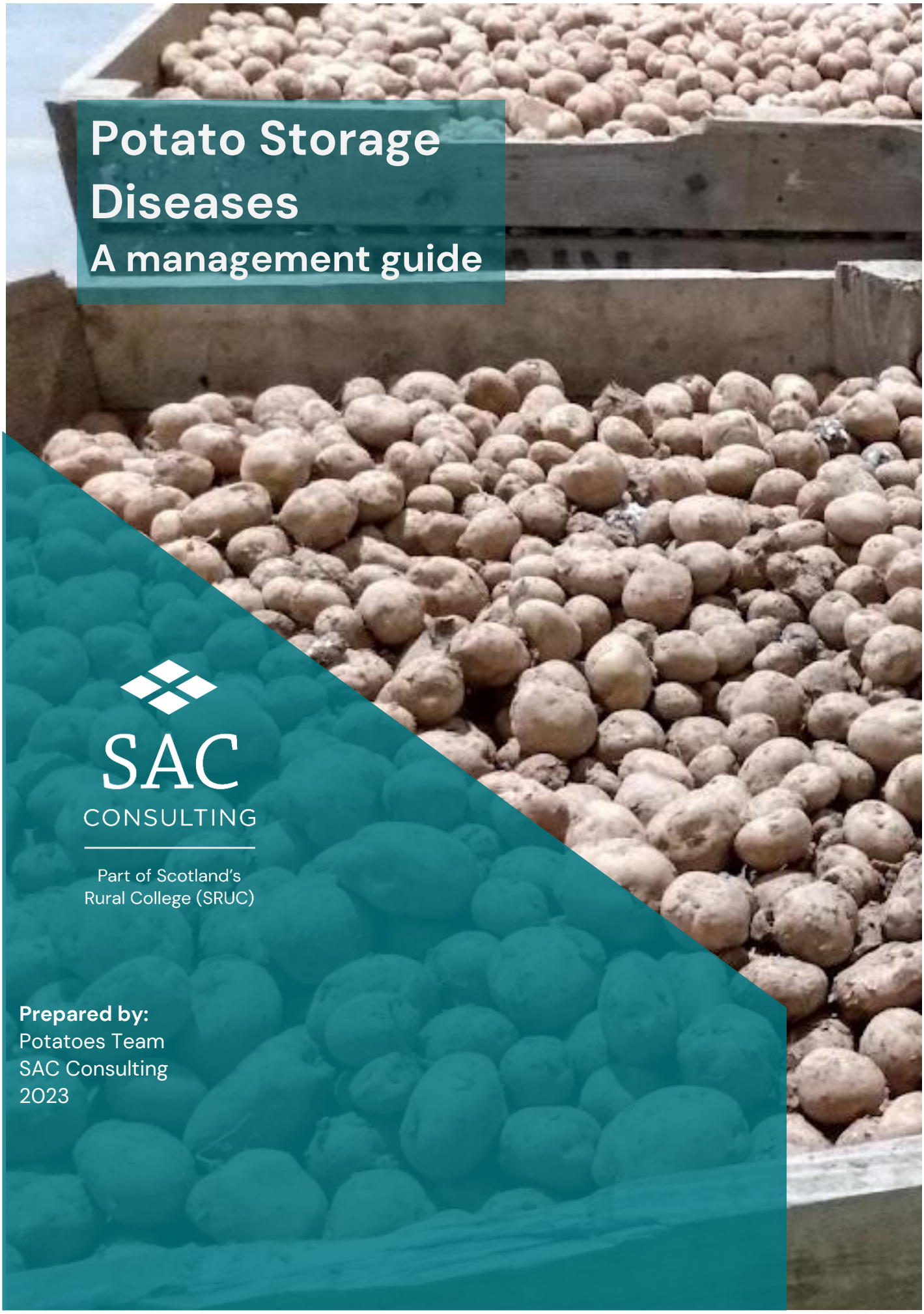

Potato Storage Diseases

A management guide

SAC CONSULTING

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Introduction

Well-managed modern potato stores regulate storage conditions very effectively, and thankfully loses to post-harvest disease during storage of potatoes has reduced markedly in recent decades.

Nevertheless, if not properly managed or safeguarded against economically damaging in-store losses can still occur. Prevention of an issue is always preferable to management of an issue. Potato storage disease fall into two groups: **blemish diseases** that impact skin finish and quality and **rots** which cause decay of tubers and direct loss of crop.

This guide begins by outlining **general principles** of **integrated disease management** (see below) followed by details on commonly encountered **blemish** (page 4) and **storage rot** disease (page 8). Finally, you can find a summary of cultural control methods for specific diseases on page 13, comments on using seed tuber treatments on page 15, and a brief discussion of fungicide resistance management on page 16.

There are some basic principles that reduce the risk of most disease, but there are also measures that are disease specific. It is important that you **assess the risk** of tuber diseases and determine which are a threat ***before*** deciding on control measures.

Integrated disease management

The best approach is to use and integrated disease management strategy. A chemical control measure may or may not be appropriate given the circumstances.

Some diseases originate in the field, and some are spread within store. Some diseases may not spread between tubers, but symptoms can worsen during storage depending on how the store is managed.

The following general steps should be carried out for all stores and stocks:

1. Practice good store hygiene.
2. Assess the risks to diseases.
3. Consider if a more resistant variety can be used.
4. Minimise handling and damage.
5. Avoid condensation.
6. Use ventilation judiciously and appropriately.
7. Store at appropriate temperatures.
8. Monitor stocks, diagnose correctly and act quickly.

Blemish diseases

Black dot

- Use an integrated management strategy in the growing crop.
- Cool crops rapidly following harvest
- Avoid contaminated fields
- Harvest early where possible
- Use a seed treatment if risk is high

Caused by the fungus *Colletoteicum coccodes*, black dot is a very important disease for the fresh potato market. The disease causes **unsightly silvery blemishes** to appear on the surface of the tuber, reducing their appeal and marketable value. These lesions can increase the rate at which water is lost from tubers. Some varieties such as Maris Piper and Estima are very susceptible to black dot.

Black dot lesions are very easy to confuse with **silver scurf**. Black dot lesions tend to be darker and less regular, but only by examining them under magnification can the characteristic small "black dots" (microsclerotia) be observed. The pathogen has been implicated in potato early dying disorder (PED).

Black dot is predominantly a **soil borne disease**, and many agricultural soils in GB are infested with the pathogen. There are some **soil tests** available to quantify the level of infestation and thus the risk to crops. The black dot pathogen can infect plant organs other than tubers – it is very common to see symptoms on stolons and stems following haulm destruction. It is not known if black dot spreads in store.

Prevention & Management

Choosing a **resistant variety**, **testing your soils**, and selecting **input seed** that is uncontaminated are important first steps – inspect stocks with a hand lens or send tubers for disease assessment. Select fields which are as **free as possible from contamination** – this can be very challenging in areas of intensive potato production.

Soil tests are available, but a knowledge of the **cropping history** and records of when black dot has occurred previous can be very informative. Short rotations increase the risk substantially. **Reducing crop stress** by ensuring adequate water and nutrient provision makes plants less susceptible to many diseases including black dot. If, and only if, the risk of black dot is judged as high then chemical control options may be necessary. Soil applications of azoxystrobin (applied in-furrow) have proven effective in field trials. Some trials have demonstrated a reduction in black dot from seed treatment with fluxapyroxad and fludioxonil. Both Honesty and Maxim 100FS have label claims for reduction in black dot.

Silver scurf

- Select healthy input seed
- Harvest early where possible
- Practice good store hygiene
- Keep stocks cool and avoid condensation
- Use a seed treatment if disease is present

Commonly confused with black dot, the blemish disease **silver scurf** is caused by the fungus *Helminthosporium solani*. As with black dot, silver scurf presents as **silver lesions** on the surface of the tuber – these are generally more circular and with more of a shiny appearance than black dot, but **examination under magnification** is needed to truly distinguish between the two diseases.

The disease is most obvious on red skinned or russeted varieties, but often occurs on white skinned varieties as well.

When examined with a hand lens or under a microscope it is possible to see **black thread-like** conidiophores (which hold fungal spores). This is sometimes said to give the lesions a **sooty appearance**.

Silver scurf is very unlikely to affect yield, but it can have a large impact on **quality**. The disease affects the tuber periderm (skin) making it more **permeable to water** and stocks affected with silver scurf can sometimes **shrivel in store**, particularly if ventilation rates are high.

The disease is predominantly **seed borne**. Lesions present on planted tubers produce spores that threaten daughter tubers, and spores present on seed tubers at planting can rapidly develop into new lesions. The disease can also **spread in store**, making **store hygiene** and **stock assessment** very important.

Prevention & Management

Health of input seed is key to the management of silver scurf. Choose stocks with a **low disease burden** and if possible, select **varieties** that are resistant to the disease. **Store hygiene** is paramount for silver scurf control as spores can persist in store dust and infect stocks during the storage period.

There are chemical control options (imazilil and thiabendazole), these are best applied **early following harvest** to stocks going into store. Treated seed must never enter the human or animal food chains.

Rhizoctonia (black scurf & growth distortions)

- Select fields which are low-risk
- Reduce interval between haulm destruction and harvest
- Delay planting if conditions are poor
- Use a seed treatment if disease present

Perhaps one of the most important threats to potato production; the fungal pathogen *Rhizoctonia solani* causes several issues to potato crops including the blemish disease **black scurf**, **growth distortions** to tubers, and stem and **stolon canker**. If not adequately managed Rhizoctonia can cause a great deal of damage.

Several different strains of the pathogen known as AGs (anastomosis groups) exists – a few of these attack potato plants, the most commonly encountered in potato production as well as the most likely to cause black scurf is AG-3.

Rhizoctonia can be both **seed and soil borne**. Soil testing for the pathogen is technically possible, but as it occurs in a patchy distribution, results can be difficult to interpret. Cropping history can be a useful guide but Rhizoctonia has a **wide host range** meaning wide rotations are not always a guarantee of low pressure. Seed tubers contaminated with **black scurf** (jet black or dark brown structures on the tuber surface called sclerotia) can readily be detected after washing, but **latent infections** are also possible – several laboratories can perform **visual tests** to detect runner hyphae on the tuber surface.

Black scurf **reduces quality** and **marketability**. **Stem** and **stolon cankers** (reddish brown lesions) can result in **pruning** that **reduces yields** and throws off **tuber size distribution**. This is particularly likely if infection occurs early in situations where **emergence is slow**. Lesions on the stems can interfere with water transport and cause **wilting** and **stunting** symptoms in the stem system.

Prevention & Management

Rhizoctonia can only be managed through an **integrated approach**, and no one single control measure is completely effective. The pathogen is **very common** in soils in northern Europe and has a large host range – but field history should inform risk. The most critical timings for **disease risk** are **planting** (when early infection may occur) and the interval between **haulm destruction and harvest** (when black scurf develops). Encouraging **rapid emergence** (for example by chitting seed or only planting when conditions are good) will lower risk. As reliable information on varietal susceptibility is poor, but varieties where skin set is rapid will allow for earlier harvest. Several **chemical control options** are available for Rhizoctonia, see the table on page 15.

Skin spot

- Use disease free seed
- Avoid susceptible varieties if possible
- Extend rotations
- Lift early in warm conditions
- Practice good store hygiene
- Use a seed treatment

Skin spot is a very unsightly blemish diseases caused by the fungal pathogen *Polyscytalum pustulans*. Symptoms of the disease are small clusters of raised dark spots or bumps on the tuber surface.

These are often clustered around the tuber eyes, and if infection is particularly severe eyes can be killed resulting in poor emergence and a reduction in stem numbers.

The disease is much less common than it once was, but it can still be encountered in **susceptible varieties** such as King Edward. The disease also **spreads in store**, and certain stores can have issues – **particularly if they are damp**.

Spores of the pathogen can survive in **crop debris**, **soil**, and in **store dust**. The disease is both seed and soil borne, but **long rotations** (greater than five years) can significantly reduce soil inoculum.

One distinctive feature of skin spot is that the disease is **encouraged by lower temperatures** and has an extremely **long latent period**. It takes several months following harvest for symptoms to develop. So **regular inspection** of higher risk stocks in store, **particularly where holding temperatures are cold** is very important.

Prevention & Management

Skin spot is promoted where conditions are **cold and wet**, so an early harvest in **dry conditions should reduce** the risk of infection. Wet conditions early in the storage period are also very conductive to infection. **Lifting as early as possible** is preferable, as it is period of **dry curing** and **ventilation** immediately following lifting. There is some evidence that using sprout suppressants increases disease risk for skin spot.

Good store hygiene is very important for the control of skin spot. If you have a store where the disease has occurred healthy stocks could become contaminated, so ensure thorough cleaning and disinfection. Spores of the fungus are very small and so sweeping should be avoided if possible – vacuuming is preferable.

Tuber rots

Bacterial soft rotting

- Strong store hygiene
- Ventilation & temperature control
- Early harvest
- Minimizing damage

Soft rotting is probably the most important cause of post-harvest losses. **Bacteria** cause soft rotting by releasing enzymes which break down the structure of the potato tuber. Once tubers have begun to break down, they can **contaminate neighbouring tubers** within a stock. It is very common for bacterial soft rotting to occur as a **secondary infection** – for example a stock with tuber blight or dry rot may develop **secondary bacterial rots**. Such stock can breakdown rapidly.

Bacteria can invade tubers at the **lenticels**, along **stolons**, or at **damage points**. Soft rotting can occur both in-field and later during storage. Infected tissue is initially cream coloured but darkens with time. Diseased tissue loses integrity and becomes a liquid ooze containing bacteria. There are many species of bacteria that could cause soft rots, but the most common in the UK is *Pectobacterium carotovorum*. A related species, *Pectobacterium atrosepticum* is the major cause of **blackleg** in Britain and Ireland – bacteria may multiply latently on contaminated tubers and result in blackleg in the field.

Prevention & Management

Bacteria thrive where there is **moisture** and **warmth** – their multiplication rate is very rapid, so it is important to **identify** and **manage soft rotting quickly**. There are no chemical control measures available. **Avoiding condensation** is key, as is bringing tubers to **as low a holding temperature** as practical as quickly possible. If a stock is high risk (e.g. if **harvest has been wet**) or contains soft rots, then **active ventilation** will mummify infected tubers and limit spread.

Preventing damage and **early harvesting** should reduce the risk of soft rotting. Disinfection of surface and equipment will limit spread to clean stocks. High health input seed with low bacterial contamination is an important first step.

There are varietal differences to blackleg susceptibility in field and some **varieties** may be more prone to soft rotting, but because it is often a secondary condition ranking them is difficult.

Dry rot

- Good hygiene
- Avoid damage during harvest and grading
- Ensure skin set is complete before harvest
- Use a seed treatment if stock judged to be at risk

Dry rot is a fungal disease caused by several species of *Fusarium*, in GB there are four common species with *F. coeruleum* the most encountered in northern Britain. The pathogens can only infect tubers **through wounds** so factors such as **incomplete skin set** or **overhandling** are risk factors.

As its name suggests, dry rot lesions are **firm**, but they can frequently become invaded by soft rotting bacteria (see page 8). Externally dry rot lesions are roughly circular and brown/black in colour. A distinctive feature is the **wrinkled skin** at the edge of the lesion. It is common to see **white pustules** on the tuber surface. Internally disease tissue is **brown coloured** and often contains **cavities** lined with fluffy **mycelium**. The edge of internal lesions usually grades into healthy tissue. Symptoms can vary a great deal depending on the species of *Fusarium* and the potato cultivar. Dry rot is commonly be confused with gangrene.

The four common species of *Fusarium* that cause dry rot differ in their **aggressiveness** (the severity of disease which they cause), *F. sambucinum* (formally known as *F. sulphureum*) is thought to be the most aggressive. Seed tubers or seed pieces that are planted with dry rot infection may **break down rapidly** and cause **uneven emergence** and **blanking**.

Prevention & Management

The two most important steps for managing the risk of dry rot are the **prevention of damage** and **good hygiene** (as spores can spread in store). As with most other diseases good **ventilation** and **temperature** control can reduce risks**. Dry curing** is particularly important as is warming seed before grading to prevent damage.

Varieties prone to damage are more at risk of dry rot infection. There are thought to be differences between which potato varieties are susceptible to which *Fusarium* species. There are several **seed treatments** which are highly effective against dry rot, particularly if they are applied in a timely manner, see page 13.

Gangrene

- Good store hygiene
- Early harvest and haulm destruction
- Dry curing
- Careful handling
- Seed treatment if risk is high

Gangrene is a firm rot of tubers which is easy to mistake for *Fusarium* dry rot. Potato gangrene is caused by the fungal pathogen *Phoma foveata*. Gangrene lesions can be variable in appearance which makes diagnosis challenging, but in general they appear as **discoloured grey depressions**, sometimes described as "thumb print like" the edges can sometimes appear **wavey**.

Internal lesions are again very variable in size and appearance – a small surface lesion may hide an extensive tuber rot. In general gangrene lesions are **very dark**, almost **purple/black coloured** and have a **well-defined edge** between healthy and diseased tissues.

P. foveata produces very small spores called pycnidiospores which can lay dormant in **store dust** and contaminate seed tubers. The pathogen infects plant stems early in the growing season but grows asymptotically. **Senescence** or **haulm destruction** triggers the release of spores from lesions which can then threaten the daughter tubers.

As with dry rot, **damage** is the most important route of pathogen ingress. The disease is often associated with **cold storage temperatures** – probably because risk of damage is increased, and wound healing is slowed at low temperatures.

Prevention & Management

Because of the pathogen's life cycle **early haulm destruction** and **harvest** should decrease disease risk as long as damage is not increased. As with dry rot, **reducing damage** at harvest is an important management priority.

Dry curing is an effective strategy for reducing the risk of gangrene attack, but it must be done rapidly following harvest. There are differences in susceptibility between varieties, but very little information is available on the relative rankings.

There are seed treatment options for the control of gangrene, which are most effective if applied in a timely manner (page 13).

Watery wound rot (Pythium)

- Avoid damage
- Avoid condensation
- Dry cure lifted crops
- Avoid fields with a history of the disease

Watery wound rot, also called Pythium leak is a condition that occurs sporadically, but the incidence is probably higher than is generally appreciated because it is often misidentified as bacterial soft rot. The disease is caused by a fungus-like pathogen *Pythium ultimum* and related species.

The disease manifests as a spongy rot, firmer than bacterial soft rotting. An affected tuber may have a stretched-out blister like appearance which fluid may leak from. Within the tuber affected tissue has a creamy/cheesy texture which darkens as the lesion ages. There may be vacuoles present in the infected tissue, but a key feature of these is that there will be no fluffy mycelium lining them.

Lesions are very frequently invaded by bacteria which cause secondary rots.

The *Pythium* pathogens that cause watery wound rot are common inhabitants of agricultural soils and can persist for many years as resting spores. The pathogen requires an opening, so infection usually happens through wounds at harvest (hence watery *wound* rot), but disease development in-field has been reported (though damage is probably still involved).

Prevention & Management

Tuber temperatures at harvest are a major risk factor, with temperatures above 20 °C increasing risk substantially – if harvest can be timed for cooler conditions risk will be reduced. Fields with a history of the disease should be avoided for potato production.

As with many of the diseases mentioned in this guide, free moisture is important for infection so dry curing and managing stocks to avoid condensation are key to reducing risk.

The disease is associated with damage, so careful handling is important. Differences in varietal susceptibility do exist, but there is sparse information on them.

Late blight

- Practice good blight control during the growing season
- Ventilate blighted stocks
- Find end-use for stock as soon as possible
- There are no chemical control options once a stock is infected

Caused by the fungus-like pathogen *Phytophthora infestans*, **tuber blight** is a very serious issue if found. It is important to note that in GB there are **no approved control measures that can be applied to tubers for this phase of this disease**.

If late blight has been **active in the crop** foliage (even at a low level) and if conditions are wet, **spores** can be **washed** onto the soil, swimming spores (**zoospores**) can then be released, particularly if temperatures are cool. These can infect tubers in the field.

Blighted tubers have external **irregularly shaped** slightly shrunken brown or purple patches (lesions). Internally, affected tissue is **light brown** and **grainy** in appearance. Once tuber blight develops it is very common for secondary infections to occur and for bacterial soft rotting to set in.

Prevention & Management

Good crop protection practice including the use of **fungicides** in the growing crop is crucial. This is beyond the scope of this document, but information can be found from sources such as **Euroblight**[1] and PPP manufacturers' websites[2].

Tuber blight develops quickly and can **spread in store**. It is also commonly associated with **secondary bacterial soft rotting**. If you identify a stock with tuber blight, you must act quickly as whole crop loss is possible. **Ventilate** the affected stock and, if possible, **isolate** the affected boxes. **Limit storage duration**. If you suspect a stock is at risk from tuber blight, you must inspect it frequently – wash up samples as the disease can be difficult to identify in unwashed tubers.

[1] https://agro.au.dk/forskning/internationale-platforme/euroblight
[2] https://www.agricentre.basf.co.uk/en/Crop-Solutions/Potatoes/

Table of cultural control measures

The table below summarises the cultural control measures for the diseases covered in this guide – you should address these first before considering a seed treatment.

Disease	Control measure								
	Varietal resistance	Minimise Damage	Harvest early	Dry curing	Low holding temp	Rapid temp. pulldown	Store hygiene	Chitting	Long rotation
Blemish diseases									
Black dot	✓	–	✓	✓	✓	✓	–	–	✓
Silver Scurf	–	–	✓	✓	✓	–	✓	–	–
Rhizoctonia	–	–	✓	–	–	–	–	✓	✓
Skin Spot	✓	–	✓	✓	–	–	✓	–	–
Tuber rots									
Bacterial soft rot	✓	–	–	✓	✓	✓	✓	–	–
Watery wound rot	✓	✓	–	✓	✓	–	–	–	✓
Dry rot	✓	✓	–	✓	✓	–	✓	–	–
Gangrene	✓	✓	–	✓	–	–	✓	–	–
Late blight	✓	–	–	–	–	–	✓	–	–

Varietal resistance to blemish diseases

The groupings below are taken form the potatoes variety database which is derived from National List testing and Independent Variety Trials.

Black dot	
Highly susceptible	Highly resistant
Arsenal Jazzy Lady Claire Maris Piper Safiyah	Harmony Innovator Ivory Russet Saxon Taurus
Silver Scurf	
Highly susceptible	Highly resistant
Asterix Daisy King Edward Sylvana	Cara Eurostar Jazzy Nectar
Skin Spot	
Highly susceptible	Highly resistant
Daisy Kerr's Pink King Edward	Amora La Strada Taurus

Table of seed treatments

Label claims for control and/or reduction for commonly encountered diseases are given in this table – other factors such as disease burden and timing play an important role in performance.

Disease	Into store		Pre-planting			
	Storite Excel (thiabendazole)	Gavel (imazilil)	RhiNo (flutolinil)	Maxim (fludioxonil)	Serenade (biological)	Honesty (fluxapyroxad)
Blemish diseases						
Black dot	–	–	–	✓	–	✓
Silver Scurf	✓	✓	–	✓	✓	✓
Rhizoctonia Black Scurf	–	–	✓	✓	–	✓
Skin Spot	✓	✓	–	(✓)	–	(✓)
Tuber rots						
Bacterial soft rot	–	–	–	–	–	–
Watery wound rot	–	–	–	–	–	–
Dry rot	✓	✓	–	(✓)	–	(✓)
Gangrene	✓	✓	–	(✓)	–	(✓)
Late blight	–	–	–	–	–	–

✓ = Label claim for control or reduction

(✓) = SAC trials evidence

Staying compliant with seed treatments[3]

Labels must always be followed when potato seed treatments are applied to tubers. First, no treated tubers must ever enter the human or animal food chains. There is no issue with treating seed tubers from which the *progeny* tubers will be used for consumption or stockfeed.

When treating seed tubers there are different restrictions for different products, and it is important that you consult the relevant label before use, but in summary:

RhiNo and Honesty may be used to treat seed tubers for ALL CROPS.

Gavel, Storite Excel and Serenade can ONLY be used on seed tubers grown to PRODUCE SEED.

Maxim 100FS can be used on crops for consumption and seed tubers grown to produce SEED ONLY FOR EXPORT ONLY.

[3] All information accurate at time of writing (Sept. 2023). Check currently labels before use.

Using a seed treatment

Risk Assessment

We advocate assessing the risk of tuber diseases before a seed treatment is considered. Not every stock requires treatment and the use of a seed treatment where it is not required is wasteful. Equally, omitting a seed treatment where it is genuinely required risks substantial losses.

Each disease has key **risk factors** which can be found in the relevant sections of this guide (pages 4 - 12). For example, if harvest of a **susceptible variety** occurred under **dry conditions** and damage likely occurred the risk of ***Fusarium* dry rot** is high. You would be well advised to consider a seed treatment in this instance. Similarly, if harvest has been delayed then the risk of **gangrene** and **skin spot** is increased.

Always gain a recommendation from a BASIS qualified advisor before using a plant protection product. Seed treatments will not cure infections on mother tubers but may help to prevent spread to healthy tubers within a stock and can sometimes reduce transmission to daughter tubers in the field. All seed treatments approved for use on potato tubers can only be applied to seed tubers – tubers treated with plant protection products cannot be used for human or animal consumption. There is no issue with daughter tubers from a seed treated mother tuber as long as other label restrictions are followed (see page 14).

Presence of a disease on a seed stock can be an important factor in risk to daughter tubers for some, but not all, tuber diseases. There is limited information for risk thresholds, so it is prudent to take a conservative approach and to treat stocks if any disease is found. This is particularly the case for Rhizoctonia, which can cause a great deal of damage from even light contamination of input seed.

Remember that some disease such as **dry rot**, **gangrene**, and **skin spot** have latent periods and are unlikely to be found early in the storage period.

There are several commercial risk assessments such as **eye plug incubation tests** or **molecular diagnostics** available, including some that can detect latent infections (of *Pectobacterium* for example) that are not obvious from a simple wash-up.

Sometimes a seed treatment can increase the risk of certain diseases – this is particularly the case for bacterial sort rotting, whereby the introduction of free moisture encourages bacterial multiplication. It is important to correctly identify a problem before using an intervention.

The condition of tubers is also an important – tubers with a high soil covering will be shielded from tuber treatments. If tubers are wet at time of treatment, then seed treatment performance may be compromised.

Disease Identification

Proper disease identification is important for appropriate management. Several diseases within this guide are easy to confuse, and some occur together which complicates diagnosis. If in doubt, seek expert advice from your agronomist or by sending samples to a plant clinic.

Fortunately, several of the basic management methods (good hygiene, ventilation, temperature control) apply to all diseases. That said, correct identification is very important for deciding if a seed treatment is appropriate.

Timing

It is important to consider **when** a seed treatment will be applied and if the intended effect is to protect the tubers themselves or to limit transmission to progeny tubes. Broadly speaking there are two potential timings:

1. In-to-store or at harvest treatments to prevent disease development during storage.
2. Pre-planting treatments to protect progeny tubers.

It's often convenient to treat tubers following grading to fulfil orders. When selecting a timing you should always stay within the specification of the product label. As a general rule **early timings** are better at limiting disease spread within a stock.

If the objective is to protect progeny tubers, treatment closer to planting is appropriate, but provided that seed is stored in an appropriate manner tubers can be treated well ahead of planting without a substantial drop in efficacy. However, it is best to avoid treated seed that has broken dormancy – the likelihood of damaging sprouts is high.

Fungicide resistance

There is very limited information on fungicide resistance for the pathogens detailed in this guide (apart from for the field phase of *Phytophthora infestans*).

Historically, some resistance to thiabendazole has been detected in *Helminthosporium solani* (silver scurf), *Polyscytalum pustulans* (skin spot) and some (but not all) of the *Fusarium* species that cause dry rot. Resistance to other fungicides is found in other regions. The current prevalence of resistance in most

potato tuber pathogens is not known for the United Kingdom and the Republic of Ireland.

There are some resistance management steps that should always be taken when using seed treatments. These include:

1. Only using a fungicide where there is a genuine need, following an appropriate risk assessment.
2. An integrated approach is used, where cultural methods such as dry curing, store hygiene, and ventilation are used in conjunction with a fungicide.
3. Minimise the use of the same fungicide actives in consecutive years. This is challenging with seed treatments as the number of available actives is small, again highlighting the importance of an integrated approach.
4. More information can be found at the FRAC[4] and FRAG[5] websites.

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[4] https://www.frac.info/

[5] https://ahdb.org.uk/knowledge-library/the-fungicide-resistance-action-group-frag-uk