Technical Note **TN627**

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SAC

Barley Disease Control

SUMMARY

Many factors influence the types and severity of diseases, which affect your crops including: -

- **Variety**
- **Weather conditions**
- **Crop rotation**
- **Cultivation**
- **Sowing date**
- **Fungicides**

This technical note describes how these factors can influence the severity of foliar, stem base, root and head diseases in barley and how you can use them to manage disease in an integrated disease programme.

The common names for the key barley diseases are listed in Table 1 along with their relevance in the UK

Table 1: Common names of diseases in barley

	Incidence in winter crops	Incidence in spring crops	Potential risk of yield loss
Foliar diseases			
Rhynchosporium	Common, particularly in north & west UK.	Common, particularly in north & west UK.	High. Currently most damaging foliar disease.
Powdery mildew	Common in early sown crops and susceptible varieties (e.g. Saffron, Purdey, Cassata).	Common in susceptible varieties (e.g. Optic, Forensic). Many spring varieties have good resistance e.g. NFC-Tipple, Quench, Westminster (due to presence of *mlo* gene).	Potentially high yield loss in susceptible spring variety Optic, Forensic or in backward winter barley crops.
Net blotch	Now more widespread. Resistance to QoI fungicides has also increased.	Becoming more widespread.	Can flare up late in season causing loss in yield and infecting seed.
Yellow rust	Currently rare, but can occur in susceptible varieties.	Currently rare, but occasionally seen in commercial crops. Number of varieties susceptible to disease are increasing.	Potentially high yield loss once disease established in cool wet season.
Brown rust	Becoming more common in many areas, particularly East Anglia.	Becoming more common in many areas, particularly East Anglia.	High where upper leaves are affected.
Ramularia	Common in north of UK and sporadic further south in wet summers. Present in seed throughout the UK, but levels lower in dry east of England.	Common in north of UK and sporadic further south in wet summers. Seed infection also increases risk.	High in north with average loss of 0.4-0.6 t/ha plus an increase in screenings of 4% regularly reported. 0.9 t/ha loss recorded in Optic.

SAC receives financial support from the Scottish Government

	Incidence in winter crops	Incidence in spring crops	Potential risk of yield loss
Stem base diseases			
Snow rot	Common in continuous barley, where manganese deficiency and snow cover cause stress over a long period in the winter. Minimum tillage increases risk.	Uncommon, but winter sown spring cereals may be at risk.	Where it occurs, whole crops can be severely affected. Currently rare but may reappear if continuous barley is grown.
Common eyespot	Less damaging in winter barley than winter wheat but can occur in second cereal crops or following 1 year break from cereals.	Uncommon in spring barley.	Moderate loss of yield but this can increase if crop lodges as a result of disease.
Sharp eyespot	Common in North east Scotland.	Uncommon in spring barley.	Low loss of yield unless disease causes crop to lodge.
Fusarium seedling blight & Cochliobolus foot rot	Poor emergence due to *Microdochium nivale* is rare unless sown in cold wet seed beds. Stem base browning caused by other Fusarium species and *Cochliobolus sativus* are common and can occasionally lead to early ripening.	Poor emergence due to *Microdochium nivale* is rare unless sown in cold wet seed beds. Stem base browning caused by other Fusarium species and *Cochliobolus sativus* are common and can occasionally lead to early ripening.	Risk of crop loss low unless extensive damage present on stem base and nodes at heading. *Cochliobolus sativus* can lead to secondary foot rots, but it can be controlled with seed treatments.
Root diseases			
Barley stunt (Rhizoctonia)	Seen in light land in Inverness region. Most common after grass.	Seen in light land in Inverness region. Most common after grass.	Low yield losses where incidence low but high where whole fields are affected.
Take-all	Less common compared to wheat. Winter crop at higher risk than spring crop.	Generally rare unless soil compaction problems.	Moderate risk of yield loss in second cereal crops.
Head diseases			
Fusarium species	Some species like *Fusarium graminearum* are more common in the south of the UK, but incidence is lower than in France and Germany. Higher risk in minimum tillage situations where maize is grown in rotation.	Some species like *Fusarium graminearum* are more common in the south of the UK, but incidence is lower than in France and Germany. Higher risk in minimum tillage situations where maize is grown in rotation.	Key issue of loss refers to quality and the production of the mycotoxins e.g. deoxynivalenol (DON), HT-2 T-2 linked with *Fusarium langsethiae,* and zearalenone (ZEA).
Microdochium nivale	Common in harvested grain in recent years. in all areas of the UK, but cool and wet areas most affected.	Common in harvested grain in recent years in all areas of the UK, but cool and wet areas most affected.	Negligible impact on yield but contamination on seed may impact on germination in cool wet seed-beds. This fungus does not produce mycotoxins and competes with the more damaging fusarium species.
Ergot	High risk in seasons where flowering period is prolonged due to wet weather, or where immature secondary tillers extend flowering.	High risk in seasons where flowering period is prolonged due to wet weather, or where immature secondary tillers extend flowering.	Significant loss due to quality and not yield. A single ergot in a batch of grain can lead to rejection. Quality issues affect all markets as ergots are highly poisonous.
Virus diseases			
Barley yellow dwarf virus BYDV	High risk in mild winters & crops after grass & crops in south and west UK.	High risk in late sown crops following a mild February.	Moderate to high yield loss depending on disease severity.
Barley mild mosaic virus (BaMMV) & Barley yellow mosaic virus (BaYMV)	Common on infected land. Symptoms more severe in cold winters.	Rare unless sown in winter.	Losses higher in early sown crops. Resistant varieties should be grown where risk is known. A new race (race 2) has been detected in BaYMV, which can overcome resistance to both existing viruses in current RL varieties.

Variety

Varieties differ in their susceptibility to disease and this information is available in the HGCA Recommended List and the SAC Cereal Recommended List (www.hgca.com, www.sac.ac.uk/crops). Table 2 shows scores for varieties recommended in 2010. The current system uses a 1 – 9 scale where a low number represents poor genetic resistance and a high number good resistance. Disease resistance scores are predominantly based on disease levels present late in the season. This tends to provide a true reflection for rusts and net blotch, but they may not truly reflect the resistance to rhynchosporium in winter barley, which develops early and reaches a peak on the lower leaves at boot stage (GS45). Later epidemics of rhynchosporium which develop on the upper leaves are usually less severe except in wet summers. Powdery mildew in the spring barley variety Optic may also develop early and rapidly at tillering, so a disease resistance score of 4 for mildew would be more realistic early in the season.

Although the main criteria for choosing a variety will be the market, you can make good use of these tables to determine which diseases are likely to cause concern in a specific variety.

Table 2 Disease resistance ratings for Winter barley varieties recommended in 2010

Variety	Rhynchosporium	Mildew	Yellow rust	Brown rust	Net blotch	BaYMV	Diversification Group (DG) for Powdery mildew
Whinsome	8	6	9	6	7	-	0
Flagon	8	7	8	7	6	-	0
Purdey	8	4	6	5	8	R	0
Cassata	8	4	2	7	5	R	0
Pearl	6	6	7	6	5	-	0
Retriever	8	6	8	6	6	R	0
KWS-Cassia	4	5	6	7	8	R	0
Saffron	4	3	6	7	8	-	10
Suzuka	8	6	8	7	7	R	0
Carat	5	7	7	5	6	R	0
Volume	8	5	6	5	8	R	0
Pelican	8	7	5	8	6	R	0
Colibri	7	8	8	7	8	R	0
Boost	7	7	8	4	7	R	10
Sequel	8	6	6	6	7	R	10
Malabar	8	7	5	6	6	R	No data

1-9 where higher number represents better disease resistance or better standing power.
[ ] Limited data
R resistant to BaMMV and to BaYMV strain 1
DG Group see table 4 for explanation
Most ratings derived from the HGCA Recommended List for full details of lists see www.hgca.com
*Ratings for ramularia derived by SAC.

Table 3 Disease resistance ratings for Spring barley varieties recommended in 2010

Variety	Rhynchosporium	Mildew	Yellow rust	Brown rust	Ramularia*	BYDV	Diversification Group (DG) for Powdery mildew	Ergot risk**
Propino	7	8	-	5	7	-	1	-
Quench	8	9	4	4	5	[6]	1	Low
Concerto	4	8	-	7	7	[7]	1	Intermediate
Publican	7	9	4	5	6	[6]	1	Low
Forensic	5	4	-	6	5	[7]	0	-
NFC-Tipple	4	8	4	7	7	[7]	1	Low
Belgravia	8	9	7	7	7	[6]	1	Intermediate

Variety	Rhynchosporium	Mildew	Yellow rust	Brown rust	Ramularia*	BYDV	Diversification Group (DG) for Powdery mildew	Ergot risk**
Westminster	8	9	6	6	7	[6]	1	Intermediate
Oxbridge	7	7	5	6	6	[6]	14	Low
Optic	4	5	9	7	6	[5]	0	Intermediate
Decanter	6	9	8	5	7	-	1	High
Garner	7	9	-	6	5	-	1	-
Waggon	3	9	7	6	7	[7]	1	Intermediate
Cropton	5	9	-	6	7	[5]	1	-
Sweeney	5	9	-	9	6	[7]	1	-
Scout	4	8	2	6	7	[7]	1	Intermediate
Jolika	5	9	-	4	5	[7]	1	-
Cocktail	6	6	4	8	5	[7]	4	Intermediate
Doyen	7	6	4	8	6	[7]	3	Intermediate
Cairn	6	9	-	4	6	-	-	-
Yard	6	9	-	5	6	-	-	-
Benchmark	5	9	-	6	7	-	1	-
Mirage	4	9	-	5	5	-	-	-
Tartan	3	8	8	5	7	-	-	-

1-9 where higher number represents better disease resistance or better standing power.
DG Group see table 4 for explanation
[ ] limited data
Most ratings derived from the HGCA Recommended List for full details of lists see www.hgca.com
*Ratings for ramularia are unofficial and derived by SAC.
**Ergot risk is based on inoculation experiments and flowering habit. Low risk varieties can still get ergot.
- no data

Diversification of varieties

It is possible to minimise disease spread by diversifying varieties. Powdery mildew in barley is a good example of this. There are many races of powdery mildew of barley and they may not all attack the same varieties. Varieties are placed in different diversification groups (Table 2 & 3). Future information on these different Diversification Groups (DG) can be found found in the reports of the UKCPVS at www.hgca.com, at www.sac.ac.uk/crops and the SAC Cereal Recommended List.

Severe infections may result if mildew spreads between varieties susceptible to the same races of the pathogen. This risk is reduced if varieties with good resistance are grown. The spread of disease can be further limited by growing different varieties in neighbouring fields, provided that the varieties are not susceptible to the same races of powdery mildew. The Diversification Scheme (Table 4) can be used to choose varieties to grow adjacent to one another.

Choosing varieties to grow together

1. Select first-choice variety and locate its Diversification Group (DG)
2. Find this DG number under ‘Chosen DG’ down the left-hand side of the table.
3. Read across the table to find the risk of spread of powdery mildew for each companion DG.

Table 4 Diversification table for barley powdery mildew

	Companion DG					
Chosen DG	1	3	4	10	14	0
1	L	L	L	L	L	L
3	L	H	M	M	M	H
4	L	M	H	M	M	H
10	L	M	M	H	M	H
14	L	M	M	M	H	H
0	L	H	H	H	H	H

L	= Low risk of mildew spread
M	= Moderate risk of mildew spread
H	= High risk of mildew spread

+ = Low risk of mildew spread; **M** = High risk of mildew spread

Note: Varieties in **DG1** (e.g. NFC Tipple, Cropton, Waggon, Decanter) have **good resistance** to mildew spreading from any other variety and can be used to diversify with varieties in all other **DG’s**, including **DG1**. **DG0** varieties (e.g. Retriever, Optic) are **susceptible** to mildew spreading from other varieties.

Variety mixtures

The malting barley industry does not currently endorse the use of variety mixtures - instead it prefers purity of type in a single variety. However feed producers and grain distillers generally accept grain on broader quality criteria. Mixing varieties can reduce the variability in yield, quality and diseases. They work well to reduce the spread of powdery mildew for example where varieties with different resistance ratings are sown. The mix does not have to be uniform and crude mixing or patches can be as good as a uniform mix. Research is ongoing to determine the potential commercial benefits of using mixtures. There is evidence that mixtures of 3 varieties or more reduces the risk of varietal resistance breaking down to disease. There is also dialogue with end users regarding the use of mixtures. Despite the potential benefits, ensure you discuss this approach with your end market first.

Crop characteristics

Some varieties have the potential to escape from disease through different characteristics of crop development, height and leaf architecture. As a general rule, tall varieties will be able to escape from rain splash diseases more efficiently than short varieties. Varieties which extend earlier in the season may also be able to escape more efficiently from the same disease. Where leaves are horizontal, they may trap more moisture and humidity than varieties where the leaves are more upright. In contrast however, Varieties with horizontal leaves may lead to more shading in the crop, leading to a reduction in ramularia.

Elicitors to manage disease

Elicitors are chemicals which are applied to plants which have no direct fungicidal activity, but they trigger the natural responses of the plant to fight disease. At present no elicitors are available on the market, but research into their effectiveness to 'elicit' better varietal resistance in susceptible varieties is ongoing at SAC.

Weather conditions

Weather can have a major influence on disease development. Each major disease can tolerate a wide range of weather conditions, but they may become more severe where the weather conditions are most suitable for their development or spread.

Brown rust prefers warm temperatures and high humidity, but it can still develop in crops over the winter. In the warm spring in 2007, it was widespread throughout the UK. It can cause more of a problem during the summer when it can attack the upper leaves on susceptible varieties.

Net blotch requires high humidity and wet weather to infect a plant but it develops faster at higher temperatures. This is one reason why it may become most serious on the upper leaves and heads in the height of summer. Crops may show severe infection after emergence where the seed has been the main source of infection.

Powdery mildew requires some moisture to infect the crop, but since it spreads via wind blown spores, very wet weather may slow down disease development. Warm and humid weather conditions (not wet) suit the disease best. Some spring barley varieties (e.g. Forensic, Optic) are more susceptible earlier in the season.

Ramularia requires periods of wet weather during June and July, or periods when leaves remain wet for long periods. Sunshine following wet humid spells of weather will result in a greater risk of abiotic leaf spots.

Rhynchosporium poses a greater risk to crops in high rainfall areas, since this provides the optimum conditions for spores to develop and spread from stubble to the crops and for subsequent infection. A long period of dry weather will slow down a disease epidemic, but in high risk crops, early protection is essential to manage the disease.

Yellow rust is currently rare on barley, but some varieties are susceptible. It is occasionally seen in untreated commercial crops. Yellow rust prefers wet and cool weather to develop and it is most likely to be found in the early spring when weather conditions are ideal for disease spread, but when crops may be unsprayed or treated with cyprodinil-based programmes which will give poor control.

Incidences of **Fusarium species** which cause head blights and produce mycotoxins, are currently low in the UK compared to Germany and France. Warm and humid weather can increase the risk of these fungi on the heads, but minimum tillage and maize in the rotation are greater risk factors than weather alone. The greatest concern with Fusarium species, (including F graminearum, F poae, F avenaceum, F culmorum and F langsethiae) is the production of mycotoxins. The European commission has set maximum levels for the Fusarium mycotoxins DON and zearalenone (ZEA) in unprocessed and finished products intended for human consumption. For unprocessed cereals (other than durum wheat, oats and maize), the maximum limits for DON are 1250 parts per billion (ppb) and for ZEA 100 ppb. Fortunately mycotoxin levels in barley in the UK are below these thresholds, but changes in cropping and climate may increase the risk in the longer term. Maximum levels have also been set for animal feed. More information is available from the Food Standards Agency and from the HGCA.

Microdochium nivale is most common in wet cool regions, including the north of the UK. Disease levels were high on barley grain since 2007. This fungus can compete with Fusarium species on the head and grain and it does not produce mycotoxins. The main problem with Microdochium nivale is its impact on germination. Sowing affected seed in cold and wet seedbeds can lead to poor germination. Fortunately the risk of poor germination is lower in barley than in wheat and many seed treatments are effective against the disease.

Ergot can be a major problem in all cereals. It is most common when wet cool weather coincides with flowering, or where flowering period is extended due to many secondary tillers. Decanter is the most susceptible variety on the spring barley Recommended List. Maresi is however more susceptible. Definition of risk in Table 3 is based on inoculation experiments and flowering habit. Open flowering varieties (e.g. Decanter) are more likely to be infected than closed flowering varieties (e.g. NFC-Tipple).

Crop rotation

Crop rotation has most influence on soil borne disease, for example take-all and snow rot and other diseases, which are spread through trash from previous crop e.g. common eyespot.

Common eyespot is present in trash from previous cereal crops so it is worse in second or subsequent winter cereal crops. A single years break from cereals is insufficient to remove trash so the risk is high in these crops too. There are airborne spores of the fungus as well, which can blow into a crop, and it is possible these are causing more eyespot to develop in first cereal crops than was previously the case.

Take-all rarely causes severe damage in a first cereal crop where there has been a year's break from all cereals and where grasses and volunteer cereals have been controlled. Take-all is generally common in a second, third or fourth consecutive winter cereal as the fungus builds up in the soil on roots. Continuous cereal crops may experience 'take-all decline'. This occurs when natural antagonistic organisms build up in the soil and help control the disease.

Snow rot can develop during the winter in second or subsequent winter barley crops, particularly where crops are stressed from manganese deficiency. Prolonged periods of snow cover as occurred in the 2009 winter can cause stress to the crop and ideal conditions for the disease to develop, but prolonged damp weather can mimic the conditions of snow cover.

Foliar diseases including mildew and rusts are generally less affected by crop rotation, but continuous barley crops can maintain a 'green bridge' where the disease spreads from the first crop, survives on volunteers, and subsequently infects the second barley crop. Rhynchosporium is the most significant foliar disease with a trash-borne component.

Fusarium can be affected by crop rotation. There is a higher risk of disease following maize and in close cereal rotations where trash is left on the soil surface as in minimum tillage. As changes in climate and changes in varieties occur, these could become more common in the rotation in the UK.

Cephalosporium leaf stripe is a soil borne disease which can attack barley. Crops most at risk are those sown under minimum tillage situations where trash is incorporated into the root zone and where roots are waterlogged in the winter. Work on potential varietal resistance is ongoing.

Cultivation

Minimum tillage is being used by some growers to save on cultivation costs. This approach can lead to more crop trash in seedbeds, which can harbour diseases. Crops are also sown earlier, which can increase the risk of diseases such as eyespot, take-all and foliar diseases. However take-all may not be able to survive as effectively in a minimum tillage situation where the seedbed is firm compared to a seedbed produced following ploughing. Where conditions are too compacted however, this will have a detrimental effect on root development allowing take-all to damage the roots more severely. Minimum tillage has been shown to reduce eyespot levels compared to ploughing. Fusarium species can be higher under minimum tillage. Some of these fungi can be of concern since they can lead to an increase in the mycotoxins deoxynivalenol (DON), HT-2, T-2 and ZEA in grain. Greatest risk from Fusarium occurs in minimum tillage situations where maize is grown in the rotation.
Ergot may also be influenced by cultivation, since ploughing will bury the resting bodies. Since they survive for only a year, ploughing is an effective way of reducing the disease. Ergots are more likely to remain on the surface in a minimum tillage situation and increase the risk. Grass weeds are also likely to be higher where minimum tillage is used and many grasses (i.e. ryegrass, couch, black grass) are susceptible to ergot. Minimum tillage has been shown to have a small suppressing effect on eyespot.

Sowing date.

Early sown crops tend to have greater yield potential than late sown crops. They also have a greater risk of disease. Since the interval between harvest and sowing is short, it allows many diseases to survive from one crop to the other on trash or via the 'green bridge'. The risk of stem based and foliar diseases is also increased as the crops are exposed to inoculum earlier and for longer.

Early sown winter crops generally become well established in the autumn so they are also able to tolerate disease better than later sown crops. Disease in a late sown backward crop can potentially cause more damage than disease in a well established crop in the autumn.

Where spring barley is sown in the winter, disease pressures can be high, especially rhynchosporium. Late sown crops (sown in May) generally have lower disease pressures, but also lower yield potential. BYDV will be a greater risk in late sown crops following a mild February. These conditions will lead to high numbers of aphids colonising crops at a time when they are most susceptible.

For a summary of the impact of rotation cultivations and sowing dates on disease development, please see Table 9.

Fungicide efficacy

The graphs in Figures 1-3 show the impact a single application of the fungicide has on disease protection and yield. Although it is recommended that growers use products in mixtures for best control and to minimise the risks of resistance, the graphs do show the relative efficacy against the common diseases and also performance as dose rate alters. The information is based on HGCA funded "Fungicide Performance" trials. The dose curve generator was developed by SAC. Access can be obtained from the HGCA website and at *www.sac.ac.uk/crops*.

Figure 1 Fungicide performance to major barley diseases in winter sown crop

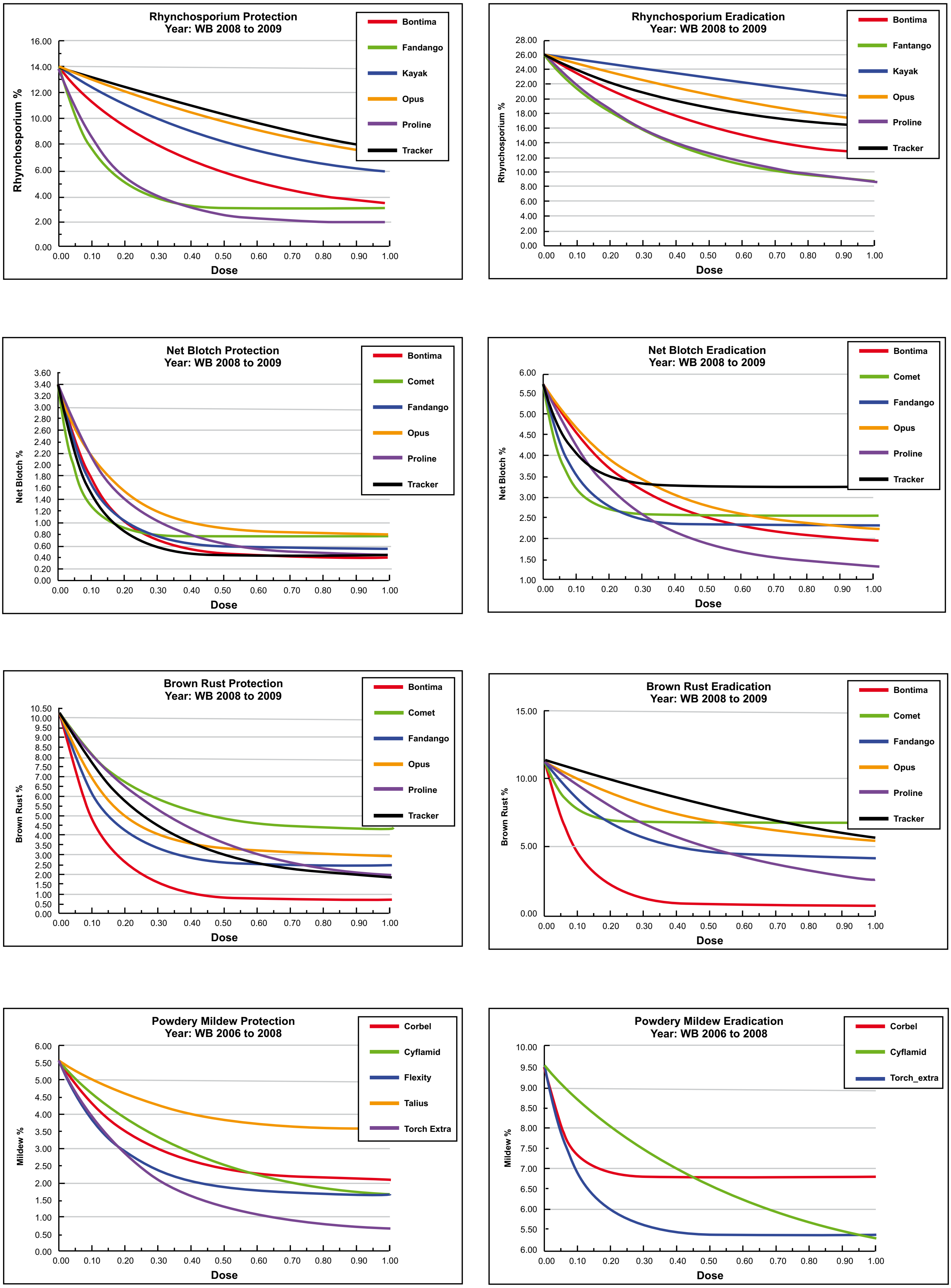


Figure 2 Impact of fungicides on yield and green leaf area

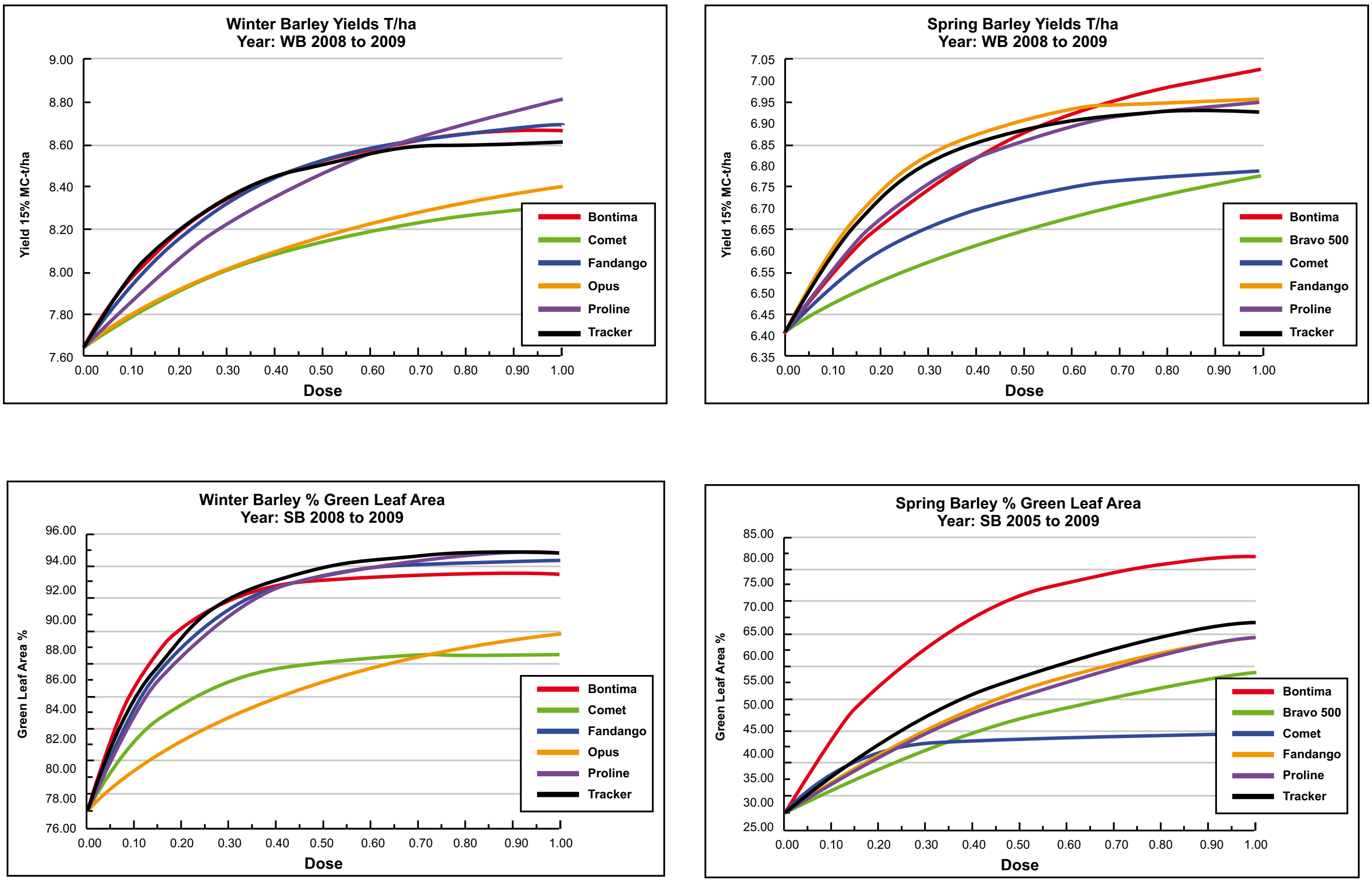
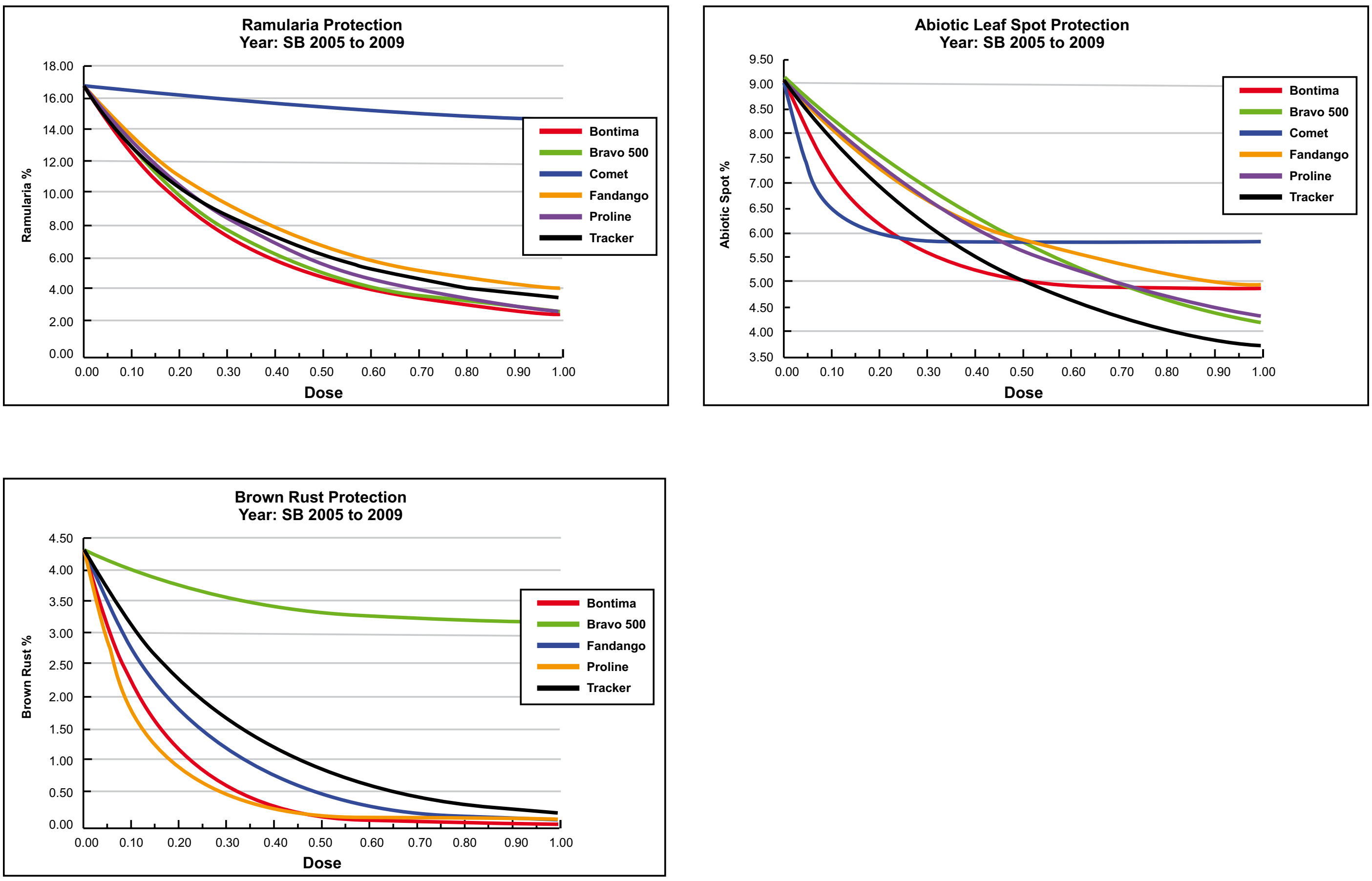


Figure 3 Fungicide performance to major diseases in spring sown crop



Fungicide mixtures

In practice, fungicides are used in mixtures to broaden disease protection. It is often assumed that with the individual fungicides protectant and eradicant activity will be additive or complementary. Specific positive or negative effects can be seen from fungicides when applied in mixture (Table 5).

An HGCA research programme has taken this research further to determine the impact different mixtures have on disease control, yield and fungicide resistance (Table 6). The fungicide prothioconazole continues to be the best mixing partner for rhynchosporium control, but cross resistance with other triazole fungicides (epoxiconazole) has started to develop. Over-use of this fungicide in a programme could increase this risk. HGCA research has shown that the risk of resistance to Proline can be minimised by using the fungicide in mixture with another fungicide group. It must not be applied alone, as this has been shown to increase the chance of resistance developing.

Table 5 Contribution of specific fungicides when used in a fungicide mixture

	Impact of fungicide in mixture on:				
Fungicide in mixture	**Rhynchosporium**	**Ramularia**	**Late green leaf area**	**Yield**	**Specific weight**
Opus	Neutral	Neutral	Neutral	Neutral	Positive
Strobilurin	Positive	Neutral	Positive	Neutral	Neutral
Prothioconazole	Positive	Positive	Positive	Positive	Positive
Chlorothalonil	Positive	Positive	Positive	Positive	Positive
Cyprodinil (applied early)	Neutral	Neutral	Neutral	Positive	Neutral
Morpholine (applied late)	Positive	Negative	Negative	Negative	Neutral

Positive – significant positive effect compared to other products in a mixture
Negative - significant negative effect compared to other products in a mixture
Neutral – impact on disease or yield not significantly different from other products in a mixture

Table 6 Effective mixtures for rhynchosporium control and yield

.Fungicide mixtures (half dose of each)	Rhynchosporium eradication	Rhynchosporium protection	Yield & value (winter barley)	Yield & value (spring barley)	Change in activity if strobilurin resistance occurs
Proline + Corbel	++	+++	+++	++	None
Proline + Comet	+++	+++	+++	+++	Reduced
Proline + Unix	+++	+++	+++	+++	None
Proline + Bravo	+++	+++	+++	++	None
Corbel + Comet	++	+++	+	++	Reduced
Corbel + Unix	+++	+++	+	++	None
Corbel + Bravo	+	+++	+	++	None
Comet + Unix	+++	+++	+	++	None
Comet + Bravo	+	+++	++	++	None
Unix + Bravo	+	+++	+++	++	None
Proline + Corbel + Comet	+++	+++	+++	++	Reduced
Proline + Corbel + Unix	+++	+++	+++	+++	None
Proline + Corbel + Bravo	++	+++	+++	+++	None
Proline + Comet + Unix	+++	+++	+++	+++	Reduced
Proline + Comet + Bravo	+++	+++	+++	+++	Reduced
Proline + Unix + Bravo	+++	+++	+++	+++	None
Comet + Corbel + Unix	+++	+++	++	+++	Reduced
Comet + Corbel + Bravo	+++	+++	+++	++	Reduced
Comet + Unix + Bravo	+++	+++	++	+++	Reduced
Unix + Corbel + Bravo	++	+++	++	+	None

Good	+++
Average	++
Poor	+

Cyprodinil is a useful mixing partner with prothioconazole for both disease control and as an anti resistance strategy against rhynchosporium. It is now available co-formulated with isopyrazam. Chlorothalonil gives poor control when used alone, but contributes to two and three way fungicide mixtures. It can however reduce the eradicative activity of other fungicides in the mixture where disease is already well established.

Effective mixtures to control rhynchosporium include prothioconazole + pyraclostrobin + chlorothalonil (e.g. Proline + Comet 200 + Bravo) and prothioconazole + pyraclostrobin + fenpropimorph (e.g. Proline + Jenton). Best yields were achieved with prothioconazole + cyprodinil + chlorothalonil (e.g. Proline + Unix + Bravo) and Proline + Bravo in situations where rhynchosporium was the dominant disease.
In winter barley crops there is a greater likelihood of established disease and consequently products with eradicant activity will be more important in the fungicide programme than is the case in spring barley. Monitoring your crop for the severity and incidence of disease present will help you judge which products will be most suitable.

Fungicide resistance

Strobilurin resistance

Recent issues concerning strobilurin (QoI) resistance to major disease pathogens demonstrate how quickly situations can change. Currently strobilurin fungicides should be avoided for specific control of barley mildew. The situation concerning net blotch has changed and there is a high risk that net blotch will be less effectively controlled with a strobilurin fungicide.

The mutation that has been detected in net blotch (F129L) is different from that for the fungi which cause powdery mildew and Ramularia leaf spot (G143A) and confers only a partial level of resistance, so that increasing dose rate can compensate for the reduction in efficacy. Differences in the activity of different strobilurin fungicides against net blotch are now apparent. Pyraclostrobin and picoxystrobin continue to give good control even where resistance is present.

The most effective way to manage the net blotch situation is to use a mixing strategy selecting fungicides from different chemical groups. It is important that both components in a mixture have efficacy against the target disease for this strategy to be effective in preventing further resistance developments. In this role, cyprodinil (Kayak or Unix) shows good protectant activity. Prior to the introduction of the strobilurins, control relied on the triazole fungicides, including epoxiconazole (Opus). Prothioconazole (Proline 275) shows better activity against net blotch than epoxiconazole, so it makes a good mixing partner with the strobilurin to manage net blotch.

One mixture to avoid in the future for net blotch control, will be chlorothalonil (Bravo) applied with a strobilurin, since it relies solely on the strobilurin for net blotch control, and it could increase the risk of both the disease occurring and resistance developing. A three way mixture of strobilurin, triazole and chlorothalonil used at boot stage in barley has been shown to be more cost effective and will be a safer option to ensure overall disease management, as well as providing better stewardship of the strobilurins.

Research shows that QoI fungicides now provide little control of ramularia. Strobilurin fungicides remain effective against abiotic spots and the addition of a strobilurin to the fungicide mixture contributes to a reduction in abiotic leaf spots and an increase in yield, although some formulations are better than others.

Another potential candidate to develop resistance to QoI fungicides is rhynchosporium. To date, this has been detected at low levels in France, but it has not been found in the UK and strobilurin fungicides remain a key component to control this disease in 2010.

Triazole resistance

Resistance to triazole fungicides tends to be more subtle than the single step resistance seen with QoI fungicides, but recent research shows that epoxiconazole (Opus) and flusilazole (Sanction) are now less effective at controlling rhynchosporium. The shift with epoxiconazole appears to have stabilised, but epoxiconazole is now best used to protect against rhynchosporium rather than be relied on to eradicate the disease. Epoxiconazole is, however, more effective in Northern Ireland than Scotland.

The triazole fungicide prothioconazole (Proline 275) currently provides good control of rhynchosporium and field performance has remained stable from 2002- 2009. Within the rhynchosporium population there is a wide range of sensitivities and there is some evidence of some sites in Scotland being more sensitive than others. There is also evidence of cross-resistance with epoxiconazole and the most insensitive isolates of rhynchosporium were found where crop had already been pre-treated with triazole. This provides evidence in support of alternating products and avoiding over-reliance on the triazole group. Field control however is still good and prothioconazole remains the most effective fungicide for control of rhynchosporium.

Using prothioconazole alone caused the biggest shift in resistance during the season. This was not the case where prothioconazole was applied in a two-way mixture with chlorothalonil, cyprodinil, pyraclostrobin or fluoxastrobin or fenpropimorph. Sensitivity data from three-way mixtures are limited due to the effective control of disease, but it can be assumed three-way mixtures will behave similarly to the two-way mixtures.

Other fungicides and resistance

Rhynchosporium secalis isolates were generally very sensitive to cyprodinil (Unix). Some isolates were outside this range however and were more resistant. Isolates were also sensitive against fenpropimorph (Corbel).

Diagnostics as an aid to disease risk

Rhynchosporium DNA can be detected in the leaves, shoots and stems of barley before symptoms appear. DNA levels were higher in winter barley compared to spring barley where the subsequent level of symptoms was also higher. Weather plays an important part in disease infection and in the three seasons of trials, higher disease pressures occurred in a wet spring as opposed to a dry spring. DNA levels alone are therefore an insufficient trigger to determine a high risk crop. Diagnostics were as effective as visual assessment to determine the potential high risk of an outbreak. Diagnostics are however more sensitive than visual assessment at the early stages of an epidemic before symptoms appear. Since seed is known to be an important source of infection, testing leaves and shoots over the winter will be a useful guide to the crops with the greatest risk of disease developing. This information will be used in risk decision tools currently being developed in Scottish Government funded research.

Importance of asymptomatic infections

The detection of *Rhynchosporium secalis* DNA inside plants which show no symptoms leads to the question of the relative importance of symptom versus symptomless infection. To address this question, trials were categorised into high and low visual disease late in the season (based on spring rainfall) and high and low DNA levels at the end of the season. Where visual symptoms were high, yield responses to fungicide were also high. However, the same yield response was seen where symptoms were low, but *R secalis* DNA levels were high in the leaves. This observation requires further study, but if the effect is consistent, future advice on late fungicide use may be based upon the level of DNA in the upper leaves to determine risk of yield loss from disease.

Fungicides programmes

Fungicides remain an effective method to protect crops from disease, but integrating them with agronomic factors can help you use them more cost effectively. Timing of fungicides are listed in Table 7 for winter barley and Table 8 for spring barley.

Table 7 Main fungicide timings in winter barley

Spray timing	Main Diseases	Main fungicide	Mixing partner	Other options	Avoid
Early spring GS25-30	Mildew Net blotch Rhynchosporium Brown rust	cyprodinil (e.g. Kayak or Unix) (triazole e.g. Opus for brown rust)	morpholine (e.g. Torch)	triazole* chlorothalonil** cyflufenamid metrafenone proquinazid	strobilurin++
GS31-32	Mildew Net blotch Rhynchosporium Brown rust	triazole (e.g. Proline)	strobilurin (e.g. Comet 200 or Galileo), SDHI (e.g. Bontima)	Cyprodinil chlorothalonil** morpholine*** cyflufenamid metrafenone+++ proquinazid	
GS45-49	Mildew, Rhynchosporium Ramularia Net blotch Brown rust	Triazole +/- boscalid or strobilurin (e.g. Tracker or, Fandango) or SDHI (Bontima)	chlorothalonil (e.g. Bravo)**	strobilurin cyprodinil (Kayak)	morpholine*** cyprodinil (Unix)+

Table 8 Main fungicide timings in Spring barley

Spray timing	Main diseases	Main fungicide	Mixing partner	Other options	Avoid
Pre GS25	Mildew	metrafenone (e.g. Flexity)	morpholine (e.g. Torch, Corbel)	chlorothalonil** cyflufenamid proquinazid	strobilurin++
GS25-30	Mildew, Rhynchosporium, Brown rust	triazole (e.g. Proline) or cyprodinil + isopyrazam (e.g. Bontima)	chlorothalonil** (e.g. Bravo) or strobilurin (e.g. Comet, Galileo, Twist, Amistar)	morpholine*** cyflufenamid metrafenone+++ proquinazid	
GS45-49	Mildew, Rhynchosporium Brown rust, Ramularia, Net blotch	triazole +/- boscalid or strobilurin (e.g. Tracker or, Fandango) or SDHI e.g. Bontima	chlorothalonil** (e.g. Bravo)	strobilurin (e.g. Amistar) cyprodinil (e.g. Kayak)	morpholine*** cyprodinil (Unix)+

*Do not over-use triazoles in a programme to minimise sensitivity shift. A key strength of the triazole epoxiconazole is in leaf spot protection at GS45-49, but prothioconazole has eyespot, net blotch and rhynchosporium benefits at GS31-32.
** This fungicide provides rhynchosporium protection only. It can reduce green leaf loss from leaf spots when used at GS45-49
*** This fungicide will be essential if rhynchosporium eradication is required, but it can cause leaves to die back if used at GS45-49
+Unix is not compatible with common plant growth regulators & is weak against leaf spots.
++ Strobilurin (QoI) fungicides must not be applied more than twice to barley. Note potential resistance to net blotch.
+++ Apply in sequence with another mildew fungicide.

New fungicide approvals

It is likely that new fungicides will be introduced over the next few seasons which will provide effective alternatives to suggestions in this note. Check www.sac.ac.uk/crops for details of any changes and how they may affect disease programmes suggested here.

Seed treatments

Seed treatments are a cost effective way to get crops off to a good start. If corners are cut here, there is little you can do to rectify a disaster other than ploughing in and starting again. The more you know about a stock, the lower the risks should you decide not to treat. Knowledge about germination, net blotch and loose smut are essential. If you do not want to use a seed treatment, ensure a good seed treatment was used in the last crop, test the seed for the diseases mentioned in tables 9 and 10, and if they are not present, you may want to take the risk. If you intend to save seed next year, always treat. Seed borne diseases can build up very quickly after 1-2 generations where no seed treatment has been used.

Seed treatments primarily control seed borne diseases, but the seed treatment Latitude (silthiofam) will provide some reduction from take-all in winter barley. Please note that some seed treatments are approved for winter cereals only. The potential to use seed treatments to control seed-borne rhynchosporium and ramularia is under investigation.

Table 9 Spring barley seed treatments

Spring barley seed treatment	Net blotch	Leaf stripe	Loose smut	Brown / yellow rust	Microdochium nivale	Wire-worm	Wheat bulb fly
Anchor	+	+	-	-	+	-	-
Austral plus	+	+	+		+	+	+
Beret Gold	+	+	-	-	+	-	-
Beret multi	+	+	+	-	+	-	-
Raxil Pro	+	+	+	-	+	-	-
Tripod	+	+	+	P	(+)	-	-

\+ Good control in normal situations (+) Some control P Good protection of early foliar disease - Not recommended

Table 10 Winter barley seed treatments

Barley seed treatment	Net blotch	Leaf stripe	Loose smut	Brown / yellow rust	BYDV via aphid control	Wire-worm	Take-all
Anchor	+	+	-	-	-	-	-
Beret Gold	+	+	-	-	-	-	-
Beret multi	+	+	+	+	-	-	-
Deter*	-	-	-	-	-	+	-
Epona	+	+	+	-	-	-	+
Evict*	-	-	-	-	-	+	-
Jockey							
Kinto	+	+	+	-	-	-	-
Latitude*	-	-	-	-	-	-	+
Rancona 15ME	-	+	+	-	-	-	-
Raxil Deter	+	+	+	-	+	+	-
Raxil Pro	+	+	+	-	-	-	-
Redigo Deter	+	+	+	-	+	+	-
Robust	+	+	+	-	-	-	-
Tripod	+	+	+	P	-	-	-
Tripod plus	+	+	+	P	+	(+)	-

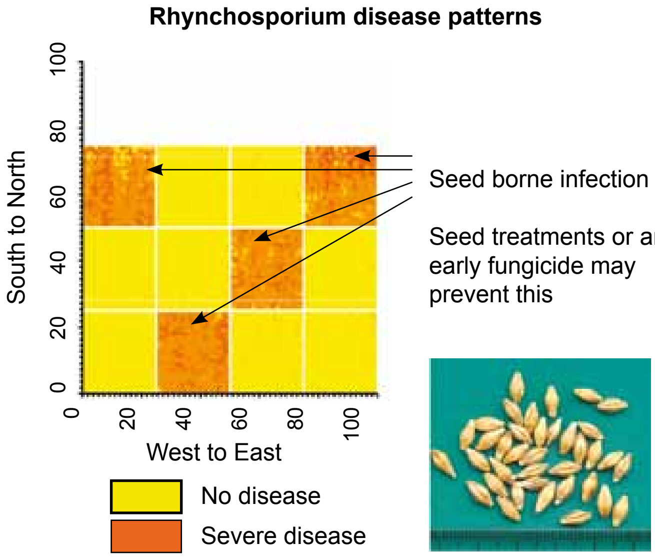
\+ Good control in normal situations
(+) Some control
P Good protection of early foliar disease
\- Not recommended
* For disease control, co-apply with a compatible fungicide seed treatment

Seed as source of foliar disease

The fungus which causes net blotch (*Pyrenophora teres*) is known to be carried on the seed. It can lead to early infection on seedlings and it can be reduced using seed treatments.

Recent research at SAC suggests seed-borne infection of rhynchosporium is an important source of the fungus, leading to widespread symptoms early in the season. Observations of rhynchosporium development in winter barley show the sudden appearance of symptoms throughout the crop in January. Diagnostics show the presence of the pathogen which causes rhynchosporium on the seed, roots and leaves before symptoms appear. Work is ongoing to determine the impact seed treatments can have in controlling early diseases. Since none show effective control, best control of early rhynchosporium is achieved by starting foliar treatments early and trials show that treating crops with Kayak + Torch in March, before the main stem extension timing, can effectively delay the development of the disease. Ensure late disease does not affect the heads, particularly in seed crops.

Figure 4: Widespread symptoms of rhynchosporium associated with seed infection



Many winter and spring barley seed stocks show infection with ramularia. Harvested samples of grain from throughout the UK are affected and not just in the north. It has been shown that the fungus can infect emerging seedlings and cause lesions on the top leaves with no external infection. Seed infection is thought to be the main source of disease. Seed treatments are being tested to see if they can help reduce the disease. Current seed treatments appear to offer poor control however. Although ramularia is less important in the winter crop, it can be a source of spores for the spring crop, so effective control with seed treatments may also be required with winter barley in the future. Figure 5 shows the lifecycle for this disease. Key issues which lead to high disease levels are seed infection, poor varietal resistance, crop stress and leaf wetness. New research is looking at these factors to produce a risk forecast and new methods of control through varietal resistance and seed treatments.

Figure 5: Lifecycle of ramularia collo-cygni

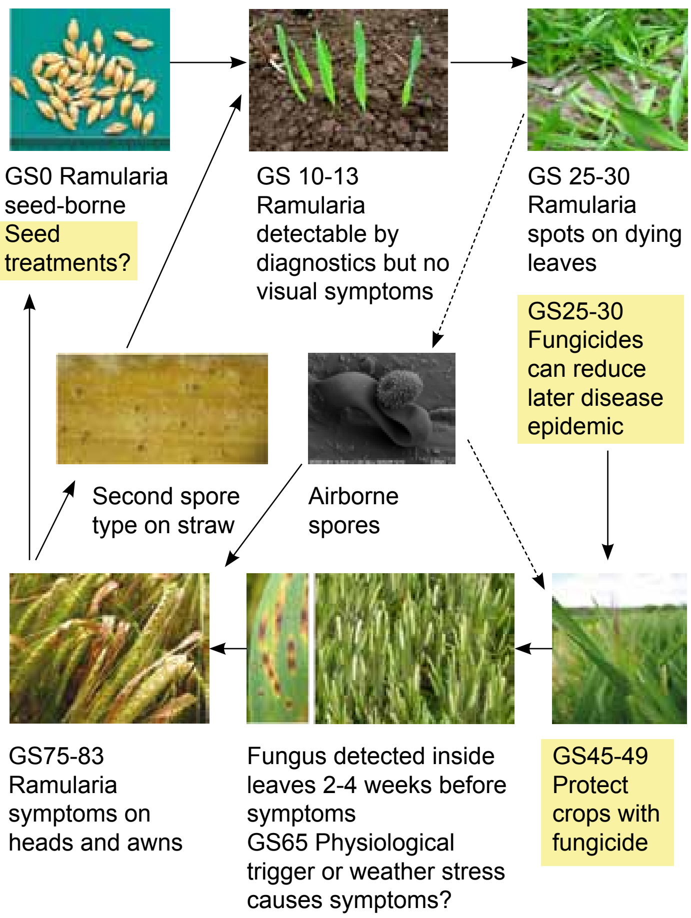
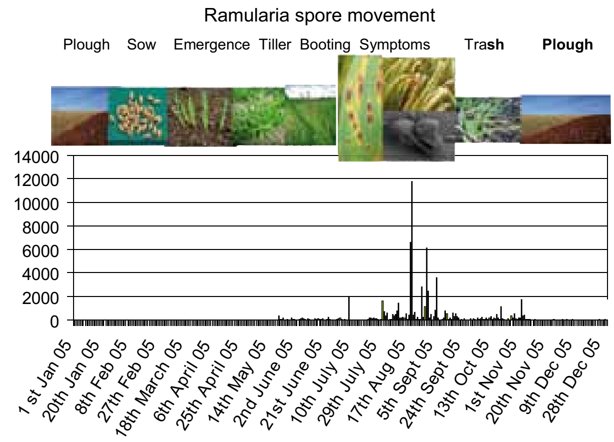


Figure 6 shows the release of airborne spores during the season (measured in picograms of DNA). The fungus appears to be detected most after lesions can be seen in the field. Spores are released 48 hours after the leaves have been wet for a period of time. Absence of spores over the winter suggests alternative hosts are not as important as seed infection. A second fungal spore has been found which is present on straw. The importance this has on the disease is not fully understood. Current seed treatments appear to offer little control of ramularia.

Figure 6 Airborne spores of Ramularia collo-cygni

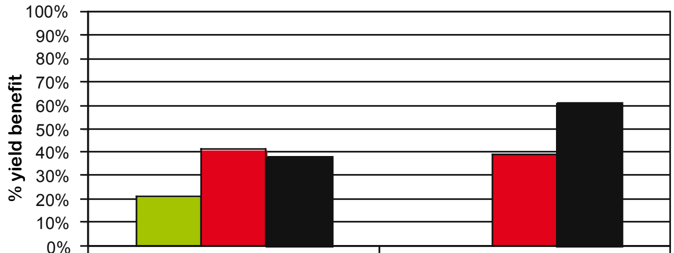


Yield response to fungicide

Winter barley achieves a greater yield response from early fungicides applied at GS30 and GS32 than from the later fungicide applications at GS45. (Figure 8). The later timing is however becoming more important where ramularia leaf spots develop. Approximately 60% of the yield benefit from fungicides comes from early treatments at tillering (GS25-30) and stem extension (GS31-32). The additional 40% comes from the treatment at boot stage to ear emergence (GS49-59). In spring barley, the greater yield responses are achieved with a later application at GS45-49 than with the early application at GS25-30 (Figure 7). The early fungicide provides 40% of the yield benefit and the later timing

60% of the yield. Applications at both spray timings are generally still required on both winter and spring crops, but the relative responses indicate where you should focus your major spend on the crop.

Figure 7 Yield responses at early and late different growth stages in winter and spring barley



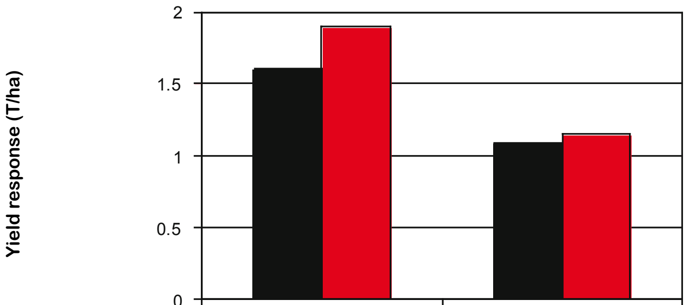
	Winter	Spring
GS25	21%	
GS32	41%	39%
GS49	38%	61%

100 = 1.41t/ha winter barley
100 = 0.93t/ha spring barley

These differences between the winter and spring crops may be partly due to the presence of eyespot early in the season in winter barley and the greater incidence of ramularia on spring barley post flowering.

The disease pressure will also impact on the response to fungicides. Figure 8 shows better yields overall and a better response to fungicide where disease pressure is low.

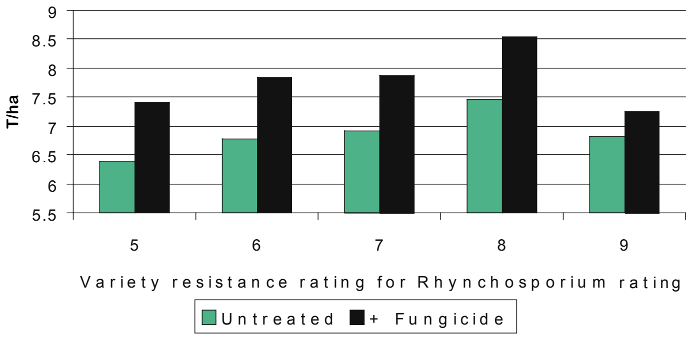
Figure 8 Yield response to fungicide in high and low disease pressures



	High disease sites	Low disease sites
GS32 & GS49	1.61	1.09
GS25, GS32 & GS49	1.9	1.15

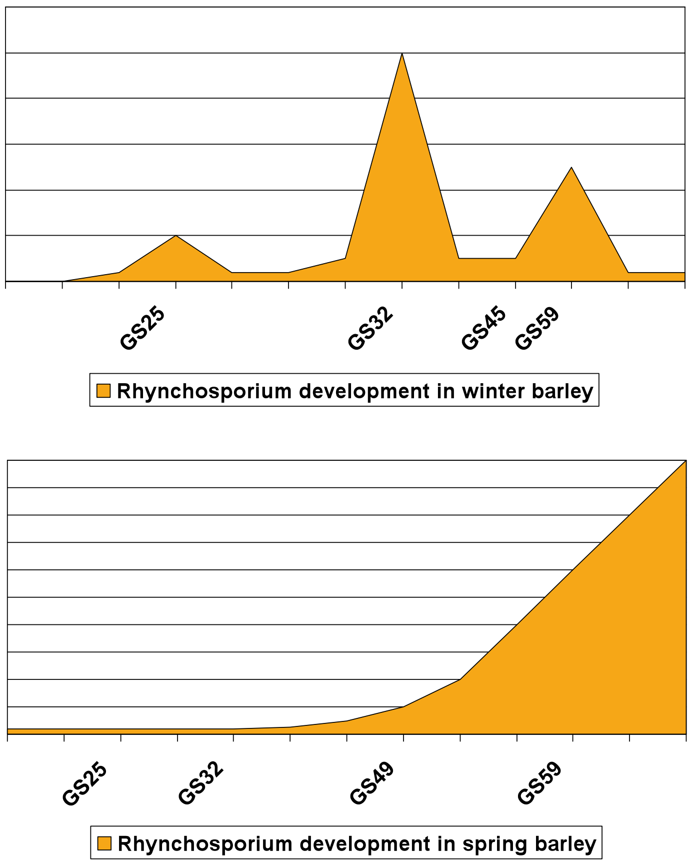
One method to reduce the pressure from disease is to make use of resistant varieties. Winter barley varieties with true varietal resistance to rhynchosporium will respond differently to susceptible varieties in high disease pressure regions. A susceptible variety may respond well to fungicide (Figure 9), but it can potentially lose 20-30% of yield where the disease is left unchecked. Varieties with good resistance (some with a score of 8), give growers more choice. Resistant varieties may still respond well to fungicide, but the yield loss in the absence of a robust programme may be lower.

Figure 9 Yield response and variety resistance



There are however differences in the development of rhynchosporium (Figure10) in winter and spring crops. In winter barley, the disease is present over the winter, reaching a peak at GS49-69 on the lower leaves. In spring barley, the disease is mostly absent until late in the season on the upper leaves.

Figure 10 Development of rhynchosporium in winter and spring barley



Winter barley foliar treatments

Autumn: Rhynchosporium, mildew, net blotch and brown rust can all develop in the autumn, but no action is recommended at this stage. In the autumn, net blotch levels can be a concern in some crop. The advice remains the same; to leave the crop untreated until early spring unless disease thresholds affect the potential for a crop to survive the winter. Yield benefits can be seen for an autumn fungicide, but the same response can be found from an early spring application. The two treatments are not additive.

Early spring: Rhynchosporium, which may have developed over the autumn and winter, may be present on the bottom leaves. If rhynchosporium was present on the seed, infections could occur rapidly in January to February. When the crop starts to grow in the spring, it is recommended that a fungicide mixture is applied to protect the developing leaves. Although these leaves may not be major contributors to yield, the aim of protecting the crop now is to prevent an upsurge in disease at GS31-32.

Torch or Corbel is a useful component of the mixture due to its short-term eradicant activity. The preferred mixing partner would be Kayak or Unix which will provide rhynchosporium protection. This mixture achieves good control and a yield benefit of up to 0.6 t/ha. The average yield response over a four year period was 0.3 t/ha. If brown rust is an issue and requires attention, a triazole (e.g. Opus) would be more appropriate than Kayak. Bravo is another option, which may delay rhynchosporium kickback, but which will provide rhynchosporium protection on developing leaves. This approach would limit later application of bravo to the crop as there is a maximum two application limit per crop.

GS31-32: This is a key timing to ensure the crop is protected to prevent the first peak of rhynchosporium developing on final leaf 3 and 4. Prothioconazole (Proline) is now the key fungicide required here. It has broad-spectrum activity including common eyespot. When the main fungicide is mixed with a strobilurin fungicide, this will ensure effective protection of rhynchosporium. If no earlier fungicide was applied, or if fresh rhynchosporium lesions are developing, then the addition of a morpholine fungicide (e.g. Torch or Corbel) will help eradicate developing rhynchosporium. Examples of fungicide co-formulated with a morpholine include Helix (prothioconazole + spiroxamine) and Jenton (pyraclostrobin + fenpropimorph). If brown rust or yellow rust protection is required, be aware cyprodinil (Unix and Kayak) and trifloxystrobin (Twist) will give poor control. Prothioconazole will give good protection against barley brown rust at dose rates above half the label rate. Epoxiconazole may be slightly weaker for rhynchosporium but will provide strong protection against brown rust.

GS45-49: At this stage, the role of the fungicide mixture is to protect the upper leaves from rhynchosporium at the second infection peak and where required, and in warmer regions, net blotch and brown rust. At this timing, the triazole fungicide plays an important role along with the strobilurin fungicide to protect the crop from rhynchosporium, rusts, net blotch and leaf spots. Prothioconazole is likely to be an important component of the mixture used here where rhynchosporium pressure is high, but Tracker or Bontima maybe more appropriate in high risk brown rust or ramularia situations. Chlorothalonil (e.g. Bravo) is an important component of a mixture to assist in protecting the upper leaves from rhynchosporium and to reduce the risk of ramularia and to maintain green leaf area. Strobilurin fungicides can contribute to yield and the control of rhynchosporium, brown rust and net blotch. They are however weak on ramularia. Comet 200 is the best strobilurin for net blotch, but Amistar is the best to reduce physiological leaf spots. Assuming no disease is established on the upper leaves, a morpholine fungicide should be avoided, since using this type of fungicide at this growth stage can sometimes cause premature leaf death and yield loss.

By using fungicides no more than twice and in mixtures, it may be possible to minimise the potential risk of resistance to any particular fungicide. The current programme recommended is reliant on prothioconazole and strobilurin fungicides playing a major role in controlling rhynchosporium. If there are any changes in resistance of these groups of fungicides to rhynchosporium, the guidelines will need to be reviewed.

Spring barley foliar treatments

Early spring: (pre mid-tillering): In spring barley, an early spring treatment for rhynchosporium is unlikely to be required (at seedling growth stages). Mildew susceptible varieties (e.g. Optic and Forensic) may require early mildew control with a protectant fungicide (e.g. metrafenone (Flexity) or proquinazid (Talius), or cyflufenamid (Cyflamid) +/- a morpholine (Torch or Corbel)). These fungicides will not however protect the crop from rhynchosporium. Occasionally chlorothalonil (e.g. Bravo) may be applied early with herbicides, but in most situations this will not be required.

GS25-30: This is the main time to apply a protectant fungicide to the crop to protect the crop from the first peak of disease. This can be based on a triazole fungicide (e.g. Proline or Opus) + chlorothalonil (e.g. Bravo). Other mixing partners include a strobilurin fungicide (e.g. Comet 200 or Galileo). A morpholine fungicide (e.g. Torch or Corbel) would only be required if rhynchosporium or mildew were established.

GS33-39: Growers, who are reluctant to protect the crop earlier, may find disease starts to develop at this time. This situation should be avoided, since rhynchosporium can be difficult to eradicate. If rhynchosporium has started to develop, a morpholine fungicide will have to be applied. This type of fungicide may affect the green leaf area on the upper leaves under certain conditions. If the use of a morpholine is unavoidable, the addition of chlorothalonil may reduce the negative impact of morpholine on green leaf retention. Flag leaf emerging stage (GS37-39) is too early to achieve effective protection of the upper leaves against leaf spots. This compromise spray timing may suit lower input feed barley systems where the rhynchosporium disease pressure was low earlier in the season and where quality (in particular screenings) are not important.

For feed varieties with good resistance to rhynchosporium and mildew (e.g. Wicket, Westminster, Doyen), a single treatment may be all that is required. The timing of the fungicide may need to fit in with other priorities on the farm, but assuming no early disease has developed, this time is a reasonable single treatment compromise. Proline + Bravo would be a good foundation. It is likely that feed crops would benefit most from the use of variety mixtures to reduce disease risk. A morpholine should only be added if established disease levels are high and taking on board comments on the impact on green leaf noted above.

GS43-49: This is the optimum timing to protect the crop from the second peak of rhynchosporium infection and also from leaf spots, brown rust and net blotch. A mixture of a triazole (e.g. Proline or Opus) plus chlorothalonil (e.g. Bravo) + strobilurin (e.g. Amistar or Comet) will be a good option. For malting barley crops, some triazoles (e.g. Opus) should not be applied if any of the head has emerged. Tracker (epoxiconazole + boscalid) shows good activity against ramularia and rusts, but will be weaker against net blotch when compared to Fandango + Bravo (prothioconazole + fluoxastrobin + chlorothalonil). Bontima (isopyrazam + cyprodinil) will have effective activity against ramularia, rusts and net blotch. It should be mixed with Bravo to ensure control of ramularia is not reliant on isopyrazam.

Crop monitoring

SAC monitors crops regularly for disease as part of Scottish Government funding in Crop Health. The information is published at www.sac.ac.uk/crops and alongside advice in the SAC published Crop Protection Reports. The information on disease development can help you decide on the potential risks of diseases throughout the season. We have now built up information on crop development and since 1978 and this makes a valuable resource as part of SAC's research into the impact of climate change on crop and disease development.

Disease identification

Use the following pictures to help you identify major barley diseases.

Rhynchosporium (*Rhynchosporium secalis*)

Powdery mildew (*Blumeria graminis*)

Net Blotch (*Pyrenophthora teres*)

Ramularia (*Ramularia collo-cygni*)

Brown rust (*Puccinia recondita*)

Snow rot (*Typhula incarta*)

Common eyespot (Oculimacula *spp*)

Take-all (*Gaeumannomyces graminis*)

Barley yellow dwarf disease (BYDV)

Barley mild mosaic virus (BaMMV)

Ergot in spring barley head

Fusarium species in winter barley head

Table 11 Summary of agronomic factors to reduce disease risk

Situation / Disease	1st barley 1 year cereal break	1st barley 2 years cereal break	2nd barley	Variety choice	Adjacent barley crop	Early sown	Late sown	Manganese deficient site	Fungicide Seed treatment
Take-all	Low risk	Low risk	High Risk	Little difference	No difference	High risk	Lower risk	Affects rooting so high risk	Latitude will give reduction
Eyespot	High risk from buried trash	Lower risk but eyespot can be wind blown	High risk	Choose stiff straw variety	Unknown possible risk of eyespot spreading	High risk	Lower risk	No difference	None effective
Sharp eyespot	No difference rotations don't reduce disease	No difference	No difference	Choose stiff straw variety	No difference	High risk	Lower risk	No difference	None effective
Mildew	No difference assuming no volunteers	No difference	High risk if volunteers	Some more resistant e.g. Amarena. Saffron is susceptible.	High risk if variety susceptible Diversify varieties	High risk	Lower risk	High risk	None effective
Yellow & brown rust	No difference assuming no volunteers	No difference	High risk if volunteers	Sequel susceptible	High risk if variety susceptible	High risk	Lower risk	Unknown	Early protection from Tripod
Rhynchosporium	Potential but low risk from trash	Low risk	High risk from trash	Amarena resistant, Saffron & Camion susceptible	High risk if variety susceptible	High risk	Lower risk	Unknown	Under investigation. Seed is major source of disease.
Net blotch	Potential but low risk from trash	Low risk	High risk from trash	Cannock resistant, Pearl susceptible	Higher risk	High risk	Lower risk	Unknown	Some provide good control
Ramularia	No difference	No difference	No difference	Some more resistant e.g. Decanter, NFC Tipple. Optic & Retriever are susceptible	Higher risk	No difference	No difference	Unknown	Under investigation. Seed infection is important source
Barley mild mosaic	Infected fields high risk	Infected fields high risk	Infected fields high risk	Some resistant e.g. Sequel, Carat, Cassata, Wintmalt	No difference	No difference	No difference	Unknown	None effective

Table 12 Summary of fungicide activity against the major barley diseases

The table below shows the relative activity of some of the fungicides available for barley disease control. Control has been defines as protectant and eradicant activity. Be aware than in high disease pressure situations, effective eradication will be a challenge for any fungicide.

	Rhynchosporium		Powdery mildew		Brown rust		Net blotch		Ramularia	Abiotic spots
Fungicide	Protection	Eradication	Protection	Eradication	Protection	Eradication	Protection	Eradication	Protection	Protection
Amistar	P				PPP	++	P			PP
Amistar opti	PPP	+			PPP	+	P		PPP	PPP
Bontima	PPP	+++	PP		PPPP	+++	PPP	++	PPP	PPPP
Bravo_500	PPP								PPP	PPPP
Comet 200	PPP	++			PPP	++	PPP	++		PPP
Corbel	P	++	PP	++	P	++	P			
Cyflamid			PPP	+++						
Fandango	PPPP	+++	PP		PPP	++	PPPP	+++	PPP	PPPP
Flexity			PPPP	+						
Fortress			PP							
Galileo	PPP	++			PPP	++	PPP	++		
Helix	PPP	+++	PP	++	PP	++	PPPP	+++		
Jenton	PPP	+++	PP	++	PPP	+++	PPP	++		
Kayak	PP	++	P				PP	+	P	PP
Landmark	PP	++	P		PPP	++	PP	++	P	PP
Opera	PP	++	P		PPP	++	PP	++	P	PP
Opus	PP	++	P	+	PPP	++	PP	++	PP	PP
Proline	PPPP	++++	PP	+	PP	++	PPPP	+++	PPP	PPPP
Swift SC	P				P		PP	+		
Talius			PP	+						
Torch	P	+++	PP	+++	PP	++	P			
Tracker	PPP	++	PP		PPP	++	PPPP	++	PPP	PPPP

Note Torch and Torch extra contain the same active ingredient, but the label doses are different.

Key	Comment	Key	Comment	Key	Comment
PPPP	Excellent protection	P	Low protection	++	Moderate eradication
PPP	Good protection	++++	Excellent eradication	+	Low eradication
PP	Moderate protection	+++	Good eradication		Poor control or not recommended

For full details of fungicides, contact the manufacturer or the CRD Database.

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