Crop Profile for Cucumbers (Pickling) in Maryland

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General Production Information

- Maryland ranked 14th in national total cucumber (pickle and fresh market) production in 1997, and accounted for 2% of U.S. total cucumber production (1).
- Maryland harvests about 2,600 acres of pickling cucumbers annually (2, 3). This represents 3% of annual national pickle production (4).
- Production cost per acre for pickling cucumbers was about $474.73 in 1997. Total annual production cost in Maryland is about $1,234,298.00 (2, 3, 5).
- IPM practices are used on 100% of Maryland's pickling cucumber acreage (3).

Production Regions

Pickling cucumber acreage is distributed throughout the middle and lower Eastern Shore counties of Maryland; very little is grown west of the Chesapeake Bay (6).

Production Methods

Cucumbers thrive in light textured, well-drained soils high in organic matter, with a pH between 6 and 6.8. These prostrate, annual vines have deep roots, and require adequate moisture (7). Two or three crops of pickling cucumbers are often produced from a single field during a single growing season, but are generally rotated with other crops from season to season (6, 8). Conventional tillage is used during bed preparation (6). Flat beds are used to enhance cucumber pick up to minimize field loss (9). Based on data from the 1998 growing season, 21% of Maryland acreage is fumigated annually, 13.6% of acres with 1,3-dichloropropene (Telone II 12 gal/A) and 7.3% of acres with metam-sodium (Vapam HL 75-100 gal/A) (3). Fertilizer is applied during bed preparation, with 50% or more nitrogen applied in the nitrate (NO_3) form. Pickling cucumbers grown in Maryland are direct-seeded into bare ground, initially between mid-April and early May in the mid-Atlantic, with successive plantings continuing through early August (10, 11). The regions's growing season of about 180 days allows double cropping of pickles or multiple cropping of pickles with other vegetables. 19% of Maryland and Delaware pickling cucumbers were double cropped in 1998. Successive plantings are made to provide continuous harvests of pickles for processors (3). All pickles grown in Maryland are machine harvested and are planted 2 to 3 inches apart with 20 to 28 inches between rows, and 3 rows per bed (3, 10, 12). The seeding rate of 4 to 5 pounds per acre produces the optimal

density of 65,000 plants per acre for harvesting (10). Pickling cucumbers are in the field 38-42 days from seeding to harvest (6). Overhead, center pivot irrigation systems are used to provide adequate moisture throughout the growing season (8, 10). Growers establish honeybee colonies to assure adequate pollination (12).

Insect Pests

Major Insect and Mite Pests in Maryland

The only major insect pests of pickling cucumbers are striped and spotted cucumber beetles (13). They cause feeding damage and vector bacterial wilt, a disease which causes up to 10% losses in pickling cucumbers (6).

Striped and spotted cucumber beetles

Damage and Life Cycle:
Striped cucumber beetles, *Acalymma vittata* (Fabricius), and spotted cucumber beetles, *Diabrotica undecimpunctata howardi* (Barber), are the most destructive insect pests of pickling cucumbers in the mid-Atlantic area. Both cucumber beetles share a similar life cycle, and inflict similar damage to host plants. Both species overwinter as adults in neighboring woodlands or other protected areas and move onto cucurbit crops in May, just after plant emergence (13, 14). The major feeding injury and disease transmission takes place from the time cucumbers are emerging until they form runners (15). Beetle feeding on the young seedlings often kills the plants or greatly retards their growth. Beetles also burrow into the soil to feed on seedlings below the surface. Female cucumber beetles deposit eggs in the soil at the base of host plants or on the underside of leaves. Larvae feed on the roots of the plants for 2 to 3 weeks before they pupate in the soil. A second generation of beetles appears later in the summer and will attack the fruits. Both species of cucumber beetles feed on the roots, stems, foliage and fruit of cucumbers (13, 14).

Cucumber beetles vector bacterial wilt disease to cucumbers and certain other cucurbits (16). The disease organism, *Erwinia tracheiphila* (E.F.Sm) Holland, overwinters in the digestive tract of the beetles and is transmitted to the plant from beetle feces via open feeding wounds (17). The pathogen is carried from plant to plant and field to field as the beetles feed. Infected plants eventually wilt and die (14). Losses from this disease vary greatly from field to field and among different cultivars (10). Once a plant has been infected with bacterial wilt, it cannot be saved. Infected plants rarely produce marketable fruit. Control of the beetle vector is the primary control strategy for the disease (13). However, studies indicate that transmission rates of the disease may be lower than previously thought, even when beetle populations are high. Further, low infection rates of bacterial wilt (up to 20% of plants affected) may not be economically yield-limiting in machine-harvested pickling cucumbers. This may be due to improvements in bacterial wilt resistant varieties and the short growing season for machine-harvested pickling cucumbers (17, 9). Cucumber beetles also can transmit another important disease, cucumber mosaic virus (14). (Also see disease section.)

Frequency of occurrence:
Cucumber beetles are serious annual pests of pickling cucumbers (13). Beetle populations can vary widely depending on weather conditions in late spring when spotted cucumber beetles emerge (6).

IPM Program:
All fields are scouted at least twice weekly, beginning immediately after transplanting or emergence. Plants are inspected for feeding damage, and the percentage of plants with light, moderate, and heavy damage is used to determine the need for treatment (15). The action threshold for treatment in machine-harvested pickling cucumbers is when 10% to 20% of plants are infested with beetles and/or showing serious fresh feeding injury. Cucumber beetle populations exceeding this threshold are treated with one or two insecticide applications in the first 2 weeks after plant emergence (18, 9).

Chemical Controls:
Due to a much shorter growing season, pickling cucumbers are far less vulnerable to secondary infections of bacterial wilt than are fresh market cucumbers. Also, the denser plant stands in pickling cucumbers can compensate for more plant losses due to insect pests and disease. The control strategy for cucumber beetles in nearly all acres of pickling cucumbers is the use of foliar insecticides as needed, based on scouting and established thresholds (6). Foliar treatments applied as needed are less expensive and equally as effective as preventive carbofuran applications (6, 9). In a 1998 survey, 11% of pickling cucumber acres in Maryland received a single preventive application of carbofuran(Furadan 3.8 fl oz 4F/1,000 ft of row at planting), but carbofuran use in the state is declining (11). Most growers use foliar insecticides, if needed, based on scouting (6). One foliar application is applied when cucumber beetles exceed recommended thresholds, which is not every year (6, 11). Most growers are applying these products at a mid-range rate. All of the products listed here are effective and are used in Maryland (11, 9):
-esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) [This is the most frequently used foliar insecticide].

-endosulfan (Thiodan l.33-2.67 Pt 3EC/A)

-carbaryl (Adios 12 oz/A or Sevin l.25 lb 80S/A) [Carbaryl bait is effective but kills slowly. It is safe for humans but is lethal to bees, and isn't used during flowering (11).]

-methomyl (Lannate l.5-3 pt LV/A) [used when melon aphid is also present.]

-permethrin (6.4-12.8 fl oz Ambush 2EC/A or 4-8 fl oz Pounce 3.2EC/A)

Alternative Controls:
Row covers can be used in small plantings to screen out adult beetles during the critical period of disease susceptibility, and trap crops of squash can be used as an early planting to lure beetles away from cucumbers (19). However, these practices are not cost effective and are not used by commercial growers in Maryland (9). Bacterial wilt resistant cultivars are not available (8).

Minor Insect and Mite Pests in Maryland

Seedcorn maggot (*Delia platura*)

Damage and Life Cycle:
Seedcorn maggot is a common insect throughout the Northeast (20). Adults emerge from overwintering puparia during spring planting time and females lay eggs just below the surface of the soil. Eggs hatch in 4 to 7 days, and emerging larvae feed on decaying organic matter. Maggots may burrow into the seed and consume the germ, preventing germination. Larvae feed for 21 days, then pupate in the soil. There are 4 to 5 generations per season in Maryland (19).

Frequency of Occurrence:
Seedcorn maggot is a very rare pest of pickling cucumbers (4). Injury is most severe in cool wet springs when germination is delayed. Fields high in crop residue and other organic matter are most susceptible to high levels of infestation (13). Fluctuations in seedcorn maggot populations don't affect chemical applications, since seed treatments are used (11).

IPM Program:
Since maggot feeding results in no detectable above-ground symptoms, low germination rate is often the first sign of trouble. Ungerminated seeds are examined for signs of larval feeding (20). If damage is extensive enough to warrant replanting, seed treatment or soil insecticide is applied to prevent re-infestation (15). All of the pickling cucumber fields in Maryland are scouted for this problem.

Chemical Controls:
Seed treatments are the only means of chemical control, and are used by all Maryland growers (3, 10). Chlorpyrifos (Lorsban 50SL, 2 oz/100 lb of seed) is the primary seed treatment used because it offers the best control of seedcorn maggot (11). Chlorpyrifos is generally combined with one or more fungicides to prevent damping off and other fungal diseases. Typically thiram and metalaxyl (Apron) are used (9).

Alternative Controls:
A variety of cultural control measures are effective against this pest. Late plantings during cool springs and shallow placement of seed may speed germination times and reduce injury levels, but these are not practical options for commercial growers (11). Fields with cover crops or those high in organic matter are generally plowed prior to fly emergence in early spring (11, 20). Removal of plant debris is also an important practice (3).

Melon aphid (*Aphis gossypii*)

Damage and Life Cycle:
Melon aphids are the most important of several aphid species that attack cucurbits, particularly melons and cucumbers, although they are considered to be very minor pests (4, 14). Melon aphids and other aphids are found primarily on the underside of the leaves, where they suck sap from the plant and cause a reduction in the quality and quantity of the fruit. Infested leaves curl downward and may turn brown and die. The melon aphid is also one of the primary vectors of cucumber mosaic virus. Cucurbits usually are not attacked by aphids until the vines form runners, and then infestations commonly begin in small scattered spots over the field (14). Aphid species identification is critical, since available chemical controls are not equally effective against all aphid species (16). (See Chemical Controls, below.)

Frequency of :
Aphids are a very rare and localized pest on pickling cucumbers in Maryland. Because of the short growing season

for pickles, their populations very rarely reach damaging levels in Maryland (4). However, melon aphids can be a problem under extreme drought conditions (9).

IPM Program:
Scouting for aphids is done by looking for wilting and curled leaves throughout the field. When aphids are detected, more intense sampling is done to determine infestation levels and natural enemy activity. An insecticide treatment is applied if more than 20% of runners have 5 or more aphids, natural enemy populations are low, and humidity is low to moderate (15).

Chemical Controls:
Chemical treatments generally are not necessary for aphids on pickling cucumbers. The short growing season prevents population buildup from reaching economic levels (4). In a year when conditions favor aphid population increases, generally less than 1% of acres in Maryland require treatment. Methomyl (Lannate l.5-3 pt LV/A) is the product of choice because it is the most effective and fast-acting insecticide for aphid control (9, 21).

Alternative Controls:
When making a treatment decision, natural enemy populations are considered. Aphids may be controlled by parasitic wasps and a variety of predators, including lady beetles and their larvae, lacewing larvae, and syrphid fly larvae. During periods of high humidity, fungal diseases may also help reduce aphid populations (13). Natural enemies are important to a certain extent but do not always keep pest populations in check. There is no manipulated attempt to enhance natural enemy populations, nor are any alternate or biological controls used to manage aphids in Maryland (6, 9).

Pickleworm

Damage and life cycle:
Pickleworms overwinter in semitropical regions, and annual infestations depend on moth flights north (14). Moths migrate to the mid-Atlantic region by late July (22). Eggs are deposited on hairy plant parts, such as the blossoms and young leaves. Young larvae usually feed among small leaves at the growing tips of vines, or within blossoms. When about half grown, they may bore into fruits and continue to feed there, causing internal damage to the fruit (14). In Maryland, larvae are seen feeding in plant terminals in late August, but they have very rarely been detected in the fruit (22).

Frequency of occurrence:
Many growers consider pickleworm to be a potential pest problem in pickles. Although the larvae can be found on the foliage of late-planted pickling cucumbers after early August, pickles are generally harvested before the larvae infest the fruit (3, 6). Processors will reject any field identified with fruit infestation from pickleworm, however they do not recommend spraying. Larvae are present in 100% of later pickle plantings, but only 2 infested fruits have been found in the past 10 years (9). Due to the zero tolerance for this pest and the fact that it does migrate to our area, pickle growers continue to be concerned about pickleworm (22).

IPM Program:
No thresholds or control decision guidelines have been established for pickleworm in Maryland. An experimental threshold of 5% of the terminals infested with pickleworm larvae has been evaluated on 40% of the pickle acreage in Delaware. No insecticides were applied from one week prior to harvest if larvae are small and found only in the

terminals. Although this threshold resulted in reduced foliar sprays, it may still be too conservative, since larvae were never found in the fruit in unsprayed fields. Growers are very conservative in their management of this pest, since there is zero tolerance for larvae found feeding in the fruit (22).

Chemical Controls:
Insecticide use for control of pickleworm in Maryland is very rare and based on scouting (3). Less than 1% of pickling cucumber acres in Maryland are treated annually. In those rare instances when an insecticide is applied, the products that may be used are esfenvalerate (Asana XL 5-6 fl oz 0.66EC/A), permethrin (6-8 fl oz Ambush 2EC/A or 6-8 fl oz Pounce 3.2EC/A), or endosulfan (Thiodan l.33-2.67 Pt 3EC/A) (3, 9).

Alternative Controls:
Pickleworm problems can be avoided by planting early, but commercial growers growing for a processor use successive plantings, since a steady supply of pickles is needed throughout the season. For this reason, some late plantings are unavoidable (22). No alternative control strategies are commonly used against this pest in Maryland (6).

Spider mites

Pickling cucumbers are not generally seriously damaged by mites, due to the short growing season (6). Some damage can occur in the most extreme drought conditions, but treatment for this pest is extremely rare (9).

Diseases

Infectious diseases of cucumbers are caused by fungi, bacteria, viruses, and nematodes, and some are vectored by insects (10). Most diseases are controlled through host plant resistance. Two varieties that exhibit resistance to a combination of diseases account for 86% of acres grown in Maryland and Delaware. Other common varieties offer disease resistance as well. The prevalence of excellent host plant resistance in this crop eliminates the need for fungicide applications for foliar diseases in most years. 100% of pickling cucumber acres are moldboard plowed prior to planting to bury plant residue and reduce pathogen levels in the soil. Fields are generally rotated into non-cucurbit crops following harvest, but some growers double crop pickling cucumbers, increasing the risk of yield loss to soil-borne diseases or nematodes (3).

Several diseases are not adequately controlled by resistance and cultural techniques. For these, seed treatments and soil applications of fungicides are necessary (3). The soil-borne diseases belly rot and phytophthora blight cause sporadic but severe yield and quality losses in pickles (8). Damping off and Pythium cottony leak also cause economic losses and are of concern for growers. Damage from bacterial wilt is less common, but yield losses do occur in some fields in some years (3, 8).

Belly rot

Damage and Life Cycle:
Belly rot is caused by *Rhizoctonia solani*, a common soil-borne fungus. The disease develops on the portion of the cucumber fruit which is in contact with the soil. On immature fruit the disease appears as a superficial yellowish-brown discoloration. As the fruit matures, this discoloration develops into large water-soaked areas of decay. A dense mold growth may develop on diseased areas during periods of high humidity. The disease proceeds rapidly when temperatures exceed 82ºF (23).

Frequency of Occurence:
Belly rot is the most important disease in pickling cucumbers in Maryland (16). Pickle packers consider belly rot to be their greatest pest management problem (24). On average, about 2% of all pickling cucumbers harvested are discarded due to belly rot damage, but yield loss in individual plantings can range from zero to 14% (9). Yearly outbreaks are sporadic and the conditions that favor the disease are not well understood (24). Incidence increases several days after heavy rain and high temperatures. Over-irrigated fields and plantings with dense foliage and poor air circulation tend to have higher levels of outbreaks (9). Chemical control is expensive and growers are uncertain they see benefits from fungicide applications (8). Effective controls for belly rot are badly needed (24).

Management:
Belly rot is managed with a combination of chemical and cultural controls (4).

Chemical Controls:
In 1998, 68% of Maryland acreage was treated with chlorothalonil (Bravo, Terranil) (3). Generally, a single application of chlorothalonil is made in August, under cooler temperatures and moist field conditions (4). Application rates vary considerably from the recommended use rate of 6.9 lbs ai/A (8.25 pt 6F/A), or slightly higher, down to 1.17 lbs ai/A (1.40 pt 6F/A) on acres that received treatment (3). In fall of 1998, azoxystrobin (Quadris) was registered, and it was used on about 10% of acres during the 1999 growing season for control of belly rot (8, 9). It is applied twice at a rate of 11-15.4 oz/acre, once at the 1 to 3 leaf stage, and again before the vines run (9). Fields are not cultivated following fungicide application, to avoid disruption of fungicide activity (4, 10).

Alternative Controls:
Belly rot resistant cultivars are not available (4).

Phytophthora blight

Damage and Life Cycle:
The fungus that causes Phytophthora blight, *Phytophthora capsici*, is primarily soil-borne, has a number of hosts, and can remain in the soil for years. All above-ground plant parts can be affected. Initial symptoms include a sudden, permanent wilt of infected plants (crown blight phase). A white mold and spores develop on the affected area, and later appear as a yeast-like growth. Fruits that develop are undersized and distorted (25). The disease is promoted by warm, wet weather and frequently appears in the wettest part of the field (23). Movement of the fungus in water and in soil can be an important means of spreading the disease within fields (25).

Frequency of Occurence:
Yield loss from phytophthora is increasing in Maryland, though damage is typically less than 5-10% of crop acreage (4, 8). Outbreaks of this disease are an economic disaster for growers, who have had several large plantings (about 300 acres) rejected in the past 2 years. It is unclear whether this increase in phytophthora is an anomaly or the

beginning of a trend (9).

Management:
This disease is managed primarily with cultural controls, but fungicides are applied on some acres (3, 10).

Chemical Controls:
Preventive fungicide applications are expensive and of questionable benefit, but are used by some growers (3, 8). In 1998 A single application of Mefenoxom (Ridomil Bravo) was used at flop (the stage of growth when the vines elongate enough to flop over instead of growing upward) on 48% of Maryland acres. The typical application rate is 0.045 lb ai/A (3). The Bravo is for belly rot control. The Ridomil may offer some limited benefit in controlling phytophthora, however, University trials have not confirmed this (8).

Alternative Controls:
Cucumbers are rotated with crops other than peppers, eggplants, tomatoes, and other cucurbits, on a 3 year schedule where possible (10, 26). All pickling cucumber fields in Maryland are moldboard plowed prior to planting, which improves drainage (8). Any practice which reduces the duration of standing water reduces disease development (3).

Damping-off

Damping-off refers to diseases caused by several species of *Pythium* that cause seeds to rot before they germinate, shoots to decay before they emerge, or seedlings to collapse (8).

Frequency of occurence:
Severity of infection is strictly dependent upon the weather. The *Pythium* species which cause damping off differ in the temperature that is optimal for their growth. Therefore the disease can be a problem in cool wet soils or warm wet soils (8).

Chemical Controls:
Seed treatments and soil-applied fungicides are used to control damping-off (8). Seed treatments are used on 100% of commercial pickle acres in Maryland. Thiram (0.0056 lb ai/acre) and metalaxyl (Apron 0.0014 lb ai/acre) are used, often combined with chlorpyrifos for control of seedcorn maggot (3, 9). Another strategy is to apply mefenoxam (Ridomil Gold) in a 7-inch band after seeding at a rate of 1 to 2 pints 4E/A (0.5-1.0 lb ai/A) (10). In 1998, mefenoxam was applied to 48% of pickling cucumber acreage in Maryland, mainly for belly rot, Phytophthora, or pythium. It is not typically used specifically to control damping off, since seed treatments are effective (3).

Alternative Controls:
Maryland growers select well-drained fields for pickle production, and, when possible, avoiding planting into cool wet soils (9, 26).

Cottony leak (Pythium)

Damage and Life Cycle:

Cottony leak is caused by the fungal pathogen *Pythium aphanidermatum*. In an unusually wet season, it can cause damping-off or vine cankers, but the most typical symptom is fruit rot. The fungus penetrates wounds in the fruit as well as old flower parts and plant parts in contact with the soil. The disease starts as a dark green water-soaked area which rapidly develops into a wet, mushy rot. This rot can become covered with a white cottony mold during wet weather. The fungus can be spread from fruit-to-fruit during shipping (23).

Frequency of Occurence:
Disease incidence is sporadic. It generally occurs in low areas of the field during damp conditions (8, 9). Annual yield loss attributed to this disease in Maryland pickling cucumbers is usually less than 1% but can be as high as 5% (4, 9). Pythium outbreaks can be a serious hardship for growers, causing the rejection of some fields (3).

Management:
Management is difficult. Chemical control efforts are not always successful (3).

Chemical Controls:
This disease is not managed specifically with fungicides. However, some incidental control may be achieved when products such as Ridomil Gold Bravo are used for belly rot control (8).

Alternative Controls:
Crop rotation and moldboard plowing help to reduce pathogen levels in the soil, and are practiced by nearly all Maryland growers (3).

Bacterial wilt

Damage and Life Cycle:
Erwinia tracheiphila, the bacterium that causes bacterial wilt, overwinters in the digestive tract of cucumber beetles (primarily striped) and is transmitted by beetles feeding on the leaves. Although cucumber beetles are not the only insects known to vector this disease to cucumbers, transmission by other insects is of less economic importance(8, 23). Epidemics of bacterial wilt may follow warm winters, which favor cucumber beetle survival. The disease is characterized in its early stages by wilting and dying of individual leaves, and in its later stages by wilting of leaves on laterals or throughout the entire plant (23). Additional symptoms include interveinal chlorosis and marginal necrosis of the leaves, with the leaves eventually becoming totally brown (frosted) and standing upright. Internodes may be stunted and leaves take on a "tufted" appearance, because they are underdeveloped (26). Plants may die before fruit forms. Plants that survive are less vigorous and wilt in the middle of the day (8).

Frequency of Occurence:
Although bacterial wilt is an important disease throughout the Eastern United States, it is relatively rare on pickling cucumbers grown in Maryland (4, 8). Its occurrence and severity depend on several factors, including winter weather conditions, the growth stage of cucumber infected, the bacterial strain, host susceptibility (which varies among varieties), and nutritional factors. Yield losses from bacterial wilt in pickles can be up to 15% in severely affected fields (8).

Management:
The short growing season and density of plantings prevent bacterial wilt from becoming a major concern for pickle growers (3). Control of the cucumber beetle vector is the primary management strategy for this disease (10).(See

cucumber beetle section.)

Chemical Controls:
There are no chemical controls that work directly on bacterial-wilt infected plants (15). The disease is managed by chemical control of the cucumber beetle vector (10). (See cucumber beetle section.)

Alternative Controls:
Bacterial wilt resistant cultivars are not currently available (8).

Angular leaf spot

Damage and Life Cycle:
Angular leaf spot is caused by the bacterium *Pseudomonas syringae* pv. *lachrymans* and occurs in squash, cucumber and pumpkin (23). The bacterium overwinters in seed and crop residue from infected plants, and can survive for at least one year in the field (10). The bacterium can be spread in the field by splashing rain, equipment, or workers. Following foliar infection, irregular, angular spots appear on leaves and turn brown before dropping off to leave ragged holes (23). Fruit infections also occur, as water-soaked spots which become covered with a white crust (23, 26). Infection of young fruit may result in curved or deformed mature fruit. Secondary soft rots usually develop on infected fruit (26).

Frequency of Occurence:
Angular leaf spot is a relatively rare and sporadic disease of pickling cucumbers in Maryland (8, 9). The availability of genetically resistant cultivars has helped to reduce its occurrence (4). Only a few fields in the last 10 years have reported yield losses from angular leaf spot. It is most problematic in poorly rotated fields and those that reuse irrigation water from a previous cucumber crop (9).

Management:
This disease is managed primarily through the use of resistant varieties and cultural controls. The most common varieties grown on the Eastern Shore of Maryland have an intermediate level of resistance (Vlaspik, Excel, Vlasspear), tolerance (Lafayette), or a high level of resistance (Atlantis) to this disease (3). Although foliar symptoms may be easily overlooked, early detection is important, since control in the foliar phase can reduce infection of the developing fruit. If resistance fails, chemical applications on a weekly basis are required. However, resistance levels are effective currently and chemical applications are rarely used (16).

Chemical Controls:
Chemical control is rarely necessary in pickling cucumber production (8). Typically a single application per year on less than 1% of acres is needed (9). A tank mix of fixed copper (rate and formulation can vary considerably) plus mancozeb (1 lb ai/A) is applied when symptoms appear (8). Usually, the high label rate is used when spraying for this disease (9). Mancozeb has a 5 day pre-harvest interval. PHI varies considerably for copper products, depending on the specific formulation used (16).

Alternative Controls:
To reduce the rate of infection, growers moldboard plow all pickling cucumber acreage prior to planting, rotate away from cucurbits for at least two years, and avoid planting cucumbers next to other cucurbits whenever possible (8, 26). The high value of this crop, the requirement for 100% irrigated plantings, and a preference for center-pivot

irrigation have caused rotations on about 50% of fields to drop below 2 years (9).

Viral Diseases

Four distinct viruses have the potential to cause disease problems on pickling cucumbers in Maryland: cucumber mosaic virus, watermelon mosaic virus, papaya ring spot virus and zucchini yellow mosaic virus (10). Watermelon mosaic virus has been positively identified in Maryland on cucurbits. The relative occurrence of each of these viruses is uncertain. This is because specific viral identification is costly and time consuming and virus symptoms and management are similar regardless of the species involved (8). There is generally no yield loss in pickles due to viral diseases (9).

Damage and Life Cycle:
All four of these viruses are transmitted by aphids, and Cucumber mosaic virus may also be spread by cucumber beetles (23, 26). Cucumber mosaic virus can overwinter in Maryland in a broad range of biennial and perennial host plants, including pokeweed, and can be carried by aphids to new plantings (8, 12). Watermelon mosaic virus overwinters in *Trifolium* species while papaya ring spot virus overwinters in wild and cultivated cucurbits (8). These viruses cause mosaic, distorted growth, stunting, distortions in leaf coloration, and small, misshapen fruit (25).

Frequency of Occurrence:
Viruses rarely if ever have a significant impact of pickle production in Maryland (4).

Management:
No pesticides are available specifically to control viruses. Some of the most commonly grown varieties are resistant or moderately resistant to Cucumber mosaic virus. Controlling aphid populations with insecticides, a common strategy in the past, has been found to be ineffective in reducing disease occurrence, and is no longer practiced (8). Chemical control of weeds that can serve as alternate viral hosts, especially pokeweed, is practiced by growers to reduce disease transmission rates (12). Growers also rely on cultural control practices (25).

Chemical Controls:
There are no chemical controls available that work directly for virus control. No pesticides are applied to pickling cucumbers specifically for this purpose (8).

In early spring, clumps of emerging pokeweed occurring around field borders, fence rows, and non-irrigated ditch banks are spot-treated with dicamba (Banvel) when shoots are 6 to 20 inches high. Pokeweed foliage and stems are saturated with a dilute spray solution. Dicamba is not labeled for use on cucumbers and should not be applied where drift or runoff may affect desirable crops (12).

Alternative Controls:
Nearly all varieties grown in Maryland and Delaware show some level of resistance to Cucumber mosaic virus, and don't show color breaking on the fruit (3, 26). Growers isolate late plantings from early plantings and plant fields as far as possible from existing cucurbit plantings to help prevent the spread of infection (10, 26). Maintaining good weed control to prevent the buildup of aphid populations is also an important strategy (16).

Gummy stem blight/Black rot

Damage and Life Cycle:
Gummy stem blight is caused by the fungus, *Didymella bryoniae,* and refers to the foliar and stem-infecting phase of the disease. Black rot refers to the fruit rot phase (8). The pathogen overwinters in seed and residue from diseased plants, and may also be soil-borne (23, 26). It can survive for a year and half in the absence of a plant host. Infection occurs when temperatures are warm and moisture is available. Wounding, insect damage, and powdery mildew infection predispose plants to infection with gummy stem blight. Gummy stem blight begins as pale brown or gray spots on leaves, petioles and stems (23). It causes leaf and stem necrosis and tissue death (26). In severe infections plants are killed. Black rot starts as irregular faded green or yellow spots on the fruit that later turn gray or black. The fungus penetrates the rind and causes a dry rot. Other rot-inducing pathogens may follow to produce a wet rot that destroys the entire fruit (23).

Frequency of Occurence:
Gummy stem blight is rare on pickling cucumbers in Maryland (4). It occurs primarily in late summer, especially following prolonged rainy periods with an accumulation of 4 to 6 inches (9, 10).

Management:
Gummy stem blight is managed with a combination of chemical and cultural controls.

Chemical Controls:
Fungicide applications are infrequently used to control gummy stem blight. In 1998, no applications were made to control this disease (8). The following products may be used rarely in Maryland for control of gummy stem blight (10):
-chlorothalonil (Bravo or Terranil 2 pt 6F/A)
-mancozeb 2-3 lb 80WP/A

Alternative Controls:
Host plant resistance to gummy stem blight is not widely available in pickling cucumbers in the Mid-Atlantic (8).

Scab

Damage and Life Cycle:
Scab is caused by a fungus called *Cladosporium cucumerinum,* which overwinters in seeds and on residue from diseased plants. It affects a number of cucurbits. Moist, humid weather conditions accompanied by cool nights promote disease development (23). Fungal activity is limited to wet weather and temperatures below 21ºC (8). The fungus can attack any above-ground portion of the plant, including leaves, petioles, stems and fruits. The disease is most damaging because of the unsightly scab lesions that develop on fruit, usually making them unmarketable (25).

Frequency of Occurence:
This disease is rare on pickling cucumbers in Maryland (4). Disease occurrence is limited to periods when temperatures are 21ºC or below, so damage is confined to very early and very late plantings of pickling cucumbers (8).

Management:

Chemical Controls:
No fungicide applications are used to control this disease on pickling cucumbers in Maryland (4).

Alternative Controls:
All varieties grown in Maryland are moderately to fully resistant to scab (3). Growers practice a minimum two year rotation away from cucurbits (except for double crop fields) and select sites with good drainage (8, 25). Growers use only disease-free fungicide-treated seed to control seed decay and damping-off (25).

Powdery Mildew

Damage and Life Cycle:
Powdery mildew, caused by the fungus *Sphaerotheca fuliginea* and to a lesser extent by *Erisiphe cichoracearum*, occurs on cucumber, muskmelon and pumpkin, as well as squash (8, 26). The fungus does not overwinter in Maryland, but may be introduced into the field by airborne conidia from southern cucurbits (8). High temperatures promote the development of the disease. A powdery white growth first appears as spots on the leaves and young stems. The crown leaves are usually the first to be affected (23). Later the spots turn brown and dry, and plants may appear stunted. Plants infected early tend to produce smaller fruit if left untreated. Fruit may be poorly colored and/or sunburned because of the loss of foliage (26).

Frequency of Occurrence:
Powdery mildew generally occurs from mid-July through the end of the growing season, but is uncommon due to widespread use of resistant varieties (8, 10).

Management:

Chemical Controls:
Fungicides are not used on pickling cucumbers in Maryland for control of powdery mildew (4).

Alternative Controls:
Typically, adequate control is achieved by the use of resistant varieties (10). No cultural or biological control strategies are directed specifically against this disease (26).

Downy Mildew

Damage and Life Cycle:
Downy mildew is caused by the fungus *Pseudoperonospora cubensis* (23). The pathogen does not overwinter in Maryland but can be carried on the wind into our area (8). Irregular yellowish to brown spots on the underside of the leaves characterize the early disease stages. Under moist weather conditions, a purplish mildew develops on the underside of the leaf spots. Leaf spots increase in size, killing the leaves (23). Plants may be rapidly defoliated under conditions favoring the disease. However, downy mildew typically occurs late in the growing season (8).

Frequency of Occurence:
This disease generally does not occur in Maryland until mid-August (10). Its occurrence is sporadic, but it can spread very quickly (26).

Management:

Chemical Controls:
Because of the widespread use of resistant varieties, fungicides are not needed (4).

Alternative Controls:
The major varieties grown in Maryland are resistant to downy mildew (3). There are no cultural or biological control strategies used against this disease (8).

Anthracnose

Damage and Life Cycle:
Anthracnose is caused by the fungus *Colletotrichum orbiculare*, and occurs on a variety of crops, including cucurbits. The causal fungus overwinters in seed and in residues from diseased plants, and can survive for up to 2 years in the absence of a host. It is spread by splashing water, irrigation, insects, workers, or equipment. Foliar infections first appear as water-soaked areas that quickly enlarge to form the brown spots with light centers that characterize the disease (23, 26). Young fruit that becomes infected may be killed. Older infected fruits develop depressed dark-bordered cankers with creamy pink-colored ooze in the center (23). Humid conditions and wet weather promote disease development (8, 23).

Frequency of Occurrence:
Incidence of Anthracnose is low because of the widespread use of resistant varieties (8). Warm humid weather favors disease development in susceptible plants (26).

Management:

Chemical Controls:
Chemical controls are not used (3).

Alternative Controls:
The commonly grown pickling cucumber varieties in Maryland exhibit excellent resistance to this disease (3). Growers use commercially-produced, disease-free seed (26).

Nematodes

Nematodes are extremely common, tiny (less than 0.25 inches long), nonsegmented roundworms, many of which are soil-dwelling. Plant parasitic nematodes complete their life cycle by feeding on living plants, most often the

roots. They may feed on plant tissues from the inside (endoparasitic) or from the outside (ectoparasitic) (20). Several species of plant pathogenic nematodes occur in Maryland soils (10), generally as mixed populations unevenly distributed throughout a field (20).

Root knot nematode

The most important nematode pest of pickling cucumbers in Maryland is the root knot nematode (*Meloidogyne spp.*) (27).

Damage and Life Cycle:
The life cycle and plant pathogenicity is similar for *Meloidogyne* species on all vegetable crops. Like most nematodes, root knot nematodes have a broad host range, and feed on a variety of crops and weeds. Females feed within the root of the plant. They produce eggs in a gelatinous sac attached to their posterior end. Juveniles develop and undergo one molt within the egg before emerging. The second-stage juvenile invades the roots, feeding within the vascular system by piercing cell walls with its stylet (28). Secretions exuded by nematodes during feeding cause plant cells to swell, producing the diagnostic elongated or rounded "knots" on the roots (23, 28). The nematodes feed within the plant and undergo 3 more molts before reaching reproductive maturity (28). Generation time is 25 to 40 days, depending upon host susceptibility, moisture, temperature, and soil type (27, 29).

Above-ground symptoms of root knot nematode infestation include erratic stands, stunted and wilted plants, and chlorosis. In addition to root galls, infected plants usually have reduced secondary roots (28). Nematode feeding produces the most severe symptoms under drought conditions, when plants are under increased stress (27). Yield reductions are highly variable, but can be significant. Also, the presence of nematodes has been associated with an increased rate of infection by fungi or bacterial pathogens, which can further reduce yield (30).

Frequency of Occurrence:
Root knot nematode is a serious recurring pest of pickling cucumbers in Maryland (4, 9, 16). Nematode populations are at problematic levels in about 20% of pickle acres in Maryland. Infected plantings suffer a 10 to 20% yield loss (9). Populations of root knot nematode are increasing in Maryland, due to mild winters and possibly in association with an increase in white potato production (9, 16). Potatoes are an excellent host for root knot nematodes, and pickles or other crops following potatoes can experience severe nematode problems (16). Routine soil sampling, fumigation, and crop rotation practices help prevent populations from reaching economic levels on most fields in most years (21, 31). However, rotations which include two susceptible crops within one field season, a common practice in Maryland, risk high nematode levels (8). Populations tend to be highest, and outbreaks more likely, in light, sandier soils as opposed to heavier clay soils. Population levels are prone to drastic fluctuations (27).

Detection:
Ideally, nematode management should be considered prior to planting, because once above ground symptoms are apparent it may be too late to avoid significant yield loss (30). On the Eastern Shore, samples are taken from fields after harvest but before tillage, when nematode populations are generally highest, to determine if nematodes are present in a field and to plan the cropping sequence (20, 21). If nematode damage is suspected after crop emergence, soil and root samples are generally submitted for laboratory analysis to determine the kind and number of nematodes present (10). Nematologists estimate the injury potential of a nematode population and use thresholds to determine if a control measure is warranted (20).

Management:
Nematode resistant pickling cucumber varieties are not available (4, 8). Generally, pickle growers in Maryland practice a 1 to 2 year rotation out of pickling cucumbers (4). This practice decreases the potential for nematode problems and also helps to control a variety of diseases. Crop rotation can be a useful strategy for maintaining low populations of soil nematodes, but rotation alone is not always sufficient to prevent root knot nematodes from reaching economic levels, due to their broad host range. Rotation into sorghum is especially effective for reducing nematode populations, but this is not an economically feasible option for Maryland growers (16, 21). Also, land limitations and market demands can limit the usefulness of crop rotation as a control measure for nematodes or diseases (31).

Other nonchemical practices that help to prevent the build-up of nematodes include the incorporation of green manure or other organic matter into the soil (10), cleaning of farm equipment (which can spread nematodes from field to field), and maintaining good weed control (32). Post-harvest discing can also help to reduce soil populations of nematodes (21). These strategies are used by at least half of Maryland growers (9, 21). When combined with crop rotation and soil sampling, these practices help to prevent nematode populations from reaching economic levels (21).

University of Maryland researchers are currently undertaking an investigation of the effect of certain crop rotations on root knot nematode populations (16).

Chemical Controls:
Crop rotation and other cultural practices help to prevent nematode buildup in pickling cucumbers, but in some cases, chemical control is warranted (21). Chemical control of nematodes is generally achieved by the use of fumigants or nonvolatile nematicides (32). Field fumigation is generally done after a nematode problem has been recognized. Since nematodes can be spread mechanically by farm equipment, a grower with a nematode problem in one field is advised to fumigate all fields prior to the next planting (21).

Typically, about 21% of Maryland's pickle crop land is fumigated for control of nematodes and other soil-borne pests (8, 9). In 1998, 7.3% of Maryland's pickle acres were treated with metam-sodium (Vapam HL 30 gal/A) and an additional 13.6% were treated with 1,3-dichloropropene (Telone II 12 gal/acre). All fumigated acres in this case were located in Dorchester county, however, root knot nematode is widespread throughout Maryland (3). Metam-sodium is a very broad spectrum, water dispersible, crystalline product that is generally applied through irrigation systems. The rate of metam-sodium applied varies considerably, depending on the objective of the grower. It is used well below the labeled rate if the primary concern is weeds, and is often applied at the maximum labeled rate for optimal disease and nematode control (21). Fumigation can effectively reduce populations of soil-inhabiting nematodes for up to 3 years. Some growers on the Eastern shore fumigate every 3 years to prevent nematode populations from reaching economic levels in pickling cucumbers and rotational crops. This practice is important because most of the rotational crops grown provide suitable hosts for root knot nematodes. Fumigation is done in the fall and cover crops are used to prevent soil erosion (16). Although expensive, the cost of field fumigation is generally recovered with the first crop harvested (9).

A chemical alternative to fumigation is oxamyl (Vydate L), which is somewhat effective against nematodes. It can be incorporated into the top 2 to 4 inches of soil at a rate of 1-2 gal 2L/A or applied 2 weeks after planting at a rate of 1-2 pt 2L/A, and again 2 to 3 weeks later (10). Oxamyl is used on about 1% of Maryland pickling cucumber acres annually, as a rescue treatment (4).

Weeds

Weeds are ubiquitous in pickling cucumbers in Maryland and cause economic loss by interfering with mechanical harvesting and by impeding the application of fungicides and insecticides (3). Weeds also compete with crop plants for nutrients, water, and light, and some can act as reservoirs for insect pests and diseases (33). Weed escapes can produce seed that will be in the soil and increase weed populations for the next several years. Therefore, any weeds present may not only be a problem this year but also for many future years (34).

Major Weeds:

Table 1: Major weeds in pickles (12).

species	avg. annual % yield loss*	avg. % control achieved*
crabgrass sp.	3	98
fall panicum	2	98
pigweed sp.	6	94
commmon lambsquarters	10	90
jimsonweed	2	85
morningglory sp.	5	80
yellow nutsedge	2	50
common purslane	4	80

*With current cultural practices and herbicide use.

Cultural Controls:
Herbicides alone do not control all weed species, but are used in conjunction with dense plantings and cultivation practices (3, 34). Prior to planting, fields are moldboard plowed. This practice reduces weed seed populations by redistributing a high proportion of seeds below the upper soil layer to prevent germination. A high seeding rate produces dense plantings which provide a competitive stand and reduce weed seed germination after the canopy closes (3). After planting, 90% of fields are cultivated. Of these, about 25% are cultivated twice (12).

When weed escapes occur, additional cultivation may be preferable to hoeing or applying post-emergence herbicides (34). Hoeing is more expensive and labor intensive than cultivation, and post-emergent herbicides may injure the crop and cause a delay in harvest. Also, since post-emergent herbicides are selective, it is unlikely that all weed escapes will be controlled (12). Herbicides are an aid to cultivation because they delay weed growth until the plants become large enough for cultivation. Fields are not allowed to remain idle after harvest because weeds will produce seeds until the first frost. Fields are always tilled after harvest to prevent late summer and fall weed seed production (34).

Chemical Controls:
In a 1998 survey of pickle growers in Maryland and Delaware, no significant regional difference in herbicide use

patterns were noted (3).

Preemergence and Preplant-Incorporated Herbicides

All pickling cucumber acreage in Maryland is treated with a preemergent herbicide, either ethalfluralin, clomazone, naptalam, or some combination of these (3). Irrigation, cultivation or rotary hoeing may be used to increase weed seed contact with herbicides and to help activate preemergent herbicides (3, 33). Preplant incorporated and preemergence herbicide selection is based on the mixture of weeds present in the field, soil type, and the percent of organic matter in the soil (10).

- **bensulide** - 5 to 6 lbs ai/A (5-6 qts/acre Prefar 4EC) is registered for use in transplanted and direct seeded cucumbers in Maryland for control of grasses. Bensulide may be applied preplant incorporated or preemergence. Bensulide provides excellent to good control of many grasses, including barnyardgrass, large crabgrass, fall panicum, foxtail species, and johnsongrass seedlings. It provides good to fair control of goosegrass. The maximum rate is used for preemergent applications to suppress certain broadleaf weeds such as common lambsquarters, common purslane and smooth pigweed. Bensulide does not control most broadleaf weeds. Bensulide is tank mixed with other herbicides to control more weed species. If applied preemergence, rainfall or irrigation must occur within 36 hour for the best weed control (10). The irrigation amount should be less than 0.4 inches or excessive dilution of the herbicide may occur (34). If incorporated, the depth should be 1 to 2 inches (10). This product is not used by large commercial producers of pickling cucumbers, but may be used in small-scale production. It is safer than ethalfluralin and presents less risk to rotational crops than clomazone. Bensulide is also the only preemergent herbicide available to Maryland growers for use on transplants (12). One reason it is not used in large commercial production is that its cost was 3 times that of alternative effective herbicides in 1998. However, it is an important tool for weed management in other transported vine crops (3).

- **naptalam** - 2 lbs ai/A (1 gal/acre Alanap 2SC) preplant incorporated 2 inches into the soil prior to seeding or transplanting offers limited control of certain grassy and broadleaf weeds (10). Naptalam is more commonly applied as a preemergent treatment, in combination with clomazone + ethalfluralin or ethalfluralin (3, 12). It provides good to fair control of pigweed species and common purslane and fair control of foxtail species, carpet weed, galinsoga, jimsonweed, common lambsquarters, morningglory species, common ragweed and velvetleaf. Naptalam offers fair to poor control of goosegrass and large crabgrass and poor control of barnyardgrass, fall panicum, cocklebur, Pennsylvania smartweed and eastern black nightshade. Weed control may not be satisfactory on sandy soils with less than 1% organic matter (10). In Maryland, this herbicide is applied preemergence to about 40% of pickle acres annually, always in combination with other herbicides (3).

- **ethalfluralin** - A special Local-Needs Label 24 (c) has been approved for the use of Curbit 3E on cucumbers in Maryland and other mid-Atlantic states. For cucumbers, 0.56 to 0.75 lb ai/A of ethalfluralin (1.5-2 pts/acre Curbit 3EC) is applied preemergence to control annual grasses and certain annual broadleaf weeds, including carpetweed and pigweed species. Control of many broadleaf weeds, including common lambsquarter, jimsonweed, morningglory sp., ragweed sp., mustard sp., and others may not be acceptable. Dry weather following application may reduce weed control. Growers cultivate to control emerged tolerant weeds if rainfall or irrigation does not occur prior to weed emergence (10). Ethalfluralin may be used at a rate of 3 pints per acre on soils with at least 2% organic matter, especially if manures have been applied. Ethalfluralin may be combined with clomazone to improve control of ragweed, velvetleaf, and jimsonweed (3, 34). Ethalfluralin is not preplant incorporated or applied under plastic mulch or applied when soils are cold or

wet, as injury may occur (10). In Maryland, this herbicide is applied to 100% of pickle acres annually (3).

- **clomazone** - A special Local Needs Label 24 (c) has been approved for the use of Command 4EC (clomazone) on cucumbers in Maryland and other mid-Atlantic states (10). Clomazone may be applied preplant incorporated or preemergence, and herbicide effectiveness is the same for both methods of application (34). For cucumbers, 0.12 to 0.19 lb ai/A of clomazone (4 to 6 fl oz/acre of Command 4EC) is applied for good to excellent preemergent control of annual grasses and many broadleaf weeds including common lambsquarter, velvetleaf, spurred anoda, jimsonweed and purslane (10, 34). Mustards, morningglory species, and pigweed species will not be controlled by clomazone. Clomazone is combined with ethalfluralin to greatly improve control of pigweed species. The lowest recommended rate is used on coarse-textured, sandy soils low in organic matter. Higher rates are only used on medium and fine-textured soils and sites that have been heavily manured. Preplant incorporation reduces the risk of vapor drift, but increases the risk of crop injury. Some temporary crop injury (partial whitening of leaf or stem tissue) may be apparent after crop emergence. Complete recovery will occur from minor early injury without affecting yield. Banding the herbicide reduces the risk of crop injury and offsite movement due to vapor drift. Clomazone spray or vapor drift may injure sensitive crops and other vegetation up to several hundred yards from the point of application (10). Application should be made when wind is calm or less than 5 mph and blowing away from critically sensitive areas such as businesses, homes, vegetables and ornamental plant nurseries (34). In Maryland, this herbicide is applied to about 85% of pickle acres annually (3, 12).

- **Ethalfluralin + clomazone** - A combination of Ethalfluralin (1.5 pts/acre Curbit 3EC) + clomazone (3-4 oz/acre Command 4EC) is used on about 90% of pickling cucumber acres in Maryland and Delaware. This combination provides excellent control of most weed species in our area and is superior to the control level achieved with either product applied alone (3). This combination is the primary chemical method for preemergent weed control in pickling cucumbers in Maryland (9, 16). Generally, treatment with other preemergent materials is not necessary (12).

Postemergence Herbicides

Very little postemergent weed control is used in pickling cucumbers in Maryland. In 1998 postemergents were not used at all (3). This is due to the excellent weed control provided by the ethalfluralin + clomazone combination (12).

- **naptalam** - 1 lb ai/A (2 qts/acre Alanap 2SC) can be applied when the crop is ready to vine to extend residual weed control and to suppress or control smooth pigweed. It is not used early in the season when growing conditions are cold and wet. It is not applied less than 6 hours prior to rainfall, and should not be mixed with liquid fertilizer. Naptalam provides good to fair control of pigweed species and common purslane and fair control of foxtail species, carpet weed, galinsoga, jimsonweed, common lambsquarter, morningglory species, common ragweed and velvetleaf. Naptalam offers fair to poor control of goosegrass and large crabgrass and poor control of barnyardgrass, fall panicum, cocklebur, Pennsylvania smartweed and eastern black nightshade (10). In Maryland, naptalam is applied postemergently to a very small percent of pickle acres annually (12).

- **Paraquat** - A Special Local Needs 24(c) label has been approved for the use of Gramoxone Extra 2.5SC postemergence as a directed shielded spray in Maryland and other mid-Atlantic states. For cucumbers, 0.5 lb ai/A of paraquat (1.6 pts/acre of Gramoxone Extra 2.5S) is applied as a directed spray to control emerged weeds between the rows after crop establishment. Growers use shields to prevent spray or spray drift contact with the crop plants, and do not exceed a spray pressure of 30 psi to avoid injury of crop. Paraquat gives

good control of cocklebur, foxtail species, galinsoga, yellow nutsedge, pigweed species, and common ragweed, and gives good to fair control of large crabgrass, morningglory, common purslane, fall panicum, and common lambsquarter. It provides poor control of Pennsylvania smartweed (10). Paraquat is used in situations when weeds occur prior to crop emergence. This is most likely under wet conditions when tillage is poor and herbicides are more likely to fail. Some years, under better conditions, its use is not required (12). It was not applied to commercial acres surveyed in 1998 (3). On average, this herbicide is applied to less than 5% of pickle acres in Maryland annually (12).

- **sethoxydim** - 0.2-0.3 lb ai/A (1 to 1.5 pts/acre of Poast 1.5 EC) is applied with oil concentrate as 1% of the total spray solution for postemergent control of annual grasses and certain perennial grasses. The use of oil concentrate may increase the risk of crop injury when hot or humid conditions prevail**.** To reduce the risk of crop injury, growers omit additives or switch to nonionic surfactant when grasses are small and soil moisture is adequate. Control may be reduced if grasses are large or if hot, dry weather or drought conditions occur. For best results, growers treat annual grasses when they are actively growing and before tillers are present (10). Sethoxydim provides excellent control of fall panicum, goosegrass, lovegrass, and foxtails. Sethoxydim will control johnsongrass and shattercane and it is also effective for control of volunteer rye and wheat. Crabgrass (smooth and large) is sprayed when it is in the 2 leaf stage or smaller for effective control. A second application may be made for grasses that are difficult to control or for new flushes of germinating grasses, although this is rarely necessary (12, 34). Yellow nutsedge, wild onion, and broadleaf weeds will not be controlled with sethoxydim (10). Generally, sethoxydim is most effective if applied 3 to 5 days prior to cultivation because it will weaken grasses and make them more vulnerable to killing by cultivation (34). Growers do not tank-mix sethoxydim withpesticides or apply within 2 to 3 days of any other pesticide unless labeled, because the risk of crop injury may be increased, or reduced control of grasses may occur. A minimum preharvest interval of 14 days is observed and applications must not exceed 3 pints per acre in one season (10). Sethoxydim, like paraquat, is used in situations where weeds occur prior to crop emergence. This is most likely under wet conditions when tillage is poor and herbicides are more likely to fail. Some years, under better conditions, its use is not required (12). It was applied to less than 1% of commercial acres in Maryland in 1998 (3). On average, this herbicide is applied to less than 5% of pickle acres in Maryland annually (12).

Postharvest

- **paraquat** - A Special Local-Needs 24(c) label has been approved for the use of Gramoxone Extra 2.5SC for post-harvest desiccation of the cucumber crop in Maryland and Virginia. Paraquat may be applied as a broadcast spray at 0.5 to 0.6 lb ai/A (1.6 to 1.9 pts/acre of Gramoxone Extra 2.5SC) postharvest to prepare plastic mulch for replanting, or to aid in the removal of mulch (10). However, in Maryland this herbicide is not typically applied after harvest of pickling cucumbers (12).

Chemical Control Issues for Herbicides:
Good preemergent weed control in pickling cucumber is critical, since postemergent weed control options are severely limited, particularly for broadleaf weeds. Sethoxydim is the only chemical that provides good postemergent grass control and paraquat is the only product available for postemergent broadleaf weed control. Paraquat must be applied as a directed spray between the rows to prevent damage to the crop. For this reason, it may not sufficiently control weed infestations that encroach on the crop plants (33).

Because of the very narrow range of herbicides available for weed control in pickling cucumbers, the loss of any of these products could have a significant negative impact on pickle production in Maryland. This narrow product

range also raises concerns about the development of herbicide resistant or tolerant weed populations, however this has not been a problem to date (4, 33).

Table 2. Pickling Cucumber herbicides for grasses and sedges.

GRASSES AND SEDGES							
Herbicide	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (seedling)	Yellow nutsedge
Preemergence or Preplant Incorporated:							
naptalam	P	P/F	P	F	P/F	I	N
clomazone	G	G	G	G	G	G	N
bensulide	G	G	G	G	F/G	I	N
Preemergence Only:							
ethalfluralin	F	G	G	I	G	I	N
Postemergence:							
naptalam	N	N	N	N	N	N	N
paraquat	F/G	F/G	F/G	G	F/G	G	G
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 (34). (Table modified from 1999 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 236)

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

Table 3. Pickling cucumber herbicides for broadleaf weeds.

BROADLEAF WEEDS									
Herbicide	Carpet-weed	Cocklebur, Common	Galinsoga, Hairy	Jimsonweed	Lambsqtr., Common	Morning-glory sp.	Pigweed sp.	Purslane, Common	Ragweed, Common
Preemergence or Preplant Incorporated:									
naptalam	F	P	F	F	F	F	F/G	F/G	F

clomazone	N	N/F	F	G	G	P	N/P	G	F
bensulide	N	N	N	N	F/G	N	F	F	N
Preemergence Only:									
ethalfluralin	G	N	N	N	P/F	P	F	F/G	N
Postemergence:									
naptalam	N	N	P	I	P	P/F	F	F	P
paraquat	G	G	G	G	F/G	F/G	G	F/G	G
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 (34). (Table modified from 1999 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 236)

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Contacts

Dr. C. Ed Beste, Weed Specialist
University of Maryland
Lower Eastern Shore Research and Education Center
27664 Nanticoke Road
Salisbury, MD 21801-1648
(410) 742-8780
cb20@umail.umd.edu

Dr. Galen Dively
Department of Entomology
University of Maryland
4124 Plant Sciences Building
College Park, MD 20742
gd7@umail.umd.edu

Dr. Kathryne Everts, Plant Pathologist
University of Maryland
Lower Eastern Shore Research and Education Center

27664 Nanticoke Road
Salisbury, MD 21801-1648
(410) 742-1178
ke35@umail.umd.edu

Dr. James Linduska, Entomologist
University of Maryland
Lower Eastern Shore Research and Education Center
27664 Nanticoke Road
Salisbury, MD 21801-1648
(410) 742-8788
jl43@umail.umd.edu

Reviewers:
Ms. Betsy Gallagher, County Extension Agent, Dorchester County Extension
Ms. Sandra Sardanelli, Nematologist, University of Maryland, College Park
Mr. Randy Spence, Manager of Manufacturing Services, Vlasic Foods International, Millsboro, Delaware.

Compiled and Edited by:
Mr. Al Fournier, Program Assistant, PEAP, University of Maryland

Edited by:
Dr. Amy Brown, PEAP Coordinator, University of Maryland

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1. Throughout this profile, the terms 'pickle' or 'pickling cucumber' refer specifically to cucumbers grown for processing. The term 'cucumber' refers to all cucumbers produced for the fresh market and for processing. Cucumbers produced for the fresh market are specified as such.