Crop Profile for Cucumbers (Fresh Market) in Maryland

Prepared January, 2000

General Production Information

- Maryland ranked 14th in national cucumber and pickle production in 1997, and accounted for 2% of U.S. cucumber and pickle production (1). Pickles made up the bulk of this production (2).
- Maryland farmers harvest about 600 acres of fresh market cucumbers a year.(1) The average annual cash value of this crop is about $907,500.00 (3).
- The annual production cost for fresh market cucumbers in Maryland is about $839.30 per acre, or $461,615.00 total, based on annual production (4, 5).
- More than 75% of fresh market cucumber growers statewide participate in IPM programs (6). In Caroline county, 65% of acres are scouted for pest problems (7).

Production Regions

The highest production for the state is in Wicomico county on the southern Eastern Shore which produces about 200 acres annually (8). Other counties on the Eastern Shore account for about 60 acres (7, 8, 9). Counties west of the Chesapeake bay account for the remaining acres, with the highest production in Anne Arundel and Prince Georges counties (10**,** 11).

Production Methods

Production and pest management practices for fresh market cucumbers vary considerably among growers in Maryland. There are regional differences and differences related to the scale and timing of production. About half of the cucumbers produced for the fresh market are grown by producers with a small acreage scattered around the state, and it is difficult to provide a generalized account (6). Practices of the few major producers also differ from those of the many growers with a small amount of cucumber acres (12).

Cucumbers thrive in light textured, well-drained soils high in organic matter, with a pH between 6 and 6.5 (13). These prostrate, annual vines have deep roots, and require adequate moisture (14). Fresh market cucumbers are generally grown on raised beds with conventional tillage (15, 16). Beds are prepared and covered with black plastic mulch (if used) 30 days prior to planting. Fertilizer is applied during bed preparation, with at least 50% of nitrogen in the nitrate (NO_3) form (15). Growers with large acreage usually direct-seed into bare ground. Production for

early markets and some other small scale production for roadside or direct markets is done by transplanting into black plastic (7, 12). Transplanting is very expensive compared to direct seeding, and is not profitable except in these situations (12). For this reason, 75% to 90% of Maryland's fresh market cucumber acres are direct seeded (6, 7). It is estimated that about 50% of Maryland acres are grown on black plastic with drip irrigation (6, 11, 12) and the rest are on bare ground. Typically, less than 5% of acres are fumigated with methyl bromide (6, 7). Fumigation is expensive, but is the only recourse in some situations, where a severe disease or nematode problem would otherwise prevent economic production of a crop (12). Cucumbers are initially seeded between mid-April and early May in the mid-Atlantic, with successive plantings continuing through early August. Plants are spaced 9 to 12 inches in rows 3 to 4 feet apart. The seeding rate is 1.5 pounds per acre (15). Container-grown plants are planted through black plastic when the mean daily temperature reaches 60ºF (15.6ºC), typically in May or June (6, 15).

Cucumbers are generally rotated with other crops and often are doubled cropped. In some cases, cucumbers may follow winter cover crops, but this is not a routine practice (16). Growers establish honeybee colonies (at least one hive per acre) to assure adequate pollination (13). Trickle irrigation is used to provide adequate moisture throughout the growing season (15). When conditions are favorable, plants begin producing fruit about 8 weeks after planting. Fruit is picked daily during the harvest season. Plants are picked clean of mature fruits, to maintain plant vitality and to prolong the picking season (13).

Pest Management Overview

Pest management practices, including chemical treatments, vary tremendously among growers in Maryland, depending upon the timing of the crop, scale and method of production, weather conditions and other factors (12). Because of their longer growing season relative to pickling cucumbers, fresh market cucumbers are more susceptible to insect and disease damage. The plants also are less able to compensate for pest damage once it occurs, due to lower plant density in the field. These differences have a significant impact on pest management strategies, and are particularly important for management of bacterial wilt (16). Cucumber beetles are a consistent problem, and virtually all growers use an insecticide treatment for this pest, mainly foliar products on an as-needed basis. Growers using plastic mulch and drip irrigation and those harvesting early are more likely to apply carbofuran preventively to protect their investment. Disease potential is directly dependent upon weather conditions, and for this reason fungicide use can vary dramatically from season to season and regionally as well. The general approach is preventive applications made only when conditions favor disease development. The timing and total number of applications is dependent upon weather conditions and economics. Growers harvesting for the profitable early markets, or those for whom this crop has greater value, are more likely to adopt a conservative approach when making spray decisions (12). A careful monitoring-prevention approach is adopted by most major growers while preventive cover sprays of fungicides for general disease control are more likely to be used in small scale production (6, 12). Chemical control tactics for weeds are generally more consistent among growers and from year to year, as described in the weed section of this profile (12).

Insect Pests

Major Insect and Mite Pests in Maryland

The only major insect pests of fresh market cucumbers are striped and spotted cucumber beetles (17). They cause feeding damage and vector bacterial wilt, a disease which can cause severe yield losses in fresh market cucumbers (18).

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 fresh market 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. 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 (17, 19).

Both species of cucumber beetles vector bacterial wilt disease to cucurbits (20) (see disease section). This disease is particularly problematic in fresh market cucumbers, due to the longer growing season as compared to pickling cucumbers (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 (20). The pathogen is carried from plant to plant and field to field as the beetles feed. Infected plants eventually wilt and die (19). Losses from this disease vary greatly from field to field and among different cultivars, but average annual yield loss is around 10% (6, 7, 15). Once a plant has been infected with bacterial wilt, it cannot be saved. Infected plants rarely produce marketable fruit. Chemical control of the beetle vector is the primary control strategy for the disease (17). Cucumber beetles also can transmit another important disease, cucumber mosaic virus (19).

Frequency of occurrence:
Cucumber beetles are serious annual pests of fresh market cucumbers (17). Beetle populations can vary widely depending on geographic location, weather and environmental factors. In some areas, beetles are a consistent problem from year to year (12).

IPM Program:
The importance of scouting while cucumber plants are young cannot be overstated. The major feeding injury and disease transmission takes place from the time cucurbits are transplanted or emerging through the surface until they form runners. Fields are scouted at least twice weekly, beginning immediately after transplanting or emergence. Visual counts of beetles are too variable to be a reliable measure of population levels. 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, although no action thresholds have been established for this pest on fresh market cucumbers in Maryland (21). About 65 to 75% of Maryland growers participate in IPM programs (6, 7).

Chemical Controls:
Product choice and the number of insecticide applications can vary considerably, based on cucumber beetle

populations. In areas with a consistent cucumber beetle problem, control is sometimes accomplished with a single preventive treatment of carbofuran (Furadan 3.8 fl oz 4F/1,000 ft of row) applied at planting (12, 15). A Special Local-Needs Label 24(c) is in effect in Maryland for the use of liquid Furadan at 3.8 fl oz 4F/1,000 ft of row at planting (15). When carbofuran is used, it is generally effective and the only treatment needed. However, a very small percent of acres may receive a single foliar application in addition to carbofuran (7). As little as 5% or as much as 80% of acres are treated with carbofuran, depending on region and location, environmental conditions and past experience of the grower (6, 7, 12, 16). Statewide, it is estimated that under 50% of acres are treated (16) and in general, use is declining throughout the state (7, 22). Use of carbofuran at planting frequently leads to spider mite outbreaks later in the season (15). Long-term usefulness of carbofuran may be limited due to enhanced chemical breakdown by soil microorganisms which have adapted to the chemical (23).

Where carbofuran is not used, foliar insecticides are generally applied to control beetles before they feed extensively on young plants and spread bacterial wilt (15, 21). If foliar applications are timed right, there may be little difference between these two strategies in the incidence of bacterial wilt (16). Foliar products are favored where beetle populations pose a less consistent problem. If needed, spraying begins shortly after plant emergence, and applications are repeated weekly as long as new beetles continue to invade the fields. Treatment is required until vines begin to run (usually about 3 weeks after plant emergence) (15). In some cases no treatment at all may be necessary, but more typically, 1 to 3 sprays are used (12). Foliar product usage can vary considerably depending on local beetle populations, but it is estimated that an average of about 50% of fresh market cucumber acreage is treated at least once with one of the foliar products (16).

The most popular foliar insecticides for cucumber beetle control are permethrin (6.4-12.8 fl oz Ambush 2EC/A or 4-8 fl oz Pounce 3.2EC/A) and esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A). Both of these products are inexpensive, effective, and relatively safe for applicators. One or the other make up about 60% of foliar applications in Maryland (12). However, multiple applications of permethrin may lead to outbreaks of aphids (17). Endosulfan (Thiodan l.33-2.67 Pt 3EC/A) is effective against cucumber beetles and also against most aphid species, except melon aphids. Its usage currently makes up about 20% of foliar applications (12). Carbaryl bait (Adios 12 oz/A or Sevin l.25 lb 80S/A) is effective, but kills slowly. It is increasing in popularity and is currently used on a small percentage of acres statewide (6, 12). In Carroll county, Adios is used on as much as 30% of acres (7). Methomyl (Lannate l.5-3 pt LV/A) has an important place in the overall pest management program for fresh market cucumbers (also see aphid section). It kills quickly and is the only product available to Maryland growers that offers fast and effect control of melon aphids. Methomyl use makes up about 20% of foliar applications targeting cucumber beetles, and is used in situations where melon aphid is also a concern (12).

Alternative Controls:
No bacterial wilt resistant cultivars are available for the fresh market (6). 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 (16). However, no commercial growers in Maryland employ these practices to any extent (24).

Minor Insect and Mite Pests in Maryland

<u>Seedcorn maggot</u> (*Delia platura*)

Damage and Life Cycle:
Seedcorn maggot is a common insect throughout the Northeast (25). 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 the emerging larvae feed on decaying organic matter. Maggots may burrow into the seed and consume the germ, preventing germination (26). Generally, cucurbit seedlings are destroyed by maggots more often than other susceptible crops, since a few maggots per seed is enough to prevent germination (21). Larvae feed for 21 days, then pupate in the soil. There are 4 to 5 generations per season in Maryland (26).

Frequency of Occurrence:
Seedcorn maggot is a sporadic pest of fresh market cucumbers (16). Injury is most severe in cool wet springs when germination is delayed. Fields high in crop residue and other organic matter are more susceptible to high levels of infestation, especially when soils are cool and damp (6, 17). Fluctuations in maggot populations don't affect chemical applications, since seed treatments are used (24). Although typically easily controlled with seed treatments or a soil insecticide, uncontrolled populations can devastate entire fields (12). This pest is not a problem where fumigation is used (22).

IPM Program:
Since maggot feeding results in no detectible above-ground symptoms, low germination rate is often the first sign of an infestation. Ungerminated seeds are examined for signs of larval feeding (25). If damage is extensive enough to warrant replanting, seed treatment or soil insecticide is applied to prevent reinfestation (21). Most of the fresh market cucumber fields in Maryland are scouted for this problem (7, 16).

Chemical controls:
Seed treatments or in-furrow treatments are the only means of chemical control for seedcorn maggot. Nearly all Maryland growers use seed treatments, mainly chlorpyrifos (Lorsban 50SL) (7, 24). Statewide, about 10% of direct-seeded acres are treated with diazinon (1 qt/A AG500) preplant incorporated (16). The figure may be as high as 35% on the Eastern Shore. This is used in addition to seed treatments, and only on fields at high risk for a seedcorn maggot problem. Conditions that favor high maggot populations include high surface organic matter or the use of certain legume cover crops, especially clover (12).

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 (25). In some counties, late plantings are common due to market demands, and in these cases seedcorn maggots are less of a problem (7). Fields with cover crops or those high in organic matter are plowed prior to fly emergence in early spring (25).

Melon aphid (*Aphis gossypii*) and other aphids

Damage and Life Cycle:
Melon aphids are the most important of several aphid species that attack cucurbits, particularly melons and cucumbers. Melon 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. Cucurbits usually are not attacked by aphids until the vines form runners, and then infestations commonly begin in small scattered spots over the field. The melon aphid is also one of the primary vectors of cucumber mosaic virus (19). (See disease section for more information on viruses.)

Frequency of occurrence:
Aphids are a sporadic pest on fresh market cucumbers (16). The worst infestations occur during hot, dry summers following cool, dry springs, since such weather conditions reduce the efficiency of the natural enemies (19).

IPM Program:
All Maryland acres are scouted by growers or crop advisors at least once during the growing season for aphid problems, but few growers use detailed sampling as part of the decision making process (6, 7, 16). When aphids are detected, sampling is usually done to determine infestation levels and natural enemy activity (12). It is generally recommended that an insecticide be applied if more than 20% of runners have 5 or more aphids, natural enemy populations are low, and humidity is low to moderate (21). If natural enemy populations are high, a scout may recommend no treatment, but return to the field after 3 days to determine if aphid levels have changed. In some cases no treatment is required, but if aphid populations are still high, methomyl (Lannate) is applied (12).

Chemical Controls:
Insecticide applications vary from year to year, based on aphid population pressure. In a year without much aphid pressure, one application on about 5% of fresh market cucumber acres may be necessary to control aphids. During the worst infestations, no more than two sprays are used on about 20% of acreage (7, 12, 16). Spot treatments are an effective way to control localized infestations and maintain predator populations. Treatment is applied to an area of about 100 feet beyond the area of infestation (17). The only insecticides that offer effective control of melon aphid in Maryland are methomyl (Lannate l.5-3 pt LV/A or other labeled formulations), which is the most effective, and endosulfan (Thiodan 1.33-2.67 pt 3 EC/A). Each of these insecticides account for about 50% of applications made for aphids, and methomyl is generally used if melon aphids are the specific target (12, 24). Diazinon (1 pt 4EC/A) is used on rare occasions for green peach aphid (24).

Chemical Control Issues:
Methomyl (Lannate) is a critically important component of insect pest management programs for fresh market cucumbers. It is the only insecticide available that works quickly and effectively against melon aphids. Because it is fast-acting, it allows growers to delay spraying for aphids and allow natural enemies a chance to control populations. If natural enemy populations fail to control aphids, it will not be too late to treat with methomyl. Without this product, it is likely that the number of foliar treatments made for aphid control would increase. It is also effective against cucumber beetles and is the product of choice for controlling them when melon aphid populations are also a concern (12).

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 (17). 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 in Maryland (16).

Spider mites

Damage and Life Cycle:
These minute mites feed on the contents of individual cells of the leaves, which become blotched with pale yellow and reddish-brown spots ranging from small specks to large areas on the upper sides of leaves. Damage can develop

very quickly, and a severe infestation can seriously stunt the growth of plants (19). In severe infestations, spider mite damage can result in a 5 to 20% reduction in yield (7).

Frequency of occurrence:
Mites are a sporadic and relatively minor pest problem in cucumbers (6, 17). Although not a problem every year, spider mites can be a serious problem during hot, dry weather, particularly if carbofuran is used at planting (14, 16). Infestations tend to be localized within a field (16).

IPM Program:
Because of their small size, spider mites are hard to detect until the vines are damaged with hundreds of mites on each leaf (19). About 5% of fresh market cucumber acres are scouted for mites weekly from early July through August during hot, dry weather, particularly around field edges (7, 16, 19). If feeding injury is detected, plants are sampled to determine the extent of mite infestation (21). An insecticide treatment is applied in mid-summer if 50% of the runners show leaf injury and mites are present, or if 10-15% of the crown leaves are infested early in the season (15, 21).

Chemical Controls:
Most growers seldom treat for spider mites (23). Many years, chemical control of mites is unnecessary. During the worst infestations, two sprays may be used on about 30% of fresh market acres, but this is rare. Localized infestations are spot-treated. The most frequently used chemical control in Maryland is dicofol (Kelthane 1.25 lb 50WP/A) (16). Some oxydemeton-methyl (Metasystox-R 1.5-2 pt 2SC/A) is also used. Abamectin (Agri-Mek 8-16 fl oz 0. l5EC/A) is rarely used, since it is very expensive (16, 23).

Chemical Control Issues:
Continuous use of carbofuran, carbaryl, or pyrethroids to control other insect pests may result in mite outbreaks (15).

Alternative Controls:
One control strategy is to leave grassy areas adjacent to fields unmowed in mid-summer, as a disturbance to these areas drives mites onto the crop (21). A relatively small percentage of Maryland growers do this (6, 7).

Diseases

Infectious diseases of cucumbers are caused by fungi, bacteria, viruses, and nematodes, and some are vectored by insects. Maryland growers use IPM practices to manage diseases in fresh market cucumbers. Successful and cost-effective disease management requires planning, monitoring of weather conditions and the development of symptoms, accurate identification of pathogens, and timely application of control measures (12, 15). The development of nearly all diseases that affect cucumbers is extremely weather dependent. Occurrence of certain diseases can be assured if weather conditions are favorable and preventive measures are not taken. Preventive fungicide applications are the only means of effectively managing some diseases, but the timing and frequency of applications is determined by weather conditions (12). Other diseases are controlled mainly by management of insect vectors or cultural controls (15). Many cultivars of fresh market cucumbers with varying levels of resistance to one or a number of diseases are available. However, there is no single cultivar which offers resistance to all potential disease problems, and so growers must select varieties based on previous disease problems (6).

The most important diseases of fresh market cucumbers in Maryland generally are damping off, bacterial wilt, Phytophthora, Anthracnose, scab, belly rot and gummy stem blight. However, which diseases are most problematic depend upon local or seasonal weather conditions and on crop rotations. All the diseases listed in this profile can be significant given the proper conditions or if controls fail, though many of them will not develop every year (12).

Damping-off

Damage and Life Cycle:
Damping-off refers to a number of fungal disease organisms that cause seeds to rot before they germinate, shoots to decay before they emerge, or seedlings to collapse (27).

Frequency of Occurrence:
The frequency and severity of damping-off is strictly dependent upon the weather (27).

Management:

Chemical Controls:
Seed treatments are the most cost-effective means for prevention of damping-off, and are used by most Maryland growers (12, 28). A wide variety of treatments are available, and many different ones are used. Germate (lindane, maneb, diazinon) and Isotox (captan, lindane) are popular choices. Formulations and rates used vary. One of the formulations that contains diazinon is best, since this will also control seedcorn maggot. Chlorpyrifos (Lorsban 2 oz per 100 lbs 50SL) and thiram (3 oz per 100 lbs 75WP, combined with an insecticide) are also used (12, 15).

Another strategy, for direct-seeded cucumbers, 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) (6). This option is expensive, and used on a small percentage of acres where disease risk is very high or where rotations are limited (6, 12). For areas at risk for Phytophthora or where tight rotations of cucurbits and peppers are used, this may be the only viable option (12).

Alternative Controls:
Varieties that are resistant to damping-off are available, and are used by about 75% of growers in Maryland (6). Cultural practices that aid in disease management include selecting well-drained fields, and avoiding planting into cool wet soils (28). Also, growing on raised beds, laying plastic early to warm the soil, adding organic matter and increasing drainage all help to reduce occurrence of damping-off (6).

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 (29). Although cucumber beetles are not the only insects known to vector this disease to cucumbers, transmission by other insects is of less economic importance (18). 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 (29). Additional symptoms include interveinal chlorosis and

marginal necrosis of the leaves, with the leaves eventually becoming totally brown and standing upright. Internodes may be stunted and leaves take on a "tufted" appearance, because they are underdeveloped (28).

Frequency of Occurence:
Bacterial wilt is an important disease throughout the eastern United States, but its occurrence and severity depend upon 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 fresh market cucumbers can be up to 100% in severely affected fields, though a 10-15% yield loss is more typical (7, 18, 28). When beetle control is effective, however, there is very little impact of bacterial wilt on yield (6).

Management:
Resistant varieties are not available (6). Management of bacterial wilt is achieved by control of the cucumber beetle vector (15). (See cucumber beetle section.)

Chemical Controls:
There are no chemical controls that work directly on bacterial wilt-infected plants (21).

Alternative Controls:
There are no effective alternative controls for bacterial wilt that are practiced in Maryland (18).

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 are 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 (30). The disease is promoted by warm, wet weather and frequently appears in the wettest part of the field (14, 29). Movement of the fungus in water and in soil can be an important means of spread between fields (30).

Frequency of Occurence:
Phytophthora is always problematic in Maryland during wet growing seasons (6, 12).

Management:
This disease is managed with a combination of chemical and cultural controls (15).

Chemical Controls:
Growers use a preventive approach for managing this potentially devastating disease (6, 12). About 50% of growers follow a strict spray schedule (6). In this case, applications start when the runners are formed, and following periods of wet weather. Three to 4 applications are used in all (6). The other 50% of growers apply preventive sprays, but vary timing and number of applications according to weather conditions (12). The following product combinations are used in Maryland (15): mefenoxam + chlorothalonil (Ridomil Gold/Bravo 3 lb 81WP/A) [Applied as a cover spray when the runners form and following heavy rains, as a preventive measure (6).] mefenoxam + copper hydroxide (Ridomil Gold/Copper 1.5-2 lb 70WP/A) Chlorothalonil is applied on alternate weeks to help control other diseases (15).

Alternative Controls:
To minimize the occurrence of this disease, fresh market cucumbers are grown on raised beds in fields with adequate drainage so that soil water does not accumulate around the base of the plants (15). Cucumbers are rotated with crops other than peppers, eggplants, tomatoes, and other cucurbits, on a 3 year schedule where possible (15, 28).

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 (28, 29). Young fruit that becomes infected may be killed. Older infected fruits develop depressed dark-bordered cankers with creamy pink-colored ooze in the center (29). Humid conditions and frequent rain promote disease development (14, 29).

Frequency of Occurrence:
Anthracnose occurs primarily during warm humid weather (28).

Management:
Excellent resistance is available in many fresh market cucumbers grown in Maryland. Resistant varieties, disease-free seed, and crop rotation are the management strategies used (18).

Chemical Controls:
Fungicides usually are not used specifically to control Anthracnose, but chemicals applied for the control of downy mildew likely result in some repression of this disease (6, 18).

Alternative Controls:
Resistant varieties are used whenever possible (15). Growers use commercially produced, disease-free seed and usually practice a minimum two year rotation with unrelated crops (2, 28).

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 (29). 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 (30).

Frequency of Occurence:
This disease occurs during cool periods, when temperatures are at or below 70ºF. Because disease development is

favored by cool temperatures, it occurs primarily early or late in the season (18).

Management:
Disease management is by scheduled fungicide sprays, the use of resistant varieties, and a variety of cultural techniques (15, 29).

Chemical Controls:
Fungicide applications begin when the first true leaves form and are repeated every 5 to 7 days, as long as weather conditions favor disease development. The following products are used in Maryland (18):
-chlorothalonil (Bravo or Terranil 1.5-3 pt 6F/A)
-azoxystrobin (Quadris 11-15.4 fl oz 6L/A)
-mancozeb (1.5-3 lb 80WP/A)

Alternative Controls:
Growers use resistant varieties where possible, plant disease-free fungicide-treated seed, select sites with good drainage, and practice a minimum two year rotation away from cucurbits (15, 30).

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 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 (29).

Frequency of Occurence:
Yearly outbreaks are sporadic and not all the conditions that promote disease development are well understood (31). Extremely wet conditions are known to contribute to disease outbreaks regardless of fungicide treatments (12). Effective disease controls are badly needed for belly rot (31).

Management:
This disease is managed with cultural controls and by preventive fungicide applications (15, 18).

Chemical Controls:
Preventive fungicide treatments are used in some areas, especially during wet weather conditions (12). In other areas, not much fungicide is applied specifically for belly rot (6). Chlorothalonil (Bravo or Terranil 3 pt 6F/A) is applied at flop and on a 7 to 10 day schedule after that. Azoxystrobin (Quadris 11-15.4 fl oz 6L/A) is also be used by some growers (12).

Alternative Controls:
Research indicates that anything which places a barrier between the fruit and the soil reduces the incidence of the disease (18).

Gummy stem blight/Black rot

Damage and Life Cycle:
Gummy stem blight and black rot are caused by the fungus, *Didymella bryoniae* (29). Gummy stem blight refers to the foliar and stem-infecting phase of the disease, and black rot refers to the fruit rot phase of the disease (18). The pathogen overwinters in seed and residue from diseased plants, and may also be soil-borne (28, 29). 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 (29). It causes leaf and stem necrosis and tissue death (28). 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 (29).

Frequency of Occurence:
Gummy stem blight occurs primarily in late summer during warm, moist weather (15). Its occurrence is extremely weather dependent. It is not a major problem for growers most years (12).

Management:
This disease is managed with chemical controls .

Chemical Controls:
Fungicide applications begin when the vines start to run and are repeated every 7 days. The following products are used in Maryland (15):
-chlorothalonil (Bravo or Terranil 2 pt 6F/A) or
-mancozeb 2-3 lb 80WP/A

Alternative Controls:
No alternative controls are used in Maryland for control of gummy stem blight (15).

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 (18, 29). The fungus may be introduced into the field from airborne conidia from southern cucurbits. It does not overwinter in Maryland (18). 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 (29). 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 (28). Average annual yield loss from powdery mildew is about 10% (7).

Frequency of Occurrence:
Powdery mildew occurs from mid-July through the end of the growing season (15). Resistant varieties work well, but on susceptible varieties yield losses can easily reach 50% (6).

Management:
Typically, adequate control is achieved by the use of resistant varieties (15). However, some growers favor less resistant varieties for other qualities (6). In the absence of resistance, fungicides are the primary means of controlling the disease (28).

Chemical Controls:
When necessary, growers alternate chlorothalonil (2-3 pt Bravo or Terranil 6F/A which is 1.5 - 2.25 lb ai/A) with one of the following fungicides every 7 days (18):
-azoxystrobin (Quadris 11-15.4 fl oz F/A)
-trifloxystrob (Flint 3 oz WG/A) [This new product has not seen much use yet, but appears to be safe and effective. Use is likely to increase in the coming year (6).]

The registration of Nova, another fungicide with a different mode of action against powdery mildew, is anticipated for the 2000 growing season. This fungicide will be recommended for use in combination with chlorothalonil in this program to control powdery mildew (18).

Alternative Controls:
Resistant varieties are used by more than 90% of growers, and usually provide adequate control of this disease in fresh market cucumbers (15). No cultural or biological control strategies are effective against this disease (28).

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 (29).

Frequency of Occurence:
This disease is only a problem for Maryland growers during wet years, or where short rotations are used (6).

Management:
This disease is managed with fungicides (15).

Chemical Controls:
Mefenoxam (Ridomil Gold 1-2 pt 4E/A) is applied in a 7 inch band after seeding. When the vines begin to run, mefenoxam + chlorothalonil (Ridomil Gold/Bravo 3 lb 81WP/A) is applied on a 14-day schedule as long as conditions for disease development exist. A maximum of 4 applications per crop is used (12, 15).

Alternative Controls:
There are no alternative controls available for this disease (15).

Downy Mildew

Damage and Life Cycle:
Downy mildew is caused by the fungus *Pseudoperonospora cubensis* (29). The pathogen does not overwinter in Maryland but can be carried on the wind into our area (18). 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 (29). Plants are rapidly defoliated under conditions conducive to downy mildew development. However, disease onset is usually late and many fresh market varieties have excellent resistance to the pathogen races that are prevalent in Maryland (18). Affected plants show a general loss of vigor and produce smaller fruit (6).

Frequency of Occurence:
Downy mildew is not a problem every year or in all areas of the state, and generally does not occur in Maryland until mid-August (15, 18). It is sporadic, but can spread very quickly (28). It is relatively easily controlled by most fungal spray programs (6).

Management:
The use of resistant cultivars is a very important management strategy (6). Fields are scouted for disease occurrence beginning in mid-July (15). There is a web page from North Carolina State University at http://www.ces.ncsu.edu/depts/pp/cucurbit/ that forecasts the spread of downy mildew northward. Maryland Extension personnel refer to this information and some use it to recommend more vigorous scouting at the appropriate times (18). This disease is controlled mainly with fungicides (15).

Chemical Controls:
When necessary, this disease is controlled by preventive fungicide applications. Chlorothalonil (1.5-3 pt 6F/A of Bravo or Terranil) is the most frequently used product. Mancozeb (1.5-3 lb 80WP/A) is also used, but is difficult for growers in some areas to obtain (6, 15). Fungicide applications begin when weather conditions become favorable for disease development and are repeated every 10 to 14 days for as long as conditions remain favorable. The total number of applications used is dependent on weather conditions, but because this is a late season disease, a maximum of 2 to 3 applications are used (12, 18). The following fungicides may also be used, and are rotated with chlorothalonil on alternate weeks (15):
-mefenoxam + chlorothalonil (Ridomil Gold/Bravo) 1.5-2 lb 81WP/A
-mefenoxam + copper hydroxide (Ridomil Gold/Copper) 1.5-2 lb 70WP/A
-mefenoxam + mancozeb (Ridomil Gold MZ) 1.5-2 lb 58WP/A

Alternative Controls:
Growers use resistant varieties where possible (15). However, the pathogen that causes downy mildew seems to adapt easily, and resistant cultivars are only effective for a short time (12). There are no cultural or biological control strategies used against this disease (28).

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 (29). The bacterium overwinters in seed and crop residue from infected plants, and can

survive for at least one year in the field (15). The bacterium can be spread in the field by splashing rain, equipment, or workers. Following foliar infection, irregular, angular spots appear on the leaves and turn brown before dropping off to leave ragged holes (29). Fruit infections also occur, as water-soaked spots which become covered with a white crust (28, 29). Infection of young fruit may result in curved or deformed mature fruit. Secondary soft rots usually develop on infected fruit (28). Average annual yield loss from angular leaf spot is about 5% (7).

Frequency of Occurence:
This disease is not a major problem for growers. Fungicides applied for more serious disease problems generally will control it (12).

Management:
Although foliar symptoms may be easily overlooked, early detection is important, since control in the foliar phase can reduce infection of the developing fruit. This disease is managed with a combination of resistance, crop rotation, and chemical controls (15).

Chemical Controls:
When symptoms are first detected, a tank mix of fixed copper (4 pt 2.4F/A or 2 pt 4.6F/A) plus mancozeb (1 lb ai/A) is applied. Applications are repeated every 7 days (15). In an average year, about 10% of Maryland acres require treatment for this disease. The highest labeled rates are used, and 2 to 4 applications are made, up to one week prior to harvest (6, 7).

Alternative Controls:
Angular leaf spot resistance is available in many fresh market cucumber varieties, and these varieties are used by about 50% of growers (6). To reduce the rate of infection, growers rotate away from cucurbits for at least two years and avoid planting cucumbers next to other cucurbits (28). To minimize the spread of the disease, growers avoid working in the field while foliage is wet (15).

Viral Diseases

Four distinct viruses have the potential to cause disease problems on fresh market cucumbers in Maryland: cucumber mosaic virus, watermelon mosaic virus, papaya ring spot virus and zucchini yellow mosaic virus (15).

Damage and Life Cycle:
All four of these viruses are transmitted by aphids, and cucumber mosaic virus may also be spread by cucumber beetles (28, 29). 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 (29, 32). Watermelon mosaic virus overwinters in *Trifolium* species while papaya ring spot virus overwinters in wild and cultivated cucurbits (18). These viruses cause mosaic, distorted growth, stunting, distortions in leaf coloration, and result in undersized, misshapen fruit (27). Viruses cause similar symptoms on cucumbers, and positive identification to the species level is not often made (6, 27)

Frequency of Occurrence:
Viruses generally do not cause major problems for cucumber producers in Maryland, since the short growing season typically is not sufficient for severe symptom development (12). No more than 5% of Maryland acres are affected by viruses annually (6).

Management:
Some of the most commonly grown varieties are resistant or moderately resistant to cucumber mosaic virus. Growers also rely on cultural control practices (28).

Chemical Controls:
Chemical controls are not used directly to treat viral infected plants. Controlling populations of the aphid vectors with insecticides, a common strategy in the past, has been found to be ineffective in reducing disease occurrence, and is no longer practiced by most producers (6, 12, 18). Also, chemical control of weeds that serve as alternate hosts for viruses may be practiced. 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 is not applied where drift or runoff may affect cucumbers or other desirable crops* (32).

Alternative Controls:
Growers choose resistant varieties when possible or varieties that don't show color breaking on the fruit (28). 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 (15, 28). Maintaining good weed control to prevent the buildup of aphid populations is also an important strategy. Some growers use specialized reflective mulches to repel aphids. The use of row covers has limited value because of the spreading nature of most cucumber vines (28).

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) (25). Several species of plant pathogenic nematodes occur in Maryland soils, generally as mixed populations unevenly distributed throughout a field (15, 25).

Root knot nematode

The most important nematode pest of cucumbers in Maryland is the root knot nematode (*Meloidogyne spp.*) (33). Like most nematodes, they have a broad host range, and feed on a variety of crops and weeds (34).

Damage and Life Cycle:
The life cycle and plant pathogenicity is similar for *Meloidogyne* species on all vegetable crops. Females feed within the root of the plant. They produce eggs in a gelatinous sac attached to their posterior. 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 (34). Secretions exuded by nematodes during feeding cause plant cells to swell, producing the diagnostic elongated or rounded "knots" on the roots (26, 34). The nematodes feed within the plant and undergo 3 more molts before reaching reproductive maturity (34). Generation time is 25 to 40 days, depending upon host susceptiblity, moisture, temperature, and soil type (33, 35). Cucumbers are not a

favored host for root knot nematodes, but are suitable and are not resistant (9).

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 (34). Nematode feeding produces the most severe symptoms under drought conditions, when plants are under increased stress (33). 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 (10).

Frequency of Occurrence:
Root knot nematode is a potentially serious pest of fresh market cucumbers in Maryland. Population levels can vary significantly regionally and from field to field (9, 12). Populations tend to be highest, and outbreaks most likely, in light, sandier soils as opposed to heavier clay soils. For this reason, nematodes are often more problematic on the Eastern Shore than elsewhere in Maryland (33). Population levels are prone to drastic fluctuations, but seem to be increasing in Maryland, possibly due to an increase in white potato production (9, 33). White potatoes are a favorable host for root knot nematodes. Nematode populations tend to increase in potatoes without significant damage to the potato crop, but cucumber and other susceptible crops following potatoes can suffer significant losses (12).

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 (36). Routine sampling is practiced by most large producers on the Eastern Shore (12). 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 (12, 25). Most vegetable growers west of the Chesapeake Bay don't sample for nematodes routinely, but will if a problem is suspected (10). 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 (15). Nematologists estimate the injury potential of a nematode population and use thresholds to determine if a control measure is warranted (24).

Management:
Routine soil sampling and crop rotation practices can prevent populations from reaching economic levels on most fields most years, but in some situations, soil fumigants are essential to crop production (10, 12).

Alternative Controls:
Nematode resistant fresh market cucumber varieties are not available (18). Crop rotation can be a useful strategy for maintaining low populations of soil nematodes, but because of their broad host range, rotation alone is not always sufficient to prevent root knot nematodes from reaching economic levels (9, 12). In Maryland, most of the crops grown in rotation with cucumbers are potential hosts for root knot nematodes. Land availability and market factors often limit the usefulness of crop rotation as a control measure for nematodes or diseases (12). University of Maryland researchers are currently undertaking an investigation of the effect of certain crop rotations on root knot nematode populations (9).

Other nonchemical practices that help to prevent the build-up of nematodes include the use of nematode-free transplants (36), incorporation of green manure or other organic matter into the soil (15), cleaning of farm equipment (which can spread nematodes from field to field), and maintaining good weed control (37). Post-harvest discing can also help to reduce soil populations of nematodes. Most of these practices are used for reasons other than nematode control, but when combined with crop rotation and soil sampling usually prevent nematode

populations from reaching economic levels (12). Leaving fields fallow for a length of time can greatly reduce nematode populations, but the practice is avoided for agronomic and economic reasons (9).

Chemical Controls:
Crop rotation and other cultural practices generally prevent nematode buildup in cucumbers, but in some cases, chemical control is warranted (12). Chemical control of nematodes is generally achieved by the use of fumigants or nonvolatile nematicides (37). 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. Fumigation is rarely done strictly for nematode control, but may be used to combat a combination of nematode, weed, and disease problems (12).

It is estimated that about 5% of Maryland's fresh market cucumbers are fumigated for control of nematodes and other soil-borne pests, but this figure may be conservative (6, 7, 16). The main products used are metam-sodium (Vapam HL 30 gal/A) and 1,3-dichloropropene (Telone II 12 gal/acre) (9). A small percentage of those fumigating in certain areas may be using methyl bromide, but its use is being phased out (6, 9). 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 may be applied at the maximum labeled rate for optimal disease and nematode control. Though not widespread, fumigation is a valuable practice in situations where crop rotation options are limited. Unfortunately, many crops grown in Maryland provide suitable hosts for root knot nematodes (12). The recent dramatic increase in white potato production in Maryland has apparently triggered an increase in nematode populations. Cucumbers and other crops following potatoes can experience severe nematode problems. Fumigation is generally done in the fall and cover crops are used to prevent soil erosion (9).

Weeds

Weed Management in Cucumbers:
Weeds cause economic loss in cucumbers in several ways. These include competition for nutrients, water and light, which will reduce yields; interference with application of fungicides and insecticides resulting in reduced pest control; and a reduction in the efficiency of harvesting (28). Weeds may also act as reservoirs for insect pests and diseases (32). 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. Fields should not be allowed to remain idle after harvest because weeds will produce seeds until frost. Fields are always cultivated after harvest to prevent late summer and fall weed seed production (27).

The Major Weeds:

Table 1: Major weeds in fresh market cucumbers.

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 seldom control all weed species. They must be used in conjunction with cultivation to ensure high yields in cucumbers. When weed escapes occur, cultivation is preferable to hoeing or applying post-emergence herbicides (27). 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 (32). Herbicides are an aid to cultivation because they delay weed growth until the cucumber plants become large enough for cultivation (27). Fresh market cucumbers in Maryland are typically cultivated 4 times during the growing season (32).

About 20% of Maryland's fresh market cucumbers are grown without the use of herbicide. This is practical for smaller growers with cucumbers in a 1 to 5 acre block. Fields are cultivated once or twice weekly for 6 weeks (32).

Chemical Controls:
Herbicides are used on about 80% of Maryland's fresh market cucumber acreage (32).

Preplant incorporated herbicides are generally less soluble than preemergence materials, and incorporation into the soil profile increases the products' contact with weed seeds, which are typically found 1 to 2 inches below the soil surface. Preemergence herbicides are generally more soluble and irrigation or rainfall is required to activate these herbicides by providing soil moisture that will deliver the herbicide into contact with the germinating weed seeds or sprouts. Cultivation or rotary hoeing may also be used to increase weed seed contact and help activate preemergent herbicides (38). 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 (15).

Preplant Incorporated

- **naptalam** - 2 lbs ai/A (1 gal/acre Alanap 2SC) incorporated 2 inches into the soil prior to seeding or transplanting offers limited control of certain grassy and broadleaf weeds. Naptalam 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 (15). In Maryland, this herbicide is applied to 40-60% of fresh market cucumber acres annually (12, 32).

- **bensulide + naptalam** - 4-6 lbs ai + 2 lbs ai/A (1-1.5 gal Prefar 4EC + 1 gal Alanap 2SC/acre) may be incorporated in the upper 2 inches of soil prior to seeding or transplanting for increased control of grassy

weed species over naptalam alone (15). About 10% of Maryland's fresh market cucumber crop is treated with this herbicide combination (32). In Caroline county this combination is used on as much as 40% of acres (7).

Preplant Incorporated or Preemergence Herbicides

- **bensulide** - 5 to 6 lbs ai/A (5-6 qts/acre Prefar 4EC) are used 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 broadleafed weeds. Bensulide is tank mixed with other herbicides to control more weed species. If applied preemergence, rainfall or irrigation must occur within 36 hours for the best weed control (15). The irrigation amount should be less than 0.4 inches or excessive dilution of the herbicide may occur (27). If incorporated, the depth should be 1 to 2 inches (15). In Maryland, this herbicide is applied to about 20% of fresh market cucumber acres annually (12, 32).

- **clomazone** (Command 4EC) - A special Local Needs Label (24 (c)) has been approved for the use of Command 4EC on cucumbers in Maryland and other mid-Atlantic states (15). Clomazone may be applied preplant incorporated or preemergence, and herbicide effectiveness is the same for both methods of application (27). 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 (15, 27). Mustards, morningglory species, and pigweed species will not be controlled by clomazone. Clomazone is combined with ethalfluralin (Curbit) 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 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 (15). 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 (27). In Maryland, this herbicide is applied to about 30%-40% of fresh market cucumber acres annually (32).

Preemergence Herbicides

- **ethalfluralin** - A special Local-Needs Label 24 (c) has been approved for the use of Command 4EC 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 (15). 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 herbicides such as clomazone (Command) and bensulide (Prefar) (27).

Ethalfluralin is not preplant incorporated or applied under plastic mulch or applied when soils are cold or wet, as injury may occur (15). In Maryland, this herbicide is applied to about 55% to 70% of fresh market cucumber acres annually (7, 12, 32).

Postemergence Herbicides

- **naptalam** - 1 lb ai/A (2 qts/acre Alanap 2SC) is 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 applied less than 6 hours prior to rainfall and is not 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 (15). In Maryland, this herbicide is applied to about 20% at most of fresh market cucumber acres annually (12, 32).

- **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 lambsquarters. It provides poor control of Pennsylvania smartweed (15). In Maryland, this herbicide is applied to about 5% to 10% of fresh market cucumber acres annually (7, 31). It is used mainly on cucumbers grown on plastic (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 (15). 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) should be 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 (27), but a single application is more common (7). Yellow nutsedge, wild onion, and broadleaf weeds will not be controlled with sethoxydim (15). 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 (27). Growers do not tank-mix sethoxydim with any other pesticide, nor do they apply it 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 (15). In Maryland, this herbicide is applied as needed to about 15% of fresh market cucumber acres annually (7, 32).

Chemical Control Issues for Herbicides:

Good preemergent weed control in cucumbers 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 (38).

Because of the very narrow range of herbicides available for weed control in cucumbers, the loss of any of these products could have a significant negative impact on fresh market cucumber production in Maryland. This narrow product range also raises concerns about the development of resistant weed populations (38).

Table 1. 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 (27). (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 2. 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 (27). (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

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1. This estimate was arrived at by speaking to several extension personnel and IPM consultants throughout the state.
