Understanding ergot risk in spring barley

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Contents

Abstract

The cereal disease commonly known as ergot is caused by the fungus *Claviceps purpurea.* This study comprises two field trials using spring barley varieties on the HGCA Recommended List. Ergot symptoms which developed through natural infection were assessed. Plots which were inoculated with the fungal pathogen were also assessed for disease symptoms. The results based on the 2007 season provide information on the potential genetic susceptibility of spring barley varieties to the disease. Cereals most susceptible to ergot are those with an open flowering habit which flower over a long period of time (i.e. rye). Open flowering enables the fungal spores to infect the grain sites leading to the development of ergots. Assessments of the flowering habit of the spring barley varieties were undertaken over two seasons. Differences in the flowering habit and the duration of flowering were observed. Most varieties flowered for a short duration of up to 6 days. A risk assessment was developed on the basis of the genetic resistance to ergot determined through the inoculations and on the flowering type and habit. On this basis, the assessment confirmed the susceptibility of the varieties Decanter and Maresi which both have an open flowering habit and are genetic susceptible to ergot. Varieties which showed no infection after inoculation which have a closed flowering habit were defined as being low risk. The variety Appaloosa is an example of this type of variety.

Project Summary

Ergot (*Claviceps purpurea*) is an important disease of cereals which can lead to extensive financial losses to growers due to the toxicity of ergot present in the grain. Ergot levels vary from year to year, and are influenced by weather at flowering, which affects both the host and the pathogen. Open flowering grass species are known to be at greater risk from the disease. An increase in alternative grass hosts in crops, field margins buffer strips and beetle banks has led to an increased risk of the problem in recent years.

This project focussed on the risk of ergot developing in spring barley varieties. Decanter and Maresi are known to be susceptible to this disease. This project looked at the flowering habits of these susceptible varieties alongside the Recommended List varieties to determine if the more susceptible varieties had a prolonged flowering period and an open flowering habit. These flowering characteristics would provide a greater opportunity of infection with ergot spores. Inoculation experiments also determined the genetic susceptibility of varieties to ergot.

The results confirmed that Maresi and Decanter were genetically susceptible to ergot. Both varieties also have a more open flowering habit potentially enabling ergot spores to more readily infect the heads compared to varieties with a closed flowering habit. On the basis of the inoculation results and the assessments of flowering habit, a table of the potential risk of varieties to ergot has been produced. It must be emphasised that low risk varieties may still get ergot, but for feed barley growers in high risk situations, choosing varieties which did not show ergot when inoculated which also have a closed flowering habit would be potentially at a lower risk from ergot compared to genetically susceptible varieties and varieties with an open flowering habit, or which flower for a greater length of time.

Potential risk of ergot development in spring barley varieties.

Variety	Flowering timing	Flowering duration	Flower habit	Ergot pieces/plot	Ergot severity	Risk
Fairytale	late	2	closed	0	Non detected	L
Maltby	late	2	closed	0	Non detected	O
Publican	late	2	partly open	0	Non detected	W
Appaloosa	early	3	closed	0	Non detected	
Rebecca	early	3	partly open	0	Non detected	
Troon	early	3	partly open	0	Non detected	
NFC Tipple	late	4	closed	0	Non detected	
Wicket	late	4	closed	0	Non detected	
Quench	early	5	closed	0	Non detected	
Belgravia	late	2	closed	1.3	Low	
Jolika	late	2	closed	1.3	Low	M
Knightsbridge	late	2	closed	1.3	Low	O
Sweeny	late	2	closed	1.3	Low	D
Scout	early	3	closed	1.3	Low	E
Azalea	early	3	partly open	1.3	Low	R
Optic	early	3	partly open	1.3	Low	A
Waggon	late	4	closed	1.3	Low	T
Westminster	late	4	closed	1.3	Low	E
Oxbridge	early	5	closed	1.3	Low	
Power	early	5	closed	1.3	Low	
Snakebite	late	2	closed	2.5	Moderate	
Cellar	early	3	closed	2.5	Moderate	
Riviera	early	3	closed	2.5	Moderate	
Decanter	early	3	partly open	2.5	Moderate	H
Cocktail	late	4	closed	2.5	Moderate	I
Doyen	late	4	closed	2.5	Moderate	G
Maresi	early	5	partly open	6.3	High	H

Key	
Low risk factor	
Moderate risk factor	
High risk factor	

Introduction

Ergot (*Claviceps purpurea*) is an important disease of cereals which can lead to extensive financial losses to growers due to the toxicity of ergot present in the grain. The disease has been known for centuries due to the harmful effects of consumption of the ergots (Murray *et al.,* 1998). The characteristic symptoms are horn shaped purple-black ergots or sclerotia (approx 10-50 mm long) which appear in mature cereal heads as replacements for individual grains (see figure 8). Consumption of ergots can lead to convulsive and gangrenous symptoms in humans and livestock. The last reported incident in humans in the United Kingdom occurred in Manchester in 1927, when 200 people were affected (Matossian, 1989). However, outbreaks in ancient times have been correlated with a decline in human population (Matossian, 1989).

The fungus overwinters as compact fungal tissue and germinates to produce stalked stromata which release airborne ascospores. During humid weather ascospores alight on cereal florets, germinate and penetrate the ovary. Infected florets can release asexually produced conidia in honeydew which can be dispersed by insects or via rainsplash to other florets. The production of honeydew declines gradually and the ergot is produced in place of a normal grain (Murray *et al.,* 1998). The disease is favoured by wet, cool weather as this prolongs the flowering period of the host plant and encourages spore germination. Therefore, pollination prior to inoculum production favours the host (Murray *et al.,* 1998). Ergot levels vary from year to year as a result of fluctuation of weather patterns.

Open flowering grass species are known to be at greater risk from the disease (Wood & Coley-Smith, 1982). An increase in alternative grass hosts in crops, field margins, buffer strips and beetle banks has led to an increased risk of the problem in recent years. In England, an increase in the grass weed black-grass has been associated with an increase in ergot. Weed species have been shown to vary in their production of isolates which can infect cereal plants (Mantle *et al.,* 1977).

A LINK project titled “Towards a sustainable whole farm approach to ergot” led by NIAB focussed on wheat crops and sites in the south of the UK. A Scottish Government funded campaign in Scotland highlighted that ergot is also an important problem in barley, in areas where black-grass is not a major problem. This HGCA

research complements the LINK project by focussing on ergot infection in spring barley.

This research investigated the flowering timing and habits of the spring barley varieties on the HGCA Recommended List (RL) to help understand whether varietal susceptibility to ergot is associated with different flowering properties. The susceptible variety Maresi was used as a standard susceptible variety in the trials. The variety Decanter is currently associated with most ergot outbreaks, but it is not understood if this is due to flowering habit, or due to the variety being sown on farms where grassland predominates, leading to a higher risk. This research would help determine the reason for the susceptibility of this variety to ergot.

The three aims of this project were:

1. Compare the susceptibility of Recommended List spring barley varieties to ergot.
2. Investigate the flowering habits of spring barley varieties.
3. Inoculate selected varieties with ergot.

Materials and Methods

Field trials

Twenty four RL spring barley varieties and the susceptible variety Maresi were sown in small plots (2x5 metres) replicated 4 times at one site at Bush, Midlothian in 2006 and 2007. The trial surrounds in 2006 were sown with "Westerwolds ryegrass mixture" which flowers in the year of sowing. In 2007, the trial surrounds were Decanter spring barley. The plots received a full fungicide programme to manage foliar diseases. Standard applications of herbicide and other inputs were applied. See appendix 1 for site details and the full protocols which provide details of the products applied in 2006 and 2007.

Spore production

Conidia were produced from single sclerotia of *Claviceps purpurea* obtained from Dr Rosemary Bayles (NIAB, Cambridge). Sclerotia were cultured on Potato Dextrose Agar (PDA) plates and conidia harvested by flooding the plate with sterile distilled water and gently abrading the surface of the plate with a glass spreader. Spores were counted using a haemocytometer and an aqueous suspension of 10^6 spores mL^{-1} prepared for inoculation of plants in the field. Tween 20 was added to make a 0.1% solution.

Inoculation

In 2006 small patches of crop were inoculated and covered with plastic bags for 48 hours to give a high relative humidity and encourage infection.

In 2007 one metre strips of each Recommended List variety were inoculated using two methods. The first treatment relied on natural infection through flowering ears. The second treatment involved damaging the ears to allow entry points for the ergot by compressing them using a block with hypodermic needles embedded in them, following the method of Thomas *et al.,* 2007. Inoculum was applied using a knapsack sprayer.

Environmental conditions 2006

Inoculum was applied on the 26th of June 2006. Figures 1, 2 and 3 show the weather conditions at the time of inoculation. Rainfall during this period was nil.

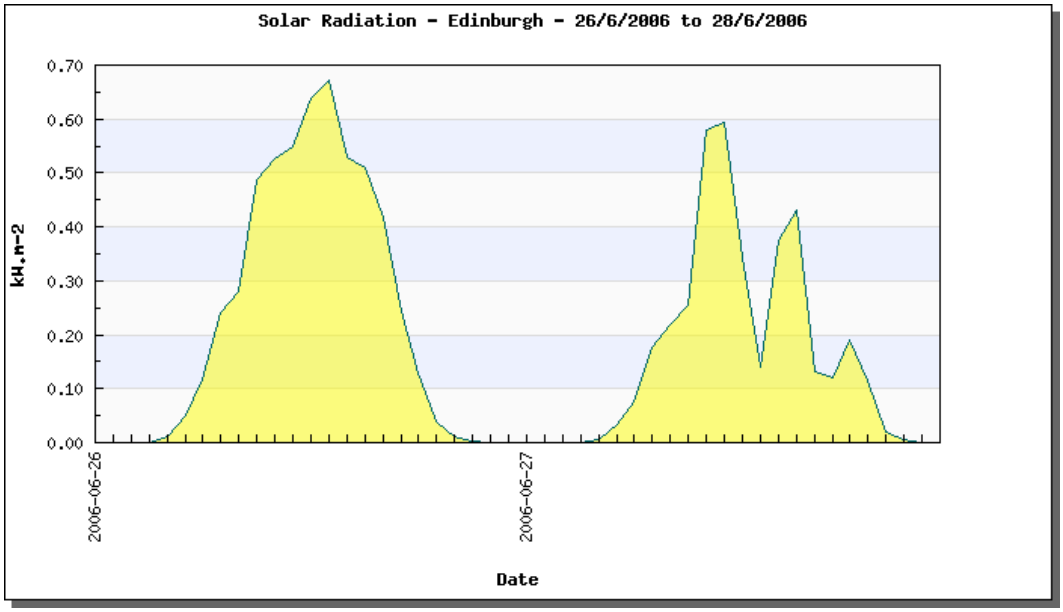


Figure 1 Solar radiation at time of inoculation

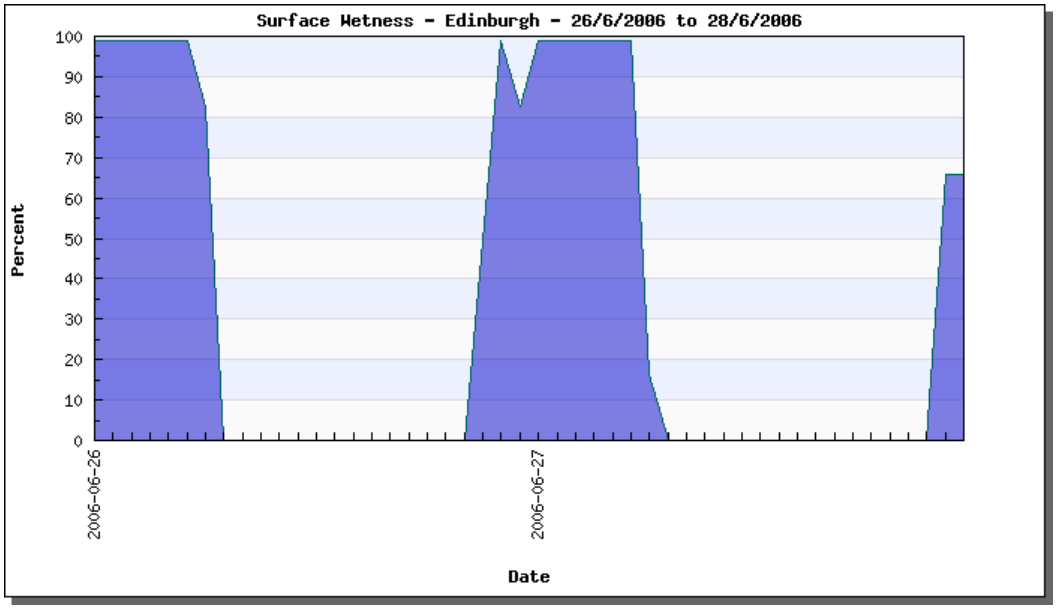


Figure 2 Leaf surface wetness at time of inoculation

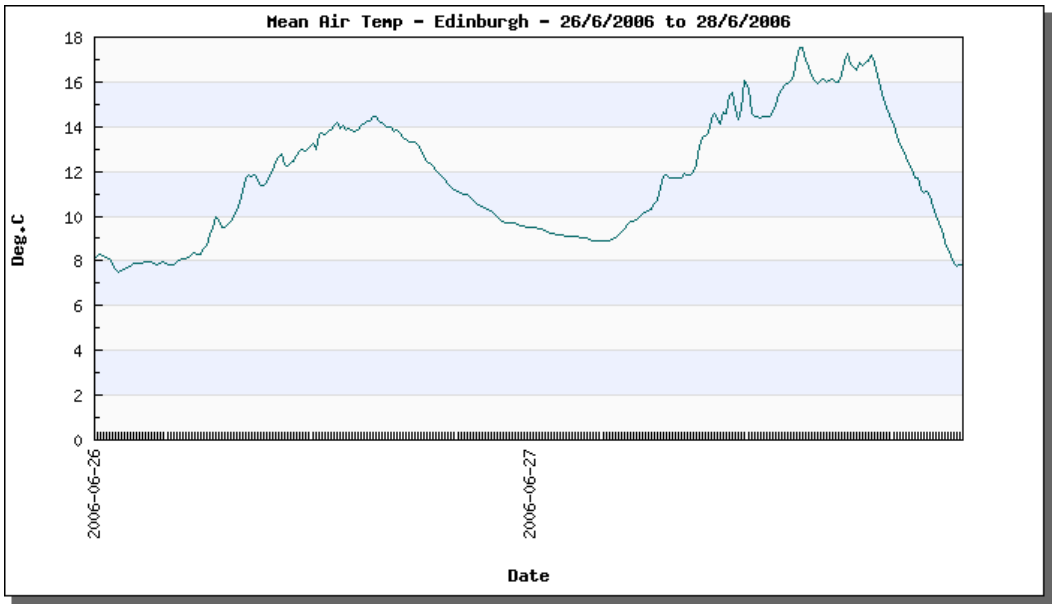


Figure 3 Air temperatures at time of inoculation

Environmental conditions 2007

In 2007, the inoculum was applied on the 21st of June 2007. Weather conditions can be seen in figures 4, 5, 6, and 7. In 2007, rainfall coincided with the inoculation period and the leaf wetness duration was greater compared to 2006.

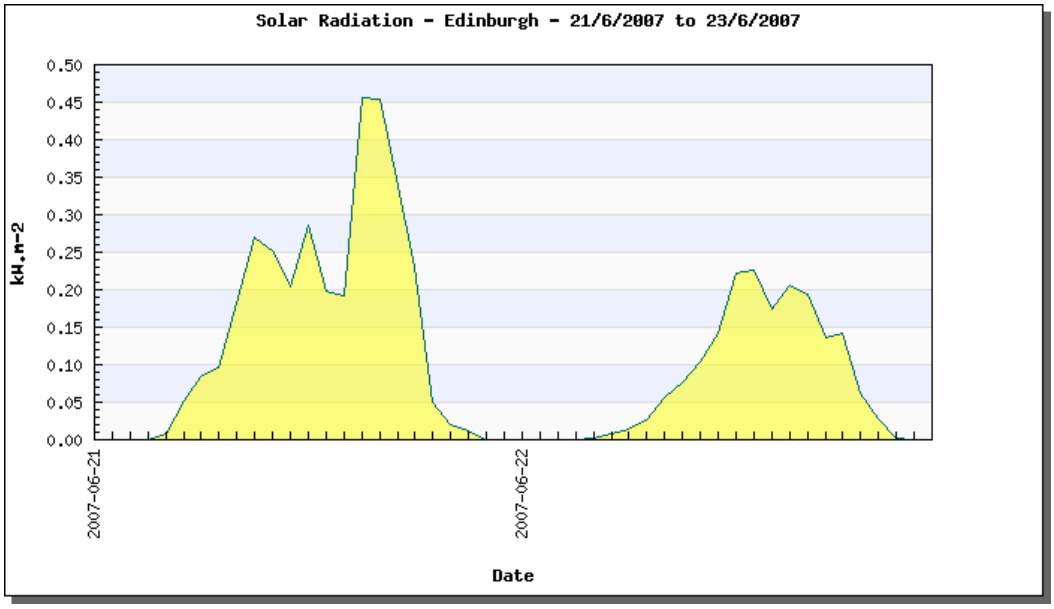


Figure 4 Solar radiation at time of inoculation in 2007

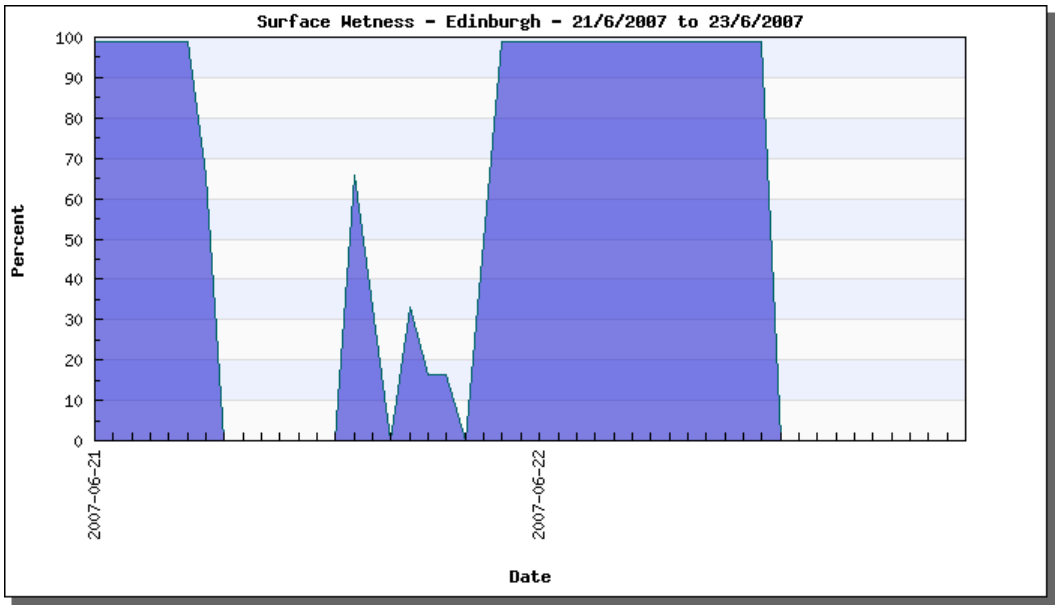


Figure 5 Leaf surface wetness at time of inoculation in 2007

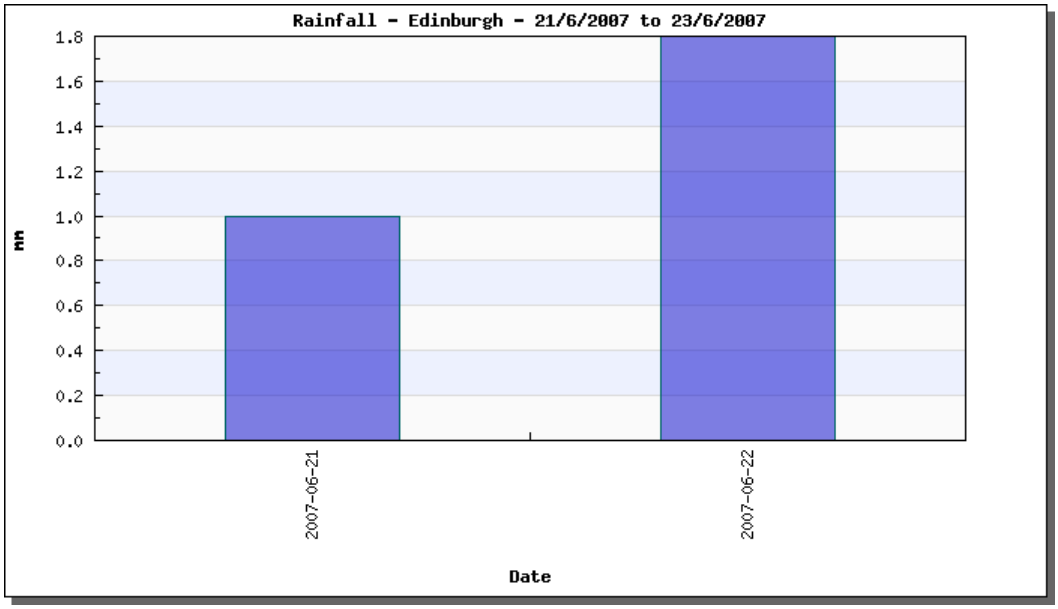


Figure 6 Rainfall at time of inoculation in 2007

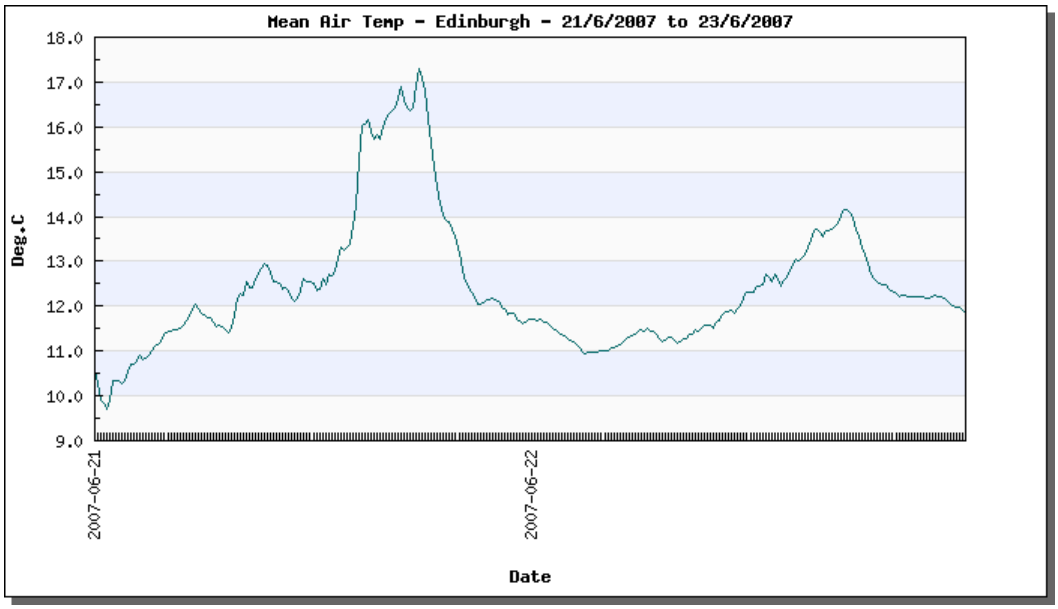


Figure 7 Air temperatures at time of inoculation in 2007

Disease assessments

A visual assessment and tally of ergot numbers was undertaken in the inoculated and non-inoculated plots at GS85. Scores are given as number of ergot pieces per plot.

Flowering assessments

Flowering characteristics thought to be associated with a variety's 'openness of flowering' were studied over a two-week period from booting growth stages. These include ear density and blind florets / ear.

Assessment of ear and flower habit

Flowering habit may influence a crop's susceptibility to infection by ergot. In particular, an 'open' flowering habit or prolonged flowering phase (across the ear population) could increase the risk of infection.

Although flowering in spring barley tends to be 'closed', spikelets (few or many within an ear) can show varying degrees of 'open' or 'closed' habit. This is influenced by variety, time of sowing and weather, though it is not easy to predict.

Anthesis lasts only a few minutes. However, across a population of ears there is considerable variation in both ear and spikelet habit, such that the period for potential infection is wide i.e. several days. To take this into account, a method was devised to

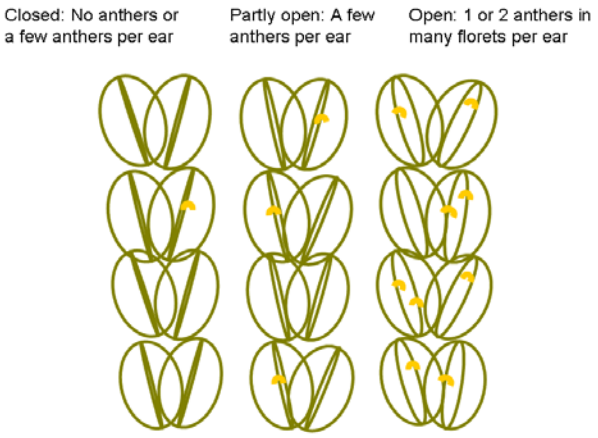
assess features of the ear and flowering that might predispose a variety or a crop to infection.

Ear habit at flowering

Anthesis usually takes place when the ear is fully emerged. However, it can also occur while the ear is still completely or partially within the flag leaf sheath. This is problematic for assessing the precise timing of anthesis, but the position (growth stage) of the ear at flowering could be a contributing factor in ergot infection. Therefore, crop development was recorded from the 'booting' growth stages (GS41-49). At the start of anthesis (GS61-69) crops were assessed on a daily basis – as evidence of the crop having flowered at a precise stage of 'booting' or 'ear emergence': this ranged from flag leaf sheath opening (GS47) or awns first visible (GS45) to ear emergence completed (GS59). Variation in crop development was recorded in replicate plots by visual assessment across patches approximately 1 m^2. Individual shoots or ears were hand-held for estimating the timing of anthesis.

Flowering habit and duration

The start of flowering (anthesis) was defined as elongation of the stamen i.e. filaments and anther (Kirby and Appleyard, 1984). In open or partly open flowering the anthers emerge from the floret (i.e. palea and lemma) such that a few anthers per ear are observed in partly open types or many anthers per ear appear in open types (see Scheme 1 below). In closed flowering the anthers may only partly emerge or not emerge, such that very few anthers per ear are apparent. The start of flowering in the closed type is observed by gently squeezing of the florets to assess if the filament of the stamen has elongated.



Scheme 1 Flowering types in ears of spring barley

From the start of anthesis, replicate plots for each variety were assessed for (a) variation in flowering within the plot and (b) openness of florets during the flowering period.

Variation was scored as:
0 = flowering not occurred,
1 = completed in 20% of ears,
2 = completed in 50% of ears,
3 = evidence of flowering having started in all ears*,
4 = completed in 75% of ears,
5 = completed in all ears.

*Note that score 3 could last for just a few hours and score 4 would be a more appropriate measure, especially when recording on a daily basis only.

Flowering habit was scored as:
0 = not flowering,
1 = closed flowering,
2 = partly open,
3 = open flowering.

Both scores were carried out in replicate plots by visual assessment across patches approximately 1 m^2. Their combination enabled an approximate duration of flowering period, in days.

Results

Ergot symptoms

In 2006 no ergot was observed in the inoculated or non inoculated patches of the crop. In the 24 hours after inoculation, solar radiation was high, peaking at 0.65 kw m^{-2}. Although the mean air temperature did increase much above 18 °C the temperature under the plastic may well have risen much higher, with detrimental effects on fungal development. Surface wetness was high during the night hours after inoculation but 2006 was a short and hot summer in general which did not suit the pathogen.

In 2007 ergot was observed in the inoculated and uninoculated strips. An example is shown in figure 8. Conditions at inoculation were much more favourable for infection. The lack of plastic bags removed the problem of excessively high temperatures. Surface wetness and rainfall were high during the 48 hours after inoculation and the cool wet summer of 2007 was much more conducive to disease development. Ergot counts were averaged for each variety (Table 1).

Figure 8 Ergot kernels from 2007 inoculated field trial.

Table 1 Ergot kernels per plot in 2007

Variety	Ergot kernels (inoculated plot)	Ergot kernels (natural infection)
Appaloosa	0	0
Belgravia	2.5	1.3
Cellar	2.5	2.5
Cocktail	10.0	2.5
Decanter	10.0	2.5
Doyen	15.0	2.5
Fairytale	0	0
Jolika	2.5	1.3
Knightsbridge	2.5	1.3
Maltby	0	0
Maresi	12.5	6.3
NFC Tipple	0	0
Optic	2.5	1.3
Oxbridge	2.5	1.3
Power	2.5	1.3
Publican	0	0
Quench	0	0
Rebecca	0	0
Riviera	10.0	2.5
SB02146	2.5	1.3
Scout	2.5	1.3
Snakebite	2.5	2.5
Sweeney	0	1.3
Troon	0	0
Waggon	0	1.3
Westminster	2.5	1.3
Wicket	0	0
SED	2.19	1.70
LSD	4.51	3.39
Sig	<.001	Ns

Maresi gave the highest levels of ergot kernels, with Cellar, Cocktail, Decanter Doyen, Riviera and Snakebite the next most susceptible. No ergot was detected in Appaloosa, Fairytale, Maltby, NFC Tipple, Publican, Quench, Rebecca, Troon and Wicket.

Other diseases

In 2007, ramularia leaf spot and other head moulds developed in the trial, despite the application of a full fungicide programme. Results from this assessment are found in Table 2. Levels of these other diseases were significantly different. Levels of head moulds were greatest on Knightsbridge, Oxbridge, Waggon, Westminster, and Sweeney. Lowest levels of visual head moulds were seen on Rebecca, Publican, Optic, and Azalea.

Table 2 Foliar diseases in 2007

Variety	% Ramularia flag leaf	% Ramularia leaf 2	% Green leaf area flag leaf	% Green leaf area leaf 2	Head moulds %
Appaloosa	11.0	13.3	52.5	62.5	7.8
Belgravia	10.0	8.0	50.0	50.0	7.0
Cellar	7.3	6.3	37.5	37.5	4.8
Cocktail	7.3	10.5	42.5	57.5	5.5
Decanter	9.3	14.0	57.5	62.5	5.5
Doyen	16.0	17.5	50.0	45.0	10.5
Fairytale	14.3	20.8	57.5	52.5	5.5
Jolika	2.5	8.5	65.0	70.0	7.0
Knightsbridge	4.5	8.3	18.7	26.3	15.0
Maltby	10.8	18.0	40.0	50.0	10.3
Maresi	6.8	8.3	6.2	8.8	6.3
NFC Tipple	9.3	13.8	62.5	57.5	9.0
Optic	9.8	18.3	42.5	42.5	2.5
Oxbridge	8.8	9.0	40.0	50.0	14.5
Power	3.5	7.5	52.5	65.0	3.5
Publican	5.0	9.0	41.2	60.0	2.8
Quench	10.8	11.5	57.5	56.2	3.5
Rebecca	5.8	12.0	60.0	65.0	2.0
Riviera	9.0	17.5	50.0	47.5	4.3
Azalea	10.3	11.5	50.0	37.5	2.5
Scout	10.0	15.8	47.5	50.0	5.8
Snakebite	14.3	11.8	45.0	50.0	7.5
Sweeney	11.8	15.8	42.5	56.2	11.3
Troon	15.0	21.8	27.5	27.5	7.0
Waggon	5.5	7.5	55.0	65.0	12.0
Westminster	7.5	16.5	55.0	58.8	11.3
Wicket	4.3	6.5	37.5	52.5	11.3
SED	2.78	3.58	13.40	13.6	3.05
LSD	5.54	7.12	26.68	27.0	6.07
Sig	<.001	<.001	0.02	0.008	<.001

Head moulds were identified to include Fusarium and botrytis species.

Flowering

A summary of the flowering assessments for 2006 are shown in Table 3 and for 2007 in Table 4. Full details from the assessments can be found in Appendix 2.

The length of flowering ranged from 2-6 days in 2006 and 2-5 days in 2007. This is a relatively short period of time, but the duration of flowering may however be longer were many secondary tillers develop.

Table 3 Flowering assessments in 2006

Variety	Timing of flowering	Approx length of flowering (days)	Type of flowering
Appaloosa	early	2	closed
Cellar	early	2	closed
Chalice	late	2	closed
Cocktail	late	2	closed
Decanter	early	4	partly open
Doyen	late	4	closed
Maresi	early	2	partly open
NFC Tipple	late	4	closed
Optic	early	2	open
Oxbridge	early	4	closed
Poker	early	4	closed
Power	late	2	closed
Prague	early	2	partly open
Publican	early	2	open
Quench	late	6	closed
Rebecca	early	2	partly open
Riviera	late	2	closed
Static	early	2	partly open
Taphouse	late	6	closed
Tartan	early	2	closed
Tocada	early	2	partly open
Troon	early	2	open
Waggon	late	2	closed
Westminster	late	4	closed
Wicket	late	6	closed

Table 4 Flowering assessments in 2007

Variety	Timing of flowering	Approx length of flowering (days)	Type of flowering
Appaloosa	early	3	closed
Azalea	early	3	partly open
Belgravia	late	2	closed
Cellar	early	3	closed
Cocktail	late	4	closed
Decanter	early	3	partly open
Doyen	late	4	closed
Fairytale	late	2	closed
Jolika	late	2	closed
Knightsbridge	late	2	closed
Maltby	late	2	closed
Maresi	early	5	partly open
NFC Tipple	late	4	closed
Optic	early	3	partly open
Oxbridge	early	5	closed
Power	early	5	closed
Publican	late	2	partly open
Quench	early	5	closed
Rebecca	early	3	partly open
Riviera	early	3	closed
Scout	early	3	closed
Snakebite	late	2	closed
Sweeny	late	2	closed
Troon	early	3	partly open
Waggon	late	4	closed
Westminster	late	4	closed
Wicket	late	4	closed

To analyse the flowering data across the two seasons, a value of 1 was given to an early flowering variety and 3 for a late flowering variety. A value of 1 was given to a closed flowering variety and a value of 3 to an open flowering variety. Table 5 shows the results of the analysis blocked by year. The results show varieties can vary in the openness of flowering, timing of flowering and length of flowering. The year had the biggest impact on the flowering habit. Closed varieties however were closed habit in both years. Open varieties in one season were recorded as partially open in a second year. Varieties recorded with a closed flowering habit were recorded with the same habit in the second year.

Table 5 Summary of flowering type 2006 and 2007

Variety	Timing of flowering (1 = early, 3 =late)	Approx length of flowering (days)	Type of flowering (1=closed, 3 =open)
Appaloosa	1.0	2.5	1.0
Azalea	1.1	2.7	2.0
Belgravia	3.1	1.7	1.0
Cellar	1.0	2.5	1.0
Chalicel	2.9	2.4	1.0
Cocktail	3.0	3.0	1.0
Decanter	1.0	3.5	2.0
Doyen	3.0	4.0	1.0
Fairytale	3.0	1.7	1.0
Jolika	3.0	1.7	1.0
Knightsbridge	3.0	1.7	1.0
Maltby	3.0	1.7	1.0
Maresi	1.0	3.5	2.0
NFC Tipple	3.0	4.0	1.0
Optic	1.0	2.5	2.5
Oxbridge	1.0	1.5	1.0
Poker	0.9	4.4	1.0
Power	2.0	3.5	1.0
Prague	0.9	2.4	2.0
Publican	2.0	2.0	2.5
Quench	2.0	5.5	1.0
Rebecca	1.0	2.5	2.0
Riviera	2.0	2.5	1.0
Scout	1.1	2.6	1.0
Snakebite	3.1	1.7	1.0
Static	0.9	2.4	2.0
Sweeny	3.0	1.7	1.0
Taphouse	2.9	6.4	1.0
Tartan	0.9	2.4	1.0
Tocada	0.9	2.4	2.0
Troon	1.0	2.5	2.5
Waggon	3.0	3.0	1.0
Westminster	3.0	4.0	1.0
Wicket	3.0	5.0	1.0
SED	0.809	1.13	0.32
LSD	1.71	2.39	0.69
Sig (Year)	Ns	Ns	0.009
Sig (Variety)	0.009	0.05	<.001

Discussion

The hypothesis tested in this study was that the potential risk of ergot can be determined by the genetic susceptibility of the variety to ergot (tested through inoculation) and through changes in flowering habit, whereby open flowering varieties and varieties which flowered for a longer duration were at a greater risk.

The research comprised a single trial in two years at one site. In 2006, the summer was warm and dry compared to 2007. Disease developed in 2007 in both inoculated and uninoculated plots and it is on the basis of this trial that ergot severity is based.

Flowering assessments showed similarities in flowering type in the two years. Closed flowering varieties showed the same habit in each of the two years. Open flowering varieties in 2006 were defined as partially open in 2007. The earliness or lateness of flowering was recorded, but not used in a risk forecast.

Table 6 summarises the results from the inoculation study and the assessments on flowering habits of the varieties. The results confirmed that the ergot susceptible variety Maresi achieved the highest level of infection. It is also a variety with an open flowering habit which flowers for a relatively long period of time. Decanter had two high risk factors (partially open flowering and genetically susceptible). This is a variety where ergot is a common occurrence in a year where there are favourable conditions for ergot development. Only Fairytale and Maltby achieved the lowest risk factors of closed flowering type, short flowering duration and genetically less susceptibility.

Table 6 would be of interest to growers of feed spring barley; it provides the start of a potential method to avoid varieties which are likely to develop ergot.

Table 6 Potential risk of ergot in spring barley (based on 2007 data)

Variety	Flowering timing	Flowering duration	Flower habit	Ergot pieces / plot	Ergot severity
Fairytale	late	2	closed	0	Not detected
Maltby	late	2	closed	0	Not detected
Publican	late	2	partly open	0	Not detected
Appaloosa	early	3	closed	0	Not detected
Rebecca	early	3	partly open	0	Not detected
Troon	early	3	partly open	0	Not detected
NFC Tipple	late	4	closed	0	Not detected
Wicket	late	4	closed	0	Not detected
Quench	early	5	closed	0	Not detected
Belgravia	late	2	closed	1.3	Low
Jolika	late	2	closed	1.3	Low
Knightsbridge	late	2	closed	1.3	Low
Sweeny	late	2	closed	1.3	Low
Scout	early	3	closed	1.3	Low
Azalea	early	3	partly open	1.3	Low
Optic	early	3	partly open	1.3	Low
Waggon	late	4	closed	1.3	Low
Westminster	late	4	closed	1.3	Low
Oxbridge	early	5	closed	1.3	Low
Power	early	5	closed	1.3	Low
Snakebite	late	2	closed	2.5	Moderate
Cellar	early	3	closed	2.5	Moderate
Riviera	early	3	closed	2.5	Moderate
Decanter	early	3	partly open	2.5	Moderate
Cocktail	late	4	closed	2.5	Moderate
Doyen	late	4	closed	2.5	Moderate
Maresi	early	5	partly open	6.3	High

Key	
Low risk factor	
Moderate risk factor	
High risk factor	

References

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Thomas JE, Fanstone V and Bayles RA. (2007) Variation in infectivity of ergot (*Claviceps purpurea*) isolates to wheat. *Aspects of Applied Biology* **83**, *Crop Protection in Southern Britain*; pp79-80

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Appendix 1

Protocol & Site details in 2006

Crops Division Study Number 1036 (2006 season)

Study Title: HGCA Spring barley ergot

Name of Sponsors / Contacts: HGCA

Study Objectives:

Study Timetable: Oct 05-Dec 06

Study status: non regulatory.

QA SAC responsibility

The study will be conducted within SAC Crops Division Quality Assurance System

Trial Maintenance. Kirsty Brayson

Application Details: Plot size 2 x 5 metres.

4 replicates

25 varieties

please sow westerwolds ryegrass around the trial and between the blocks

Overspray all varieties:

Note please avoid the use of graminicides. Herbicides which affect grass surrounds are to be avoided.

Code	GS25	GS45-49
All varieties	Proline 0.4 + Bravo 1.0+ Flexity 0.25	Fandango 0.75 + Bravo 1.0

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Randomisation

Plot	Block	Variety name	Plot	Block	Variety name
1	1	Doyen	51	3	Publican
2	1	Prague	52	3	Waggon
3	1	Publican	53	3	Cocktail
4	1	Riviera	54	3	Optic
5	1	Waggon	55	3	Rebecca
6	1	NFC Tipple	56	3	Riviera
7	1	Power	57	3	Appaloosa
8	1	Decanter	58	3	Cellar
9	1	Troon	59	3	Decanter
10	1	Static	60	3	Taphouse
11	1	Taphouse	61	3	Oxbridge
12	1	Quench	62	3	Static
13	1	Cellar	63	3	Doyen
14	1	Westminster	64	3	Wicket
15	1	Tartan	65	3	Quench
16	1	Optic	66	3	Poker
17	1	Chalice	67	3	NFC Tipple
18	1	Poker	68	3	Power
19	1	Appaloosa	69	3	Troon
20	1	Maresi	70	3	Maresi
21	1	Tocada	71	3	Prague
22	1	Rebecca	72	3	Westminster
23	1	Cocktail	73	3	Tartan
24	1	Wicket	74	3	Tocada
25	1	Oxbridge	75	3	Chalice
26	2	Optic	76	4	Appaloosa
27	2	Static	77	4	Optic
28	2	Tocada	78	4	Prague
29	2	Westminster	79	4	Tartan
30	2	NFC Tipple	80	4	Oxbridge
31	2	Decanter	81	4	Rebecca
32	2	Wicket	82	4	Tocada
33	2	Oxbridge	83	4	NFC Tipple

34	2	Quench	84	4	Quench
35	2	Taphouse	85	4	Poker
36	2	Troon	86	4	Waggon
37	2	Poker	87	4	Cellar
38	2	Chalice	88	4	Westminster
39	2	Riviera	89	4	Publican
40	2	Publican	90	4	Decanter
41	2	Doyen	91	4	Static
42	2	Prague	92	4	Maresi
43	2	Power	93	4	Doyen
44	2	Tartan	94	4	Cocktail
45	2	Cellar	95	4	Troon
46	2	Waggon	96	4	Power
47	2	Maresi	97	4	Taphouse
48	2	Rebecca	98	4	Riviera
49	2	Appaloosa	99	4	Chalice
50	2	Cocktail	100	4	Wicket

Methods (SOPS used)

Methods Equipment

EQU 001 Fertiliser applicator calibration

EQU 002 Fertiliser applicator cleaning

EQU 003 Fertiliser application

EQU 006 The calibration, operation and cleaning of commercial seed drill

EQU 012 Sprayer calibration and operation- knapsack

EQU 014 Pedestrian operated sprayer cleaning

EQU 016 The use and calibration of weigh balances

EQU 019 Combine harvester setting and operation

EQU 028 Use of drying ovens

EQU 020 Plot yield balance calibration and operation

TRIAL

TRL 001 Trial design

TRL 002 Site identification and selection

TRL 003 Soil analysis

TRL 004 fertiliser requirements for sites

TRL 005 calculation of fertiliser rates

TRL 006 Seed bed preparation

TRL 007 Marking out trials (combinable crops)

TRL 010 Burning out plots to length

TRL 011 Plot labelling

TRL 012 Grain /seed sampling

TRL 013 Grain/seed storage

TRL 014 Grain/seed cleaning

TRL 020 Crops sampling, labelling, transport, storage and disposal policy

TRL 021 Crop destruction and disposal policy

TRL 022 % Dry matter determination

TRL 023 Calculation of corrected yield

CEREALS

CER 002 Cereal crop maintenance

CER 003 Cereal growth stage assessment

CER 004 Procedure for detailed disease and green leaf assessments in cereals

CER 006 Procedure for detailed cereal ear assessments

CER 008 Ripening / harvest date determination in cereals

CER 009 Lodging / brackling / necking and leaning assessments in cereals

CER 017 Specific weight determination in cereals

CER 018 Cereals emergence, vigour and establishment assessments in the field

CER 019 Tiller counts in cereals.

Location of raw data SAC

Archiving of documentation and samples. All raw data and documentation relating to the study should be archived in the Crops Division Archive

Study personnel: Study Director, Simon Oxley. Sponsor HGCA

END of PROTOCOL

SITE DETAILS 2006

FARM		Boghall						
ADDRESS		Biggar Road, Edinburgh						
FIELD		Low Fulford						
GRID REF:-		NT 243649		ELEVATION		210m		
SOIL SERIES:-		Alluvial Fans		SOIL TEXTURE:-		Medium		
pH:-	5.6	AVAILABLE (mg/l)	P	Mod	K	Low	Mg	Low
OM%	7.5		Mn	Mod	Cu		S	
PREVIOUS CROPPING		2005 Grass		2004 Grass				
		2003 Grass		2002 Grass				
DESIGN	RBD		NUMBER OF REPLICATES	4				
			DATE SOWN	5 Apr 06				
VARIETY	Various		DATE HARVESTED	8 Sep 06				
SEED RATE	360 seeds/m^2		PLOT SIZE	5m x 2m				

FERTILISER APPLIED (Kg/ha)	N	P_2O_5	K_2O	DATE	GS
	45	45		18 Apr 06	Pre-em
				3 May 06	11-12
HERBICIDE APPLIED	RATE	PRODUCT		DATE	GS
	35 g	Ally Max		31 May 06	25-30
	0.7 l	Briotril Plus		31 May 06	25-30
	1.0 l	Isomec		31 May 06	25-30
FUNGICIDES APPLIED	RATE	PRODUCT		DATE	GS
	0.67	Unix		7 Jun 06	30-31
	1.0	Acanto		7 Jun 06	30-31
	0.25	Flexity		7 Jun 06	30-31
	0.4	Corbel		7 Jul 06	30-31
	0.8	Amistar		26 Jun 06	52
	0.75	Corbel		26 Jun 06	52
	1.0	Bravo		26 Jun 06	52
OTHER TREATMENTS					
	1.5	Cyren		31 may 06	25-30
	1.0	Mantrac 500		31 May 06	25-30

Protocols & Site details in 2007

Crops Division Study Number 1036 (2007 season)

Study Title: HGCA Spring barley Ergot Trial

Name of Sponsors / Contacts: HGCA

Study Objectives: Understand varietal differences to ergot

Study Timetable: Mar 07-Dec 07

Study status: R&D
QA SAC responsibility

The study will be conducted within SAC Crops Division Quality Assurance System

Trial Maintenance. Kirsty Brayson

Application Details:
Please apply RL fungicide treatments to the trial.

Plot	Block	Variety	Variety name	Plot	Block	Variety	Variety name
1	1	7	Cellar	55	3	7	Cellar
2	1	24	Snakebite	56	3	14	Wicket
3	1	22	Knightsbridge	57	3	17	Publican
4	1	11	Power	58	3	13	Waggon
5	1	27	Maresi	59	3	18	Scout
6	1	13	Waggon	60	3	25	Maltby
7	1	14	Wicket	61	3	21	Belgravia
8	1	25	Maltby	62	3	2	Riviera
9	1	16	Quench	63	3	6	Decanter
10	1	20	Fairytale	64	3	8	Troon
11	1	10	Rebecca	65	3	15	Appaloosa
12	1	15	Appaloosa	66	3	20	Fairytale
13	1	12	Oxbridge	67	3	12	Oxbridge
14	1	18	Scout	68	3	1	Optic
15	1	8	Troon	69	3	23	Sweeney
16	1	19	SB02146	70	3	24	Snakebite
17	1	26	Jolika	71	3	9	Doyen
18	1	17	Publican	72	3	27	Maresi
19	1	23	Sweeney	73	3	5	Westminster
20	1	2	Riviera	74	3	26	Jolika
21	1	4	NFC Tipple	75	3	10	Rebecca
22	1	1	Optic	76	3	19	SB02146
23	1	6	Decanter	77	3	11	Power
24	1	3	Cocktail	78	3	16	Quench
25	1	5	Westminster	79	3	22	Knightsbridge
26	1	9	Doyen	80	3	4	NFC Tipple
27	1	21	Belgravia	81	3	3	Cocktail

Plot	Block	Variety	Variety name	Plot	Block	Variety	Variety name
28	2	25	Maltby	82	4	21	Belgravia
29	2	27	Maresi	83	4	5	Westminster
30	2	17	Publican	84	4	15	Appaloosa
31	2	20	Fairytale	85	4	23	Sweeney
32	2	7	Cellar	86	4	12	Oxbridge
33	2	19	SB02146	87	4	1	Optic
34	2	10	Rebecca	88	4	22	Knightsbridge
35	2	3	Cocktail	89	4	11	Power
36	2	6	Decanter	90	4	8	Troon
37	2	9	Doyen	91	4	25	Maltby
38	2	11	Power	92	4	3	Cocktail
39	2	16	Quench	93	4	9	Doyen
40	2	21	Belgravia	94	4	17	Publican
41	2	14	Wicket	95	4	6	Decanter
42	2	24	Snakebite	96	4	4	NFC Tipple
43	2	26	Jolika	97	4	2	Riviera
44	2	8	Troon	98	4	18	Scout
45	2	13	Waggon	99	4	24	Snakebite
46	2	1	Optic	100	4	10	Rebecca
47	2	18	Scout	101	4	16	Quench
48	2	23	Sweeney	102	4	19	SB02146
49	2	12	Oxbridge	103	4	20	Fairytale
50	2	22	Knightsbridge	104	4	26	Jolika
51	2	2	Riviera	105	4	14	Wicket
52	2	4	NFC Tipple	106	4	27	Maresi
53	2	5	Westminster	17	4	7	Cellar
54	2	15	Appaloosa	108	4	13	Waggon

Methods (SOPs used)

Methods Equipment

EQU 001 Fertiliser applicator calibration

EQU 002 Fertiliser applicator cleaning

EQU 003 Fertiliser application

EQU 006 The calibration, operation and cleaning of commercial seed drill

EQU 012 Sprayer calibration and operation- knapsack

EQU 014 Pedestrian operated sprayer cleaning

EQU 016 The use and calibration of weigh balances

EQU 019 Combine harvester setting and operation

EQU 028 Use of drying ovens

EQU 020 Plot yield balance calibration and operation

TRIAL

TRL 001 Trial design

TRL 002 Site identification and selection

TRL 003 Soil analysis

TRL 004 fertiliser requirements for sites

TRL 005 calculation of fertiliser rates

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TRL 010 Burning out plots to length

TRL 011 Plot labelling

TRL 012 Grain /seed sampling

TRL 013 Grain/seed storage

TRL 014 Grain/seed cleaning

TRL 020 Crops sampling, labelling, transport, storage and disposal policy

TRL 021 Crop destruction and disposal policy

TRL 022 % Dry matter determination

TRL 023 Calculation of corrected yield

CEREALS

CER 002 Cereal crop maintenance

CER 003 Cereal growth stage assessment

CER 004 Procedure for detailed disease and green leaf assessments in cereals

CER 006 Procedure for detailed cereal ear assessments

CER 008 Ripening / harvest date determination in cereals

CER 009 Lodging / brackling / necking and leaning assessments in cereals

CER 017 Specific weight determination in cereals

CER 018 Cereals emergence, vigour and establishment assessments in the field

CER 019 Tiller counts in cereals.

Assessments

Carry out detailed flowering assessments as per 2006 (Steve Hoad to provide details)

Inoculate key varieties with ergot at boot stage/early ear emergence.

Assess whole trial for presence of ergot at milky ripe to soft dough stage.

Location of raw data SAC

Reporting date DEC 07

Archiving of documentation and samples. All raw data and documentation relating to the study should be archived in the Crops Division Archive
Study personnel: Study Director, Simon Oxley. Sponsor HGCA

END of PROTOCOL

SITE DETAILS 2007

FARM		Boghall							
ADDRESS		Biggar Road, Edinburgh							
FIELD		March Park							
GRID REF:-		NT 250659		ELEVATION		210m			
SOIL SERIES:-		Easter Bush		SOIL TEXTURE:-		Medium			
pH:-	5.9	AVAILABLE	P	High	K	High	Mg	High	
OM%	7.5	(mg/l)	Mn	Mod	Cu	Mod	S		
PREVIOUS CROPPING		2006 S Barley		2005 W Wheat					
		2004 S Barley		2003 Trials					
DESIGN	RBD		NUMBER OF REPLICATES		4				
			DATE SOWN		20Mar07				
VARIETY	Various		DATE HARVESTED		04Sep07				
SEED RATE	360 seeds/m^2		PLOT SIZE		5m x 2m				

FERTILISER APPLIED (Kg/ha)	N	P_2O_5	K_2O	DATE	GS
	60	60	60	21Mar07	Pre-em
	60	0	0	13Apr07	11

HERBICIDE APPLIED	RATE	PRODUCT	DATE	GS
	100g/ha	Harmony	03May07	21
	0.75l/ha	Isomec	03May07	21
	0.5l/ha	Mextrol Biox	03May07	21
	1.0l/ha	High Load Mircom	15May07	25

OTHER TREATMENTS				
	1.0 l/ha	Mantrac 500	03May07	21
	3.0l/ha	Kernel (Glyphosate)	23Aug07	91

Appendix 2 Details of flowering assessments

2006 Flowering assessment - growth stages by date.

	19-Jun	21-Jun	22-Jun	24-Jun	26-Jun	28-Jun	05-Jul	10-Jul
Variety	**Growth stage**	**Growth stage**	**Growth stage**	**Growth stage**	**Growth stage**	**Growth stage**	**Growth stage**	**Growth stage**
	GS45 to GS49	GS47 to GS49	Start of anthesis	Anthesis ongoing	Anthesis ongoing	Anthesis almost complete	Grain filling	Grain filling
Appaloosa	45	49	61	69	69	69	71	73
Cellar	47	49	61	69	69	69	73	77
Chalice	47	49	51	61	69	69	71	73
Cocktail	47	49	51	61	69	69	72	76
Decanter	47	49	61	65	69	69	71	73
Doyen	47	49	51	61	69	69	71	73
Maresi	47	49	61	69	69	69	71	75
NFC Tipple	47	47	49	65	65	69	71	75
Optic	45	49	61	69	69	69	71	73
Oxbridge	45	49	61	65	69	69	71	75
Poker	47	49	61	65	69	69	71	75
Power	49	49	55	65	69	69	71	73
Prague	47	49	61	69	69	69	71	73
Publican	45	47	61	69	69	69	71	71
Quench	47	47	49	61	65	65	71	71
Rebecca	45	49	61	69	69	69	71	75
Riviera	47	49	53	65	69	69	71	75
Static	49	49	61	69	69	69	71	75
Taphouse	47	49	51	61	65	65	71	73
Tartan	49	49	61	69	69	69	71	75
Tocada	47	49	61	69	69	69	71	73
Troon	47	49	61	69	69	69	71	73
Waggon	47	49	49	61	69	69	73	77
Westminster	47	49	49	61	65	69	71	73
Wicket	47	49	49	61	65	65	71	77

2006 Flowering assessment - growth stages by date.

	19-Jun	21-Jun	22-Jun	22-Jun	24-Jun	26-Jun	28-Jun	05-Jul	05-Jul	10-Jul	10-Jul
Variety	**Growth stage**	**Growth stage**	**Ear habit**	**Awn appearance**	**Ear habit**	**Ear habit**	**Ear habit**	**Growth stage**	**Ear habit**	**Ear habit**	**Penduncle length**
			(expressed as a growth stage)	1 = GS49 2 = ½ or more (GS49+) 3 = GS51 or GS51+	(expressed as a growth stage)	(expressed as a growth stage)	(expressed as a growth stage)		(expressed as a growth stage)	(% at GS 59)	(cm)
	GS45 to GS49	GS47 to GS49	Start of anthesis	Start of anthesis	Anthesis ongoing	Anthesis ongoing	Anthesis almost complete	Grain filling	Grain filling	Grain filling	Grain filling
Appaloosa	45	49	49	1.5	51	57	59	71	59	80	0.5
Cellar	47	49	49	2.5	55	59	59	73	59	50	0.5
Chalice	47	49	51	3	55	57	57	71	57	55	0.5
Cocktail	47	49	51	3	57	59	59	72	59	65	0.5
Decanter	47	49	51	3	55	59	59	71	59	80	0.5
Doyen	47	49	51	3	57	59	59	71	59	50	0.5
Maresi	47	49	51	3	57	59	59	71	59	100	3
NFC Tipple	47	47	49	2	53	59	59	71	59	75	0.5
Optic	45	49	49	2	53	57	57	71	59	65	0.5
Oxbridge	45	49	49	2	53	59	59	71	59	50	0
Poker	47	49	49	2	53	59	59	71	59	85	3
Power	49	49	55	3	57	59	59	71	59	90	0.75
Prague	47	49	51	2.5	53	57	57	71	57	30	0.5
Publican	45	47	49	2	51	57	59	71	59	85	0.5
Quench	47	47	49	2	53	59	59	71	59	55	0
Rebecca	45	49	49	2	55	59	59	71	59	100	2
Riviera	47	49	53	3	57	59	59	71	59	100	2
Static	49	49	49	2	55	59	59	71	59	50	0.75
Taphouse	47	49	51	2.5	57	59	59	71	59	65	0.5
Tartan	49	49	53	3	59	59	59	71	59	95	0.5
Tocada	47	49	49	2.5	53	59	59	71	59	80	0.5
Troon	47	49	51	2.5	53	59	59	71	59	90	0.5
Waggon	47	49	49	2	53	59	59	73	59	60	0.5
Westminster	47	49	49	2	53	59	59	71	59	100	4.5
Wicket	47	49	49	2	51	57	57	71	59	60	0.25

2007 Flowering assessment - growth stages by date.

	17-Jun	18-Jun	19-Jun	19-Jun	20-Jun	22-Jun	24-Jun	26-Jun	28-Jun	02-Jul	07-Jul
Variety	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage	Growth stage
	GS45 to	GS45 to	Start of	Flowering started in 20% or more (i.e. early)	Start of	Anthesis	Anthesis	Anthesis	Anthesis	Grain	Grain
	GS49	GS49	anthesis		anthesis	ongoing	completed	completed	completed	filling	filling
Appaloosa	43	47	61	yes	65	69	69	69	69	71	75
Azalea	49	51	57	yes	65	69	69	69	69	71	73
Belgravia	49	50	57		65	69	69	69	69	71	73
Cellar	45	49	57	yes	65	69	69	69	69	71	73
Cocktail	49	51	51		65	65	69	69	69	71	72
Decanter	44	45	61	yes	65	69	69	69	69	71	75
Doyen	49	49	51		65	65	69	69	69	71	73
Fairytale	45	49	51		65	69	69	69	69	71	73
Jolika	45	49	51		65	69	69	69	69	71	73
Knightsbridge	47	51	51		65	69	69	69	69	71	73
Maltby	45	47	51		65	69	69	69	69	71	74
Maresi	49	51	61	yes	65	65	69	69	69	71	74
NFC Tipple	45	45	49		65	65	69	69	69	72	76
Optic	43	45	57	yes	65	69	69	69	69	71	74
Oxbridge	45	49	61	yes	65	65	69	69	69	72	73
Power	49	51	61	yes	65	65	69	69	69	71	73
Publican	44	45	51		65	69	69	69	69	71	73
Quench	49	51	61	yes	65	65	69	69	69	71	71
Rebecca	45	49	61	yes	65	69	69	69	69	71	73
Riviera	49	51	61	yes	65	69	69	69	69	73	76
Scout	47	51	57	yes	65	69	69	69	69	71	74
Snakebite	45	49	51		65	69	69	69	69	71	75
Sweeny	45	45	51		65	69	69	69	69	71	75
Troon	45	49	61	yes	65	69	69	69	69	71	71
Waggon	49	49	51		61	65	69	69	69	71	73
Westminster	47	51	51		65	65	69	69	69	71	74
Wicket	49	49	51		61	65	69	69	69	71	76

2007 Flowering assessment - growth stages by date.

	19-Jun	20-Jun	22-Jun	24-Jun	26-Jun
Variety	Openness of flowers	Openness of flowers	Openness of flowers	Openness of flowers	Openness of flowers
	Start of anthesis	Start of anthesis	Anthesis ongoing	Anthesis completed	Anthesis completed
Appaloosa	1	1	1	1	1
Azalea	2	1	1	1	1
Belgravia	1	1	1	1	1
Cellar	1	1	1	1	1
Cocktail	0	1	1	1	1
Decanter	2	2	1.5	1	1
Doyen	0	1	1	1	1
Fairytale	0	1	1	1	1
Jolika	0	1	1	1	1
Knightsbridge	0	1	1	1	1
Maltby	0	1	1	1	1
Maresi	1	2	1.5	2	1
NFC Tipple	0	1	1	1	1
Optic	1.5	2	1.5	2	1.5
Oxbridge	1	1	1	1	1
Power	1	1	1	1	1
Publican	0	2	1.5	1.5	1
Quench	1.5	1	1	1	1
Rebecca	1.5	1.5	1.5	1	1
Riviera	0.5	1	1	1.5	1
Scout	1.5	1	1	1	1
Snakebite	0	1	1	1	1
Sweeny	0	1	1	1	1.5
Troon	0.5	1.5	1	1	1.5
Waggon	0	1	1	1	1
Westminster	0	1	1	1	1
Wicket	0	1	1	1	1