas and related crops (4). Peas are generally double- cropped in Maryland, a fact which limits herbicide selection in peas. Typical rotations are lima beans, soybeans, cucumbers, and sweet corn, but other vegetables may follow as well (6).

Adequate moisture is needed throughout the growing season, and processors require that all growers have irrigation (6, 10). Center point irrigation is used by most growers (4). Yields are reduced if too much or too little moisture is available (6).

Peas are generally not very competitive against weeds. Dense stands of hardy plants compete best, but additional weed control measures may be required, especially in later plantings (4, 10). Preventive treatments and postemergent products may be used, depending on planting time, soil temperature and weed control needs, based on scouting (4).

Peas are harvested when the pods are full and the peas are still soft and immature (10). Degree-day accumulations are used to determine planting times, to prevent peas from maturing at intervals which would cause them to ripen more quickly than harvesting equipment could pick them (4). Early spring processing peas mature in 55 to 70 days (6). All processing peas are machine harvested, generally between May 20 and June 30 (9, 10).

Pest control in Peas

Due in part to the early growing season for peas, and active scouting on 90 to 95% of pea acreage, production in Maryland is done with a minimum of pesticide use. Based on a 1996 survey of pea processors in Maryland, herbicides were not used on about 20% of acres grown, and foliar insecticide treatments for pea aphid were omitted on about 15% of acres surveyed (6).

Insect Pests

Major Insect Pests of Peas

There are two major insect pests of peas: the seedcorn maggot and the pea aphid (6). Although both are important management considerations, pea aphids are the most destructive of these two pests (4).

Pea Aphid (*Acyrthosiphon pisum*)

Damage and Life Cycle

Pea aphids overwinter on alfalfa or clovers either in the egg stage or as female adults (12). Winged females migrate to peas in early spring, where they multiply rapidly by giving live birth to 10 to 14 young each day (12, 13). Aphids usually go through several generations before becoming injurious to peas during late May through June (12). Under favorable conditions, 12 or more wingless generations are produced in rapid succession throughout the summer. Winged adults appear later in the season, and many of these fly back to clover and alfalfa where males and egg-laying females are produced (13).

Large colonies of pea aphids can be found clustered on stems (usually near the terminals) and on the undersides of the leaves. Damage results from aphids inserting their sharp mouthparts into plants and sucking the sap. Heavy feeding causes the plant to wither, turn yellow, and may cause plant death. Infested leaves become thickened and curled, infested blossoms are blasted, and injured pods become stunted and deformed. Injury usually takes place from the time the peas are coming into bloom until they are nearly ready to harvest (12). In addition, aphids are the primary vectors for several viral diseases which can reduce yields (14).

Frequency of Occurrence

The pea aphid is the most important insect pest of peas in the Mid-Atlantic area. Pea aphids occur every year in every field, but the extent of infestation is dependent upon weather conditions (15). Economic levels occur most seasons, and approximately 70% of acres are typically affected in any given year. If untreated, yield losses of 20-25% are likely from direct damage from pea aphids, however, maximum losses of 5 to 10% are more typical under the current treatment regime (4, 13). Additional loss has occurred from viruses vectored by pea aphids (13). Temperatures during March and April when aphids are developing on their overwintering hosts determine the time of migration and extent of injury to peas. An early spring warmup followed by cool weather during May and early June provides the most favorable conditions (12). Insecticide applications which deplete populations of beneficial insects may also lead to aphid outbreaks (16).

Management

About 90% of processing pea acreage in Maryland is scouted for pea aphids (4). Aphids can be detected by scouting for wilted and curled leaves throughout the field (16). Fields are sampled from the bud stage until harvest using a 15-inch diameter sweep net, or by examining individual plants (13). Fields are treated with an insecticide if 5 to 10 aphids per plant are present or when 50 or more aphids are collected per sweep (9). However, if sampling reveals one or more active predators per 50 aphids, chances for natural control within a week are considered excellent and treatment may be deferred and sampling repeated later (6). Natural predators have the potential to play a role in pea aphid control, but their buildup can be slowed by cool spring weather which allows the cold-adapted aphids to reproduce more rapidly (15). For this reason, pea aphid control by predators in Maryland is seldom effective in keeping populations below economic levels (4).

Chemical Controls

Most years, peas planted prior to April 1 receive no foliar insecticide treatment, although, rarely, they may be sprayed, based on recommendations from scouting. Dimethoate is the foliar insecticide of choice because it is effective at very low rates and is relatively inexpensive (4). Pea acres planted after April 1 generally receive 1 to 2 applications of dimethoate at a rate of 0.165 ai/A (0.33 pt 4EC/A) (4, 6, 9). Virtually all 400 acres grown for one processor in north central Maryland (20% of annual crop) receive a single application of dimethoate at a rate of 0.5 pt/A (3). Typically, between 50 to 85% of pea acreage in Maryland is treated with dimethoate (4, 6). Applications are made between bloom and harvest, but exact timing is determined by scouting and the maturity of the crop. Between the timing of the first and second application, some acres will have been harvested, and some acres will be near enough to harvest that a second insecticide application offers no economic benefit. However, about half of the acres treated typically are sprayed twice (4). Instead of dimethoate, 2 applications of methomyl at 0.45-0.90 lb ai/A (1.5-3 pt Lannate LV/A) are used on about 10% of pea acres in the state (4, 9). This product, though effective, is more expensive and raises more environmental concerns than dimethoate. The loss of dimethoate could have a serious impact on economic pea production in Maryland (4). In years when pea populations are low, only 10 to 20% of the later plantings may require any chemical control action (15).

Regardless of the foliar insecticide used, thorough spray coverage on the underside of leaves is important (9). Spot treatments are not used because aphids in untreated areas will quickly multiply and spread, making an additional application necessary (4).

Alternative Controls

Aphid-resistant pea varieties are not available (13). Aphids are subject to attack by many predators and parasites (12). These natural enemies can help control pea aphids and delay insecticide treatment when weather is warm, but during a cool spring their populations cannot keep pace with

aphids which are better adapted to cool weather (4, 15). Also, some insecticides used in peas are detrimental to these beneficial insects. During periods of high humidity, fungal diseases may also help reduce aphid populations (16). No cultural control practices are used by Maryland growers (4).

Seedcorn maggot (*Delia platura*)

Damage and Life Cycle

Seedcorn maggot is a common insect throughout the mid-Atlantic area, where it overwinters, usually as puparia, in the soil (6, 12). Adults emerge around spring planting time and females lay their eggs just below the surface of the soil. Recently plowed fields high in organic matter or those with fresh manure are favored egg-laying sites (6). Eggs hatch in 4 to 7 days, and emerging larvae feed on decaying organic matter. Maggots burrow into the seed and consume the germ, preventing germination or stunting plants (12, 16). Maggots also feed on the developing hypocotyl of young plants. Infested seedlings usually die within a few days (16). Larvae feed for 21 days, then pupate in the soil. There are 4 to 5 generations per season in Maryland, but only the first generation causes damage to peas (12, 13). Weak and dying seedlings are often the first sign of a seedcorn maggot infestation, though above-ground injury may not be apparent (6, 15).

Frequency of Occurrence

Seedcorn maggot is a major pest of spring-planted peas in Maryland (13, 15). Although infestation levels vary considerably from year to year, maggots can reach economic levels on up to 80% of pea acreage (4, 13). In severely affected fields, stand losses of 25 to 35% are seen during the worst infestations. Because plants are able to compensate for these losses by producing more peas per node, this generally translates to a yield loss of around 10% (4). Injury is most severe in cool wet springs when germination is delayed and growth is slow. Fields high in crop residue and other organic matter are most susceptible to high levels of infestation (16).

Management

Cultural controls, preventive soil insecticides and seed treatments are used to control seedcorn maggot. These practices generally keep populations from causing significant economic damage. However, during cool, wet springs when seed germination and growth are delayed, maggot damage can result in significant stand reduction, and sometimes replanting is necessary (15). Application of rescue treatments after the damage is observed is ineffective. Management options must be applied to high-risk fields prior to planting (13). About 30 to 50% of Maryland pea acreage is scouted following germination to determine seedcorn maggot damage level (4).

Chemical Controls

Timing of control is at planting. About 60% of commercial acres are planted with seed which has been treated with a fungicide and an insecticide, either chlorpyrifos (Lorsban 50SL, 1 oz ai/100 lbs of seed) or diazinon (0.25 oz ai/56 lbs of seed). Diazinon seed treatment is used on 18% of the acreage while chlorpyrifos seed treatment is used on 42% of the acreage (6, 4). In 1996, 40% of Maryland processing pea acreage received no insecticide seed treatment (6).

Insecticide rates of seed treatments are not high enough to control severe infestations of seedcorn maggots. A combination of a seed treatment and soil insecticide is needed if population pressure is heavy (13). The only labeled chemical control option is the use of a broadcast application of diazinon at a rate of 0.167 lbs ai/A (2-4 qt/A) incorporated 3-4 inches into the soil immediately prior to planting (6, 13). Control with Diazinon has been about 35% (13). Diazinon is preplant incorporated on about 5% of acres grown (4, 15). Thiamethoxam (Adage), a new material from Novartis may be an effective alternative, but usage data for this product is not yet available (13).

Alternative Controls

No resistant varieties are available. The use of cultural management practices before planting is critical to reduce the potential for economic problems. A combination of the following cultural strategies are used by Maryland growers: plow down of cover crops at least 3-4 weeks before planting or transplanting; complete burial of cover crops or previous crop residue to reduce fly attraction to rotting organic matter on the soil surface; and avoiding the use of heavy manure applications close to planting (13). Late plantings during cool springs and shallow placement of seed may speed germination and reduce injury levels, but this is not a good marketing decision for growers since peas are a valuable early season crop (4, 16). Although predators, parasitoids, and pathogens are known to slightly reduce infestations, they do not provide economic levels of control (13).

Minor Insect and Mite Pests in Maryland

The lepidopteran species, cutworms, armyworm, alfalfa looper, and alfalfa caterpillar, are very minor pests of peas in Maryland. They occur in most fields and feed on the foliage but cause no yield loss. The new varieties and modern production practices produce very vigorous and tolerant plants that can withstand a great deal of foliar damage. Historically, lepidopteran pests have been a problem for pea producers because the caterpillars and chrysalis would be harvested along with peas and often contaminate the final processed product. However, modern floatation cleaners in the processing plant have greatly reduce the risks of larval contamination (15). Currently, no chemical treatments are used to control any of these insects (4).

Diseases

The cool early growing season for peas does not favor the development of most potential diseases. Pea production in Maryland requires relatively little fungicide use. Apart from seed protectants, which are widely used to reduce incidence of damping off due to Pythium root rot, very few fungicide treatments are used most years. Crop rotation, the use of resistant varieties, and preparation of fields to allow adequate soil drainage are key management strategies for diseases of peas (4, 17).

Bacterial Diseases

Bacterial blight

Damage and Life Cycle

Bacterial blight of peas is caused by the bacterium *Pseudomonas syringae* pv. *pisi* (11). Bacterial blight affects all above ground portions of the plant. The pathogen overwinters in seed (18). Infection can also result from soybean residue (4). Symptoms are first seen in seedlings grown from infected seed. The disease can spread to other plants in the same field. Secondary infections often occur when hard rain or sand drainage result in wounds where new infections can start (17). Water-soaked spots develop on the pods, stems, and leaves of infected plants. In wet weather, spots enlarge and a white to cream-colored slimy ooze may collect on the surface of the spots. In dry weather, spots dry up, becoming brown and papery (18). Blowing rain facilitates the spread of the pathogen from one plant to another in the field (4).

Frequency of Occurence

Bacterial blight is of minor economic importance in Maryland pea production. Its occurrence is linked to contaminated seed. Use of certified seed produced by reliable companies is essential, but doesn't completely eliminate the potential for the disease (4). Even rigorous seed testing cannot detect every infected seed (17). Bacterial blight can cause significant losses, but its occurrence in Maryland is relatively rare (4). A few infected fields occur about once every five years. When it occurs, it is due to the combination of a low level of contamination in the seed and weather conditions that are favorable for infection (17).

Management

This disease is managed primarily by planting certified seed (17). Resistant cultivars are not currently available to Maryland growers. Research is underway to identify the genes responsible for susceptibility, but little is known about the number of races of this bacterial pathogen or how readily it mutates (4).

Chemical Controls

There are no chemical controls that work directly on bacterial diseases (19).

Alternative Controls

Resistant cultivars are not used by Maryland growers. Some of the available cultural controls, such as reducing traffic of people and machines in the field, are not practical. Plowing down soybean residue prior to planting helps reduce disease incidence and is practiced by most growers (4).

Viral Diseases

Pea viruses can be of economic importance in Maryland. The worst of these is enation mosaic virus (4).

Life Cycle

A number of viruses are known to infect peas worldwide (14). Four of these are of potential economic importance to pea production in the Mid-Atlantic. Each of these viruses is responsible for a unique disease characterized by distinct symptoms as described below. All of them overwinter in clover, alfalfa, and other plants in the legume family, and are transmitted by aphids (18). For this reason, viruses sometimes occur in peas as complexes (14).

Damage and Frequency of Occurence

Pea Enation Mosaic - This disease is caused by the pea enation mosaic virus (PEMV). Periodic serious losses to this disease among susceptible cultivars are seen in the Northeast (18). Maryland pea producers see some incidence of enation virus every year (4). On average, about 20% of the crop is affected, however, this is generally of little economic importance (4). If contracted early, it can cause distortion of leaves and pods or plant death prior to bloom (14). Typical symptoms include areas of yellow discoloration on foliage, blister-like ridges (enations) on pods and on the underside of leaves, pod distortion and suture splitting (18). Conditions that increase aphid populations can increase the occurrence of this virus (4). Tolerant cultivars are available, but are not used by processors because economic impact of the disease is very low and because varieties are selected based on qualities related to ease harvesting and processing (4, 18).

Pea Stunt - Pea stunt is caused by the red clover vein mosaic virus (RCVMV). The virus is endemic to all major areas of pea production in the U.S. (14). This disease occurs to some extent every year. It can be seen on occasional plants in the field but does not spread easily and so is of little economic importance (4). Symptoms are characteristic chlorosis or necrosis of the veins, stunting, terminal rosetting, and poor pod set. Early infection can lead to plant death prior to bloom. Stunt-tolerant

cultivars are available and are the primary means of control (14).

Bean Yellow Mosaic - Bean yellow mosaic virus (BYMV) causes this disease, also called pea mosaic. Symptoms include green and yellow mottling or mosaic patterns and characteristic growth from axillary buds (18). This disease is of no economic importance, due the availability of good resistant varieties (14).

Pea streak - The condition known as pea streak is actually caused by multiple viruses or a complex of viruses. The primary causal agents in the U.S. are pea streak virus (PSV), red clover vein mosaic virus (RCVMV), and necrosis-inducing strains of the alfalfa mosaic virus (AMV). The most severe form of the disease is caused by PSV. Early infection with PSV kills most pea cultivars. Later infections are characterized by brown and purple leaf spots that follow the vascular system. Necrosis follows quickly after transmission of PSV by aphids, which typically carry the disease from nearby alfalfa fields. Entire fields can be devastated in a very short time. Infection by PSV at early bloom stage results in dark or sunken spots on pods (14). Other forms of pea streak are characterized by purplish brown streaks on stems, flattened purplish brown pods, death of veins, and wilting and death of terminal growth (18). Occurrence of the most severe forms of pea streak are associated with proximity of alfalfa fields, where PSV persists (14). Disease occurrence in Maryland is somewhat cyclic, with peak occurrence every 5 to 7 years. However, even in the worst years it is of no economic importance in our area (4).

Management

Although aphids are important vectors for all of these viruses, insecticide applications to control aphids are only used in cases where aphid populations are large and feeding injuries are occurring. Since one or a very few aphids may spread viral diseases quickly, the level of aphid control required to prevent any viral transmission is not economically or biologically feasible. Because viral diseases in peas are of little economic importance, no specific management strategies are used (4).

Chemical Controls

There are no chemical controls that work directly on viruses (4).

Alternative Controls

Newer pea varieties exhibit some resistance to viruses, however, economic loss due to viruses has not been severe enough to cause processors to give up the desirable characteristics of currently used varieties (4).

Fungal Diseases

Aphanomyces Root Rot

Damage and Life Cycle

Aphanomyces root rot is caused by the fungal pathogen *Aphanomyces euteiches* f. sp. *pisi*, although the other soil-borne organisms contribute to the disease complex. Oospores can remain dormant in the soil for years. When conditions are favorable, the spores germinate and pass through several life stages before developing into hyphae that can grow through host plant tissue. Infection can occur at all temperatures favorable for pea development. Once pea roots are infected, the mycelium of the fungus begins to decay the root tissue. As roots decay, the oospores return the soil to serve as inoculum in years to come (14). Characteristic symptoms include water-soaking, softening, and slight discoloration of the taproot and lower stems of infected plants. The outer root tissue of infected plants can be easily sloughed off (18). Symptoms develop faster at warmer temperatures (14).

Frequency of Occurence

Aphanomyces root rot, or common root rot, is one of the most destructive diseases of peas. It occurs in most pea producing regions of the U.S., including the Mid-Atlantic. In the Northeast, average annual yield loss to this disease is about 10%, though losses in individual fields may be up to 100% (14). In Maryland processing peas, annual yield loss is generally 1 to 5%. It would be higher without adequate crop rotation (4). Wet soil conditions and poor drainage are associated with higher rates of infection. The disease is most damaging in years when a cool, wet spring is followed by an early, warm summer with low rainfall (14).

Management

Attempts to control this disease through the development of resistant host plant strains have not been successful. Crop rotation is an extremely important practice, but because oospores can survive in the soil for years. Even the recommended rotations of 4 to 5 years may not be sufficient in all cases. Other host plants such as beans, alfalfa, and spinach must be avoided in the rotation. Many leguminous weeds can also serve as host plants and should be controlled (14). The best management strategy includes using long rotations, planting in fields with well-drained soils, and avoiding planting in moderately to highly infested fields (14, 17).

Chemical Controls

There are currently no registered fungicides that can consistently control moderate to high infestations of *Aphanomyces* (14). Soil fumigants are not used to control this disease (4).

Alternative Controls

No effective soil tests for *Aphanomyces* are being used locally, so infestation levels are not determined prior to planting (4). Crop rotations of 4 to 5 years and avoidance of double cropping peas with beans are recommended practices (9). Local growers have found that double cropping with lima beans does not add years to the required rotation interval (4).

Fusarium Wilt

Damage and Life Cycle

Fusarium wilt of peas is caused by the soil-inhabiting fungal pathogen *Fusarium oxysporum* f. sp. *pisi* (14, 18). Near-wilt, a related disease, is caused by a different race of the same pathogen. Both diseases can be introduced from soil borne pathogens, but the symptoms and control strategies for the diseases differ somewhat (17, 18). The fungus can survive in the soil as long as 10 years as chlamydospores and by association with the roots of non-host crops. The fungus penetrates the roots of peas and may colonize the vascular system of non-resistant varieties. The pathogen spreads in contaminated soil, seed, and plant debris, and can be transported from field to field by wind and water. Soil temperature, pea cultivar, and soil type can affect the rate of disease spread (14, 17).

Fusarium wilt is characterized by yellowing of the lower leaves and a general stunting of the plants. Leaf margins curl downward and, in some cases, the stem becomes swollen and brittle at the soil line (18). A discoloration of internal root tissue also occurs. At soil temperatures above 20°C, the disease progresses rapidly, plants may be killed, often in small patches (depending upon the race of the fungal pathogen). These dead plants serve as a resevoir of inoculum for spread of the disease. One of the outcomes of Fusarium wilt infection is uneven maturity among plants in the field, which leads to yield loss and reduced quality of produce (14).

The symptoms of near wilt are similar, but the disease's progress and plant death generally occurs more slowly than in Fusarium wilt. The diseases can also be distinguished by differences in the quality and extent of internal root discoloration (18).

Frequency of Occurence

Some races of the fungus are widely distributed and can kill 1 to 3% of plants in infected fields. Because warm soil temperatures are conducive to the spread of inoculum, damage can vary significantly from year to year and the most severe losses occur in late peas (4, 14).

Management

Fusarium wilt is controlled through the use of resistant varieties and crop rotation (9, 14) .

Chemical Controls

Fungicides are not used for the control of Fusarium wilt (9, 14).

Alternative Controls

Fusarium wilt-resistant varieties are available, and are increasingly popular with Maryland growers (4, 14). However, when disease potential is very high, some of these varieties do not offer sufficient control and there can still be a reduction in yield and quality (14). Good rotational practices are important. Most Maryland processors contract with growers with enough irrigated land to rotate into corn and grains for 3 years between plantings of peas or other leguminous crops. This rotation interval is not as effective for fusarium as it is for *Aphanomyces* and *Ascochyta* (4).

Damping-off (Pythium Root Rot)

Damage and Life Cycle

Damping-off refers to symptoms caused by several species of *Pythium*: seeds rot before they germinate, shoots decay before they emerge, and seedlings collapse (17). This fungus causes a soft, watery rot which can affect seeds or roots (14).

Pythium species are common in the soil and persist as spores in plant debris left in the field. They have a broad host range that includes many other crop plants and weeds. The fungus attacks peas during or immediately after germination. In established plants, immature secondary root tissue is attacked and destroyed, a condition known as "root pruning." If a plant survives, seedlings are weak and stunted and yield is reduced (14).

Frequency of occurence

In most seasons, damping off is not of great economic importance. It is seen to some degree in every field each year, but generally has little effect on yield (4). Severity of infection is dependent upon the weather. Damage is most severe when soil moisture is high. The *Pythium* species that cause damping off in peas differ in the temperature that is optimal for their growth, but the best range for most species is from 18-24^{o}C (14, 17). Fortunately, pea germination occurs at lower temperatures, giving peas the chance to outgrow *Pythium*, especially early season plantings. Cultivars with wrinkled seeds are most susceptible to *Pythium* attack. *Pythium* often occurs as a part of a complex of other diseases, significantly, *Fusarium* species (14). Damping off affects up to 20% of pea acreage annually. Fortunately, damage occurs at an early stage when healthy pea plants can compensate for losses most effectively. For this reason, damping off generally has little impact on pea yield (4).

Management

Damping off is controlled with the use of fungicide seed treatments. Some newer cultivars show some resistance to *Pythium* (14).

Chemical Controls

Seed treatments are the most cost-effective means of control and captan is the principle fungicide seed treatment, used on nearly 100% of acres (4, 6). Two different formulations were used in 1996, captan 75WP at 0.265 lb ai/a on 58% of acres and captan 4EC at 0.183 lbs ai/A on 42% of acres (6). Another option is to apply mefenoxam (Ridomil Gold) as a broadcast treatment at seeding at a rate of 0.25-0.5 lb ai/A (0.5 to 1 pt 4E/A) (9). Only about 4% of Maryland growers use mefenoxam, because the product is expensive and it is questionable whether it provides an economic benefit (4).

Alternative Controls

Cultural practices that aid in disease management include use of seed that has high vigor, seeding at the proper depth, and preparation of fields to allow for adequate drainage (14, 17).

White Mold (Sclerotinia Rot)

Damage and Life Cycle

White mold is the common name for Sclerotinia rot, a potentially destructive disease of peas caused by the fungal pathogen *Sclerotinia sclerotiorum*. The pathogen survives the winter within the soil in the form of sclerotia. Sclerotia germinate, form apothecia, and disseminate spores that infect plant tissue. The fungus grows rapidly under favorable field conditions. Mature peas develop watery lesions in infected tissue, especially where air circulation is poor and humidity is high (14, 17). White mycelial growth develops into dense mats, and the surface tissue becomes slimy. Dark, irregular sclerotia develop in infected plant tissues. Leaves, stems and pods may become infected. Stem rot is common in this disease, and is most problematic, destroying plants outright. The disease can be distributed with the seed, transmitted by farm equipment or animals, and spread by irrigation water. Also, spores can be blown on the wind from plant to plant and from field to field (14).

Frequency of occurence

The fungus can tolerate a broad range of temperatures, but fungal growth is most rapid at temperatures between 20 and 25^{o} C (14). This disease can be a recurring problem in specific fields, where it can result in a yield loss of 5 to 10% (4, 17).

Management

Chemical Controls

Fungicides are not used to control this disease in Maryland (4).

Alternative Controls

Resistant varieties are not used (4). Growers plant disease-free seed into well drained fields (14). A 5 year rotation into non-leguminous crops is recommended, but a minimum 3 year rotation is observed by most growers of processing peas in Maryland (4, 14). Plant debris is plowed deeply under the soil surface following harvest (14). Growers avoid dense stands in order to promote good air circulation among the plants. Also, careful and restricted use of irrigation helps to reduce disease incidence (4).

Ascochyta Diseases

Damage and Life Cycle

Three species of related fungal pathogens cause important diseases of peas. *Ascochyta pisi* causes leaf and pod spot; *Mycosphaerella pinodes*, the perfect stage of *A. pinodes*, causes blight; and *Phoma medicaginis* var. *pinodella*, causes foot rot. All of these diseases are characterized by lesions on leaves, stems, blossoms and pods, and by discoloration of the hypocotyl, cotyledons, and roots (14). All of these pathogens are soil-borne and persist to a greater or lesser degree in or on soil and plant debris; *A. pisi*, however, is primarily carried on or in the seeds. Infested seeds may be infected and develop into weak, stunted plants that are unproductive or die (14, 17). Leaf lesions vary in appearance, depending on the fungal species involved and on the geographic region. Stem lesions of *Mycosphaerella pinodes* can cause girdling. When flowers are infected by one of these species, sepals may become girdled, killing the developing pod or resulting in distorted pods. Leaves of infected plants become desiccated on all but the highest nodes. Root infection is often limited to the primary roots, but in some cases lateral roots are also destroyed (14).

Frequency of occurence

These diseases are common in pea production areas worldwide (14). In Maryland, infection is seen in some fields but not others, and the severity of occurrence in affected fields can vary considerably. It is difficult to estimate yield loss attributed directly to Ascochyta diseases, but 50-100 lbs/acre annually is a reasonable estimate. This might translate to 1-3% of yield. *Phoma medicaginis* var. *pinodella*, which causes foot rot, is the most serious of these pathogens in Maryland (4).

Management

Chemical Controls

Captan seed treatments are used on nearly 100% of acres and greatly reduce seed-borne sources of infection (see Pythium section for rates and formulations) (14, 6). No foliar fungicides or other chemical controls are used by Maryland growers to control *Ascochyta* diseases (4).

Alternative Controls

Good resistant cultivars are not available, though tolerance levels can vary significantly among pea cultivars for a particular region. Planting seeds that were produced in dry areas is the first line of defense against *Ascochyta* diseases (14). Field preparation to facilitate good drainage will also reduce this disease (17). Crop rotation is practiced but will not reduce infection caused by *M. pinodes*. Pea refuse is plowed under immediately following harvest to prevent dispersal of the fungus by wind (14).

Nematodes

Nematodes are very seldom an important pest control issue in peas. Fields with moderate to heavy infestations of nematodes generally have no significant effects on yield in peas (4). Peas are a good host for nematodes, but because they are planted early and grow during cool weather, they are harvested before damage from nematodes becomes evident (17). Fumigants are not used prior to planting peas, but may be used following pea harvest before planting of certain rotational crops in double cropping situations (4).

Weeds

Weed Management in Peas

Good weed control is essential to economic pea production. Because peas are not good competitors, a small number of weeds in peas can reduce crop yield considerably (4). Reduced yields result from direct competition with weeds and due to interference with harvesting equipment. Peas can become contaminated with weed plant parts (e.g. nightshade berries, Canada thistle buds or daisy buds) during harvesting, which can result in reduced selling price or in severe cases, rejection of the crop. Yield losses from weeds can be as high as 100% in severely infested fields, and all fields are affected to some extent. Fields with infestations of weeds posing contaminant problems are rejected for harvesting. While the specific weed species present can vary regionally, weeds are serious pests of peas throughout the state (20).

Weed control strategies in peas vary, depending upon planting time of the crop. It is advantageous to plant peas early because peas planted before March 25 do not require preemergent herbicides. Peas are more tolerant of cool soil temperatures than most weeds, and will germinate and grow at temperatures that prevent germination of most weeds. In some cases, postemergent herbicides are used on early plantings, based on scouting. To provide processors with a regular flow of peas to harvest, plantings are made from early March through late April. Peas planted after April 1 are usually treated with preemergent herbicides, and frequently receive postemergent herbicides applications as well, to control weed escapes (4, 6). Rotary hoeing, used on 5 to 10% of acres prior to pea emergence to loosen soil surface that has crusted, also has some weed control benefits (4).

Major Weeds of Peas

A wide range of summer and winter annual and perennial weed species are present in pea fields in Maryland. According to a 1996 survey, 29% of processing pea acres in Maryland had no weeds under current management practices. Light weed pressure was reported on 27% of acres, while moderate and heavy weed pressure were reported on 26% and 19% of acres, respectively. Lambsquarters, henbit, ragweed, cocklebur, and grasses were the principle types of severe and moderate weed problems reported. Chickweed, marestail, and smartweed were also major sources of moderate weed problems (6). Significant losses are caused by common lambsquarters, smooth pigweed, ragweed, and Canada thistle (21). Common lambsquarters, pigweed and ragweed have large stems that can interfere with harvesting equipment. Canada thistle is problematic because its flower buds may be harvested along with peas and are difficult to separate (6). Marestail is difficult to control with currently available herbicides, but because it tends to have a scattered distribution it does not generally compete well with peas (4). Grasses are less competitive against peas than some of these broadleaf weeds, especially under the cool soil conditions prevalent in early peas, but may require postemergent herbicide treatment in some situations (6).

Table 1: Major weeds in peas (21).

Weed Species	**freq. of occurrence (% of fields)**	**avg. annual % yield loss***	**avg. % control achieved***
Annual grasses	100	20 ± 0	99
Pigweed, smooth	85	50 ± 6	95
Common lambsquarters	95	50 ± 10	90
Common ragweed	70	30 ± 4	95
Common purslane	50	15 ± 3	95
E. black nightshade	15	40 ± 1	70
Shepherdspurse	10	10 ± 1	95
Henbit	70	20 ± 2	90
Common chickweed and mouseear	70	20 ± 2	90
Yellow nutsedge	15	25 ± 1	85
Johnsongrass	5	20 ± 1	96
Canada thistle	2	50 ± 1	80

*With current cultural practices and herbicide use; treatments not effective.

Chemical Controls

Early plantings of peas (before March 25) generally do not require herbicide treatments. In 1996, about 20% of Maryland pea acreage received no herbicide treatment (6). Preemergent products are used on about 35% of pea acreage, mainly those acres planted after April 1 (4, 6). These late plantings may also require postemergent herbicide applications where weed escapes occur, as determined by scouting (6).

Table 2 lists herbicides used in Maryland, acres treated, rates, and timing of applications.

Table 2: Herbicide use in Peas.

Pesticide	% Acres Trt.	Average Rates lbs ai/acre (range)	Timing	# of Appl.	PHI days
clomazone *(Command)*	2	0.16 (0.16)	preemergence	1	60
s-metolachlor *(Dual)*	29	1.19 (0.50-1.50)	preemergence	1	60
imazethapyr *(Pursuit)*	7	0.035 (0.031-0.044)	preemergence	1	60
bentazon *(Basagran)*	40	0.83 (0.24-2.00)	postemergence; when peas have 3 pairs leaves	1	21
sethoxydim *(Poast)*	9	0.20 (0.06-0.28)	postemergence; when grasses are actively growing	1	15
paraquat (Gramoxone)	7	0.39 (0.22-0.63)	Preemergence for minimum tillage and no-tillage	1	-
quizalofop - P-ethyl ***(Assure II)***	<5	(0.04-0.08)	postemergence	1	15

Table modified from data provided by Mark Van Gessel. Data sources: 4, 6, 9, 21.

I. Preemergence Herbicides

Preemergent herbicides provide improved control of annual and grasses and certain broadleaf weeds (6). Preemergent herbicides are only applied after temperatures have warmed sufficiently to allow peas to grow rapidly. Otherwise, peas could suffer significant damage from these herbicides (4). Although some of these products are labeled for preplant incorporation, all are applied as preemergents (4, 9) These products are not used on most pea acreage planted in March (which accounts for about 40-50% of Maryland pea acreage), and are not used at all by one of the processors in north central

Maryland (another 20% of acreage) (3, 4, 6). The remaining 30 to 40% of acres receive a single application of one of the following products.

? **S-Metolachlor** (0.50-1.50 lbs ai/acre Dual 8E) is the preemergent herbicide of choice for processors in Maryland, and is used on about 23% of pea acres in Maryland (3, 4, 6). There are no crop rotation restrictions with Dual, which is an important consideration (6). It is generally applied at less than labeled rates, to reduce the possibility of damage to peas. Certain weeds, notably common lambsquarters and marestail, are not well controlled by Dual and usually require postemergent treatment. A single application is used (21).

? **Clomazone** (0.16 lb ai/A Command 4EC) is used on only about 2% of acres because it causes whitening of the crop plants following each rainfall, and there is a high potential for injurious drift (4, 6). Clomazone may be used without concern about rotational crop injuries, with the exception of sweet corn (6). A single application is used (21).

? **Imazethapyr** (0.031-0.044 lb ai/A Pursuit 70DG) has rotational restrictions; its use is limited to situations where the following crops are not sensitive to this material (6). (See "General Herbicide Issues" section below.) A single application is used on about 6% of processing pea acreage in Maryland (3, 6, 21).

? **Paraquat** (0.22-0.63 lb ai/A Gramoxone Extra 2.5SC). A single application is used to kill cereal cover crops and weeds before or after peas are planted, but prior to pea emergence, in minimum tillage situations. In 1996, a single application of paraquat was applied to about 7% of the processing pea acreage surveyed in Maryland (6, 21). A processor in north central Maryland grows about 270 acres of minimum tillage peas, and applies paraquat to most of these fields prior to planting for weed kill. For fields with a perennial weed problem, glyphosate (1 to 1.5 pt/A) is used instead of paraquat (3).

See table 2 for a summary of preemergent herbicide use on peas in Maryland. See tables 3 and 4 for product effectiveness against major weeds.

II. Postemergence Herbicides

The availability of effective postemergent herbicides supports the use of scouting in peas and the application of chemical controls on an as-needed basis (20). For effective control, postemergent herbicides must be applied when weeds are at the most susceptible growth stage. This window of susceptibility lasts only a few days, and sometimes weather conditions may prevent herbicide application at the optimal time, resulting in greatly reduced weed control. A postemergent product with a longer window of application would greatly improve postemergent weed control in peas (4).

? **Bentazon** (0.24-2.0 lb ai/A Basagran 4SC) is the primary postemergent herbicide used on peas in Maryland. Bentazon is applied to 40% of Maryland pea acreage, and accounts for the largest portion of postemergent herbicide use. This herbicide offers effective control of several important broadleaf weeds in peas, including common lambsquarters, chickweed, henbit, ragweed, and Canada thistle. Canada thistle control is of particular importance because this weed forms flower buds at the same time as peas become ready for harvest. These buds, which are the same size and density as peas, are stripped by pea harvesting equipment along with peas, and are extremely difficult to separate out. The FDA has established zero tolerance for thistle buds in peas, so control of Canada thistle is a major concern for growers and processors. Bentazon effectively suppresses thistle growth and delays thistle bud formation until after pea harvest. Bentazon is safe for peas and has no rotational crop restrictions, but does not control grasses (6).

? **Sethoxydim** (0.06-0.28 lb ai/A Poast 1.5EC) is used on about 9% of acres, for control of annual grasses and certain perennial grasses (6, 9). Control is reduced under drought conditions or if application is made when grasses are large. A second application may be used for control of some grasses. Wild onion, yellow nutsedge, and broadleaf weeds are not controlled with sethoxydim (9).

? **Quizalofop-P-ethyl** (0.04-0.08 lb ai/A Assure II 0.88EC) is labeled for postemergent grass control in peas, but is currently used on less than 5% of the acreage (4, 9). It controls most annual and perennial grasses well, except for wild onion. It does not control yellow nutsedge or broadleaf weeds (9).

? **MCPB** (0.25-0.5 lb ai/A Thistrol 2EC). MCPA and MCPB, two herbicides used for postemergent broadleaf weed control in Midwestern states, are not used by most growers in Maryland, because of the risk of drift potential and delay of harvest. These herbicides are very effective for controlling certain weeds, such as pigweed, ragweed, lambsquarters, and Canada thistle. However, they can stunt pea growth and can slow maturation of the crop. In Maryland, where peas are double cropped, such a delay can cause a field to miss the harvest window when harvest equipment is available and processors are set up to process peas (21). Of the two products, MCPB has less potential for phytotoxicity to peas, and is used by one processor in north central Maryland as the primary postemergent weed control on about 400 acres annually (20% of acres in Maryland) (3, 21). MCPB (Thistrol) is used in place of bentazon because it gives better control of Canada thistle, which is a common problem in this area. The rate used is 0.25 lbs ai/A to 0.375 lbs/A, depending on the mixture of weeds present. The higher rate is more common, and is used when Canada thistle is present (3). In addition, it is rarely used as a last-resort rescue treatment in other parts of Maryland, because it is effective against large pigweed and lambsquarters plants that would be completely tolerant to bentazon, due to their size. In this situation, MCPB is applied at a rate of 0.5 lb ai/A (21).

? **Bentazon** (0.5 lbs ai/A) + **MCPB** (0.25 lb ai/A) . This combination is used on less than 2% of acres in Maryland for postemergent broadleaf weed control (3).

See table 2 for a list of postemergent herbicides used in Maryland. See tables 3 and 4 for product effectiveness.

III. General Herbicide Issues in Peas

Because of their early harvest, peas are followed by another crop. Application of imazethapyr (Pursuit) restricts the sequential crop to a legume, such as soybeans or lima beans. Other typical sequential crops in Maryland, including cucumbers, tomatoes, spinach, cabbage, sweet corn, melons, peppers and others cannot be planted until June, July, or August. This creates a problem in lambsquarters control because metolachlor (Dual) will not provide commercially acceptable control and bentazon (Basagran) postemergence will provide only partial control. Yield losses to lambsquarters could be significantly reduced with the availability of an effective herbicide substitute for imazethapyr in these situations (21).

Cultural and Alternate Controls

Rotary hoeing, used on 5 to 10% of acres prior to pea emergence to loosen soil surface that has crusted, also has some weed control benefits. Use of spring oats as a winter-killed cover crop may also help to reduce weeds in peas, although this is practiced on only 5% of acres because oats may not be killed during a mild winter. Early winter disking is used to kill henbit and chickweed on less than 5% of acres. The problem with this practice is it leaves the soil bare during the winter, which is a poor soil conservation practice (4). Biological control practices are not used for weed control in peas (20).

Table 3. Effectiveness of herbicides for control of grasses and sedges in peas.

	GRASSES AND SEDGES						
Herbicide	Barnyard-grass	Crabgrass, large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (seedling)	Yellow nutsedge
Preemergence:							
clomazone	G	G	G	G	G	G	N
Imazethapyr	P/F	P/F	P/F	P/F	I	N	G
metolachlor	G	G	G	G	G	G	F/G
Postemergence:							
bentazon	N	N	N	N	N	N	F
quizalofop-P-ethyl	G	G	G	G	G	G	N
sethoxydim	G	G	G	G	G	G	N

Herbicide performance is affected by weather, soil type, herbicide rate, weed pressure and other factors. These ratings indicate ONLY relative effectiveness in tests conducted by the University of Delaware, University of Maryland System, The Pennsylvania State University, Rutgers, The State University of New Jersey, and Virginia Polytechnic Institute and State University. Actual performance may be better or worse than indicated in this chart (22). (Table modified from 2000 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 236)

Key: G = good
F = fair
N = no control
I = insufficient data

Table 4. Effectiveness of herbicides for control of broadleaf weeds and sedges in peas.

	BROADLEAF WEEDS								
Herbicide	Pigweed sp.	Common lambs-quarters	Shepherd s-purse	Common ragweed	E. black nightshade	Canada thistle	chick-weed	henbit	Yellow nut-sedge
Imazethapyr	G	F	G	G	G	I	G	G	G
clomazone	N/P	G	F	F	I	N	G	G	N
metolachlor	G	P	I	N	G	N	F/P	F/P	F/G
Postemergence:									
bentazon	F	F	I	G	P	F	G	G	F
quizalofop-P-ethyl	N	N	N	N	N	N	N	N	N
sethoxydim	N	N	N	N	N	N	N	N	N

Herbicide performance is affected by weather, soil type, herbicide rate, weed pressure and other factors. These ratings indicate ONLY relative effectiveness in tests conducted by the University of Delaware, University of Maryland System, The Pennsylvania State University, Rutgers, The State University of New Jersey, and Virginia Polytechnic Institute and State University. Actual performance may be better or worse than indicated in this chart (22). (Table modified from 2000 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 236)

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