Insecticide or mineral oil sprays can be used for controlling insect vectors. However, several other techniques can be used as well. One of these is known as mid-bedding, where seed is planted in V-shaped trenches between plant beds in the early spring, and the trenches are covered with plastic. The main benefit is increased soil temperatures to hasten plant development for early production, but a side benefit is a possible reduction in early aphid populations and associated viruses on the young plants. Reflective mulches, which are intended to disorient aphids, have been used with varying degrees of success for limiting aphid transmitted viruses. For the viruses that are transmitted mechanistically as well as by insects, cultivation and other equipment should be cleaned and disinfected prior to being moved from infected to non-infected fields.

Geminiviruses: Diseases of Squash. During the past 25 years geminiviruses (genus Geminivirus, family Geminiviridae) have been a major problem, and have been identified on squash in desert regions where the whitefly vectors abound. There are at least three geminiviruses that have been identified to date on squash and the number continues to grow. The current list includes squash mild leaf curl virus (SMLCV) from California, squash leaf curl virus (SLCV) from Arizona, Colorado, Texas, Southern Mexico (San Luis and Sonora), and others. Increased irritation in desert regions has resulted in larger host plant and whitefly populations, and a corresponding increase in geminiviruses.

By Wayne Welte, Manager
QA Testing and Technical Services
Syngenta Seeds

SOURCES:


QA Testing and Technical Services
Syngenta Seeds

SAVINGS YIELD INFORMATION PRESENTED HEREIN IS BASED ON FIELD AND LABORATORY OBSERVATION. AS ALWAYS, AGRICULTURAL RESULTS MAY VARY AND WILL DEPEND ON MANY FACTORS SUCH AS ENVIRONMENTAL CONDITIONS AND VARIETY CHARACTERISTICS. SYNGENTA SEEDS MAKES NO REPRESENTATIONS OR WARRANTIES REGARDING THE EFFECTIVENESS OF ANY SHORT OR LONG-TERM CROP RESISTANCE FEATURES, INCLUDING BUT NOT LIMITED TO RESISTANCE AGAINST INSECT, DISEASE OR WEATHER STRESS.

Dr. Judy Brown, University of Arizona, and Dr. Robert Gillham, University of California-Davis, contributed information for this article
Eric Nettleton, a University of California Entomology Cooperative Extension Advisor in Imperial County, also provided expertise.

Insecticide or mineral oil sprays can be used for controlling insect vectors. However, several other techniques can be used as well. One of these is known as mid-bedding, where seed is planted in V-shaped trenches between plant beds in the early spring, and the trenches are covered with plastic. The main benefit is increased soil temperatures to hasten plant development for early production, but a side benefit is a possible reduction in early aphid populations and associated viruses on the young plants. Reflective mulches, which are intended to disorient aphids, have been used with varying degrees of success for limiting aphid transmitted viruses. For the viruses that are transmitted mechanistically as well as by insects, cultivation and other equipment should be cleaned and disinfected prior to being moved from infected to non-infected fields.

Geminiviruses (Begomoviruses): Diseases of Squash. During the past 25 years geminiviruses (genus Geminivirus, family Geminiviridae), which are characterized by a bipartite single-stranded DNA genome, have become a severe problem on squash in desert regions where the whitefly vectors abound. There are at least three geminiviruses that have been identified to date on squash and the number continues to grow. The current list includes squash mild leaf curl virus (SMLCV) from California, squash leaf curl virus (SLCV) from Arizona, Colorado, Texas, Southern Mexico (San Luis and Sonora), and others. Increased irritation in desert regions has resulted in larger host plant and whitefly populations, and a corresponding increase in geminiviruses.

Insecticide or mineral oil sprays can be used for controlling insect vectors. However, several other techniques can be used as well. One of these is known as mid-bedding, where seed is planted in V-shaped trenches between plant beds in the early spring, and the trenches are covered with plastic. The main benefit is increased soil temperatures to hasten plant development for early production, but a side benefit is a possible reduction in early aphid populations and associated viruses on the young plants. Reflective mulches, which are intended to disorient aphids, have been used with varying degrees of success for limiting aphid transmitted viruses. For the viruses that are transmitted mechanistically as well as by insects, cultivation and other equipment should be cleaned and disinfected prior to being moved from infected to non-infected fields.

Geminiviruses (Begomoviruses): Diseases of Squash. During the past 25 years geminiviruses (genus Geminivirus, family Geminiviridae), which are characterized by a bipartite single-stranded DNA genome, have become a severe problem on squash in desert regions where the whitefly vectors abound. There are at least three geminiviruses that have been identified to date on squash and the number continues to grow. The current list includes squash mild leaf curl virus (SMLCV) from California, squash leaf curl virus (SLCV) from Arizona, Colorado, Texas, Southern Mexico (San Luis and Sonora), and others. Increased irritation in desert regions has resulted in larger host plant and whitefly populations, and a corresponding increase in geminiviruses.

Insecticide or mineral oil sprays can be used for controlling insect vectors. However, several other techniques can be used as well. One of these is known as mid-bedding, where seed is planted in V-shaped trenches between plant beds in the early spring, and the trenches are covered with plastic. The main benefit is increased soil temperatures to hasten plant development for early production, but a side benefit is a possible reduction in early aphid populations and associated viruses on the young plants. Reflective mulches, which are intended to disorient aphids, have been used with varying degrees of success for limiting aphid transmitted viruses. For the viruses that are transmitted mechanistically as well as by insects, cultivation and other equipment should be cleaned and disinfected prior to being moved from infected to non-infected fields.

Geminiviruses (Begomoviruses): Diseases of Squash. During the past 25 years geminiviruses (genus Geminivirus, family Geminiviridae), which are characterized by a bipartite single-stranded DNA genome, have become a severe problem on squash in desert regions where the whitefly vectors abound. There are at least three geminiviruses that have been identified to date on squash and the number continues to grow. The current list includes squash mild leaf curl virus (SMLCV) from California, squash leaf curl virus (SLCV) from Arizona, Colorado, Texas, Southern Mexico (San Luis and Sonora), and others. Increased irritation in desert regions has resulted in larger host plant and whitefly populations, and a corresponding increase in geminiviruses.
Powdery Mildew in Summer Squash

In the drier areas of the Western United States and Mexico, powdery mildew epidemics often result in considerable losses to fields of summer squash. The disease is ubiquitous, however, and can also limit production of summer squash around the world. It frequently compromises yield by reducing the amount of leaves available for photosynthesis, accelerating senescence, and, ultimately, killing the infected plants.

CAUSES

Powdery mildew is caused by several fungi that affect cucurbits and other crops. Cucurbits are susceptible to powdery mildew caused by *Podosphaera xantii* (Castagne) U. Braun & S. Takam, formerly classified as *Sphaerotheca*. The pathogen has been widely confirmed in North, Central, and South America, and it is the recognized causal agent of powdery mildew in summer squash in those areas.

SYMPTOMS

Powdery mildew infections on summer squash appear as “white, talcum-like, powdery fungal growth” that develops on the leaf blades, peduncles, and stems (also called growing points) of susceptible plants. The white structures visible to the naked eye are the mycelia (body) and conidia (reproductive structures) of the fungus. Usually, infection begins on the older leaves and then spreads to other parts of the plant.

INFECTION MECHANISM

Powdery mildew fungi are obligate parasites, which means they cannot survive unless they infect a living host. Most powdery mildews do not affect petunias and tomatoes, so a susceptible host is needed. Powdery mildew prefers warm, humid conditions; temperatures for infection range from 50 to 90°F, with 65-70°F being the ideal for development.

Chemical control

Fungicides can be used as a preventive measure or to delay the production of secondary inoculum on infected plants. Complete control of powdery mildew through fungicide applications is difficult on summer squash, however, because the fungi often do not reach the lower side of the leaf blades or the more internal parts of the plant such as petals and stems. Systemic fungicides are more effective, but powdery mildew has developed resistance to the active ingredients of some fungicides. The alternation of fungicides is usually desirable to help reduce the chances of the development of this resistance. However, during intense epidemics, biweekly applications are often required and the technique is economically non-viable.

GENETIC RESISTANCE TO POWDERY MILDEW IN SUMMER SQUASH

Plant breeders are developing summer squash with genetic resistance to powdery mildew. Currently recognized genetic resistance is based on disease development on the leaf blades, peduncles, and stems and from many fungal diseases in that its spores do not require free moisture in order to germinate. Optimal temperatures for infection range from 50 to 90°F, and from 68 to 81°F for disease development. Disease development is arrested when temperatures are higher than 100°F. Thus, powdery mildew is a greater threat during the cool and dry months of the spring and fall, rather than the hot summer months. In addition, powdery mildew develops more easily on senescent leaves. Therefore, with the progressing of the plant age and the increase of exposed senescent leaves to infection, powdery mildew may overcome genetic resistance of the plant.

FIELD MANAGEMENT OF RESISTANT CULTIVARS

Genetic resistance provides the basis for successful management of powdery mildew in summer squash. Resistant cultivars benefit from weekly applications of fungicides that can reduce damage to leaves. Genetic resistance also allows for lower production costs due to less frequent fungicide applications and potentially higher yields due to the longer harvest period. When disease pressure is high, environmental conditions are close to optimum for disease development, resistant cultivars may succumb to powdery mildew. Still, their life-span will most often be a few days to several weeks longer than susceptible cultivars and their production may be higher. The timely identification of powdery mildew hot spot development in a field, combined with the proper application of fungicides, will decrease the chances that the disease will cause serious damage to the crop.

The level of resistance of the main stem is more critical than the level of resistance of the leaves (See Disease Assessment Scale for Genetic Resistance). This is because the stem generates new leaves, as well as female and male flowers, thereby replacing discolored parts and providing new marketable fruit. Leaves can be easily protected with fungicide applications, while the stem will very rarely be reached by fungus in a timely manner. On the basis of stem reaction, genetic resistance can be classified into five categories: 1 and 2 for “Susceptibility,” 3 for “Intermediate Resistance,” and 4 for “High Resistance.” Examples of cultivars with intermediate resistance to powdery mildew include: Payroll, Envy, Equinox, Amatista, Topazo, Sungla, and Gold Star (please see Key to Resistance Abbreviations for Squash on back page).

GUIDE TO RESISTANT CULTIVARS

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cultivar is susceptible to powdery mildew and production is fully lost. Stem and leaves are fully covered by secondary inoculum and the plants die.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cultivar is susceptible to powdery mildew and production is largely lost soon after the first symptoms become evident. Stem and leaves are partly covered in secondary inoculum, but the lesions are too extensive to allow further growth of the plant.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cultivar has a low level of resistance and can sustain fruit production for a slightly longer period of time, especially if fungicides are applied in a timely manner.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The stem has several large areas covered by mycelia, but very little production of inoculum. The leaves may still show a susceptible reaction, but new leaves will be less affected than old ones.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cultivar is resistant (intermediately level) to powdery mildew and fruit can be harvested longer, thus increasing total yield in comparison with susceptible cultivars. The stem shows some development of mycelia from primary inoculum, but there is very little or no production of secondary inoculum. The leaves may be affected slightly if treated with fungicides, or more heavily if not treated. New leaves are almost free of powdery mildew.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cultivar is fully resistant and yields as much as or more than a susceptible but disease-free cultivar. The stem, leaf blades, and pedicels show very limited, if any, development of mycelia from primary inoculum and inhibit production of secondary inoculum.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Disease Assessment Scale for Genetic Resistance**

For squash, stem reaction provides a better basis than leaves for determining genetic resistance to powdery mildew because extensive leaf infection can occur on resistant varieties. The following assessment scale, which is based on disease development on the stem, provides a summary of the level of resistance that can occur in commercial cultivars:

**Key to Resistance Abbreviations for Squash**

- **F**: Fully resistant
- **FR**: Fully resistant
- **R**: Resistant
- **M**: Moderately resistant
- **S**: Susceptible
- **FR**: Fully resistant

**Sources:**


**Level 1:** The cultivar is susceptible to powdery mildew and production is fully lost. Stem and leaves are fully covered by secondary inoculum and the plants die.

**Level 2:** The cultivar is susceptible to powdery mildew and production is largely lost soon after the first symptoms become evident. Stem and leaves are partly covered in secondary inoculum, but the lesions are too extensive to allow further growth of the plant.

**Level 3:** The cultivar has a low level of resistance and can sustain fruit production for a slightly longer period of time, especially if fungicides are applied in a timely manner.

**Level 4:** The stem has several large areas covered by mycelia, but very little production of inoculum. The leaves may still show a susceptible reaction, but new leaves will be less affected than old ones.

**Level 5:** The cultivar is resistant (intermediate level) to powdery mildew and fruit can be harvested longer, thus increasing total yield in comparison with susceptible cultivars. The stem shows some development of mycelia from primary inoculum, but there is very little or no production of secondary inoculum. The leaves may be affected slightly if treated with fungicides, or more heavily if not treated. New leaves are almost free of powdery mildew.

**Level 5:** The cultivar is fully resistant and yields as much as or more than a susceptible but disease-free cultivar. The stem, leaf blades, and pedicels show very limited, if any, development of mycelia from primary inoculum and inhibit production of secondary inoculum.

*Please see Key to Resistance Abbreviations for Squash on back page*