Technical Note TN630

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Potato Storage Diseases

SUMMARY

- **Potato yields and marketability are reduced significantly by a wide range of disease problems during storage.**
- **The risk of losses can be significantly reduced by appropriate storage conditions and by integrated cultural control methods (table 1), often involving varietal resistance and attention to agronomy of the growing crop.**
- **There are also fungicide treatments that can be applied as seed tubers enter and leave storage which will further reduce the risk of disease losses.**
- **Options for applying fungicides on crops destined for use as ware are more limited.**
- **Fungicide treatment of potato seed tubers can be necessary for the control of diseases such as silver scurf, skin spot, dry rot, gangrene and black scurf/stem canker.**
- **Tubers should be treated only after an assessment of the diseases/pathogens on tubers followed by an appraisal of the potential benefits of any proposed treatment.**
- **Samples of tubers should be drawn from stocks, washed and assessed for the presence of each disease prior to considering an appropriate treatment.**
- **Consideration should also be given to the amount of damage present within the stock and a judgment made as to whether or not the stock is suitable for treatment.**

Before deciding to use a fungicide:

- Consider and implement all appropriate cultural controls
- Be sure of customer requirements
- Sample and wash tubers from a stock to identify potential diseases
- Assess disease and damage levels to a stock
- Determine whether or not a stock is treatable (i.e. are tubers wet or covered in soil)

Table 1. Cultural control techniques to use in conjunction with seed treatment fungicides.

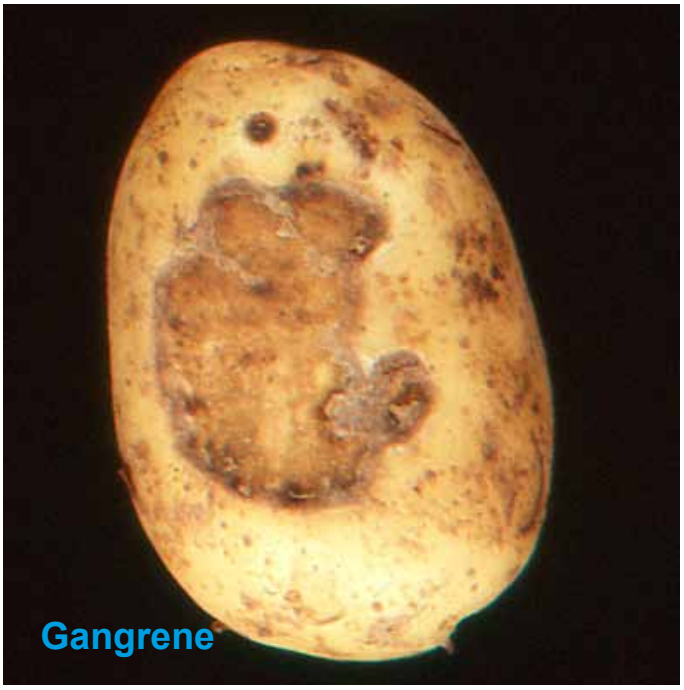
	Silver scurf	Skin spot	Dry rot	Gangrene	Rhizoctonia	Black dot
Choosing a variety with good resistance (see British Potato Variety Database www.potato.org).		+	+	+		+
Minimising damage[1]		+	+	+		
Early harvest	+	+		+		
Dry curing	+	+	+	+		+
Low holding temperature	+		+		+	+
Chitting seed					+	
Long rotation					+	+

[1]Techniques that minimise damage include good bed preparation, de-stoning, good skin set, correct harvester setting and careful handling at grading etc.

+ = some control achievable * see British Potato Variety Database (www.potato.org)

Disease risks

• Gangrene • Dry rot • Silver scurf • Black dot • Skin spot • Soft rot



Gangrene is a progressive tuber rot caused by the fungal pathogen *Phoma foveata*. Typically, the symptoms are dark, discoloured, sunken 'thumb print' lesions on the surface of the tuber. Internally the rot is dark or black in colour with a distinct margin between affected and healthy tissue which differentiates it from dry rot which will generally have a more diffuse margin. Internal cavities will occasionally show a grey / yellow mould. The fungus is both tuber and soil borne and infection generally follows handling operations in which bumps and wounds enable entry of the pathogen. The disease is favoured by low temperatures and can, therefore, be problematic in cold storage. It can also be overtaken by bacterial soft rots, especially when tubers are removed from cold storage.

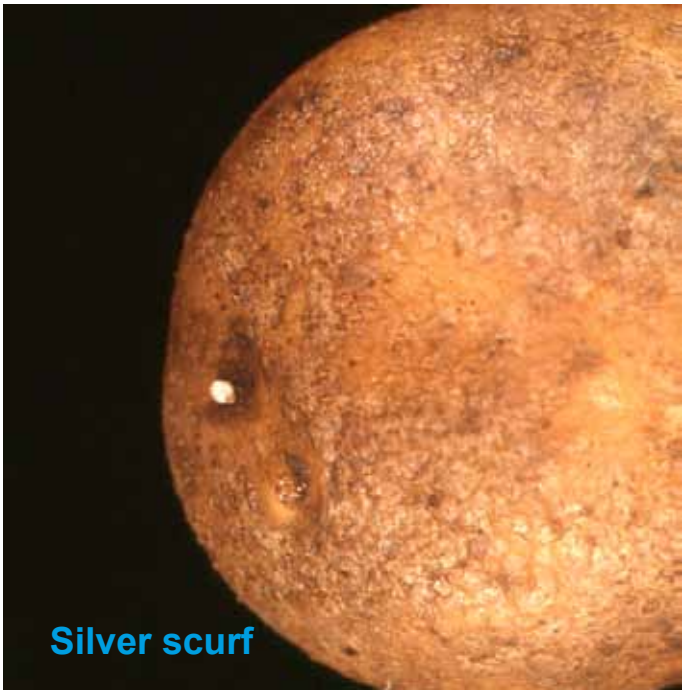
Control

Disease prevention by cultural methods is recommended including minimising damage at harvest and allowing wound healing and skin set prior to storage through adequate curing. Careful handling will also reduce the risk of disease development. Varieties differ in their susceptibility and some (e.g. Maris Peer) are less susceptible. Seed treatments have not proved effective at reducing gangrene in the following crop but treatment at harvest with imazalil and/or thiabendazole may reduce development in store.

Dry rot (*Fusarium* spp.) is a tissue rotting fungus which enters the tuber through wounds in the skin. The disease can affect seed and ware quality. Symptoms on the tuber surface vary with species of *Fusarium*. In Scotland, *F. coeruleum* is the most common cause of dry rot producing circular brown necrotic lesions on the surface of the tuber. Affected skin is often wrinkled with concentric rings and white, blue or yellow fungal growth forming in the centre of rot. Underneath these surface symptoms the rot is brown in colour and usually dry, often with a diffuse edge between healthy and affected tissue. Cavities are often lined with white mycelia. The tubers can quickly be overrun with bacterial soft rots. The fungus is soil borne and infection takes place through wounds and damage at harvest, at grading and during handling. It can also find entry points through eyes where disease pressure is high or where sprouts are removed at planting when it can give issues with blanking at emergence. During storage, the disease is favoured by warm and humid conditions. *F. sulphureum* is an equally aggressive pathogen but is much less common in Scotland than *F. coeruleum*. The pathogen is also less prevalent in Scotland than in England or northern Europe. On the surface lesions are similar to those of gangrene but internally appearance is more similar to dry rot except that cavities are filled with dry grey powdery tissue.

Control

Disease risk is reduced by avoiding mechanical damage at harvest and by avoiding planting diseased seed tubers. Allowing skin set and wound healing through dry curing prior to cold storage reduces damage levels and hence the risk of disease ingress. Cool and dry storage will further manage the problem after harvest. The risk of tuber blanking at emergence is reduced by planting into warm, dry soils. Some varieties are very susceptible to dry rot e.g. Maris Piper which increases the risk. Others, such as Golden Wonder and Rubesse have better resistance. Application of fungicides throughout seed multiplication is recommended where dry rot risk is high (e.g. susceptible varieties and high temperature storage). Treatment with imazalil and with thiabendazole (TBZ) in the absence of TBZ resistance has proved effective in reducing disease levels but should only be used in conjunction with the good cultural control measures listed above. In order to maintain TBZ efficacy until the year of ware planting, its use through the seed multiplication phases is not recommended.



The surface blemishing disease, skin spot is caused by the fungal pathogen *Polyscytalum pustulans* which gives rise to small, raised spots or pimples on the surface. The disease develops gradually in storage and can affect the marketability of pre-pack and processing ware potatoes, particularly if lesions are of a depth that is not readily removed by peeling. It also reduces the saleability of seed and can affect the emergence of plants if eyes are infected. The fungus also infects roots and shoots but this is not known to cause economic damage. The disease is favoured by wet conditions at lifting and by cold storage conditions.

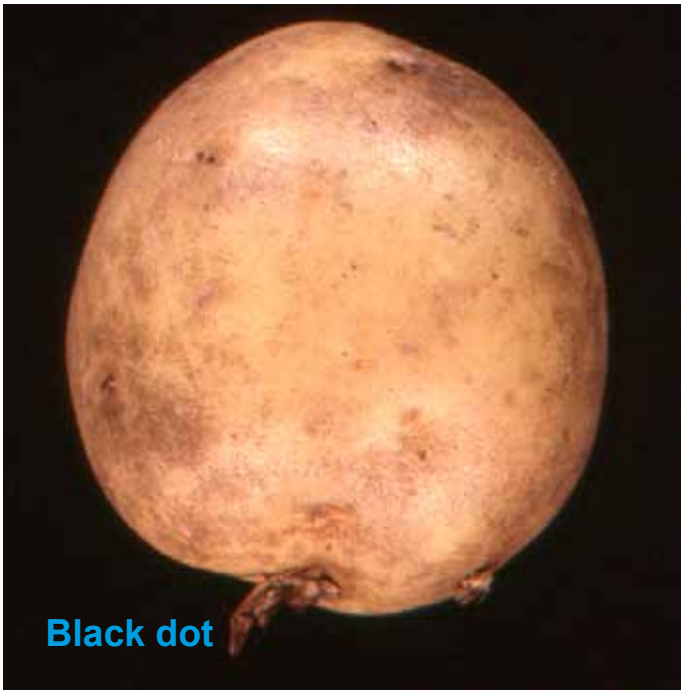
Control

No varieties are fully resistant but some are far more susceptible than others, for example King Edward is poor while Nadine is better (see British Potato Variety Database www.potato.org). Chitting seed potatoes early and planting into warm soils will reduce the risk of emergence problems. After harvest, dry curing reduces the risk of skin spot. Unfortunately the cool storage conditions necessary for long term storage are highly conducive to the disease. Preventative seed treatments going into store can reduce the risk of the disease developing. If left unchecked, the fungus can increase during seed multiplication. Application of fungicide throughout seed multiplication, following anti-resistance guidelines is recommended particularly on susceptible varieties. Best results have been achieved in the past by applying chemical treatments at store loading rather than prior to planting. Strains of skin spot fungus resistant to TBZ have been recorded in Scotland and these persist in the absence of treatment with this fungicide. The use of TBZ is discouraged during seed multiplication in order to enable its use on the ware crop as this is the only suitable fungicide approved for use on ware potatoes. Imazalil and mixtures of imazalil and TBZ can be used on seed potatoes to provide effective control. Cultural control measures starting with high grade seed, early lifting, maintaining high levels of store hygiene and drying produce into store are essential components of an effective control strategy.

Silver scurf is caused by the fungal pathogen *Helminthosporium solani*. It causes areas of skin damage resulting in a silvery appearance hence the name. Affected skin can also flake off. The silveriness is particularly apparent when lesions are wet. The lesions can also have a slightly sooty appearance from the development of the fungal spores, often around edge of older lesions. The disease affects the appearance of tubers, reducing the marketability of ware tubers particularly in the washed ware market. Although the disease is principally seed borne, there is no relationship between the amount of silver scurf on seed tuber and that on daughter tubers. Unless seed tuber is shrivelled, silver scurf will not affect yield of the growing crop but can result in some loss of tuber weight during storage when tubers are severely affected. The disease is favoured by warm and humid storage conditions and severity can increase during storage.

Control

Cultural control methods remain important and minimising disease development during seed multiplication can be helpful. Good seed health is therefore an important starting point. Varieties differ in their susceptibilities and some like King Edward are weak while others like Cara are better (see British Potato Variety Database www.potato.org). Symptoms can result in a loss of colour on varieties with pigmented skins. Early harvest reduce the amounts of disease that will be present at harvest. Controlled storage can minimise the development of silver scurf during storage and temperatures should be held at less than 5^{o}C and condensation should be minimised as this increases the risk of the disease developing. While storage at low humidities reduces silver scurf risk, it may increase water loss from tubers so a balance is required. Fungicide treatments into store are effective in reducing the amount of silver scurf developing during storage and treatments out of store reduce the further risk of development on the growing crop. Active ingredients available are thiabendazole and imazalil. As with skin spot, imazalil is not approved for use on ware potatoes and, as TBZ resistant strains can be prevalent, it is preferable to use imazalil on the seed potatoes.



Black dot is caused by the fungus *Colletotrichium coccoides* and causes similar lesions to those seen with silver scurf, with a similar loss in skin permeability. Lesions tend to be browner than are seen with silver scurf, and more irregular in shape, and they are covered with the characteristic black resting spore bodies that give the disease its name. These are just visible to the naked eye and are readily visible with the aid of a hand lens. Symptoms can become more apparent in storage and a silvery sheen can also develop. It is a surface blemishing disease that affects pre-pack product value and is both seed and soil / trash borne. The disease is favoured by wet growing conditions and by warm and humid storage.

Control

Some varieties like Saxon have reasonable levels of resistance while others like Lady Christl are quite susceptible. (see British Potato Variety Database www.potato.org). Seed treatment into store will reduce the risk of the disease progressing during storage and application of seed tubers prior to planting may reduce spread to progeny tubers. However, much of the disease is trash borne in the soil borne which will not be controlled by this treatment so results can be variable. Azoxystrobin has an approval for pre-planting soil incorporation or in-furrow treatment. Soil tests are also available which allows low risk fields to be selected and also to assist in determining treatment need.

Bacteral soft rots are a major cause of losses during storage and the primary target of preventative cold storage. Soft rotting in storage is mainly caused by *Pectobacterium carotovorum subsp. carotovorum* (formerly *Erwinia carotovara* subsp. *carotovara)* while blackleg in the field is primarily caused by *Pectobacterium atroscepticum* (formerly *Erwinia carotovora subsp. atroseptica*.). More recently, a new pathogen has emerged in Northern Europe; '*Dickeya solani'* which is more aggressive than *Pectobacterium* species, and is known to cause problems in storage and also in the field. Measures are in place in Scotland to ensure this pathogen remains out of our production chain, though it is clear that imported seed and ware carries an increased threat of infection. The Scottish Government advisory leaflet provides further information, (see attached link: http://www.scotland.gov.uk/Resource/Doc/278281/0096693.pdf).

Soft rots can develop as secondary infections to field diseases such as late blight or common and powdery scabs and will quickly over run other storage diseases such as dry rot and gangrene. It also finds easy entry through points of damage and lenticels. Soft rots are favoured by warm and humid conditions in field and storage.

Control

There are varietal differences to blackleg and some varieties e.g.Cabaret, have good levels of resistance (see British Potato Database www.potato.org). At this time, there is no known resistance/tolerance to '*Dickeya solani'*. Soft rotting in store though is often secondary to other problems such as damage or disease and to adverse harvest and storage conditions. Good seed health is important in reducing blackleg risk in the field and severely affected seed should be avoided. Early harvesting is a strategy, particularly in seed crops where late bulking is less important as it limits the potential for bacterial multiplication and rot development prior to harvest as well as reducing the risk of getting into wet harvest conditions which will increase drying difficulties and soft rot risk after harvest. Late harvesting will increase the risk of harvesting in wet conditions with the accompanying difficulties

in drying tubers and risk of soft rot developing after harvest. Haulm pulverisation can create an aerosol of bacteria from infected stems and lifting crops through this will spread bacterial contamination to the tubers. The use of a desiccant to kill haulm and allowing skins to set prior to harvest reduces the risk of damage and easy entry for bacterial rots. Avoid damage at harvest for the same reason. Good hygiene is important and grading equipment should be cleaned and disinfected after contaminated stocks, otherwise the bacterial smearing left behind from rotted tubers will contaminate clean tubers subsequently passed over the equipment. Dry curing after harvest to allow some wound healing of harvest damage can help but there is a careful judgement to be made as rots can develop rapidly in warm conditions so that for stocks with high levels of disease rapid drying and cooling can be essential to reduce the risk of soft rotting. Condensation and humidity in store will allow a rapid multiplication of bacteria, and should be avoided. Store temperatures should be pulled down and maintained as low as is tolerable for the market requirements. Sugar production at low temperatures can cause browning at frying so is an issue to those markets. There are commercial services that offer testing of seed tubers in order that only stocks with low bacterial loads are selected for purchase. Poor storage and post harvest testing will quickly turn a low risk seed lot into a high risk lot so appropriate storage up to the point of planting is crucial.

Some varieties are more susceptible than others. There are no approved chemical treatments so cultural control methods are, therefore very important.


Rhizoctonia

Black scurf (*Rhizoctonia solani*) is a seed and soil borne disease that reduces pre-packing quality. The fungus causes stem canker which affects sprout development and can cause blanking and a change in size distribution within the daughter crop. The pathogen is both soil and seed borne. Early infection, particularly in cold wet soils where emergence is slow, can increase the risks of stems being pruned and in more severe cases emergence can be patchy and significantly reduced. Brown cankerous lesions form on stems and can later reduce water movement causing stunting and wilting of the top growth. The pathogen persists on tubers as black sclerotia which reduce the marketability of both seed and ware tubers.

Control

Seed treatment with a fungicide prior to planting can help reduce levels of stem canker and black scurf. Cultural control includes using well sprouted seed, avoiding planting into cold soils, avoiding infected seed and ensuring sufficiently long (greater than 5 years) rotation. Good seed health is an important factor in reducing the risk of *Rhizoctonia* in crops. Cultural control methods also reduce the risk, such that planting into warmer soils and avoiding excessively deep planting reduce the risk of slow emergence and exacerbating stem infection and pruning. Soil tests are now available commercially which will allow heavily infected fields to be avoided. There are varietal differences in susceptibility: Sante is particularly susceptible but Nadine has good resistance (see British Potato Variety Database www.potato.org). Fungicides are available. Treating out of store prior to planting with iprodione, tolcofos-methyl or flutolonil reduces the severity of *Rhizoctonia*, particularly if the infection is seed borne.

Seed stock assessments

Assessment of the amount of disease present on a stock should help determine whether or not fungicide treatment is necessary. Draw 100 tubers at random from each 20 tonnes of a stock. Avoid selecting tubers from the tops of boxes as these will not truly reflect the whole stock. Wash tubers and assess for presence of silver scurf, black scurf and black dot and powdery scab. Where silver scurf is present on over 5% of tubers or black scurf is present on any tuber then fungicide application is likely to be beneficial, provided uniformity of size and freedom from disease are market requirements, and that fungicide usage is acceptable to the buyer. Skin spot, gangrene and dry rot are unlikely to be present early in storage. An assessment of the level of damage, varietal susceptibility and harvest date will help determine whether fungicide is necessary to control these three diseases. Late harvested susceptible varieties are likely to require treatment for skin spot and gangrene, particularly if damage levels are high. Early harvested susceptible varieties are likely to require treatment for dry rot, particularly if damage levels are high. Where soft rotting is present within a stock, fungicide treatment may exacerbate the problem. These stocks should be ventilated to dry out any rotting and then reassessed for suitability for treatment.

Where an earlier indication of presence of skin spot and silver scurf is required, then eye-plug incubation tests are available. During these tests, the presence of *Rhizoctonia* (the fungus that causes stem canker) within eyes can also be assessed.

Damage assessment

Assessment of the level of damage either at harvest or during grading will also help determine the requirement for fungicide protection against dry rot, gangrene and skin spot. Carefully wash 100 tubers and count the numbers of tubers showing presence of (1) scuffing:, (2) damage that is easily removed by one stroke of a peeler; and (3) more severe damage. Multiply the numbers of tubers in each category by 1,3 and 7 respectively and add these together to calculate a damage index (DI). Fungicide treatment may be beneficial if DI is greater than 100 for dry rot or gangrene susceptible varieties particularly if either disease has been recorded in the stock's or farm's history. Fungicide treatment may also be beneficial if levels of scuffing are high for a late lifted, skin spot susceptible variety.

Suitability of stocks for treatment

Fungicides should only be applied to stocks that are in a suitable condition for treating. When a stock is not suitable for treating, then benefits from a treatment are less likely. Unsuitable stocks include those

that contain a high level of soft rotting, those that are wet or those that have a covering of soil that would prevent fungicides from contacting the tuber surface.

Various agronomic factors can interact to seriously affect the emergence and establishment of potato crops. There is a possibility of further interaction of these factors with chemical seed treatment, making it very difficult to foresee the outcome in all situations. See product labels for full details.

Timing of application

In order to maximise the benefits from fungicide use, application at the appropriate timing is essential. For damage related diseases (dry rot and gangrene) early treatment is essential to avoid disease development within the tuber. When these pathogens start to develop within the tuber, it is more difficult to control them. Fungicides that reduce development of silver scurf and skin spot in store should also be applied soon after harvest. This may either be on the harvester or early in storage when crops are split graded. Fungicides can also be applied to reduce the development of silver scurf and skin spot in the daughter crop. If not applied earlier at intake, these may be applied prior to planting provided crops are suitable for treatment. There is also some evidence to suggest that two applications (one at harvest and one prior to planting) can further reduce further disease in the progeny crop.

Fungicides are also available for control of black scurf and stem canker. They are best used close to the time of planting but before sprout development. They may be beneficial on stocks where black scurf has been observed or where the fungus, *Rhizoctonia solani* fungus has been detected in eye plug incubation tests.

Always check the product label before treating.

Seed treatments for potatoes. Into store for control of disease development in store

Product	Active ingredient	Silver scurf	Black dot	Skin spot	Dry rot	Gangrene	Black scurf / stem canker
Storite Super	imazalil + thiabendazole	++	++	+++	+++	+++	-
Fungazil100SL	imazalil	+++	++	+++	+++	+++	-
Storite excel	thiabendazole	++*	++	+++*	+++*	+++	-

*resistance to TBZ common but only for dry rot caused *F. sulphureum*
TBZ is the only one of the above that can be used on ware potatoes

Out of store (grading or planting) for control of spread to progeny tubers

Product	active	Silver scurf	Black dot	Skin spot	Dry rot	Gangrene	Black scurf / stem canker
Storite Super	imazalil + thiabendazole	++	++	++	-	-	+
Fungazil100SL	imazalil	++	++	++	-	-	-
Storite excel	thiabendazole	+*	++	+*	-	-	+
Monceren FS	pencycuron	-	-	-	-	-	+++
Monceren IM	pencycuron + imazalil	++	+	+	-	-	+++
Rizolex Flowable	tolclofos-methyl	-	-	-	-	-	+++
Rhino	flutolanil	-	-	-	-	-	+++
Rovral AquaFlo	iprodione	-	-	-	-	-	++
Amistar**	azoxystrobin	-	+++	-	-	-	+++

*resistance to TBZ common
**applied as a soil treatment pre-planting or in-furrow

- Apply to clean potatoes
- Often as flowable concentrates on canopied, hydraulic or spinning disc equipment (+ electrostatics help)
- Areas not hit by spray usually not protected
- Some can be applied as on-planter applications

+++ = good control
++ = moderate control
+ = some control
- = not recommended for control
* = resistance to thiabendazole is common for these fungi

Summary of fungicide use for disease control

- **Silver scurf**: Treat seed both in and out of store with imazalil-based fungicide.
- **Black dot:** Mostly soil borne, but imazalil, or thiabendazole may reduce some tuber infection. Soil treatment pre-planting with azoxystrobin is also effective.
- **Skin spot:** Treat seed in-store following anti resistance strategy with fungicides imazalil, and thiabendazole.
- **Dry rot:** Treat seed in-store following anti resistance strategy with fungicides imazalil, or thiabendazole.
- **Gangrene:** Curing is important to minimise disease. Imazalil, and thiabendazole may also provide some control.
- **Black scurf:** Apply seed treatment containing pencycuron, flutolanil or tolclofos methyl prior to planting. Azoxystrobin applied as a soil treatment pre-planting also has approval.

Always consult the product label

Fungicide resistance

Resistance to thiabendazole (TBZ) has been detected in three pathogens: *Helminthosporium solani* (silver scurf), *Polyscytalum pustulans* (skin spot) and *Fusarium sambucinum* (formerly *sulphureum)* a dry rot species). It has also been detected in the less aggressive *Fusarium avenaceum*.

Research has shown that thiabendazole resistance can develop within one season after treatment with TBZ and can persist even if thiabendazole is no longer used.

Where possible, a strategy that minimises the risk of development of fungicide resistance should be adopted.

- Only use a fungicide if one or more of the following apply:-
  - the variety grown is highly susceptible to a specific disease
  - there is a history of persistent disease on the farm
  - significant levels of the disease were present on mother tubers
  - presence of a disease would have a major effect on marketability
  - treatment constitutes part of a contract
  - all other integrated measures to reduce disease risk have been taken
- An integrated control strategy should be adopted, where possible, to include lifting at the earliest date possible, dry curing, adequate store hygiene and cold storage.
- Minimise repeated use of the same fungicide from year to year throughout a multiplication programme.
- Consider the use of products constituting a mixture of active ingredients.
- Limit the use of thiabendazole alone to use on ware tubers.
- If treatment is needed on seed tubers use imazalil for silver scurf and skin spot control.
- TBZ/imazalil mixtures may be used on seed of processing varieties.
- Once grown seed from ware should not be treated with TBZ.
- The use of azoxystrobin as a soil or in-furrow treatment does not need to be taken into account when considering the total permitted number of foliar QoI fungicides for potato blight control.

Further information on resistance management can be found on the Fungicide Resistance Action Group – UK's website at http://www.pesticides.gov.uk/uploadedfiles/Web_Assets/RAGs/FRAG_potato_tuber_diseases_2008.pdf

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