Factsheet 07/13

Field Vegetables

Cucurbit fruit rots

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This factsheet collates current knowledge on the biology of pre- and post-harvest fruit rots of outdoor cucurbits (courgette, pumpkin, marrow and squash) caused by various pathogens and provides guidelines on disease management options.

Action points

- Use seed that is pathogen-free.
- Monitor crop foliage for symptoms of disease that may later develop into fruit rots.
- Ensure symptoms on foliage and fruits are diagnosed early so that appropriate management practices can be developed and implemented to minimise economic losses.
- Practise crop rotations in which cucurbits are not planted for 2-3 years.
- Avoid damaging fruit, including bruising, before, during and post-harvest.

Background

1. Cucurbit wastage due to fruit rots

Courgette and pumpkin comprise the largest acreage of outdoor cucurbits in the UK, with smaller areas grown of marrow and a range of squash types. Production systems are contrasting for courgette and pumpkin. Courgette may be harvested every other day during the season and distributed immediately to retailers, with a relatively short recommended shelf life (about 7 days). Rot issues are restricted to those on developing and mature fruit. Losses due to fruit rots are variable but can result in yield reductions of up to 25%, together with increased labour costs for quality control in the field and pack-house. For pumpkin fruits which may be stored for up to 8 weeks prior to sale (either under plastic or glass, or in field wind-rows), post-harvest storage rots are the main problem and can cause losses in excess of 25%. Figure 1 shows an example of wastage due to fruit rots. Outdoor cucurbit crops are susceptible to fruit rots caused by a range of fungal and bacterial pathogens, with sources of inoculum including seed, soil, crop debris and air-borne spores. Depending on the pathogen, fruit rots may develop as a progression from foliar disease symptoms, directly on undamaged fruit or following damage to the fruit (due to either physical causes or infection by another organism). Alternatively, infections from early in the season may remain latent (symptomless) until after prolonged storage.

Description of fruit rots

This section describes the major rots caused by pathogens on outdoor cucurbits in the UK, with information on symptoms, causal organisms, sources of inoculum and conditions favourable for disease development.

Botrytis grey mould (*Botrytis cinerea*)

Botrytis grey mould is a common disease that can develop at any stage throughout cucurbit production, including post-harvest. Spores are readily carried by air currents from other infected crops or debris. The pathogen is opportunist and may colonise seedlings, flowers, leaf and fruit tissue that is old, or that has been damaged physically or as a result of some other primary infection. When plants have a high fruit load, some of the developing fruit and flowers may abort prematurely and these may get colonised by Botrytis (Figure 2). This can occur if there are lapses in harvesting or if plants are left to form marrows.

Infection is most common in cool wet conditions (around 15ºC) following periods of prolonged high humidity, for example, when foliage is very dense or when plant tissue is in contact with the soil. Lesions on flowers and fruit are irregular in shape, initially water-soaked and then turning brown. Infection may spread from flowers to developing fruit, so symptoms are often at the blossom-end of fruit. Typically, symptoms are seen as abundant fluffy grey-brown fungal strands bearing spore masses, while underlying tissue becomes rotted. When symptoms are severe, plant collapse and death can occur.

2. Rotting due to Botrytis grey mould on squash, with abundant spore production

Sclerotinia rot (*Sclerotinia sclerotiorum*)

Sclerotinia rot is rare on courgette but can occasionally be severe on pumpkin and squash. Sclerotinia rot may occur in the field during fruit production or develop post-harvest, and is favoured by cool weather and extended wet periods. *S. sclerotiorum* affects a wide range of crop and weed hosts so neighbouring fields previously infested with resting bodies (sclerotia) of the fungus can be an important source of inoculum. These sclerotia survive in the soil and germinate to produce small (ca. 1 cm diameter) fungal structures (apothecia) on the soil surface that release spores to infect cucurbit crops (Figure 3). Infection occurs via senescent plant tissues such as dead tendrils and petioles, stem injuries or withered flowers on developing fruit.

Early symptoms are water-soaked lesions on stems and fruit, followed by the development of dense masses of white, cottony fungal strands (mycelium) which may later become matted and discoloured. The presence of sclerotia (initially white-grey turning black as they mature) embedded within the cottony fungal strands is usually diagnostic of the disease (Figure 4). Soft wet rots may develop within fruit, and secondary infections are likely. Sclerotia develop in stems and fruit, particularly in seed cavities. The size of sclerotia varies from a few millimetres to over 1 cm in diameter. Occasionally diseased fruit dry and become mummified.

3. Spores released from apothecia infect cucurbits to cause Sclerotinia rot

4. Sclerotinia rot on squash, showing mycelium and developing sclerotia

Anthracnose (*Colletotrichum orbiculare*, syn. *C. lagenarium*)

This fungal disease is associated mainly with warm, wet weather since infection requires 24 hours of high relative humidity and optimum temperatures of 22-27ºC. Anthracnose symptoms were observed on the foliage and stored fruit of pumpkin from at least one UK farm in 2012. The pathogen overwinters on infested crop residues and can also be seed-borne; spores are spread by rain splash and during periods of overhead irrigation.

Leaf symptoms vary with cucurbit species but generally lesions are brown sometimes with a yellow border, roughly circular and may exceed 1 cm in diameter. Leaf distortion may occur and old lesions may crack or fall out giving a 'shot-hole' appearance (Figure 5). On petioles and stems, lesions are shallow, with elongated brown areas. Fruit symptoms are circular, water-soaked areas that later become black sunken lesions (Figure 6). Fruit and stem lesions may become covered with minute black fungal structures and pink spore masses which are useful diagnostic features.

5. Anthracnose symptoms on leaves with top right lesion showing a 'shot-hole' appearance

6. Dark anthracnose lesions on pumpkin fruit (top right) alongside Fusarium rots (left)

7. Scab lesions on cucurbit leaf, squash fruit and pumpkin fruit

Scab (*Cladosporium cucumerinum*)

Scab (also known as 'gummosis') was previously a constraint to courgette production in parts of the UK but there have been few reports of the disease in recent years. The pathogen can survive in crop debris and soil for up to 3 years and may also be seed-borne. It requires free water or high relative humidity for infection to occur and can develop over a wide temperature range (optimum 17-27ºC).

Leaf lesions are initially pale green and irregularly shaped, progressing to grey, sometimes with yellow borders. When humid, dark green fungal growth (spores) cover leaves and petioles. When severe, leaf distortion occurs and dead tissue cracks giving a tattered appearance. Small (2-4 mm) water-soaked sunken lesions on fruit subsequently darken to grey or brown, and develop as large cavities in which secondary rots may occur. Dark green spore masses cover lesions which produce sticky exudates (hence the alternative name of 'gummosis'). Figure 7 shows symptoms on leaf and fruit.

Fusarium rots (*Fusarium* spp.)

Rots due to *Fusarium* species occur primarily on pumpkin and squash, and fruit quality can be severely affected. Infected fruit samples from UK farms diagnosed in winter 2012 showed that a range of species were implicated including *F. culmorum* and *F. oxysporum*, which are both soil-borne pathogens. *Fusarium solani* f. sp. *cucurbitae* is also known to cause this disease and can be seed-borne. *Fusarium* species may infect crops at the seedling stage, affecting the crown and upper root tissues and causing water-soaked lesions at around soil level. Lesions become darker and may girdle the stem resulting in wilting and stem breakage, with white to pink fungal growth on affected tissues. Upper stem and lower root tissues are not usually infected.

For fruit rots to develop, fruit must be in contact with moist soil infested with pathogenic *Fusarium* species (Figure 8). On maturing fruit or after cutting, developing lesions can girdle stem 'handles' resulting in stem breakage (Figure 9). Surfaces

of fruit in contact with infested soil develop circular to oblong brown, firm, sunken lesions. White to pink fungal growth characteristic of *Fusarium* species often develops on affected areas, sometimes in concentric rings. Secondary infection by other pathogens may result in soft wet rots and fruit collapse.

8. Fusarium rot developing on pumpkin fruit surface that has been in contact with moist infested soil

9. Fusarium rot girdling stem 'handle' of squash

Gummy stem blight / Myco / black rot (*Didymella bryoniae* previously *Mycosphaerella melonis* / *Phoma cucurbitacearum*)

This disease (sometimes referred to as 'Myco') includes both foliar symptoms known as gummy stem blight (caused by the asexual form of the fungus *Didymella bryoniae*) and fruit symptoms called black rot (caused by the sexual form of the pathogen, *Phoma cucurbitacearum*). In glasshouse cucumber crops, leaf symptoms can be identified quite readily but are more difficult to distinguish for outdoor cucurbits. Initial leaf symptoms of brown spots often at leaf margins enlarge and merge to give leaf blight. Brown stem lesions expand into cankers which may girdle the stem (Figure 10), resulting in foliar wilting and death of seedlings; characteristic brown sticky exudates may ooze from cankers. Tiny black fungal structures (pycnidia) can develop in older leaf and stem lesions. Fruit symptoms are more obvious and the disease occurred relatively frequently in outdoor crops in 2012. On infected fruit (particularly pumpkin and squash), small water-soaked spots enlarge and exude gummy material. Lesions appear black as they contain densely clustered black fruiting bodies sometimes in concentric rings (Figure 11). White cottony fungal growth sometimes develops on fruit stored at high humidity. Older lesions can crack and there may be decay of inner fruit tissue.

Sources of inoculum for this disease include seed, soil and crop debris, with research showing that the pathogen can survive in fields for 2 years in the absence of susceptible crops. Warm (20-24ºC), moist conditions are most conducive for development of gummy stem blight and black rot, so this disease is more commonly associated with protected crops in the UK or in outdoor tropical climates. Fruits become infected either through wounds or through flower scars. Under ideal conditions, fruit rot can occur just 2-3 days after infection has taken place.

10. Close-up of a gummy stem blight canker girdling a cucumber stem

11. Black rot on pumpkin: densely clustered black fruiting bodies are an important diagnostic feature

Undiagnosed rots

A range of rots on UK cucurbits remain misdiagnosed or undiagnosed. For example, one grower reported that hail damage in 2012 resulted in corky sunken spots on foliage that could have been easily confused with a fungal leaf spot. Similarly there may be confusion between symptoms of oedema on courgette (caused by water stress) and those caused by the fungal disease scab.

Of particular concern is a symptom that was prevalent on courgette in 2012 ('internal rot disorder'). This symptom is associated with wet weather, soil splash and flowers in contact with the soil. Instead of normal flower senescence and drop, flowers develop a wet rot and remain attached to the developing fruit, with the rot spreading to the fruit at the blossom end. External symptoms may be seen as softness at the

fruit end and occasional dark rot (which could be confused with the abortion scar). Internally, brown discolouration occurs as a 'v-shape' in the vascular tissue at the blossom end and may develop further (Figure 12). Yield losses up to 25% can occur, plus extra labour costs for quality checks in the field and packhouse. The rot remains undiagnosed and is likely to be due to a pathogen (possibly *Didymella bryoniae*), although nutrient deficiency (as for 'blossom end rot') or physiological causes cannot be ruled out. Management of this problem with fungicides is difficult since it is undiagnosed and many products cannot be applied when fruits are being harvested every other day, due to harvest intervals. Cultural management practices include the use of varieties that drop their flowers early or manual flower removal which requires skilled labour as timing is critical.

Undiagnosed rots and breakdown of pumpkin can occur at any time in storage. One grower reports that despite very good post-harvest handling practices and glasshouse storage, fruit breakdown can occur even when there is no visible skin damage (possibly due to latent infections). The rot starts with a small blemish on the fruit surface and results in complete fruit collapse within a few days. The problem has not been diagnosed but is thought to be a result of earlier pathogen infection. The grower notes that sometimes the earliest harvested fruit store the best perhaps due to drier harvesting conditions and higher ambient temperatures in the glasshouse, enabling better 'curing' of harvested fruit.

12. 'Internal rot disorder' of courgette with brown 'V-shaped' discolouration of vascular tissue

Secondary rots

Extensive and severe fruit rots often develop when tissue that has been colonised by a primary pathogen (e.g. *Phoma cucurbitacearum*) or has been physically damaged, is subsequently invaded by secondary pathogens and saprophytes. Bacteria (such as *Pectobacterium* species and *Pseudomonas* species), fungi (e.g. *Mucor, Rhizopus* and *Geotrichum* species) and yeasts, enter via wounds and proliferate under warm and wet conditions resulting in soft rots, slimy tissue and rapid fruit breakdown.

Cucurbit rots reported elsewhere

Cucurbit fruit rots reported as major problems from other countries particularly the USA include Phytophthora crown and root rot (*Phytophthora capsici*) and angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*). Phytophthora has not been a major problem on UK cucurbits to date though there has been at least one confirmed case on outdoor cucurbits in the last few years (G.M. McPherson, pers. comm.).This soil-borne pathogen could potentially cause serious root and fruit rots particularly during wet seasons on poorly drained soil. Angular leaf spot symptoms are occasionally observed on cucurbit foliage (confirmed on courgette in 2012). Under conducive environmental conditions (warm and wet), infection could readily spread to fruits causing spotting and internal rots.

Bacterial wilt (caused by *Erwinia tracheiphila*) is a serious threat to cucurbit production in parts of North America but has not, to date, been reported in the UK. Symptoms on squash and pumpkin include wilting during the hottest part of the day, then recovery by the following morning. Wilting foliage is initially dark green then becomes yellow and necrotic around leaf margins before plant collapse and death. Bacterial ooze may be observed from the cut ends of affected stems. Squash fruit may become infected and develop small, irregular water-soaked areas on the fruit surface.

Disease management guidelines

- If available, use cultivars that are disease resistant.
- Several fruit rots (e.g. anthracnose, scab and gummy stem blight / black rot) can originate from seed-borne pathogens so it is important to use seed that is free from these pathogens (check with your supplier whether tests have been done).
- Certain cucurbit fruit rot pathogens can survive on crop debris between seasons, so ideally rotate crops to non-cucurbits for 2-3 years.
- Monitor crop foliage for diseases that may later develop into fruit rots. Ensure symptoms on foliage and fruits are diagnosed early (e.g. by a diagnostic plant pathology laboratory), particularly when new symptoms are observed, so that appropriate eradication or management practices can be developed and implemented.
- Diseases such as anthracnose can be spread by water splash and require leaf wetness for infection to occur; avoid using overhead irrigation especially late in the day when foliage may remain wet for long periods.
- If pumpkin crops have a history of fruit rots including anthracnose, scab or gummy stem blight / black rot, preventative fungicides (e.g. azoxystrobin) during the growing season could help to minimise foliar diseases and subsequent rots. Note that there are USA reports of strains of *Didymella bryoniae* / *Phoma cucurbitacearum* that are resistant to strobilurin fungicides such as azoxystrobin so follow label guidelines for minimising resistance risk.
- The biological fungicide Serenade ASO (*Bacillus subtilis*) can be used on outdoor cucurbits (under

an Extension of Authorisation for minor use). This could be used, for example, on courgette during fruit development (one application per crop) as it has no stated harvest interval. This fungicide has activity against a wide range of pathogens including *Botrytis cinerea*.

- Harvest, pack, handle, and store fruit carefully to avoid injuries as wounds enable pathogens to enter fruit during storage.
- Avoid harvesting during wet weather. Discard all fruit that are injured, or have rots or blemishes.
- Harvested fruit should be stored dry, with good ventilation and avoiding extremes of temperature.
- Fruit that develop rots during storage should be removed and disposed of carefully before infection spreads to other fruit.

Further information

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