Controlling Pepino Mosaic Virus in Tomato

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Introduction

In the begin of 1999 pepino mosaic virus (PepMV) was first observed in the Dutch tomato production. (Vlugt et al., 2000) Previously, pepino mosaic virus was only described on the crop Pepino, in Peru. (Jones, Koenig and Lesemann, 1980). At the same the virus was also mentioned in England. (Wright and Mumford, 1999, unpublished). At presence the virus has been found in other European countries such as France (Anonymous.2000), Germany (Lesemann et al. 2000, unpublished), Spain (Jorda et al., 2000), and Italy (Roggero et al., 2001). Not only in Europe is the virus wide spread, but also in countries such as Canada and the United States (Ferguson, 2001). Increasing unease among several plant disease regulating institutes has lead to regulation by the European Commission to retain the spread of PepMV within the European Community (EPPO, 2001).
PepMV belongs to the Potex Group, characterized as highly infectious and persistent. The symptoms of pepino mosaic virus in tomatoes can vary depending on cultivar, age of the plant at infection and growing conditions. The damage caused by the virus varies among countries from no loss or insignificant, up to 15% production losses. At present damages up to 20 % production decrease, can be contributed to the combination of PepMV and *Verticillium* (de Buck and Stijger, 2002).
The virus was first isolated from pepino plants, a South American crop which fruits resemble egg plants, in Peru from plants collected by Jones et al. in 1974. He found that the virus could infect various tomato cultivar and related wild species such as *Lycopersicon peruvianum* without showing symptoms. The virus has not yet been observed in the greenhouse production. In 2000, Spanish researchers (Soler et al., 2002) collected samples in Peru to generate information on origin, spread and its natural hosts serving as a natural reservoir for the virus. Within the Netherlands , extensive research has been undertaken on characteristics of the virus, level and intensity of infection and spread, and its threat to the tomato production. In this article a review will be given on the research at presence and undertakings to master the virus.

Symptoms

PepMV can cause various symptoms in tomato. This is dependent on the cultivar, age and plant vitality expressed in age and growing conditions at infection.
In a young cultivation the following symptoms can be expressed on the young plants, showing the possible presence of PepMV:
- Clear chloritic spots on the leaves, usually under ‘the head’ and a few spots on a leaf. Sometimes on older leaves, sharply border yellow spots which can be very small.
- On young leaves blisters and other malformation can be observed. The leaves on the top of the plant can be ‘spike like’ referred to as ‘nettlehead’: these leaves are narrow and some what sturdy. The top of the plants are grayish, pale yellow, while the leaves just below appear darker. Nettle heads resemble growing substance damage. Usually these are the first symptoms and should be view closely.
- The older leaves have a striking yellowing of the ‘inter-veinal’ tissue. At times mosaic of enlarged chloritic areas on the leaf.
Ussually the symptoms disappear in time or become vague.
Later in the growing season the following symptoms become apparent:
- Sharply border spots on the leaves, weak yellowing of the inter-veinal tissue or partial chlorosis of the leaves

- Some fruits ripen unevenly, showing orange to red spotting, usually confined to a few fruits on a bunch, while most bunches will be symptomless. Similar spotting can be seen on tomato fruits infested with CMV or PVX.

Losses
The view on damage varies from insignificant to 15% production loss, but was not backed with research. Yet, depending on circumstances, losses in production can be expected.
As with the development of symptoms, causes can differ: the susceptibility of the cultivar, growing conditions at infection, the presence of other pathogens, and the physiological condition of the plant at the moment of infection and thereafter. Recent studies have shown that PepMV in combination of Verticillium can lead to damage, expressed in a production loss of 10 to 15%. Remarkable was in this study is that a certain cherry tomato cultivar was not sensitive to the virus, even in combination with Verticillium. Presently research is undertaken in several counties on the true damage or potential damage caused by PepMV.

Transmission and spread
Seed
The seed industry, Applied Research Greenhouse Horticulture in Naaldwijk (PPO Glastuinbouw) and the Plant Protection Service have conducted research on seed transmission. The studies conclude PepMV can only be detected in poorly clean fresh seed, leading to a remote change of infecion of a seedling. In well cleaned seeds and in mature seeds the virus was never detectable. One can therefor conclude that if the seed is properly cleaned, no transmission of PepMV can occur.

Contact
Possible source of infection are infected plants, old planting material from a previous production, plant sap on hands, tools, fruit tissue around seeds, carts, barrels, etc.
The virus can be easily transfer by mechanical means. Spreading of the virus can occur by those who perform crop treatments, or packing of the fruit. Transmission can also occur via clothing, jewelery, or harvest carts. Mechanical transmittable viruses can be easily and quickly spread throughout the crop. In general spread will occur within the line of plants, starting with one infected plant spreading in the working direction. This is why a often one can observe a group of infected plants.The virus can also appear in other places in the greenhouse.

Drain water.
Pepino mosaic virus has been found in drain water of infected plants grown on substrate. With the drainage little pieces of roots or pieces plant tissue can easily be spread. If infection of PepMV is observed, and drainage is circulated for reuse, the water should be disinfected. One of the options is UV radiation. Using a Vialux UV Des-infector, a dosage of 150 mJ/cm^2 will be sufficient to kill the pepino mosaic virus. The transmission value of the drain water should be a minimal of 15%.

Insects
Research indicates that bumble bees can spread the virus, yet it is still preferable to use bumble bees because the risks of infection by mechanical pollination is greater. *Macrolophus caliginosus*, a biological agent,can in principle, spread the virus. Virus transmission by *Macrolophus caliginosus*, originating from an infested greenhouse could not be indicated. Greenhouse white flies (*Trialeurodes vaporariorum*) thus not seem to be able to transmit the pepino mosaic virus.

Compost
If compost is regularly turned and stored for a long period, it is unlikely that the pepino mosaic virus will survive the composting.

Infectivity period of pepino mosaic virus
Clothing
On clothing, which has been in contact with infected material, infectious virus particles were obtained after 14 days

Leaves, roots and plant sap
Temperature and humidity have both a clear influence on the infectivity of the virus.

At 10 ^{o}C the virus in the plant material is longer infectious than at 20 ^{o}C. Wet leaf and roots stored at these temperatures were longer infectious than the same dried material. Roots of infected plants were longer infectious than the leaves. Diseased plant sap spread out on glass plates, laboratory dried, lost their infectivity after four days (plant sap stored in a sealed tube was still infectious after 20 days).

Disinfection
To curtail infection it is recommendated to dip hands and knives(or scissors) in skim milk, during crop handling, per plant.
Also the disinfectant Virkon, at 1 % solution, can be used. Disadvantantage is that with plenty of sunshine, it can result in phytotoxicity. For disinfecting surfaces and tools, Virkon has been proven effective.
Note that one should remove all organic material, as all disinfectants work insufficiently when they come in contact with organic material. In a study, the efficacy of a washing method for barrels was investigated and it concluded that the method to be effective, and no risk of infecting the barrel during the washing.

Resistance
Till present, no resistance has been found after screening several tomato cultivars.

Origin
In 1974, PepMV was first found in in Pepino plants, in Peru and in 1980 a publication appeared.
Early 1999, the virus was found in England and the Netherlands. In 2000, the virus had its presence in several European countries and the United States. It is unclear how the virus was introduced into tomato. The virus is found in different tomato species and cultivars of several seed companies. It appears from research that the origin might be in South America. Studies show that wild *Lycopersicon sp*. in central and south Peru, often latent, are infested by PepMV. Differences in symptoms between Peruvian and European isolates on the same host indicate genetical differences could be present.The (natural) isolates from Peru are less virulent than the tomato isolates. Besides tomato (and Pepino), egg plant is also a host of PepMV.

Hygiene Protocol
A hygiene protocol has been developed in the Netherlands, based on the results of research and monitoring at companies with PepMV infection in tomato. The effectiveness of the protocol was illustrated by the fact that growers followed the advised measures and precautions were able to eradicate the virus. The protocol has been translated in English and French.

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