Crop Profile for Squash in Maryland

General Production Information

- Maryland ranked 14th in national squash production in 1997, and accounted for 1.5% of total U.S. squash production (1), and 5% to 10% of squash produced for processing nationwide (2).
- Maryland growers harvested 1,400 aces of squash in 1997, 1,200 acres (75%) for the fresh market and 400 (25%) acres for processing (2, 3).
- The demand for squash in the processed food market is prone to fluctuation. The acreage of squash grown for processing in Maryland has been reduced from 400 acres in 1997 to 200 acres in 1998 (2).
- The average annual production cost for fresh market squash in Maryland is about $1,050.04 per acre, or $1,260,048.00 total for 1997 (3, 4). The average annual production cost for processing squash in Maryland is about $752.04 per acre, or $300,816.00 total for 1997 (2, 4).
- The average annual cash value of fresh market squash harvested in Maryland between 1995 and 1997 was $2,542,666.67 (3). Squash grown for processing is valued at about $2,500.00 per acre, or $1,000,000.00 for 1997 (2).
- All acres of processing squash grown in Maryland are scouted for pest problems throughout the season (2). A relatively small percentage of fresh market squash acres are scouted for pest problems on a routine basis (5, 6).

Production Regions

- Counties west of the Chesapeake Bay (Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Charles, Frederick, Garrett, Harford, Howard, Montgomery, Prince George's, St. Mary's, and Washington) harvest 88.4% of the state's fresh market squash (3).
- Northern Eastern Shore counties (Caroline, Cecil, Kent, Queen Anne's, and Talbot) harvest 8.8% of the state's fresh market squash (3).
- The Southern Eastern Shore counties (Dorchester, Somerset, Wicomico, and Worcester) harvest 2.8% of the state's fresh market squash (3).
- All squash grown for processing in Maryland is produced on the Eastern Shore (2).

Production Methods

Squash are annual plants that grow well during hot summer weather. Summer squash are bush plants while most winter squash varieties have a vining growth habit. Squash favor light textured soils but can be grown on almost any soil type as long as soil pH is maintained at around 6.5 (7). Conventional tillage practices are used in Maryland (6). Winter squash are seeded for the fresh market between mid-June and early to mid-July in Maryland (8). Winter squash is not grown for processing in Maryland (2). Summer squash are seeded for the fresh market from April 15 through August 15 in warmer areas and from May 10 to August 1 in cooler areas (8). Some fresh market growers use successive plantings to take advantage of late season markets. Under current practices, a single planting of summer squash around May 15 is used by processors (2). Seeds typically are treated with a fungicide by the seed company to prevent damping off. Bush types are planted 2 to 3 feet apart with 5 to 6 feet between rows. Vining types are planted 2 to 5 feet apart with 6 to 8 feet between rows (8). Most fresh market summer squash is direct-seeded into black plastic (5). Processing summer squash is direct seeded into raised beds without plastic (2). Large commercial growers transplant fresh market squash through plastic into prepared, fumigated beds, but these growers represent a small percentage of fresh market acres in Maryland. These large commercial producers of fresh market squash typically fumigate prepared beds to control weeds, cucumber beetle larvae, nematodes, and soil-borne diseases (5). Fumigation is not used in processing squash (2). Fertilizer is applied during bed preparation, with 50% of nitrogen applied in nitrate form. Honey bees are important to assure pollination and fruit set (8). Squash plants grow rapidly, and fruit develops 4 to 5 weeks after planting. Once fruit begins developing, the harvest season can extend for 7 to 8 weeks (9).

The growing conditions in Maryland are ideal for most types of squash, and high yields are possible compared to other regions where squash is grown. For example, 15,000 pounds per acre is average for zucchini production, but Maryland growers can harvest as much as 30,000 to 40,000 pounds per acre, making squash production in our region potentially quite profitable (2, 9).

Insect Pests

Major Insect and Mite Pests in Maryland

The only major insect pests of both processing and fresh market squash are striped and spotted cucumber beetles (2, 10). They are important vectors of bacterial wilt, which is a major consideration in the production of squash (2).

Striped and spotted cucumber beetles

Damage and Life Cycle:
Striped cucumber beetles, *Acalymma vittata* (Fabricius), and spotted cucumber beetles, *Diabrotica undecimpunetata howardi* (Barber), are the most destructive insect pests of cucumbers, squash and related crops 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 crops in May, just after plant emergence or transplanting (11). Beetle feeding on the young seedlings often kills the plants within 1 to 2 days (10). 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 (10, 11). Squash are particularly susceptible to cucumber beetle damage, since planting dates often coincide with high levels of beetle activity (10). Cucumber beetles feed on the stems, foliage, and fruit, and can cause direct damage to the rind of winter squash (8, 10).

More importantly, both species of cucumber beetles are vectors of bacterial wilt, a serious disease in cucurbits (10). Bacterial wilt is a major consideration in the production of squash grown for processing and the fresh market (2, 5). There is a variable level of resistance to bacterial wilt among squash cultivars, but when cucumber beetle populations are high even the more resistant varieties will show signs of stress that translate into a reduction in fruit quality and yield (5). Beetle emergence is well synchronized, and a field with few beetles may become densely infested literally overnight. Cucumber beetles are very active dispersers and can quickly locate host plants (2). For this reason crop rotations to control for cucumber beetles are of limited value, particularly on smaller farms (5). The major feeding injury and disease transmission takes place from the time cucurbits are transplanted or emerging through the surface until they form runners (12). Older plants are far less susceptible to disease transmission. Some evidence indicates that cucumber beetle may also transmit certain plant viruses, but this has not been proven (13).

The western corn rootworm (*Diabrotica virgifera* LeConte) resembles the striped cucumber beetle, and is a closely related species (10). It often is found in squash fields but doesn't damage the crop or transmit bacterial wilt (10, 14), though it is a significant pest of sweet corn and field corn grown in Maryland (2, 13). Adult beetles are attracted to squash flowers, and females will often lay their eggs in squash fields (15). Eggs overwinter in the soil and larvae begin feeding on roots the following year (16). Growers rotating from squash into corn, especially sweet corn, may control western corn rootworm with an insecticide to prevent problems in corn during the following season. Processors in Maryland spray squash to control western corn rootworm as they would other cucumber beetles, and are not convinced that this species is not a vector for bacterial wilt. This is a relatively new pest in Maryland and has only become a problem in the last 10 or 15 years (2).

Frequency of Occurrence:
Cucumber beetles are regular annual pests of both fresh market and processing squash. Although their feeding injury does not always result in economic loss, their control is critical to protect the crop from bacterial wilt (2, 13). Beetle size and timing of cucumber beetle populations can vary widely depending upon weather conditions in winter and in late spring when beetles emerge (10, 13).These variations in

beetle populations have little effect on management practices of squash treated with preventive soil applications of carbofuran (Furadan), but prescribed foliar treatments vary with year to year or field to field fluctuations in beetle population density (13).

IPM Program:
A very small percentage of fresh market growers actively scout for cucumber beetles, since preventive insecticides are usually used (5, 6). All squash grown for processing is scouted for pest problems, but the use of foliar rescue treatments alone is not a viable control strategy for cucumber beetles. Beetles often have irregular distribution in the field, and localized populations can be overlooked while scouting. The resulting yield loss due to bacterial wilt infected plants can be significant. Preventive insecticide treatments are used on all processing squash to control beetles during the early growth stage when squash plants are most susceptible to bacterial wilt transmission (2).

Chemical Controls:

Fresh Market Squash
The most common control strategy for cucumber beetles and bacterial wilt in fresh market squash is the preventive use of carbofuran (Furadan 3.8 fl oz 4F/1,000 ft of row at planting). This product is applied at planting by most growers, except for a few larger growers who fumigate soils and then transplant into plastic (5). Carbofuran treatment is generally effective for up to 4 weeks, but fields are scouted to determine the effectiveness of control (2, 8). In some cases, foliar insecticides may be applied instead of, or in addition to, carbofuran treatment. One such instance is large commercial acres, where transplants are used (5). If used in place of carbofuran, foliar insecticides are applied before beetles feed extensively on the cotyledons and first true leaves. Spraying begins at emergence (or after transplanting) and continues as long as beetles continue to invade the field. For the more resistant cultivars, foliar applications are applied only if beetles severely affect stand establishment during the cotyledon stage. For winter squash, adult beetle control is less important for the prevention of bacterial wilt because these crops are more tolerant to the disease. However, cucumber beetle feeding may cause direct damage to the rind and beetles may be controlled for this reason (8). In a typical year 1 to 2 applications of foliar insecticides are used on about 50% of fresh market acres planted for cucumber beetle control. During periods of heavy infestation, 3 sprays may be needed; if infestations are light, fields may not be treated with foliar insecticides. Endosulfan (Thiodan 2 pt 3EC/A) is the most popular foliar insecticide used, because it is effective against cucumber beetles and offers some systemic control. Carbaryl (Sevin l.25 lb 80S/A) is used to a lesser extent, in part due to its high toxicity to bees. Where it is used, it is applied at night to minimize the impact on bee populations. Methoxychlor (2.5 lb 50WP/A), esfenvalerate (Asana XL 7.7 fl oz 0.66EC/A) and methomyl (Lannate) are used to a lesser extent (5).

Processing Squash:
Preventive applications of carbofuran are used on all processing squash grown in Maryland to control the spread of bacterial wilt. This product is very important to growers as the only effective control option against cucumber beetles during the young stage when plants are most susceptible to bacterial wilt transmission. Growers scout for beetles during this vulnerable seedling stage and will apply foliar products if beetle populations are high. In addition, foliar insecticides are sometimes applied during the

production season to limit feeding damage of beetles. The most popular choice is endosulfan (Thiodan 2 Pt 3EC/A), though reduced effectiveness of this chemical has caused some speculation that some cucumber beetle populations may be developing resistance to this product. Carbaryl (Sevin l.25 lb 80S/ A) is the second choice, although toxicity to bees (required for pollination) is a concern. Carbaryl bait stations (Adios 10 oz/A) are being used more frequently by growers, since they do not harm bee populations. These baits are attractive to cucumber beetles and can draw them away from the crop. They are particularly effective when beetle populations are high. Esfenvalerate (Asana 5.8-9.6 fl oz 0.66EC/ A) and methomyl (Lannate 1.5-3 pt LV/A) are also used on a small percentage of acres during the growing season. Processing squash is harvested on a 48 hour schedule, so insecticides with a days-to-harvest interval exceeding 2 days (such as esfenvalerate and methomyl) are avoided near harvest time. With the exception of the carbaryl bait stations, these insecticides are rarely used by themselves, but are included in tank mixes with fungicides and are applied aerially (2).

A Special Local-Needs Label 24(c) is in effect in Maryland for the use of liquid carbofuran at 3.8 fl oz 4F/1,000 ft of row at planting. Use of carbofuran at planting frequently leads to spider mite outbreaks later in the season (8); however, for growers of processing squash, this is a minor problem in comparison to bacterial wilt (2). Long-term usefulness of carbofuran may be limited due to enhanced chemical breakdown by soil microorganisms which have adapted to the chemical (13).

Alternative Controls:
No alternative strategies are available for controlling cucumber beetle on squash in Maryland (13).

Minor Insect and Mite Pests in Maryland

Most of the minor pests listed in this section do not cause economic damage every year. Typically, they are adequately controlled by insecticide applications directed against cucumber beetles (2). Summer squash is very short-lived and thus rarely experiences significant problems with aphids, mites, or squash bugs; whereas, winter squash has a long crop season and is more vulnerable to these late developing pests (13).

Spider mites

Damage and Life Cycle:
Spider mites can be a serious problem on squash during hot, dry weather. Adults migrate into fields in the summer and begin feeding on the underside of leaves. Each female can lay 5 to 6 eggs per day for a total of 70 to 200 eggs in her lifetime. Eggs hatch into 6-legged nymphs which quickly develop into adult mites. The life cycle can be completed in as few as 6 days during hot weather (10). 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 tops of leaves. Damage can develop very quickly, and a severe infestation can seriously stunt the growth of plants (11).

Frequency of occurrence:
Mites are a sporadic pest problem in squash and are more problematic on winter squash than summer squash because of the longer growing season (13). Outbreaks are typically more severe during hot and dry weather or when insecticide applications, particularly of carbofuran, reduce natural predator populations (10).

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(11). The problem with scouting for mites is that populations may be spotty and easily missed even by a thorough scout (5). Fields are scouted by some growers weekly, from early July through August during hot, dry weather (5, 8). Mites may be concentrated around field edges during the early stages of infestation, or they may balloon into the center of the fields and spread from there (17). If feeding injury is detected, plants are sampled to determine the extent of mite infestation. An acaricide is applied if 10-15% of the crown leaves are infested early in the season, or in mid-summer if 50% of the runners show leaf injury and mites are present (8, 12).

Chemical Controls:
Most fresh market growers seldom treat for spider mites (18). When infestation levels are low, chemical control of mites is unnecessary. During the worst infestations, two sprays may be used on about 30% of the acres. Even when mite populations are high, infestations tend to be localized and may be spot-treated (13). Applications to control mites on processing squash are not needed every year. Typically, less than 13% of processing squash acres are treated every 2 or 3 years for spider mites. Spider mite outbreaks may occur about once every 5 years. In the worst cases, up to 50% of acres are treated.(2).

The most frequently used chemical control in Maryland on both fresh and processing squash is dicofol (Kelthane 1.25 lb 50WP/A) (2, 5). Abamectin (Agri-Mek 8-16 fl oz 0. l5EC/A) is expensive but effective, and is being used with increasing frequency to control the worst spider mite populations in fresh market squash (5). Abamectin is not used during harvest because of its long (7-day) days-to-harvest interval (2). Maryland growers report some mite resistance to both of these products. Regardless of product choice, proper application techniques are essential for effective mite control. The use of surfactants and the proper spray equipment is essential to ensure that the product reaches the underside of the leaves (5).

Alternative Controls:

Cultural Controls:
Grassy areas adjacent to fields may be left unmowed during mid-summer, as a disturbance to these areas may drive mites onto the crop (12). However, this practice isn't always practical depending on how these adjacent areas are used (5).

Seedcorn Maggot (*Delia platura*)

Damage and Life Cycle:
Seedcorn maggot is common throughout the Northeast (19). 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 (20). Generally, stands of cucurbit crops are reduced more often than are stands of other susceptible crops, since a few maggots per seed is enough to prevent germination (6). Larvae feed for 21 days, then pupate in the soil. There are 4 to 5 generations per season in Maryland (20).

Frequency of Occurrence:
Seedcorn maggot is a sporadic early season pest, and is typically not a problem by the time squash is planted (2). Growers have seen some crop damage in past years. Early plantings are the most susceptible, and injury is most severe in cool, wet springs, when germination is delayed (2, 10). Seedcorn maggots are a problem in the field, and also in transplant production. Transplants infested in the greenhouse are often carried into the field (13). Seedcorn maggot is much more likely to be a problem in squash following sod, or in fields high in organic material (2, 10). This habitat preference, along with the timing of planting, makes it possible to predict which fields are at the most risk for seedcorn maggot problems. Fluctuations in maggot populations don't affect chemical applications, since seed treatments and in-furrow preventive insecticides are the only effective controls (2, 18).

IPM Program:
Since maggot feeding results in no detectable above-ground symptoms, a low level of plant emergence is often the first indication of damage. Ungerminated seeds are examined for signs of larval feeding (19). If damage is extensive enough to warrant replanting, a seed treatment is used or a soil insecticide is applied to prevent reinfestation (12). Acreage scouted for the major pest problems is also checked for stand establishment problems related to maggots (13). This includes all processing acres in Maryland and a small percentage of fresh market acres (2, 5).

Chemical Controls:
Because damage is inflicted on the seed and emerging plant, seed treatments and soil systemic insecticides are the only chemical treatments applied for this seedcorn maggot (2). Most seed comes pre-treated with fungicides from the seed companies, but not with insecticides. Some growers treat seeds with an insecticide prior to planting, especially when planting early in the season or when planting in soils high in organic matter (5). Foliar rescue treatments are not useful against this pest (18).

Seed treatments:
Insecticide seed treatments are effective and inexpensive and are used by many growers (5, 18). A diazinon-lindane combination, such as Agrox D-L Plus (which also contains captan), is most commonly used (5). About 25% of processing squash seeded uses this combination (2). These products are very effective against seedcorn maggot and deter feeding by other soil pests (10). However, these products

typically have a short residual effect and can lose their effectiveness when germination is delayed by low soil temperature or other factors (5).

Preventive soil insecticides:
In addition to seed treatments, all growers of processing squash apply carbofuran, a systemic insecticide, in the furrow at planting for cucumber beetle control. Some growers suspect that carbofuran applied for cucumber beetle control will also suppress seedcorn maggot and other soil pests such as wireworms and grubs, eliminating the need for additional chemical controls (2, 5). Several other soil insecticides are labeled for use on squash, but these products are very rarely if ever applied specifically for seedcorn maggot control (5). Chlorpyrifos (Lorsban 8 oz 15G/1,000 ft of row in furrow or 4 pt 4EC/A preplant broadcast incorporated) is used on a vary small percentage of processing acres (2).

Alternative Controls:

Cultural 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 and reduce injury levels. Fields with cover crops or those high in organic matter may be plowed prior to fly emergence in early spring (19). Growers generally do not apply manure to fields and avoid transplanting too early in the season (13).

Melon Aphid and other Aphids

Damage and Life Cycle:
Many species of aphids feed on squash, and all inflict similar types of injury to plants. Aphids overwinter as eggs on a variety of host plants. Nymphs hatch in spring and feed until they mature. Adults of this first generation reproduce sexually, bearing live young which become winged adults which migrate to crops. This generation feeds on plants and rapidly reproduces asexually, with a generation time of 5 to 7 days (10). Melon aphids are the most important of several aphid species that attack cucurbits. 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 (11). Infested leaves curl downward and may turn brown and die. In addition to feeding damage, aphids produce "honeydew," a sticky excretion which can cover fruits and promote the growth of a sooty black mold (10). More importantly, the melon aphid is also one of the primary vectors of cucumber mosaic virus (11), which may reduce yields as much as 50-80% in plants infected prior to fruit set (10). Cucurbits usually are not attacked by aphids until the vines form runners, and then infestations commonly begin in small scattered areas over the field (11).

Frequency of Occurrence:
Aphids are rarely a problem on fresh market squash, and are probably controlled by insecticides applied for major pests (5). However, populations occasionally reach damaging levels (10). Aphids are more problematic on winter squash than summer squash because of the longer growing season (13). The worst

infestations usually occur during hot, dry summers following cool, dry springs, since such weather conditions reduce the efficiency of aphid natural enemies (11). Chemical applications which deplete populations of beneficial insects may also lead to aphid outbreaks (7).

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 is applied if more than 20% of runners have 5 or more aphids, natural enemy populations are low, and humidity is low to moderate (12). Fresh market growers do not typically scout for aphids (5).

Chemical Controls:
Methomyl (Lannate 2.25 pt LV/A) is the only product that offers sufficient control of melon aphid in summer squash, and it is the most commonly used (13); however, methomyl is not labeled for use against aphids in winter squash (8). Endosulfan (Thiodan 1.33-2.67 pt 3 EC/A) is the most commonly used product in winter squash and is also used by some processors on summer squash (2). Regardless of the foliar insecticide used, thorough spray coverage on the underside of leaves is important (8). In a typical year, 1 application to about 10% of fresh market and processing acres is required specifically for aphid control; this can vary from zero to 2 applications, depending on aphid population levels during that year (13). In processing squash, aphid populations may be kept low by applications made to control other insect pests, particularly cucumber beetles. An insecticide may be tank mixed with a scheduled fungicide application if aphid or other pest insect populations are high (2). In addition to those chemicals listed above, diazinon (1 pt 4EC/A) and oxamyl (Vydate L 2-4 pt 2L/A) may rarely be used for general aphid control in winter squash produced for the fresh market (8).

Some growers spray grassy perimeters near wooded areas with an insecticide to control aphid populations before they move into the crop. Most growers practice good weed control since many weeds are alternative hosts for aphids (2).

Alternative Controls:

Natural Enemies:
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 (10). All of the insecticides used in squash are detrimental to beneficial insects, except for carbaryl bait stations (Adios) (13). During periods of high humidity, fungal diseases may also help reduce aphid populations (10). Natural enemies are important to a certain extent but do not always keep pest populations in check. There has been no attempt to enhance the existing natural enemy populations in Maryland (13).

Cultural Controls:
Foil mulches on squash planted after July 1 may repel aphids that transmit mosaic virus (8). A few small

fresh market growers may use this strategy on late planted squash, but it is rare (2, 13). A reason for this is that the squash growing season is usually over before there is heavy pressure from aphid populations (2).

Squash Bug (*Anasa tristis*)

Damage and Life Cycle:
The squash bug attacks all the cultivated plants of the cucurbit family but favors squash and pumpkins. Both adults and nymphs feed on the leaves by piercing through the surface with their sharp mouthparts and sucking the plant sap. In the process of feeding, they inject toxins which interfere with the physiological functions of the leaf. The first evidence of injury is the formation of pale green areas on the leaves. These areas later wilt, turn brown and die. When squash bugs are abundant, the foliage has a somewhat burnt appearance (6, 11).

Frequency of Occurrence:
The squash bug is an important pest in home gardens but is only an occasional pest in commercially grown fresh market squash and is never a pest on squash grown for processing (2, 13). It is more problematic on winter squash than summer squash because of the longer growing season (13).

IPM Program:
Squash bug control is not considered in IPM programs in Maryland (13).

Chemical Controls:
Less than 5% of fresh market squash is treated for this pest (13). Treatments begin shortly after vines run and are repeated every 7 to 10 days or as needed. Chemicals used for squash bug control in fresh market squash include (8):

- permethrin (12.8 fl oz Ambush 2EC/A or 8 fl oz Pounce 3.2EC/A) [winter squash only]
- esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A)
- carbaryl (Sevin l.25 lb 80S/A)

Processing squash is never treated specifically for squash bug (2).

Alternative Controls:
There are no alternative control strategies for squash bug in squash in Maryland (13).

Squash Vine Borer (*Elasmopalpus lignosellus*)

Damage and Life Cycle:
Squash vine borers are pests of squash and pumpkins, particularly in the home garden (11). Moths overwinter as pupae in the soil (10). After emergence, the wasp-like moth can be seen flying swiftly and noisily about plants during the daytime from June through August (11). Eggs are laid singly at the base of blooming plants and hatch in 7 to 10 days (10). Small larvae usually are found tunneling out the inner tissues of petioles near the base of the plant, where they feed for 14 to 30 days (10, 11). Later in the season, older larvae are located throughout the stems and sometimes in the fruit. The first indication that the borer is present is the sudden wilting of one runner or the entire plant. Inspection of the wilted vine usually reveals masses of coarse greenish-yellow excrement pushed out of holes in the vines. Infested vines often are completely girdled and usually rot and die (6, 11).

Frequency of Occurrence:
The squash vine borer is a rare, sporadic pest of fresh market and processing squash in Maryland (2, 13). Commercial plantings usually escape noticeable injury in the mid-Atlantic area (11).

IPM Program:
There are no practical methods for direct sampling of adults or eggs in the fields (12).

Plants are checked for general vigor and other factors, and borer damage may be detected, but no regular monitoring is done specifically for this pest in either fresh market or processing squash. Pheromone traps are not reliable enough to provide accurate assessment of flight activity (13).

Chemical Controls:
Less than 5% of fresh market acreage is treated for squash vine borer. Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) and endosulfan (Thiodan l.33-2.67 Pt 3EC/A) are the preferred products. A single application may be used in years when infestation levels are high (13). Processing squash is never treated specifically for squash vine borer (2).

Alternative Controls:
In small plots, infested runners may be removed or infested plants destroyed, but no cultural or alternative practices are used by commercial growers (13).

Pickleworm (*Diaphania nitidalis*)

Damage and Life Cycle:
Pickleworms overwinter in semitropical regions, and annual infestations depend on moth flights north. 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 larvae are about half

grown, they bore into fruits and continue to feed there, causing internal damage to the fruit. Both young and old fruits are attacked, but young fruits are preferred (11).

Frequency of Occurrence:
Pickleworm is a rare problem in the mid-Atlantic area, but it occasionally attacks squash. Infestation levels vary, depending upon the size of moth population migrating from the south (11).

IPM Program:
Pickleworm is not considered in the IPM programs for squash in Maryland (13).

Chemical Controls:
No insecticide is applied specifically for control of pickleworms in Maryland (2, 13).

Alternative Controls:
There are no alternative control strategies for this pest in Maryland (13).

Diseases

Infectious diseases of squash are caused by fungi, bacteria, and virues, and some are vectored by insects. Successful and cost-effective disease management requires accurate identification of pathogens and timely application of control measures. Some diseases are controlled mainly by management of insect vectors, while for others, cultural or chemical controls may be necessary, at least in some years (8).

Disease occurrence and severity can vary considerably among the many different types of squash. For some squash types, varieties which are resistant to certain diseases are available; however, growers may select more susceptible varieties in some cases due to market considerations. For example, processors prefer particular light-skinned, straight necked varieties of yellow squash that are more susceptible to Phytophthora blight than some other varieties, due to strict quality parameters and desirable processing characteristics (21). Bacterial wilt is the most important disease management consideration. Powdery mildew, Phytophthora blight and viruses are also of economic importance (2, 5).

Bacterial Diseases

The most important bacterial disease on squash in Maryland is bacterial wilt. Angular leaf spot and bacterial leaf spot are of minor importance (21).

Bacterial wilt

Damage and Life Cycle:
Erwinia stewartii, 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 squash, transmission by other insects is less frequent. 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 (22). 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 (23).

Frequency of Occurence:
Bacterial wilt is an economically important disease throughout the Eastern United States, and is a major consideration for processors and fresh market growers in Maryland (2, 5). Its occurrence and severity depend on winter weather conditions and the susceptibility of the squash variety. The extent of bacterial wilt damage depends on the growth stage of squash infected, the bacterial strain, host susceptibility, and nutritional factors (23). Squash is not as severely damaged by bacterial wilt as many other cucurbits. Summer squash will produce fruit after infection and symptom development occurs. Disease incidence in summer squash ranges from 5 to 10% annually, and yield losses range from 3 to 8% (21).

Management:
Bacterial wilt is managed primarily by insecticide treatment to control cucumber beetles. Some moderately resistant cultivars are available and are used by some fresh market growers (5).

Chemical Controls:
There are no chemical controls that work directly on bacterial-wilt infected plants (12). The disease is managed by chemical control of the cucumber beetle vector (8). (See cucumber beetle section.)

Resistant Cultivars:
There is a variable level of resistance to bacterial wilt among squash cultivars. Hubbard and Butternut squash, 2 varieties grown for the fresh market, are the most susceptible to bacterial wilt infection (10). The 4 varieties grown by processors are selected based on marketability and ease of processing, and these are all susceptible to bacterial wilt (2). Most other varieties grown show a low to moderate level of resistance to this disease. However, when cucumber beetle populations are high, host resistance can break down and even the more resistant varieties will show signs of stress that translate to a reduction in fruit quality and yield (5).

Alternative Controls:
There are no effective alternative controls for bacterial wilt in Maryland (13).

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 (22). The bacterium overwinters in seed and crop residue from infected plants and can survive for at least one year in the field (8). 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 in the leaf (22). Fruit infections also occur as water-soaked spots which become covered with a white crust (22, 23). Infection of young fruit may result in curved or deformed mature fruit. Secondary soft rots usually develop on infected fruit (23).

Frequency of Occurence:
This disease is more prevalent on winter squash than summer squash (23). In summer squash, its occurrence is not of economic importance (21).

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 in winter squash with a combination of crop rotation and chemical controls (8).

Chemical Controls:
A small percentage of fresh market winter squash is treated for this disease every year (5). Fixed copper is applied to winter squash at a rate of 2-4 pt 2.4F/A or 1-2 pt 4.6F/A when symptoms are first detected. Applications are repeated every 7 to 10 days (8). Summer squash, including all processing squash, is not treated for this disease (2, 21).

Cultural Controls:
Most Maryland growers rotate out of cucurbits for at least two years and avoid planting next to other cucurbits to reduce the rate of infection (21, 23).

Bacterial leaf spot

Damage and Life Cycle:
This bacteria is caused by the bacterium *Xanthomonas campestris* pv. *campestris*. The disease becomes systemic with symptoms showing on leaves and fruit. Leaf lesions start as water soaked areas and then appear as necrotic spots. The fruit usually develop necrotic lesions which progress to cause collapse and rotting of fruit (23).

Frequency of Occurence:

This disease is more prevalent on winter squash than on summer squash, where it is of very minor importance(8, 23).

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 (8).

Chemical Controls:
Fixed copper is applied to winter squash at a rate of 2-4 pt 2.4F/A or 1-2 pt 4.6F/A when symptoms are first detected. Applications are repeated every 7 to 10 days (8). No summer squash or processing squash in Maryland is treated for this disease (2, 21).

Alternative Controls:
No alternative controls are used to any extent in the management of this disease in Maryland (21).

Viral Diseases

Viruses are of great importance in squash production and cause major disease problems in Maryland (21). At least four distinct viruses of squash are believed to be of economic importance in Maryland. They are cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), papaya ring spot virus (PRSV) and zucchini yellow mosaic virus (ZYMV) (8). WMV, PRSV, and ZYMV all have been positively identified in Maryland squash, although 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 (21).

Damage and Life Cycle:
All four of these viruses are transmitted by aphids, and CMV may also be spread by cucumber beetles (22, 23). CMV 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 (9, 21). WMV overwinters in *Trifolium* species while PRSV overwinters in wild and cultivated cucurbits (21). These viruses cause mosaic, distorted growth, stunting, distortions in leaf coloration, and small, misshapen fruit (23). In summer squash, damage from viruses reduces yields from 5 to 20% annually (21).

Frequency of Occurrence:
These viruses are very common in Maryland, and probably occur to some extent in every field annually (21). Symptoms of viral infection are most common and severe in late-harvested summer squash. Epidemics can occur late in the season if aphid populations are not controlled (2).

Management:
No pesticides are available specifically to control viruses. Controlling aphid populations with

insecticides can reduce the severity (though not the incidence) of viruses, particularly if practiced early in the growing season. Though not a highly effective measure, it is widely practiced by Maryland growers as one of the few control options for viruses (21). Chemical control of weeds that can serve as alternate viral hosts, especially pokeweed, is practiced by growers to reduce disease transmission rates (9). Growers also rely on cultural control practices (6). Host plant resistance to viruses is being incorporated into new varieties, some of which (particularly zucchini types) are now becoming available to Maryland growers (6, 21).

Chemical Controls:
In early spring, clumps of emerging pokeweed occurring around field borders, fence rows and non-irrigated ditch banks are spot-treated with a dilute spray solution of dicamba (Banvel) when shoots are 6 to 20 inches high. Dicamba is not labeled for use on squash and is avoided where drift or runoff may affect desirable crops (9).

See aphid section for chemical controls used against aphids. These controls are most effective at reducing the spread of viruses when they are applied early in the growing season (21).

Resistant Varieties:
Many fresh market growers choose resistant varieties when possible or varieties that don't show fruit discoloration (6). Processors select varieties for other characteristics besides resistance, but plan their plantings to minimize the impact of viruses. Yellow squash has weaker vines and is generally more susceptible to viruses than green squash. Processors plant yellow squash early so that most of it is harvested by the end of July before viral populations boom. Some processors are experimenting with new resistant cultivars becoming available with other desirable traits (2).

Cultural Controls:
Many fresh market 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 (8, 23). A few fresh market growers use specialized reflective mulches to repel aphids. Maintaining good weed control to prevent the buildup of aphid populations is also an important strategy. The use of row covers has limited value because of the spreading nature of most squash vines and the need to expose flowers to pollinating insects (6, 23).

Fungal Diseases

A large number of fungal diseases have the potential to cause economic damage in squash. Of these, the key diseases are powdery mildew and Phytophthora blight. Both are managed by fungicides applied on a spray schedule (2, 5), but cultural practices and careful water management are also critical to the control of Phytophthora blight (2, 21). The frequency of scheduled applications can vary somewhat, depending on weather conditions (2). In most years other fungal diseases are held in check under this management program, but those listed here do occasionally cause economic damage in Maryland (21).

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 (21, 23). The fungus may be introduced into the field from airborne conidia from southern cucurbits or from greenhouse transplants. The fungus doesn't overwinter in Maryland, except perhaps in greenhouses (21). 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 (22). 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 (23).

Frequency of Occurrence:
Powdery mildew is the most damaging fungal disease of fresh market and processing squash in Maryland (2, 5). It occurs annually from mid-July through the end of the season (8). If left untreated, it can cause 10% or greater yield loss in squash (21).

Management:
Regular fungicide applications are often necessary to keep the disease in check, particularly late in the growing season (21). Fields are observed for the presence of powdery mildew. Fungicide treatment is recommended when one lesion is found on the underside of 45 old leaves (8). Processors have a more conservative threshold. They check for signs of the fungus on old leaves during July and August and treat quickly if necessary, before the disease can spread to younger foliage. If younger foliage is infected, control is difficult to achieve and yield losses may be significant (2).

Chemical Controls:
When thresholds are exceeded, fresh market growers alternate the following fungicides every 7 to 10 days (21):

- chlorothalonil (Bravo or Terranil 2-3 pt 6F/A) plus either benomyl (Benlate 0.25-0.5 lb 50WP/A) or thiophanate-methyl (Topsin M 0.25-0.5 lb 70WP/A)

- azoxystrobin (Quadris 11-15.4 fl oz 6L/A)

Azoxystrobin (Quadris 11-15.4 fl oz 6L/A) is an effective broad spectrum systemic fungicide newly labeled on all cucurbits. Chlorothalonil (Bravo or Terranil 2-3 pt 6F/A) is a broad spectrum contact fungicide. Both are effective, but good coverage is critical for chlorothalonil and difficult to achieve in squash. Chlorothalonil is combined with either benomyl (Benlate 0.25-0.5 lb 50WP/A) (most popular choice) or thiophanate-methyl (Topsin M 0.25-0.5 lb 70WP/A), both of which offer specific, systemic

control for powdery mildew. Benomyl and thiophanate-methyl are not applied alone due to problems with resistant fungi populations. Fresh market growers harvest squash later in the season than processors and generally require more fungicide applications to control powdery mildew (21).

Since powdery mildew only occurs near the end of their growing season, and processors complete harvest early (usually by mid-August), they are able to forego fungicide treatments for powdery mildew some years. In years with the worst disease occurrence, or when harvest continues later (this practice is unusual), more than one fungicide application may be required. When treatment is necessary, triadimefon (Bayleton 4 oz 50WP/acre) has been the primary control used by processors until recently, when registration was dropped. Currently, azoxystrobin (Quadris 11-15.4 fl oz 6L/A) is the main product being used by processors for powdery mildew control (2).

A new material called myclobutanil (Nova) has a section 18 registration for cucurbits in Maryland, but it is not yet clear how this product will change current fungicide use (21).

Resistance Issues:
Resistance to benomyl and thiophanate-methyl has been recorded in some Maryland populations of *S. fuliginea* (21).

Resistant Varieties:
Some new squash varieties with powdery mildew resistance are becoming available (21).

Cultural Controls:
The potential for losses from this disease late in the growing season is an important reason why yellow squash grown for processing is planted so that it can be harvested by the end of July in most years (2).

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 (23). The disease is promoted by warm, wet weather and frequently appears in the wettest part of the field (7, 22). Movement of the fungus in water and in soil can be an important means of spread between fields (22).

Frequency of Occurence:
Phytophthora blight is very common on summer squash grown for fresh market and processing, and can cause yield losses up to 100% in some fields (21). The heaviest infestations occur during wet summers

(5). Zucchini cultivars tend to be more resistant to this disease than yellow squash varieties, though it can be severe in both types (2, 21). This disease can affect plants as they emerge, but it is most likely to affect fruit bearing plants (2).

Management:
Cultural controls and careful water management are critical to the management of this disease (2, 17). Scheduled fungicide applications are also required (8).

Chemical Controls:
Some acres of summer squash grown for processing are treated with mefenoxam (Ridomil Gold 1-2 pt EC/A)in the row at planting for Phytophthora control. This practice is limited to low-lying fields or anywhere where wet conditions prevail at planting (2). Foliar fungicide applications generally begin at mid-season for winter squash and when the canopy closes for summer squash. For both types of squash, applications of one of the following product combinations are typically made on a 14-day schedule (8):

- mefenoxam + chlorothalonil (Ridomil Gold/Bravo 3 lb 81WP/A)
- mefenoxam + copper hydroxide (Ridomil Gold/Copper 1.5-2 lb 70WP/A)

To prevent stem and fruit rot, one of the above treatments may be alternated with fixed copper (2 lb 77WP/A) plus chlorothalonil (Bravo or Terranil 2 pt 6F/A) (8). Processors sometimes rotate one of the Ridomil combinations with fixed copper alone, although typically they add chlorothalonil to get broad spectrum control of other diseases. Chlorothalonil alone is not effective against phytothphora. The number of applications made depends upon weather. The 14-day schedule is followed in years with above average or regular rainfall. In drier summers, applications may be delayed until rain is expected. In wetter years, more frequent applications may be necessary (2).

Cultural Controls:
Cultural practices which limit the flow of water are effective for preventing the spread of this water-borne disease (2). All squash is grown on raised, rounded beds in fields with adequate drainage so that water does not accumulate around the base of the plants (2, 8). Plastic is not used on the beds, since it promotes Phytophthora. Processors use T-tape under the beds, which allows irrigation water to penetrate the squash root zone while avoiding the flow of water across the soil which will spread phytothphora from plant to plant. Overhead irrigation is avoided for this reason. In fields with low-lying areas, grass waterways are planted to prevent squash from growing in low areas (2). Squash is rotated with crops other than peppers, eggplants, tomatoes, and other cucurbits, on a 3 year schedule where possible (8, 23).

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 (21).

Frequency of occurence:
Severity of infection is strictly dependent upon the weather (24).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 or warm wet soils. Yield loss from damping off varies from 1 to 2% annually and is most prevalent in late planted squash (2, 21). At times there can be substantial losses from damping off in squash transplant seedlings in the greenhouse (5).

Chemical Controls:
Seed treatments are the most cost-effective means of control (2, 23). Most of the squash seed used in Maryland comes pre-treated with thiram from the seed company (2). In addition, under certain field conditions, mefenoxam (Ridomil Gold) is applied in a 7-inch band after seeding at a rate of 1 to 2 pints 4E/A(0.5-1.0 lb ai/A) (8). This is done when planting into damp soil or low-lying fields, or when re-planting squash into a field previously planted in squash (2).

Cultural Controls:
Resistant squash varieties are not currently available (21). Cultural practices that aid in disease management include selecting well-drained fields, and avoiding planting into cool wet soils (23), though practical considerations may allow few growers to practice these techniques (21).

Gummy Stem Blight/Black Rot

Damage and Life Cycle:
Gummy stem blight and black rot are caused by the fungus *Didymella bryoniae* (21). Gummy stem blight refers to the foliar and stem-infecting phase of the disease and black rot to the fruit rot phase. The pathogen overwinters in seed and on residue from diseased plants (23). 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 (22). It causes leaf and stem necrosis and tissue death (23). 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 (22).

Frequency of Occurence:
This disease is more prevalent in winter squash than in summer squash, and is not of economic importance in squash grown for processing (2, 21). The disease is seen to a small extent most years on fresh market squash grown west of the Chesapeake Bay. It is worst during humid spells in mid to late summer (5).

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

Chemical Controls:
When symptoms of black rot are observed on fresh market fruits, fungicide applications begin and are repeated every 7 to 10 days. The following products are used in Maryland (8, 21):

- chlorothalonil (Bravo or Terranil 2 pt 6F/A) plus benomyl (Benlate 0.5 lb 50WP/A) [Growers do not exceed 2 lb/A of Benlate per season.]
- chlorothalonil (Bravo or Terranil 2 pt 6F/A) plus thiophanate-methyl (Topsin M 0.5 lb 70WP/A)
- azoxystrobin (Quadris 11-15.4 fl oz 6L/A)

Processing squash is not treated for black rot or gummy stem blight (2).

Resistance Issues:
Resistance to benomyl occurs in the *Didymella bryoniae* population in Maryland (21).

Cultural Controls:
Growers use disease-free commercially produced seed which is treated with a fungicide, and they rotate fields out of cucurbits for at least 2 years. Fruit must be handled with care at harvest to avoid injury which increases the risk of infection (23)

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 (22). Fungal activity is limited to wet weather and temperatures below 21ºC (25). The fungus can attack any aboveground 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 (23).

Frequency of Occurence:
This disease is generally not a problem on summer squash, since weather conditions during the growing season don't generally favor its development. It is rarely seen in spring on early-planted squash or during late September on late-harvested fresh market squash (21). It is not a problem on squash grown for processing (2).

Management:
This disease is not typically a problem under current management regimes. Scheduled fungicide applications to control other diseases, the use of resistant varieties, crop rotation and seed treatments may all play a role in keeping this disease in check (8, 23).

Chemical Controls:
Processors never treat specifically for scab (2). On rare occasions fungicide applications may be made on late harvested fresh market summer squash (21). Chlorothalonil (Bravo or Terranil 1.5-3 pt 6F/A) is the primary product used in Maryland (8).

Resistant Varieties:
Growers use resistant varieties where possible (8).

Cultural Controls:
Growers practice a minimum two year rotation away from cucurbits and select sites with good drainage. Growers use only disease-free fungicide-treated seed to control seed decay and damping-off (23).

Downy Mildew

Damage and Life Cycle:
Downy mildew is caused by the fungus *Pseudoperonospora cubensis* (22). The pathogen does not overwinter in Maryland but can be carried on the wind into our area (21). 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 (21). Fruit yield and quality are reduced by downy mildew some years (21).

Frequency of Occurence:
This disease is seen on the lower Eastern Shore of Maryland about 1 in every 4 years, and is less common west of the Chesapeake bay (5, 21). Although not a common problem, it can be severe where it occurs (5). It generally does not occur in Maryland before mid-August (8).

Management:
Fields are scouted for disease occurrence beginning in mid-July. This disease is controlled with fungicides when necessary. Timing of application varies for winter and summer squash (8).

Chemical Controls:
Processors and fresh market growers in Maryland generally do not spray for downy mildew. The disease may be held in check by fungicide applications made for other diseases (2, 5).

Alternative Controls:

There are no cultural or biological control strategies that are effective against this disease (23).

Plectosporium blight

Damage and Life Cycle:
Plectosporium blight (previously known as Microdochium) is caused by the pathogen *Plectosporium tabicinum*, a common soil fungus. Plectosporium blight can infect green squash as well as pumpkin, but is most damaging to yellow squash (2, 21). Typically damage is minimal and confined to a few spindle-shaped lesions on the stems, petioles, and leaf veins. However, in years when weather conditions favor disease development, there is a profusion of leaf lesions and small tan lesions develop on the fruit. These lesions may be numerous and coalesce to form a continuous scabby surface (21). If not controlled, the disease can kill plants, devastating a field in 3 to 4 days (2)

Frequency of Occurrence:
Plectosporium is a relatively new disease on squash in Maryland. It occurs to a limited extent every year, though it generally causes little or no yield loss (21). Disease occurrence is worst during wet years from late July through August. Average annual yield loss is at least 5%, but it can be much higher some years (2, 21). When conditions favor disease development, it can be potentially devastating to yellow squash grown for processing (2).

Management:
This disease is managed with applications of protectant fungicides (21).

Chemical Controls:
Chlorothalonil (Bravo Weather-Stik 2) and azoxystrobin (Quadris 11-15.4 fl oz 6L/A) are used to control this disease in Maryland (21). For processing squash, chlorothalonil is applied on 10 to 14 day schedule beginning just prior to the start of harvest and continuing through the end of harvest (typically about 6 weeks) (2).

Cultural Controls:
At this point there is little information on the impact of cultural practices on pathogen populations or the occurrence of this disease (21). The potential for losses from this disease late in the growing season is an important reason why yellow squash grown for processing is planted so that it can be harvested by the end of July in most years (2).

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) (19). Several species of plant pathogenic nematodes occur in Maryland soils (8), generally as mixed populations unevenly distributed throughout a field (19).

Nematode populations in Maryland do not cause economic damage to squash, and few growers sample for nematodes prior to planting squash (26). Because squash is grown in rotation with other vegetable crops, some of which are susceptible to nematodes, sampling and chemical treatment for nematodes may occur in the same fields, but not during the squash growing season (21). For more information on nematode sampling and management practices, see Maryland's Tomato Crop Profile (27).

Weeds

Weed Management in Squash:
Weeds have the potential to cause economic loss in squash 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 (23). Weeds may also act as reservoirs for insect pests and diseases (28). Annual weed escapes can produce seed that will be in the soil and increase weed populations for the next several years, and perennial weeds may also persist if not properly controlled (24, 28). Therefore, any weeds present may not only be a problem this year but also for many future years. Fields are not allowed to remain idle after harvest because weeds will produce seeds until frost. Fields are always disced and/or plowed after harvest to prevent late summer and fall weed seed production (24), and cover crops are often planted to prevent erosion and reduce weed seed germination (9).

In squash, weed control by chemicals and cultivation or hoeing is 95% to 100% effective. In most years, very little or no yield loss is attributed to weeds in squash in Maryland. Squash plants grow rapidly, and fruit develops 4 to 5 weeks after planting. Once fruit begins developing, the harvest season can extend for 7 to 8 weeks. Therefore, cultivation is used for complete weed removal until the squash canopy shades the row to suppress weeds. Once squash plants are about 4 weeks old, they are very competitive with weeds and further controls are rarely needed (9).

Major Weeds

The most important grass weeds of squash in Maryland are fall panicum, large crabgrass, and goosegrass. The most important broadleaf weeds are velvetleaf, common ragweed, and pigweed species. Common pokeweed is important as an overwintering host for cucumber mosaic virus and watermelon mosaic virus (see viruses in disease section). There is regional variation within Maryland in the

occurrence and severity of these weeds (9).

Cultural Controls:
Herbicides alone seldom control all weed species. They must be used in conjunction with cultivation to ensure high yields in squash crops. When weed escapes occur, cultivation is preferable to hoeing or applying post-emergence herbicides (24). 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 (9). Herbicides are an aid to cultivation because they delay weed growth until the squash plants become large enough for cultivation (24). Most processors have crews in place prior to harvest for hoeing of weeds in the rows (2). Post-harvest rotary mowing will remove most weeds from the plastic, but this is not commonly practiced by Maryland growers (9).

Crop Rotations:
Soil persistence (carryover) from some herbicides used on previous crops may cause injury to squash. Advance planning in herbicide selections is essential to safely rotate squash after most agronomic crops and some vegetable crops. The herbicides imazaquin (Scepter), imazethapyr (Pursuit) and chlorimuron-ethyl (Classic) have a great potential for vine crop injury in the next season (24). Cyanazine (Bladex) and metribuzin (Sencor or Lexone) are triazine herbicides with a short soil life and do not cause soil residual carry-over injury to vine crops (9).

Chemical Controls:
Herbicide choices on squash have increased in the past 5 to 7 years with new registrations (9). Preplant incorporated herbicides are generally less soluble than preemergence materials, and incorporation into the soil profile increases the products' contact with weed seeds, 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 seedlings. Cultivation or rotary hoeing may also be used to increase weed seed contact and help activate preemergent herbicides (28). 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 (8).

I. Preplant Incorporated or Preemergence Herbicides

bensulide - 5 to 6 lbs ai/A (5-6 qts/acre Prefar 4EC) is used for control of grasses. Bensulide provides excellent to good control of barnyardgrass, large crabgrass, fall panicum, foxtail species, and johnsongrass seedlings. It provides good to fair control of goosegrass and common lambsquarters and fair control of common purslane and pigweed species. Bensulide does not control most other broadleaf weeds (8). Bensulide is tank mixed with other herbicides to control more weed species. Bensulide may be applied preplant incorporated or preemergence. If applied preemergence, rainfall or irrigation must occur prior to weed emergence to activate the herbicide.

Depending on the time of year, this period may be 2 to 6 days after crop planting. The irrigation amount should be less than 0.4 inches or excessive dilution of the herbicide may occur (24). If incorporated, the depth should be about 2 inches (8). In Maryland, this herbicide is applied to 30% of fresh market squash acres and less than 10% of processing acres annually (2, 9).

clomazone (Command 4EC) - A Special Local Needs 24 (c) label has been approved for the use of Command 4EC on summer and winter squash in Maryland and other mid-Atlantic states (8). Clomazone may be applied preplant incorporated or preemergence, and herbicide effectiveness is the same for both methods of application (24). For winter squash, 0.4 to 0.5 pints per acre (0.2 to 0.25 lb ai/A) of Command 4EC are applied preplant. For summer or winter squash, 4 to 6 fluid ounces per acre (0.12 to 0.19 lb ai/A) of Command 4EC are applied for good to excellent preemergent control of annual grasses and many broadleaf weeds (8). The 4 ounce rate is used in processing squash. Broadleaf weeds controlled include common lambsquarter, velvetleaf, spurred anoda and purslane (8, 24). Jimsonweed is usually suppressed by clomazone (24). Mustards, morningglory species, carpetweed, and pigweed species will not be controlled (8). Clomazone is combined with ethalfluralin (Curbit) or bensulide (Prefar) 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 (24). In Maryland, this herbicide is applied to about 20% of fresh market squash acres (9). A tank mix of Command and Curbit is applied immediately after planting to over 90% of processing acres for broad-spectrum preemergent weed control (2).

Preplant incorporation reduces the risk of vapor drift, but increases the risk of crop injury. Zucchini is particularly susceptible to injury (9). Command is not preplant incorporated in summer squash grown for processing for this reason (2). Most types of squash will completely recover from injury (partial whitening of leaf or stem tissue) apparent after crop emergence with no effect on crop yield or timing of harvest (9). 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 (8). 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 (24). Heavy rainfall or irrigation should be avoided following application, as it may deliver the chemical into the squash root zone and cause damage to plants (2).

II. Preemergence

ethalfluralin - 0.56 to 0.75 lb ai/A (1.5-2 pts/acre Curbit 3EC) is applied preemergence to control annual grasses and certain annual broadleaf weeds, including purslane and carpetweed. Control of many broadleaf weeds, including pigweed sp., 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 tolerant weeds or if rainfall or irrigation does not occur prior to weed emergence (8). 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) (24). Ethalfluralin is not preplant incorporated or applied under plastic mulch or applied when soils are cold or wet, as injury may occur.It is not used on transplanted squash (8). In Maryland, this herbicide is applied to 30% of fresh market squash acres (9). A tank mix of Command and Curbit is applied immediately after planting to over 90% of processing acres for broad-spectrum preemergent weed control (2).

III. Postemergence Herbicides

paraquat (Gramoxone Extra 2.5S) - 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. 1.6 pints per acre (0.5 lb ai/A) 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. 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 (8). In Maryland, this herbicide is applied to 40% of fresh market squash acres (primarily those grown on plastic) and less than 15% of processing acres annually. Paraquat is not often used by processors since the preemergent products Command and Curbit are so effective. However, at times paraquat can be very useful for controlling weed escapes (2).

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 (8). Sethoxydim provides excellent control of fall panicum, goosegrass, lovegrass, and foxtails. Smooth and large crabgrass should be sprayed when small, about 1 inch high with 2 to 3 leaves, for effective control (9, 24). 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. A second application may be made for grasses that are difficult to control or for new flushes of germinating grasses. Sethoxydim will control johnsongrass and shattercane and it is also effective for control of volunteer rye and wheat (24). Two applications at a rate of 1 to 1.5 pts/A are used to control most perennial grasses (except those with very narrow or waxy leaves) (2, 8). Drought or intense heat can limit the effectiveness of control (2). Yellow nutsedge, wild onion, and broadleaf weeds will not be controlled with sethoxydim. Growers do not tank-mix sethoxydim with pesticides 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

(8). In Maryland, this herbicide is applied to about 20% of fresh market squash acres and about 5% of processing acres annually (2, 9).

IV. Postharvest

paraquat (Gramoxone Extra 2.5SC) - A Special Local Needs 24(c) label has been approved for the use of Gramoxone Extra 2.5SC as a broadcast spray for post-harvest desiccation of the crop in Maryland and Virginia. Paraquat may be applied at 1.6 to 1.9 pints per acre (0.5 to 0.6 lb/A) postharvest to prepare plastic mulch for replanting or to aid in the removal of mulch. 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 (8). In Maryland, this herbicide is applied to 5% of fresh market squash acres annually and is not applied postharvest to processing acres (2, 9).

Chemical Control Issues for Herbicides:
Good preemergent weed control in squash 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 (28).

Because of the very narrow range of herbicides available for weed control in squash, the loss of any of these products could have a significant negative impact on squash production in Maryland. This narrow product range also raises concerns about the development of resistant weed populations (28).

Table 1. Herbicides for control of grasses and sedges in squash.

	GRASSES AND SEDGES						
Herbicide	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (seedling)	Yellow nutsedge
Preemergence or Preplant Incorporated:							
clomazone	G	G	G	G	G	G	N
bensulide	G	G	G	G	F/G	G	N
Preemergence Only:							
ethalfluralin	F	G	G	I	G	I	N
Postemergence:							

paraquat	F/G	F/G	F/G	G	F/G	I	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 (20). (Table modified from 1999 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 236)

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

Table 2. Herbicides for control of broadleaf weeds in squash.

	BROADLEAF WEEDS								
Herbicide	Carpetweed	Cocklebur, Common	Galinsoga, Hairy	Jimsonweed	Lambsqtr., Common	Morning-glory sp.	Pigweed sp.	Purslane, Common	Ragweed, Common
Preemergence or Preplant Incorporated:									
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:									
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 (20). (Table modified from 1999 Commercial Vegetable Production Recommendations, University of Maryland Cooperative Extension Bulletin 235)

Key:
G = good
F = fair

P = poor
N = no control

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