Internal rot in capsicums

Causes and control

Integrated Crop Protection
PROTECTING CROPS

Background

Internal rot in capsicum is an infection on the seeds, placenta or internal wall(s) of the fruit. It occurs most commonly in red fruit. Normally, symptoms are only seen once the fruit is cut open. The external appearance of the fruit is completely normal.

The disease leads to downgrades and rejections of fruit on the market, and affected fruit often progress right through the supply chain, to consumers.

The disease normally starts when fungi infect the flowers or young fruit. These latent infections lie dormant as the fruit develops. Once the fruit starts to ripen, the disease develops rapidly, leaving no sign of the disease on the outside of the fruit.

Internal rot in capsicums can be caused by five different organisms, which infect the fruit in different ways. There has been very little research on the control of this disease in Australia, although a number of detailed studies have been conducted internationally over the last 30 years.

Hortus Technical Services undertook a study of 18 capsicum fruit collected from 6 different growers in the Bundaberg region in July 2015. The study found internal fungal rots in 78% of the fruit, and concluded the predominant cause was latent infection by the fungus, *Alternaria alternata*.

The purpose of this factsheet is to bring together the most up to date information on the cause(s), control and prevention of internal rot in capsicums.

What causes internal rot in capsicum?

The disease is caused by a fungal or bacterial (rarely) pathogen establishing inside the developing fruit. The disease can be found in the fruit-stalk, fruit-base, fruit-pulp or around the seeds. Precisely how and when infections occur depends on the organism responsible. The disease does not move from fruit to fruit.

Figure 1. Internal rot in capsicums
(Photo courtesy Hortus Technical Services).

The disease can be transmitted by seed. However, the seed treatments applied by reputable seed companies, including surface sterilization and hot water treatments are effective at controlling all the organisms known to cause this disease.

The documented causes of internal rot in capsicums are:

1. Alternaria *(Alternaria alternata)*
2. Fusarium (e.g. *Fusarium solani*, *F. oxysporum*, *F. subglutinans)*
3. Botrytis *(Botrytis cinerea)*
4. Anthracnose (*Colletotrichum* spp.)
5. Bacterial soft rot *(Pectobacterium atrosepticum)*

This factsheet was funded by the Premier Fruits Group, Australia.

HORTUS TECHNICAL SERVICES

ahr applied horticultural research

RMCG Environment | Water | Agriculture Policy | Economics | Communities

PREMIER FRUITS GROUP

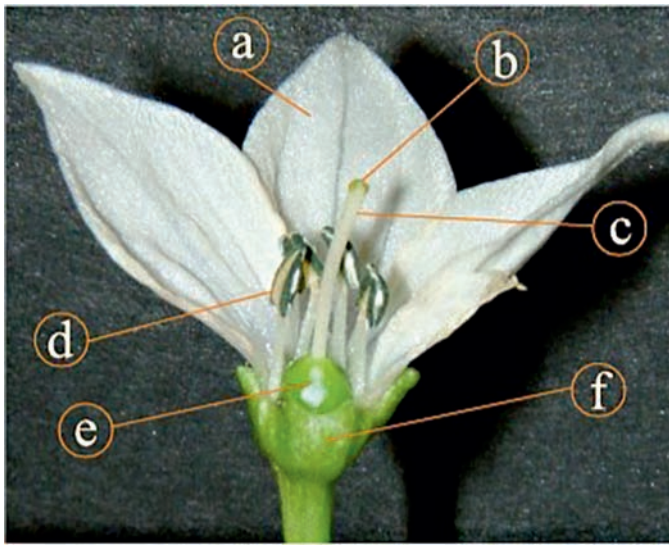

Figure 2. Parts of a capsicum flower (a=petal, b=stigma, c=style, d=anther, e=ovary and f=calyx) Photo courtesy Hortus Technical Services.

1. **Alternaria.** *A. alternata* is the most common cause of internal rot in capsicums. Infection usually occurs at the flowering stage, mainly through the stigma and the style of the flower (Figure 2 b, c), but it can occur up to 21 days after fruit set. *A. alternata* is a common fungus in the environment that can live on decaying plant material. It is favoured by warm and moist weather conditions when it produces masses of spores that are carried to flowers by wind, air currents or in water splash. Once infection occurs, the fungus remains latent in the developing fruit until the fruit ripens and softens, and the internal symptoms develop. An alternative infection pathway is after flowering, through a small gap under the calyx where *A. alternata* can establish a superficial infection and then develop into the fruit.

2. **Fusarium**. Internal rot in capsicums can be caused by various species of *Fusarium*, e.g. *Fusarium solani*, F. *oxysporum*, F. *subglutinans*. Infection normally occurs via the flower, and later results in internal infections of the fruit, with no external symptoms apparent. *F. solani* can infect capsicum stem tissue, producing masses of spores that spread to flowers. Infection can also occur through damage to the skin of the developing fruit. Transmission of *Fusarium* species with seed is possible but as with *A. alternata*, *Fusarium* species are common saprophytes that live on decaying organic matter. Their spores are easily spread by wind, air currents, water splash and by small insects such as flies.

3. **Botrytis**. This organism has been reported as causing internal rot in capsicum, and is commonly found in Australia causing the disease Grey Mould on a wide range of host plants. It is similar to the fungi, *Alternaria* and *Fusarium* species in that it can grow on decaying organic matter and its spores are spread in the air. The fungus has been found on the pollen of capsicum flowers. Infection of fruit by *B. cinerea* is likely to occur initially in the flowers, via the petals or the pollen.

4. **Anthracnose**. There are reports in the scientific literature of internal infections in capsicums caused by any of several species of the fungus, *Colletotrichum*. Infection starts in the fruit stem and later progresses into the fruit. This fungus is more commonly associated with an external rot of ripening fruit on which masses of salmon-coloured spores are produced that are spread by water splash.

5. **Bacterial soft rot**. This can occur as a latent infection, but more commonly infects fruit through damage or insect wounds.

Conditions favouring infection

The conditions favouring infection by organisms that can cause internal rots of capsicums are outlined below. It is important to note that while most infections occur during the flowering or early fruit setting stage, they can also occur directly via the fruit stems or under the calyx at other times.

Integrated Crop Protection
PROTECTING CROPS

Table 1. Optimum temperature and humidity conditions for infection

DISEASE	TEMPERATURE (°C)	OPTIMUM HUMIDITY	COMMENTS
Alternaria	24-28	98-100%, wet leaves and flowers	Favoured by warm, wet conditions. Spores spread by wind, air currents and splashing water.
Fusarium	20-28	100%, wet leaves and flowers	Favoured by warm, moist conditions. Spores spread by wind, air currents and splashing water.
Botrytis	18-23 Inhibited >32	100%, wet leaves and flowers	Favoured by mild, wet weather. Spores spread by wind and air currents.
Anthracnose	20-24	100%, wet leaves and flowers	Favoured by warm, wet weather. Spread with splashing water.
Bacterial soft rot	25-30	High – foggy, wet conditions.	Mainly entry via a wound or insect attack.

Field v's protected cropping

The fungi that lead to internal rot in capsicums all infect under wet conditions, especially when the flowers or the fruit surfaces are wet from rain or mist.

Crops grown in the open field are far more likely to be infected than those produced inside structures. However, *Fusarium solani* and *Botrytis cinerea* can occur in greenhouses with good climate controls, particularly as they infect stems through pruning wounds and masses of spores develop that spread to flowers.

Symptoms of internal rot in capsicum

The internal symptoms depend on the organism responsible for the disease. *Alternaria* and *Botrytis* rots both result in dark coloured fungal mycelium around the seeds and placenta. Disease caused by *Fusarium* species results in white, or light coloured fungal growth inside the fruit, sometimes with a pink tinge. Bacterial rots have a soft, water-soaked appearance, accompanied by a putrid odour.

Figure 3. Internal rot in capsicum caused by *Alternaria alternata*. (Photo courtesy Premier Fruits).

Figure 4. Internal rot in capsicum fruit caused by *Fusarium* sp. The green circles indicate disease at the stem or distal end of the fruit. (Photo courtesy Proefstation voor de Groenteteelt v.z.w. Sint-Katelijne-Waver).

Diagnosis of internal rot in capsicum

The only way to be sure of the cause of the disease is to have a pathologist culture the organism and identify the causal organism. The most common disease in Australia is *Alternaria*, with infection via the flowers. However the other organisms mentioned in this fact sheet can also cause the disease, and cannot be ruled out without a formal diagnosis.

Control

1. Cultural controls.

Keep the flowers dry: Infection occurs under moist and warm, or moist and mild conditions. It is important to keep the flowers and young developing fruit dry as much as possible. This can be achieved by growing under protected cropping, or by growing in regions/ season where the likelihood of rain is low. Avoid overhead, sprinkler irrigation.

Keep the level of disease inoculum around the plant low. The organisms which cause this disease, are common in the environment, and also cause other diseases on capsicums and related plants. Keep disease pressure low around the capsicum crop, especially around flowering time.

2. Biological controls
Interestingly, there are reports in the literature of the beneficial bacteria *Bacillus subtilis* being effective against internal rot in capsicums caused by *Fusarium* sp. when applied to the flowers.

3. Fungicides
Protectant Fungicides: One approach to using fungicides to control internal rot in capsicums is to protect the flowers and developing fruit by applying fungicides with a current Australian registration or permit, especially when conditions favouring infection are expected (Refer Table 1).

This means applying protectant fungicide cover sprays from the start of flowering (open flowers) up to 21 days after fruit set, or 70-80% petal fall.

The following fungicides are registered for use on capsicums as of September 2015.

- Chlorothalonil: Botrytis and Anthracnose
- Mancozeb: Alternaria
- Metiram (Polyram®): Alternaria

These fungicides are all protectant and contact only (non-systemic) in their action. Therefore the chemical would need to land on newly opened flowers prior to any infection occurring in order to protect them. This means there is only a small window available to achieve effective protection on each emerging flower before infection takes place. Furthermore, the small size and shape of the flowers makes achieving good spray coverage difficult. This means the probability of getting effective chemical protection on all flowers is not high when using these protective/non systemic products. Once infection occurs on the flowers, these protectant fungicides will not inhibit a latent infection from developing.

Systemic fungicides: The fungicides Scala®, Teldor® and Switch® are systemic, protective and may also have some curative actions on latent infections. Therefore, these fungicides are better suited to protecting floral parts as they can be applied just prior to flowering and the plant will translocate them to the flower. Furthermore, Scala® and Teldor® have shown reasonable efficacy in controlling Botrytis latent infections in grape flowers.

For optimal protection against latent internal infections, under warm+ wet (high pressure) conditions, a rotation of Scala®, Teldor® and Switch® commencing at the start of flowering should provide strong protection against floral/latent rots.

There are several current permits for the control of Botrytis. These are PER12565 for Scala®; PER12447 for Teldor® and PER 11564 for Switch®.

Permit 14354 covers the use of Rovral® (iprodione) for Sclerotinia in Capsicums.

Note: Pesticides can only be used if covered by a current Australian registration or permit for the intended use, and in compliance with label and permit instructions.

4. Varietal susceptibility
There is good evidence of differences in varietal susceptibility to internal rot in capsicum. Growers are directed to contact seed suppliers for further information.

The bottom line…
Preventing infection of the flowers is the best solution. This means applying fungicides during the flowering and early fruit development stages of the crop, especially when you expect the flowers or young fruit to be wet.

For Further Information

Aponyi, I., O. Kujani, B. Balog and A. Varga (1988). "The ovary moulding disease of tomato-shaped pepper and control possibilities." Acta Horticulturae(220): 401-406.

Ginoya, C. M. and N. M. Gohel (2015). "Evaluation of newer fungicides against *Alternaria alternata* (Fr.) Keissler causing fruit rot disease of chilli." International Journal of Plant Protection **8**(1): 169-173.

Halfon-Meiri, A. and I. Rylski (1983). "Internal mold caused in sweet pepper by *Alternaria alternata*: fungal ingress." Phytopathology **73**(1): 67-70.

Stommel, J. R., R. W. Goth, K. G. Haynes and S. Kim (1996). "Pepper (Capsicum annuum) soft rot caused by *Erwinia carotovora* subsp. *atroseptica*." Plant Disease **80**(10): 1109-1112.

Utkhede, R. S. and S. Mathur (2005). "Biological and chemical control of fruit rot in greenhouse sweet peppers (Capsicum annum L.) caused by *Fusarium subglutinans*." Journal of Biological Sciences **5**(5): 610-615.