Potentially seed transmitted pests, pathogens, and weeds on Danish malting barley – part 1

Advisory report from DCA – Danish Centre for Food and Agriculture

Chris K. Sørensen, Mette Sønderskov, Tine Thach, Johannes R. Jørgensen, Henrik Skovgård, Mette V. Madsen, Mogens Nicolaisen

Department of Agroecology, Aarhus University

Data sheet

Title:	Potentially seed transmitted pests, pathogens, and weeds on Danish malting barley – part 1
Author(s):	Assistant Professor Chris K. Sørensen, Senior Advisor Mette Sønderskov, Assistant Professor Tine Thach, Lector Johannes R. Jørgensen, Senior Scientist Henrik Skovgård, Senior Scientist Mette V. Madsen, Professor Mogens Nicolaisen – Department of Agroecology, AU
Review:	Senior Scientist Annemarie F. Justesen, Academic employee Henrik Bak Topbjerg, Lector Bo Melander – Department of Agroecology, AU
Quality assurance, DCA:	Stine Cecilie Mangaard Sarraf, DCA Centre Unit, AU
Commissioned by:	Danish Agency for Agriculture, Ministry of Food, Agriculture and Fisheries
Date for request/submission:	26.04.2023 / 04.10.2023
File no.:	2023-0512827
Funding:	This Report has been prepared as part of the "Framework Agreement on the Provision of research-based Policy Support" between the Ministry of Environment of DK, the Ministry of Food, Agriculture and Fisheries of DK and Aarhus University according to ID no. 1.05 in "Performance Agreement Plant Production 2023-2026"
External comments:	Yes, appendix E and F, and preliminary versions of Appendix B and were commented by plant protection advisors from SEGES innovation. The comment sheet can be found via this LINK
External contributions:	Yes, data on weed species observed in seed batches were retrieved from the Danish seed companies Nordic seeds and DLG and used in the assessement of important weed species in Danish malting barley.
Comments to the request:	The order consists of two parts, in two separate orders; of which this is part one.
To be cited as:	Sørensen C K, Sønderskov M, Thach T, Jørgensen J R, Skovgård H, Madsen M V, Nicolaisen M, 2023. Potentially seed transmitted pests, pathogens, and weeds on Danish malting barley – part 1, 64 pages. Advisory report from DCA – Danish Centre for Food and Agriculture, Aarhus University, submitted 04.10.2023.
Policy support from DCA:	Read more here https://dca.au.dk/raadgivning/

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Background

In an order dated 26.4.2023, the Danish Agency for Agriculture has asked DCA – Danish Centre For Food And Agriculture for an updated overview of which pests that can accompany Danish malt barley when it is harvested and exported for use in the production of beer. The grain is malted in the importing country and is not used as seed.

The importing country still requires plant health, as well as the accompanying plant health certificate, as the grain may still contain pests before it goes through the malting process. In order to make scientifically based and proportionate requirements, the importing country prepares a risk analysis (Pest Risk Analysis, PRA) before market opening.

As an exporting country, Denmark must contribute information on 1) production conditions, 2) information on pests and 3) measures to combat or eliminate them. The exporter also contributes to this, especially points 1) and 3).

The answer from AU must be used to answer points 14, 15, 16 and 17 of the questionnaire from the Mexican plant health authority attached to the order from The Danish Agency for Agriculture. In relation to this, the Danish Agency for Agriculture asks AU to balance the following considerations: a) The information must fully disclose which pests can be found in Danish spring barley and which, with the kernels, can be transferred to importing countries. b) There may be irrelevant pests, e.g., because they are not found in DK, are not seed-borne, or (in the case of weed seeds) only set seed after harvest. Due to the workload and possible deadlines, the order is divided into two parts, in two separate orders; of which this is part 1: In the present part 1: The answer is limited to plant pests that can appear during the cultivation period. The information is requested in table form in English, so that this can be attached as an appendix to answering other items in the questionnaire.

Introduction

***Authors*: Chris K. Sørensen, Mette Sønderskov, Tine Thach, Johannes R. Jørgensen, Henrik Skovgaard, Mette V. Madsen, Mogens Nicolaisen – Department of Agroecology, Aarhus Universitet.**

This report contains a comprehensive list of pests, pathogens and weeds that can occur on or in association with Danish malting barley at harvest and potentially be transmitted with exported seeds.

The report is divided into sections for each of the following organisms: Bacteria and viruses, fungi and oomycetes, nematodes, arthropods (insects and mites) and weeds. It is described in each section how the species included and treated in the main text were retrieved.

All potentially seed transmitted species listed as a problem on barley by various sources and reported to occur in on barley Denmark were included in the main text. The species importance in Danish barley was estimated based on data and references stated in the text.

Detailed information is provided about the biology of those species estimated to be of major importance in Danish barley production. The intended use of this information is to initiate the pest risk analysis required for export of Danish malting barley to Mexico by providing answers to point 14-17 (Please see appendix A) in the guidelines provided by the Mexican plant health authorities.

Bacteria and viruses

***Author*: Mogens Nicolaisen**
***Reviewer*: Annemarie Fejer Justesen**

Species of bacteria and viruses listed as pathogens on barley and as seed born by either CABI crop protection compendium (CABI – Hordeum vulgare), EPPO global database (EPPO – Hordeum vulgare), Compendium of barley diseases (Mathre 1997) or "Markens sygdomme og skadedyr" (Nielsen and Jensen 2011) were checked for presence on barley in Denmark (See appendix B). In a few cases where the seed born aspects of a species were insufficiently mentioned by these sources, google searches and searches on web of science were used to determine the status.

Species of the bacterial genera Pseudomonas and Xanthomonas have been reported to occur on barley, and *Pseudomonas syringae* pv. *atrofaciens*, *P. syringae* pv. *striafaciens*, *P. syringae* pv. *Syringae, and X. translucens* pv. *cerealis*, *X. translucens* pv. *translucens*, *X. translucens* pv. *undolosa* are known to be seed-transmissible. The species *Acidovorax avenae* has also been reported as seed born and to infect barley. There are no records of *P. syringae* pv. *striafaciens* and *P. syringae* pv. *atrofaciens* in Denmark, the latter mostly reported from central and eastern Europe (Pasichnik et. al. 2003). *Pseudomonas syringae* pv. *syringae* has a worldwide occurrence (CABI – Pseudomonas syringae pv. syringae) but is negligible in barley in Denmark (Ghita C. Nielsen, SEGES, personal communication) (Table 1). There are no records of *Xanthomonas campestris* pv. *translucens*, *X. translucens* pv. *cerealis*, *X. translucens* pv. *translucens*, or *X. translucens* pv. *undolosa* from Denmark. *Acidovorax avenae* has also not been reported on barley in Denmark.

Of the seed-transmissible viruses only Barley Stripe Mosaic Virus (BSMV) (EPPO - Barley Stripe Mosaic Virus) is reported to occur in Denmark (Table 1). However, BSMV is negligible in barley in

Denmark (Nielsen and Jensen 2011; G. Cordsen, SEGES, personal communication). Both *P. syringae* pv. *syringae* and BSMV are regulated pest in Mexico (Table 1).

Table 1. Seed transmitted bacterial and viral pathogens on barley known to occur in Denmark, including an estimation of their importance in Danish barley.

Organism	**Pest - latin name**	**English name**	**Danish name**	**Regulated pest in Mexico***	**Seed borne**	**Present in DK**	**Importance on barley in Denmark**	**Reference on importance in Denmark**
Bacteria	*Pseudomonas syringae* pv. *syringae*	Bacterial kernel blight	Syrenbakteriose	Yes	Yes	Yes, worldwide	None	Ghita C. Nielsen, SEGES Personal communication
Virus	Barley Stripe Mosaic Virus	Barley Stripe Mosaic Virus	Byg-stribemosaik	Yes	Yes	Yes	None	Nielsen and Jensen 2011; SEGES

* Information on status as regulated pest in Mexico was found on web sites of IPPC (IPPC – Mexico) and EPPO (EPPO – Mexico).

Fungi and Oomycetes

***Authors*: Chris Khadgi Sørensen and Tine Thach**
***Reviewer*: Annemarie Fejer Justesen**

Species of fungi and oomycetes listed as pathogens on barley by either CABI crop protection compendium (CABI – Hordeum vulgare), EPPO global database (EPPO – Hordeum vulgare), Compendium of barley diseases (Mathre 1997) or "Markens sygdomme og skadedyr" (Nielsen and Jensen 2011) were checked for seed borne aspects and presence on barley in Denmark (See appendix C). Scientific articles found through web of science and google searches were used in cases where the seed born aspects were insufficiently described by the previous sources. Presence in Denmark were determined based on CABI crop protection compendium, handbooks, the Danish national disease trials, and scientific articles and reports. Plant protection advisor Ghita Cordsen Nielsen (SEGES) were also consulted for advice on relevant disease on Danish barley, but no changes were made to the list.

Both *Fusarium cerealis* and *F. culmorum* are listed as seed borne pathogens on barley but according to CABI only *F. culmorum* is present in Denmark. However, the DNA sequence used by Nielsen et al. (2011) to detect *Fusarium culmorum* in Danish barley samples could not distinguish be *F. culmorum* and *F. cerealis.* Since *F. cerealis* is a regulated pest in Mexico according to information from IPPC (IPPC- Mexico) further investigations might be warranted.

The importance on Danish barley were estimated for all the seed borne species found to be present on barley in Denmark (Table 2), as either not important, or of minor or major importance. Importance were established based on results from Danish national disease trials, scientific reports and articles, and data from seed companies. The main references used to estimate importance on Danish barley are listed in Table 2.

Following Table 2, detailed information is provided in a schematic form for pathogens estimated to be of major importance on Danish malting barley. Information is given with a reference to the guideline for initiation of pest risk analysis provided by the Mexican plant health authorities (appendix A). The points in brackets in the schemes refer to the corresponding bullet point in the Mexican guidelines.

The most recent and previous scientific names of all species and taxonomic groups were found on the web site mycobank.org. All Danish species names came from the list of Danish names of plant diseases caused by bacteria and fungi (Skou 2000). English and Spanish names were mainly retrieved from CABI

crop protection compendium supplemented with information from handbooks, scientific articles and google searches.

Table 2. A comprehensive list of potentially seed transmitted fungal plant pathogens of barley with confirmed presence on barley in Denmark.
The table includes a short reasoning for the estimated importance (none, minor or major) of each pathogen on Danish barley and the main reference used to reach this conclusion.

Organism	Pathogen - Latin name	English name (s)	Danish name	Regulated pest in Mexico*	Importance on malting barley in Denmark	Reason for importance on barley in DK	References on importance
Fungus	*Alternaria alternata*	Black point or Kernel blight	Sortskimmel	No	Minor	Low incidence on Danish malt barley	Andersen et al. 1996
Fungus	*Alternaria infectoria*	Black point or Kernel blight	Sortskimmel	No	Major	High incidence on Danish malt barley	Andersen et al. 1996
Fungus	*Alternaria tenuissima*	Black point or Kernel blight	Sortskimmel	Yes	Major	Moderate incidence on Danish malt barley	Andersen et al. 1996
Fungus	*Bipolaris sorokiniana*	Spot blotch of barley	*Bipolaris* bladplet	No	Major	High natural infection in Danish field trials	Pinnschmidt et al. 2005; Jørgensen et al. 2013
Fungus	Cladosporium sp.	Black point or Kernel blight	Sortskimmel	No**	Major	Moderate incidence on Danish malt barley	Andersen et al. 1996
Fungus	*Claviceps purpurea*	Ergot	Meldrøjer	No	Minor	Incidence of 1 - 2,5% in Danish seed samples	Nordic Seed (A/S) and DLG seed test***
Fungus	*Epicoccum nigrum*	Red blotch of grains	No Danish name	No	Minor	Low incidence on Danish barley seeds.	Andersen et al. 1996
Fungus	*Fusarium avenaceum*	Fusarium head blight	Aksfusarium	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011
Fungus	*Fusarium culmorum*	Fusarium head blight	Aksfusarium	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011
Fungus	*Fusarium langsethiae*	Fusarium head blight	Aksfusarium	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011
Fungus	*Fusarium tricinctum*	Fusarium head blight	Aksfusarium	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011
Fungus	*Fusarium poae*	Fusarium head blight	Aksfusarium	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011
Fungus	*Fusarium graminearum*	Fusarium head blight	Aksfusariose	No	Major	Relative low amounts detected in Danish barley	Nielsen et al. 2011
Fungus	*Fusarium sporotrichioides*	Fusarium head blight	Aksfusariose	No	Minor	Low amounts detected in Danish barley	Nielsen et al. 2011
Fungus	*Hymenula cerealis*	Cephalosporium stripe	Byggulstribe	No	Minor	Detected in very few barley samples in Denmark	Nicolaisen et al. 2021
Fungus	*Microdochium nivale*	Snow mould, Fusarium head blight	Sneskimmel	No	Major	High amounts detected in Danish seed samples	Nielsen et al. 2011

Fungus	*Parastagonospora nodorum*	Glume blotch	Bygbrunplet	No	Major	Occasionally observed in Danish fields	Pedersen 2022 and 2023
Fungus	*Pyrenophora graminea*	Barley leaf stripe	Bygstribesyge	No	Major	Common disease in Danish barley	Kristensen and Nielsen 2001; Justesen et al. 2008
Fungus	*Pyrenophora teres*	Net blotch	Bygbladplet	No	Major	Common disease in Danish barley field trials	Pedersen 2022 and 2023
Fungus	*Ramularia collo-cygni*	Ramularia	Ramularia bladplet	No	Major	Common disease in Danish barley field trials	Pedersen 2022 and 2023
Fungus	*Rhynchosporium graminicola*	Scald	Skoldplet	No	Major	Common disease in Danish barley field trials	Pedersen 2022 and 2023
Fungus	*Ustilago hordei*	Barley covered smut	Dækket bygbrand	No	None	Only very few recent records on Danish barley	Nicolaisen et al. 2021
Fungus	*Ustilago nuda*	Loose smut of barley	Nøgen bygbrand	No	Major	High incidence in Danish seed samples	Nielsen et al. 2006

Information about regulated pests in Mexico were obtained from IPPS (IPPC - Mexico) and EPPO (EPPO - Mexico).

* Two *Cladosporium* species are listed as quarantine pest in Mexico by EPPO but none of these attack barley.

** See appendix D for data

Name of pest (Point 15.a): *Alternaria spp.* - Current scientific name: *Alternaria* spp. - English name: Black point (Kernel blight) - Danish name: Sortskimmel - Spanish name: Alternariosis - Previous scientific name (s):		**References**
Taxonomic classification (Order,family, genus, species) (Point 15.b)	Pleosporales, Pleosporaceae, Alternaria, *Alternaria* spp.	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	Of the three species *A. infectoria, A. tenuissima, A. alternate* that has been reported on Danish barley (Andersen et al. 1996), *A. tenuissima* is a regulated pest in Mexico according to information of the International Plant Protection Convention (IPPC), but the species is not listed as a quarantine pest of Mexico by the European and Mediterranean Plant Protection Organisation (EPPO). None of the three species are quarantine pest in Denmark according to EPPO and IPPC.	Andersen et al. 1996 EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	*Alternaria* spp. infecting barley seeds are facultative parasites with numerous hosts, which can also grow as saprophytes on plant debris. They attack barley heads between flowering and full grain maturation.	Murray et al. 2011 Johnston 1997
Disease epidemiology - conditions for disease (Point 15.e)	The disease is favoured by wet weather and high humidity during seed maturation. Plants stressed by other disease seem more prone to infection.	Johnston 1997 Murray et al. 2011.
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Disease caused by *Alternaria* spp. in barley leads to dark brown to black discolorations of the seeds on one or more sides. Some species are known to produce mycotoxins but the most important mycotoxin producing species *A. alternata* was by Andersen et al. (1996) only found at low incidence in Danish malting barley.	Murray et al. 2011 Johnston 1997 Bretträger et al. 2023 Andersen et al. 1996
Economic losses associated with the disease in DK (Point 15.i.)	It is known, that *Alternaria* spp. infections on barley grains can cause yield losses and accumulation of mycotoxins, which may affect beer brewing. However so far, no regulations have been established for *Alternaria* spp. mycotoxins. Black point diseases caused by Alternaria is a worldwide problem, but we were not able to find any reports about the economic losses associated with *Alternaria* spp. in Danish malting barley.	Castañares et al. 2021 Bretträger et al. 2023 Johnston 1997
Uncertainties.	The *Alternaria* genus has a complex taxonomy, which can make it difficult to differentiate between species. Most sources therefore do not discriminate between diseases caused by different species, but instead only refer to disease caused by *Alternaria* spp., which is the reason why the same was done here. It is uncertain if *A. tenuissima* is a regulated pest of Mexico since it is not mentioned on the EPPO web site for quarantine pests in Mexico.	Castañares et al. 2021 Johnston 1997 Murray et al. 2011.

Completed by **Date. 19.09.2023** **Review date:** **20.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	
Name of pest (Point 15.a): *Bipolaris sorokiniana* - Current scientific name: *Bipolaris sorokiniana* - English name: Spot blotch of barley, kernel blight, root and foot rot - Danish name: Bipolaris bladplet, bipolaris fodsyge - Spanish name: Helmintosporiosis de cereales - Previous scientific name (s): *Cochliobolus sativus*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Pleosporales, Pleosporaceae, Bipolaris, *Bipolaris sorokiniana*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information found via the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Bipolaris sorokiniana* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Seeds on barley heads and especially those in the middle of the rachis can become infected with *B. sorokiniana* which cause kernel blight. The fungus is soil and seed borne and can also infect seedlings, roots and leaves (root and foot rot and spot blotch).	Steffenson 1997
Disease epidemiology - conditions for disease (Point 15.e)	Infection on seeds is favoured by relative high humidity. Optimum growth conditions for *B. sorokiniana* are temperatures of 20-30 °C and warm soil for the soil-borne inoculum. A short latency period of approx. 3 days have been observed in semi-field trial with *B. sorokiniana*.	Jørgensen et al. 2013 Steffenson 1997
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Infected barley seeds are discoloured and become dark brown to black at harvest. Other fungi e.g. *Fusarium graminiarum* and *F. culmorum* are also able to cause these symptoms, so determining the causal pathogen requires morphological assays. Small, oval and brown lesions occur on infected roots, and lower part of leaf sheets and coleoptile. Severe infection cause root rot, stunting of seedlings, reduced tillering and premature ripening.	Steffenson 1997
Economic losses associated with the disease in DK (Point 15.i.)	The fungus has been detected in Denmark in barley and wheat. It was not possible to find economical losses associated with *B. sorokiniana* in Denmark. Although in 2012, high incidences of spot blotch were detected in Danish spring barley field. A Danish semi-field trial was then carried out the same year, assessing effects of fungicide treatments against the disease. Preventive applications provided almost complete control of disease (approx. 0% attack) whereas curative applications provided moderate to low control (approx. 6-17% attack). The disease can cause reduced grain yield also by the discolouration of seeds, and reduced quality affecting malting barley. Tests performed by LBST in 2016 and 2019 did not detect the fungus in 1 sample each of the non-cereal	Jørgensen et al. 2013 Pinnschmidt et al. 2005 Steffenson 1997 Nicolaisen et al. 2021

	crops *Helianthus annuus* and *Pisum sativum* (ZIP codes not available).	
Uncertainties.	No reports of *Bipolaris sorokiniana* in the field or on seed were found for barley in Denmark since 2012.	Jørgensen et al. 2013.
Completed by Date: 19.09.2023 Review date: 20.09.2023	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	
Name of pest (Point 15.a): *Cladosporium* spp. - Current scientific name: *Cladosporium* spp. - English name: Black point, kernel blight - Danish name: Sortskimmel - Spanish name: - Previous scientific name (s):		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Cladosporiales, Cladosporiaceae, Cladosporium, *Cladosporium spp.*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Cladosporium* spp. are not regulated pests in Denmark. *C. herbarum* and *C. sphaerospermum* have been detected in barely seed in Denmark. *C. herbarum* is according to EPPO a quarantine pest in Mexico. According to CABI, it is present in Mexico.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark Andersen et al. 1996
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	*Cladosporium* spp. on cereals are usually seen on already diseased heads or plant parts caused by other pathogens. The fungi can occur in the field from flowering to maturation of the grain, and are also considered common storage mould. The species can also grow saprophytically on plant debris.	Bianchini and Stratton 2014 Murray et al. 2011 Nielsen and Jensen 1998
Disease epidemiology - conditions for disease (Point 15.e)	Black point is favoured by prolonged moist weather conditions and soil conditions. High humidity or grain moisture content of >20% (wet-weight basis) is conducive for fungal growth of several field fungi. In temperate regions, spores of e.g. *Cladosporium* spp. and *Alternaria* spp. can be common in air samples. Some species can grow at low temperatures, although slow growing e.g. food mould.	Bianchini and Stratton 2014 Bullerman 2003 Murray et al. 2011 Nielsen and Jensen 1998
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	A dark, almost black cover of spores of *Cladosporium* spp. can be seen on mature heads or plant parts which have already been infected by other pathogens. The embryo region of the grain become brown/black discoloured which is characteristic of black point. Severe infections cause discolouration from the embryo to the base of the lemma. Usually, larger kernels in the middle of the rachis are more prone to infection.	Johnston 1997 Murray et al. 2011 Nielsen and Jensen 1998
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with black point by *Cladosporium* spp. on barley in the field in Denmark. Two species, *C. sphaerospermum* and *C. herbarum* were detected on Danish malting barley seed from field trial in 1994 but not in 1993. Discolouring of grains by black point can reduce grain quality, particularly in wheat seed for flour.	Andersen et al. 1996 Murray et al. 2011

Uncertainties	*Cladosporium* spp. have a wide host range. Specific species (including other genus) causing black point on cereals can be difficult to distinguish without morphological or molecular assays.	Andersen et al. 1996 Kulik et al. 2014 Murray et al. 2011
Completed by **Date: 19.09.2023** **Review date:** **20.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	
Name of pest (Point 15.a): *Fusarium avenaceum* - Current scientific name: *Fusarium avenaceum* - English name: Fusarium head blight - Danish name: Aksfusarium - Spanish name: Fusariosis (cereales) - Previous scientific name (s): *Gibberella avenacea*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Hypocreales, Nectriaceae, Fusarium*, Fusarium avenaceum*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information found via the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Fusarium avenaceum* is not a regulated pest in Denmark. According to EPPO, the fungus is not specified as a regulated pest in Mexico but *Fusarium* sp. is listed, and the fungus is stated as present in Mexico. According to information on IPPC, *Gibberella avenacea* is listed as a regulated pest of Mexico 2011.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *F. avenaceum* can develop Fusarium head blight (FHB). Infections can proceed until harvest. *F. avenaceum* is also able to cause common root rot and seedling blight starting from infected seed. Most *Fusarium* sp. causing FHB can survive on cereal crop debris and have spore dispersal by wind or rain splash.	Dill-Macky 1997 Parikka et al. 2012
Disease epidemiology - conditions for disease (Point 15.e)	Optimum temperature for infection by *F. avenaceum* is 28-29 °C and the minimum and maximum temperature range is 14-35.5 °C (reported for wheat spikes). High humidity or rain is required for infection as for many of the *Fusarium* sp. causing FHB, as well as inoculum production. The fungus appears to be adapted to humid and wetter conditions in some studies. *Fusarium avenaceum* is able to produce mycotoxins e.g. deoxynivalenol and nivalenol.	Nielsen et al. 2011 Rossi et al. 2001 Xu et al. 2008
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes or on the rachis. As disease develops in single spikelets or entire heads, the *Fusarium* spp. involved are usually seen as pink to reddish mycelium and abundant spores (sometimes orange appearance) usually appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains.	Dill-Macky 1997
Economic losses associated with the	It was not possible to find information on economical losses associated with FHB on barley by *F. avenaceum* alone or by *Fusarium* sp. in Denmark. FHB in barley and	Nielsen et al. 2011

disease in DK (Point 15.i.)	other cereals are often caused by a complex of *Fusarium* species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. Malting barley contaminated with particularly deoxynivalenol can have an effect on beer gushing. In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years. Despite detection of high mycotoxins levels in Danish cereals in some years, the levels did not exceed permitted levels set by EU for Fusarium mycotoxins in unprocessed grain.	Plant Protection Online (Plantevœrn online) Schwarz et al. 1996
Uncertainties.	In general, FHB are caused by a *Fusarium* species complex. Identification of specific species require morphological and/or molecular characterization. Economic loss specifically for *F. avenaceum* is not estimated in Denmark.	Nielsen et al. 2011.
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Fusarium culmorum* - Current scientific name: *Fusarium culmorum* - English name: Fusarium head blight, culm rot - Danish name: Aksfusarium - Spanish name: Fusariosis, marras de nascencia - Previous scientific name (s):		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Hypocreales, Nectriaceae, Fusarium*, Fusarium culmorum*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Fusarium culmorum* is not a regulated pest in Denmark. The fungus is not specified as a regulated pest in Mexico but *Fusarium* sp. is listed (EPPO; IPPC). *Fusarium culmorum* is present in Mexico according to CABI.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *F. culmorum* develop Fusarium head blight (FHB). Infections can proceed until harvest. *F. culmorum* is also able to cause common root rot and seedling blight starting from infected seed, and infect different plant parts, seedling, foliage, heads and developing grain. Most *Fusarium* spp. causing FHB can survive on cereal crop debris and have spore dispersal by wind or rain splash.	Dill-Macky 1997 Parikka et al. 2012 Piening 1997 Dill-Macky 1997
Disease epidemiology - conditions for disease (Point 15.e)	Optimum temperature for infection by *F. culmorum* is 26.5 °C and the minimum and maximum temperature range is 16.5-33 °C (reported for wheat spikes). Increased incidence of infection is observed under dryer conditions (lower relative humidity) compared with other *Fusarium* species causing FHB and common root rot. The fungus appears to be adapted to humid and wetter conditions in some studies. *Fusarium culmorum* is able to produce mycotoxins, e.g. deoxynivalenol and nivalenol.	Dill-Macky 1997 Nielsen et al. 2011 Piening 1997 Rossi et al. 2001 Xu et al. 2008
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes or on the rachis. As disease develops in single spikelets or entire heads, the *Fusarium* spp. involved are usually seen as pink to reddish mycelium and abundant spores (sometimes orange appearance) usually appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains.	Dill-Macky 1997 Piening 1997
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *F. culmorum* alone or by *Fusarium* sp. in Denmark. FHB in barley and other cereals are often caused by a complex of *Fusarium* species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Malting barley contaminated with particularly deoxynivalenol can have an effect on beer gushing. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions.	Nielsen et al. 2011. Plant Protection Online (Planteværn online) Schwarz et al. 1996

	In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years. Despite detection of high mycotoxins levels in Danish cereals in some years, the levels did not exceed permitted levels of Fusarium mycotoxins in unprocessed grain set by EU.	
Uncertainties.	In general, FHB are caused by a *Fusarium* species complex. Identification of specific species require morphological and/or molecular characterization. Economic loss specifically for *F. culmorum* in barley is not estimated in DenmarkK. Malting barley contaminated with particularly deoxynivalenol can have an effect on beer gushing.	
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Fusarium graminearum* - Current scientific name: *Fusarium graminearum* - English name: Fusarium head blight, culm rot - Danish name: Aksfusarium - Spanish name: Fusariosis de los cereales - Previous scientific name (s): *Gibberella zeae*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	*Hypocreales, Nectriaceae, Fusarium, Fusarium graminearum*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the international plant protection convention (IPPC), *Fusarium graminearum* is not a regulated pest in Denmark. The fungus is not specified as a regulated pest in Mexico but *Fusarium* sp. is listed (EPPO; IPPC). *Fusarium graminearum* is present in Mexico according to CABI.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *F. graminearum* develop Fusarium head blight (FHB). Infections can proceed until harvest. *F. graminearum* is also able to cause common root rot and seedling blight starting from infected seed, and infect different plant parts, seedling, foliage, heads and developing grain. Most *Fusarium* sp. causing FHB can survive on cereal crop debris and have spore dispersal by wind or rain splash.	Parikka et al. 2012 Piening 1997 Dill-Macky 1997
Disease epidemiology - conditions for disease (Point 15.e)	Optimum temperature for infection by *F. graminearum* is 29 °C and the minimum and maximum temperature range is 10-35.5 °C (reported for wheat spikes). Under optimum conditions of high temperature of 25-30 °C and continued moisture from rain or heavy dew, the latency period can be 3 days from infection to blight symptoms. The fungus is generally associated with warm and humid weather. *Fusarium graminearum* is able to produce mycotoxins, e.g. deoxynivalenol and zearalenone.	Dill-Macky 1997 Nielsen et al. 2011 Rossi et al. 2001 Xu et al. 2008
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes or on the rachis. As disease develops in single spikelets or entire heads, the *Fusarium* sp. involved are usually seen as pink to reddish mycelium and abundant spores (sometimes orange appearance) usually appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains.	Piening 1997 Dill-Macky 1997
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *F. graminearum* alone or by *Fusarium* sp. in Denmark. FHB in barley and other cereals are often caused by a complex of *Fusarium* species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Malting barley contaminated with particularly deoxynivalenol can have an effect on beer gushing. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. In Denmark, certified seed is used for sowing,	Nielsen et al. 2011 Plant Protection Online (Planteværn online) Schwarz et al. 1996

	and fungicide application is used against FHB in conducive years, although effect on FHB and mycotoxins content can vary. Despite detection of high mycotoxins levels in Danish cereals in some years, the levels did not exceed permitted levels of Fusarium mycotoxins in unprocessed grain set by EU. Tests performed by LBST in 2014 to 2016 did not detect the fungus in *Hordeum vulgare, Triticum aestivum* or *Brassica rapa* (12 samples in total).	Nicolaisen et al. 2021
Uncertainties	In general, FHB are cause by a *Fusarium* species complex. Identification of specific species require morphological and/or molecular characterization. Economic loss specifically for *F. graminearum* in barley is not estimated in Denmark.	Nielsen et al. 2011
Completed by **Date: 18.09.2023** **Review date:** **19.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Fusarium langsethiae* - Current scientific name: *Fusarium langsethiae* - English name: "Fusarium head blight" - Danish name: "aksfusarium" - Spanish name: - Previous scientific name (s):		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Hypocreales, Nectriaceae, Fusarium*, Fusarium langsethiae*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Fusarium langsethiae* is not a regulated pest in Denmark. The fungus is not specified as a regulated pest in Mexico but *Fusarium* sp. is listed (EPPO; IPPC).	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Anthesis (flowering) appears to be the growth stage where barley and e.g. oat are most susceptible to infection by *F. langsethiae*. Most *Fusarium* spp. causing Fusarium head blight (FHB) can survive on cereal crop debris and have spore dispersal by wind or rain splash. This might also be the case for *F. langsethiae*. Observations suggest possible survival in crop debris which could be important in disease epidemiology.	Dill-Macky 1997 Imathiu et al. 2013 Piening 1997
Disease epidemiology - conditions for disease (Point 15.e)	Disease epidemiology and biology of the fungus is not yet fully understood. Optimum fungal growth temperature range is 20-30 °C. High humidity or rain is required for infection as for many of the *Fusarium* spp. causing FHB. *Fusarium langsethiae* is a main producer of the mycotoxins HT-2 and T-2, which levels seems to increase in seasons with warm and dry summers.	Imathiu et al. 2013 Nielsen et al. 2011 Torp and Nirenberg 2004
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Infection by the *F. langsethiae* can be asymptomatic on heads and grain produced, on seedling stage and adult plant stage, particularly on oat. Visual assessment of FHB caused by this fungus can thus, be challenging. Despite being asymptomatic, the fungus is able to produce mycotoxins and particular high levels of the highly toxic type A trichothecenes HT-2 and T-2 toxins in infected grains. *F. langsethiae* appears to be slower growing compared to other *Fusarium* sp. and symptoms of FHB on heads might be caused by other *Fusarium* sp. overgrowing *F. langsethiae*.	Imathiu et al. 2013 Nielsen et al. 2011 Torp and Nirenberg 2004
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *F. langsethiae* alone or by *Fusarium* sp. in Denmark. FHB in barley and other cereals are often caused by a complex of Fusarium species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years. Despite detection of high mycotoxins levels in Danish cereals in some years, the levels did not exceed	Nielsen et al. 2011 Plant Protection Online (Planteværn online)

	permitted levels of Fusarium mycotoxins in unprocessed grain set by EU.	
Uncertainties.	*Fusarium langsethiae* is common in barley in Denmark and also detected in other cereals. The mycotoxin contamination with particularly HT-2 and T2 in infected grains is of concern due the food and feed safety risk. A tolerable daily intake (TDI) of the sum of T-2 and HT-2 has been set to 0.02 µg per kg body weight (European Commission, 2013). As infections by the fungus can appear asymptomatic, visual assessment can be difficult if not impossible. In general, FHB are caused by a *Fusarium* species complex where disease symptoms are usually present. Identification of specific species require morphological and/or molecular characterization.	European Commision, 2013 Imathiu et al. 2013 Nielsen et al. 2011
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Fusarium poae*		**References**
- Current scientific name: *Fusarium poae* - English name: Fusarium head blight - Danish name: Fusariose, aksfusarium - Spanish name: Fusariosis de la espiga del maíz - Previous scientific name (s): *Fusarium tricinctum* f. sp. *poae*		
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Hypocreales, Nectriaceae, Fusarium*, Fusarium poae*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Fusarium poae* is not a regulated pest in Denmark. The fungus is not specified as a regulated pest in Mexico but *Fusarium* sp. is listed (EPPO; IPPC).	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *F. poae* can develop Fusarium head blight (FHB). Fusarium root rot and seedling blight can start from infected seeds. Infections can proceed until harvest. Most *Fusarium* spp. causing FHB can survive on cereal crop debris and have spore dispersal by wind or rain splash.	Dill-Macky 1997 Murray et al. 2011 Parikka et al. 2012 Piening 1997
Disease epidemiology - conditions for disease (Point 15.e)	Optimum conditions for infection by *Fusarium poae* is around 25 °C and drier weather conditions compared to e.g. *F. graminearum*. High humidity is required for infection as for many of the *Fusarium* sp. causing FHB, as well as inoculum production. *Fusarium poae* is able to produce mycotoxins, e.g. nivalenoln and also type A trichothecenes HT-2 and T-2.	Dill-Macky 1997 Nielsen et al. 2011 Parikka et al. 2012 Piening 1997 Xu et al. 2008
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes or on the rachis. As disease develops in single spikelets or entire heads, the *Fusarium* spp. involved are usually seen as pink to reddish mycelium and abundant spores (sometimes orange appearance) usually appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains.	Dill-Macky 1997 Piening 1997
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *F. poae* alone or by *Fusarium* spp. in Denmark. FHB in barley and other cereals are often caused by a complex of *Fusarium* species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years, although effect on FHB and mycotoxins content can vary.. Despite detection of high mycotoxins levels in Danish cereals in some years, the levels did not exceed permitted levels of Fusarium mycotoxins in unprocessed grain set by EU.	Nielsen et al. 2011. Plant Protection Online (Planteværn online)

Uncertainties.	*Fusarium poae* is common in barley in Denmark and also detected in other cereals. The mycotoxin contamination with particularly HT-2 and T2 in infected grains is of concern due the food and feed safety risk. A tolerable daily intake (TDI) of the sum of T-2 and HT-2 has been set to 0.02 µg per kg body weight (European Commission, 2013). In general, FHB are is caused by a *Fusarium* species complex. Identification of specific species require morphological and/or molecular characterization.	European Commision, 2013 Nielsen et al. 2011.
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Fusarium tricinctum* - Current scientific name: *Fusarium tricinctum* - English name: Fusarium head blight - Danish name: Aksfusarium - Spanish name: Fusariosis de la espiga del maíz - Previous scientific name (s): *Fusarium tricinctum* f. *poae*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Hypocreales, Nectriaceae, Fusarium*, Fusarium tricinctum*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Fusarium tricinctum* is not a regulated pest in Denmark. The fungus is not specified as a regulated pest in but *Fusarium* sp. is listed (EPPO; IPPC).	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *F. tricinctum* can develop Fusarium head blight (FHB). Infections can proceed until harvest. *F. tricinctum* is also able to cause root rot in different hosts from infected seeds. Like most *Fusarium* sp. causing FHB, *F. tricinctum* might survive on crop debris.	Wang et al. 2022
Disease epidemiology - conditions for disease (Point 15.e)	Little information on temperature regimes for *F. tricinctum* could be found. According to Parikka et al. (2012), the fungus is favoured by precipitation after flowering and not during it. Probably, high humidity is required for infection as for many of the *Fusarium* spp. causing FHB. On barley and cereals, the fungus been reported in temperate and cool/wet regions, e.g., Denmark and United Kingdom. The fungus appears to be adapted to humid and wetter conditions in some studies. It is also able to produce mycotoxins.	Nielsen et al. 2011 Nielsen et al. 2014 Parikka et al. 2012 Wang et al. 2022
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	The description is based on the general description of FHB symptoms, since little information is available for *F. tricinctum*. It can thus vary. Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes. As disease develops in single spikelets or entire heads, the *Fusarium* sp. involved can be seen with mycelium and spores appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains. *Fusarium tricinctum* is able to produce mycotoxins, e.g. enniatins and monilformin.	Dill-Macky 1997 Laraba et al. 2022 Piening 1997
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *F. tricinctum* alone or by *Fusarium* spp. in Denmark. FHB in barley and other cereals are often caused by a complex of *Fusarium* species, all able to contribute to disease and mycotoxin contamination in grains that can result in reduced grain quality and yield. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years, although effect on FHB and mycotoxins content can vary.	Nielsen et al. 2011 Plant Protection Online (Planteværn online)

Uncertainties.	In general, FHB are caused by a *Fusarium* species complex. Identification of specific species require morphological and/or molecular characterization. Economic loss specifically for *F. tricinctum* in barley is not estimated in Denmark.	Nielsen et al. 2011. Plant Protection Online (Planteværn online)
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Microdochium nivale*		**References**
- Current scientific name: *Microdochium nivale* - English name: Snow mould, Fusarium head blight - Danish name: Sneskimmel, aksfusarium - Spanish name: Moho de la nieve - Previous scientific name (s): *Monographella nivalis, Fusarium nivale*		
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Xylariales, Microdochiaceae, Microdochium, *Microdochium nivale*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Microdochium nivale* is not a regulated pest in Mexico and Denmark. *Microdochium nivale* is present in Mexico according to CABI.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Barley or other cereals infected during anthesis or seed development by *Microdochium nivale* can develop Fusarium head blight (FHB). Infections can proceed until harvest. In temperate and northern areas, the fungus mainly causes snow mould on winter cereals and grasses. Seed born *M. nivale* can cause subterranean infections and in spring conidia and ascospores can cause head infections. The fungus can survive on cereal and grass debris and have spore dispersal by wind or rain splash.	Gaudet 1997 Parikka et al. 2012 Tronsmo et al. 2001
Disease epidemiology - conditions for disease (Point 15.e)	For FHB, optimum temperature for infection by *M. nivale* is 18 °C and the minimum and maximum temperature range is 10.5-28.5 °C (reported for wheat spikes). High humidity or rain is required for infection as for many of the *Fusarium* sp. causing FHB. Cool and wet conditions during the growing season is condusive for disease.	Rossi et al. 2001 Gaudet 1997
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Initial symptoms of FHB appear as small, water-soaked, brownish lesions at the base or middle of glumes. Single spikelets or entire heads of cereals can be infected. Like the Fusarium sp. causing FHB, the mycelia are usually seen as pink to reddish and abundant spores usually appear on the edge of outer glumes. FHB can result in shrivelled, scabby and sometimes discoloured grains. Initial lesions on leaves appear with straw-coloured centers with dark margin. Bright orange sporodochia on leaf surfaces are characteristic for the fungus, as well as pink mycelia growth on particularly lower plant parts.	Gaudet 1997
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find information on economical losses associated with FHB on barley by *M. nivale* alone or by Fusarium sp. in Denmark. FHB in barley and other cereals are often caused by a complex of Fusarium species including *M. nivale*, all able to contribute to disease and in general mycotoxin contamination in grains that can result in reduced grain quality and yield. Incidence and severity of FHB and mycotoxin levels varies between years depending on climatic conditions. In Denmark, certified seed is used for sowing, and fungicide application is used against FHB in conducive years, although effect on FHB can vary.	Nielsen et al. 2011 Nielsen et al. 2013 Plant Protection Online (Planteværn online)

Uncertainties.	In general, FHB are caused by a *Fusarium* species complex, including *Microdochium spp*. Identification of specific species require morphological and/or molecular characterization. Economic loss specifically for *M. nivale* in barley is not estimated in Denmark.	Nielsen et al. 2011
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Tine Thach, Assistant professor, tine.thach@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Parastagonospora nodorum* - Current scientific name: *Parastagonospora nodorum* - English name: Glume blotch - Danish name: Bygbrunplet - Spanish name: - Previous scientific name (s): *Septoria nodorum*, *Phaeosphaeria nodorum*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Pleosporales, Phaeosphaeriaceae, Parastagonospora, *Parastagonospora nodorum*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *Parastagonospora nodorum* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	The disease starts from infected debris or infected seeds. Early attacks occur on the leaves in spring and later on the heads.	Cunfer 1997 Nielsen and Jensen 2005
Disease epidemiology - conditions for disease (Point 15.e)	The fungus prefers relatively warm and humid conditions. Spore germination and infection are optimal between 15-25 °C and the pathogen is most virulent at 20-27 °C. Dry weather halts development of lesions and pycnidia.	Cunfer 1997 Nielsen and Jensen 2005
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	In spring, lesions appear on leaves as brown oval to lens-shaped spots. Later lesions may merge into larger irregular blotches, and brown spore-producing pycnidia appear in the infected area. On infected heads, brown-purple spots can develop on glumes and awns. Sometime pycnidia develop on the seed surface. Head symptoms may be confused with black schaff and basal glume rot.	Cunfer 1997 Nielsen and Jensen 2005
Economic losses associated with the disease in DK (Point 15.i.)	The disease used to be rare on barley in Denmark, but has been more prevalent in recent years. The disease is however, still estimated to rarely have any effect on yield. Tests performed by LBST in 2014 to 2018 detected the fungus in 3 samples of *Hordeum vulgare* (ZIP codes not available, 12 samples in total).	Jalli et al. 2020 Pedersen 2023 Nicolaisen et al. 2021
Uncertainties.	*Parastagonospora nodorum* is the most recent name of the pathogen but previous scientific names are still in use, which may cause some confusion.	
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Pyrenophora graminea*		**References**
- Current scientific name: *Pyrenophora graminea* - English name: Barley leaf stripe - Danish name: Bygstribesyge - Spanish name: helmintosporiosis de la cebada/rayado de la cebada - Previous scientific name (s): *Dreshlera graminea*		
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Pleosporales, Pleosporaceae, Pyrenophora, *Pyrenophora graminea*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC) *P. graminea* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Disease starts from infected seeds and symptoms appear already on the first leaves and leads to stunted plants in most cases with no or sterile heads. Spores from the leaf lesions are spread to heads of healthy plants, and seeds can become infected at all development stages.	Babadoost 1997 Nielsen and Jensen 2005
Disease epidemiology - conditions for disease (Point 15.e)	Maximum infection of seedlings occurs at soil temperatures below 12°C at the time of seed germination and is reduced above 15°C. Disease spread is favoured by high humidity during heading and infection of healthy seeds can occur in the temperature range 10-33 °C	Babadoost 1997 Nielsen and Jensen 2005
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	The symptoms appear as yellow stripes on the leaf sheets and leaf base, which gradually extend to the full length of the leaves and turn necrotic. This lead to leaf death and shredding of the leaf ends.	Babadoost 1997 Nielsen and Jensen 2005
Economic losses associated with the disease in DK (Point 15.i.)	The disease used to be common in Denmark but the use of seed treatment and new detection methods seem to have made the disease insignificant. A test performed by LBST in 2016 did not detect the fungus in *Hordeum vulgare* (10 samples in total, ZIP code not available).	Kristensen et al. 2001 Nicolaisen et al. 2021
Uncertainties.		
Completed by **Date: 02.09.2023** **Review date:** **07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Pyrenophora teres* - Current scientific name: *Pyrenophora teres* - English name: Barley net blotch - Danish name: Bygbladplet - Spanish name: Helmintosporiosis reticular - Previous scientific name (s): *Drechslera teres*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	*Pleosporales, Pleosporaceae, Pyrenophora*, *Pyrenophora teres*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC), *P. teres* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	The disease can start from infected seed but mainly from infected crop residues. Spores from the initial lower leaf infections spread the disease to upper leaves as the plant grows and eventually mycelium may develop on the seeds.	Steffenson 1997 Nielsen and Jensen 2005 Backes et al. 2021
Disease epidemiology - conditions for disease (Point 15.e)	The disease is favoured by wet weather and mild temperatures of 12-18 °C in spring and summer. Infections starting from seeds is most frequent at temperatures from 10-15 °C. Symptoms are most apparent at 12-25°C.	Steffenson 1997 Nielsen and Jensen 2005 Backes et al. 2021
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Infection may lead to either spot or net-like disease symptoms caused by two genetically different variants of *P. teres*. In Denmark, the net-type appear to be most common, and the symptoms are dark net-like patterns inside a chlorotic area on the leaf. Symptoms are mostly seen on the leaves but infections on the seed lead to dark seed tips and poor germination.	Steffenson 1997 Nielsen and Jensen 2005 Backes et al. 2021
Economic losses associated with the disease in DK (Point 15.i.)	In naturally infected and fungicide treated spring barley trials, yield increases ranged from 6.4-8.3 hkg/ha compared to yield of 84.1 hkg/ha in untreated plots with 25% disease on the leaves. In farmer's fields the disease is usually controlled by fungicide sprays, and fungicide treated certified seeds However since it is a very common disease and resistance in Danish varieties is highly variable some economic loss is expected	Jørgensen et al. 2023 Pedersen 2023
Uncertainties.	The level of economic losses due to this disease is uncertain as no official records of monetary effects were found. Economic losses due to this disease might be higher in organic farming because of variable resistance in Danish cultivars	
Completed by **Date: 21.08.2023** **Review date:** **07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Ramularia collo-cygni* - Current scientific name: *Ramularia collo-cygni* - English name: Ramularia - Danish name: Ramularia bladplet - Spanish name: Salpicado necrótico de la cebada/Ramularia en la cebada - Previous scientific name (s): *Ramularia hordeicola*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Mycosphaerellales, Mycosphaerellaceae, Ramularia, *Ramularia collo-cygni*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC) *R. collo-cygni* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	The disease can occur throughout the growing season but is most commonly observed on upper leaves after heading. Disease may also occur on ears and awns	Nielsen and Jensen 2005 Havis et al. 2015
Disease epidemiology - conditions for disease (Point 15.e)	High leaf wetness and temperatures around 15°C favour spore dispersal. High humidity and a high number of rainy days after heading appears to be crucial for disease outbreak and expression of symptoms.	Nielsen and Jensen 2005 Havis et al. 2015
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Symptoms mainly appear on the leaves but may also occur on the ears and awns. The symptoms are reddish-brown rectangular spots visible on both sides of the leaf and surrounded by chlorotic edges	Nielsen and Jensen 2005 Havis et al. 2015
Economic losses associated with the disease in DK (Point 15.i.)	In spring barley trials naturally infected with Ramularia and fungicide treated, yield increases ranged from 0.4-7.6 hkg/ha compared to yield of 37.3 hkg/ha in untreated plots with 22.5 percent disease. In farmer's fields, the disease is usually not considered for fungicide sprays because it comes late and no good correlation is seen between yield increase and fungicide treatment. In general, Danish varieties do not carry good resistance to this disease. In some year's economic losses might therefore be significant. On average the effect on yield in Europe is around 0.4 hkg/ha if untreated.	Jørgensen et al. 2022. Pedersen 2022 Havis et al. 2015
Uncertainties.	It is not well understood how the disease effects yield including the effect of fungicide sprays as yield protection.	Havis et al. 2015
Completed by: **Date: 29.08.2023** **Review date: 07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Rhynchosporium graminicola* - Current scientific name: *Rhynchosporium graminicola* - English name: Scald - Danish name: Skoldplet - Spanish name: Rincosporiosis de la cebada - Previous scientific name (s): *Rhynchosporium commune*; *Rhynchosporium secalis*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	*Helotiales, Ploettnerulaceae, Rhynchosporium, Rhynchosporium graminicola*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC) *R. graminicola* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Disease can start from infected seeds but mainly from spores on infected debris. In spring barley, first symptoms appear at tillering and may spread to upper plant parts as the plant grows and eventually infect the seeds.	Jackson 1997 Nielsen and Jensen 2005 Ababa et al. 2023.
Disease epidemiology - conditions for disease (Point 15.e)	The disease is favoured by cool temperatures in the range 15-20 °C. Infection of seedlings from seeds is optimal at soils temperatures around 16 °C. Sporulation requires wet leaf lesions and temperatures of 15-20 °C is optimal for spore production. Wet and rainy conditions is essential for dispersal as spores are spread by rain splashes.	Jackson 1997 Nielsen and Jensen 2005 Ababa et al. 2023.
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	Lesions begin as pale grey water-soaked blotches on the leaves, typically at the leaf base. Later they develop into pale irregular patches with a dark boarder and spread to other parts of the leaf as well.	Jackson 1997 Nielsen and Jensen 2005 Ababa et al. 2023.
Economic losses associated with the disease in DK (Point 15.i.)	In naturally infected and fungicide treated winter and spring barley trials, yield increases ranged from 0.9-12.7 hkg/ha compared to yield of 48.9 hkg/ha in untreated plots with 66.3 percent disease. In farmer's fields the disease is usually controlled by fungicide sprays, resistant varieties and certified seeds, therefore economic losses are estimated to be low.	Jørgensen et al. 2022. Pedersen 2022.
Uncertainties.	The importance of seed transmission in *R. graminicola* is still not well understood and might be insignificant. Also, it was not possible to find any official records of monetary losses but due to the reasons mentioned above it is probably minor, although it might be higher in organic grown barley.	Ababa et al. 2023
Completed by: **Date: 29.08.2023** **Review date: 07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Name of pest (Point 15.a): *Ustilago nuda* - Current scientific name: *Ustilago nuda* - English name: Loose smut of barley - Danish name: Nøgen bygbrand - Spanish name: Carbón des nudo de la cebada - Previous scientific name (s): *Ustilago nuda* f. sp. *hordei*		**References**
Taxonomic classification (Order, family, genus, species) (Point 15.b)	Ustilaginales, Ustilaginaceae, Ustilago, *Ustilago nuda*	Mycobank
Quarantine pest in Denmark and/or Mexico? (Point 15.c + 17)	According to information from the European and Mediterranean Plant Protection Organisation (EPPO) and the International Plant Protection Convention (IPPC) *U. nuda* is not a regulated pest in Mexico and Denmark.	EPPO – Mexico EPPO – Denmark IPPC – Mexico IPPC – Denmark
Period of attack in the field (growth stage and/or time of year) (Point 15.d)	Infections only start from infected seeds only. When an infected seed germinates, the fungus grows symptomless inside the emerging plant and infects the ears at early development. Black masses of teliospores eventually replace the spikelets.	Thomas 1997 Nielsen and Jensen 2005
Disease epidemiology - conditions for disease (Point 15.e)	Teliospores are dispersed by the wind to infect flowers of neighbouring healthy plants. Long flowering periods and cool and moist conditions increase the risk of seed infection. Optimal flowers infection occurs at temperatures between 16-22 °C.	Thomas 1997 Nielsen and Jensen 2005
Symptoms, type of infection, and plant parts affected by disease (Point 15.f and 15.g)	The main disease symptoms occur in the spikes where seeds in most cases are completely replaced by black masses of teliospores. Teliospores are spread by the wind to infect the flowers of healthy plants leading to seed transmission.	Thomas 1997 Nielsen and Jensen 2005
Economic losses associated with the disease in DK (Point 15.i.)	It was not possible to find any official records of economic losses to this disease in Denmark but losses are considered to be insignificant. See reasoning below.	
Uncertainties.	It is difficult to estimate the economic losses but since most growers in DK use certified and/or fungicide treated seeds the losses are expected to be insignificant, although in organic barley losses might be higher.	Nielsen et al. 1998. Nielsen et al. 2006
Completed by: **Date: 29.08.2023** **Review date:** **07.09.2023**	Chris Khadgi Sørensen, Assistant professor, chris.sorensen@agro.au.dk Review: Annemarie Fejer Justesen	

Nematodes

Author: Metter Vestergård Madsen
Reviewer: Henrik Bak Topbjerg

Species of nematodes mentioned as a major problem on barley by either CABI crop protection compendium (CABI – Hordeum vulgare), EPPO global database (EPPO – Hordeum vulgare), Compendium of barley diseases (Mathre 1997) or "Markens sygdomme og skadedyr" (Nielsen and Jensen 2011) were checked for seed born aspects and presence in Denmark.

No truly seedborne plant parasitic nematodes are present on barley in Denmark. Barley is host for the cereal cyst nematode, *Heterodera avenae*, which is present in Denmark. *H. avenae* completes its full life cycle belowground and is thus not truly seedborne. The possibility has been raised that *H. avenae* cysts could spread with seeds contaminated with cyst infested soil; however, there are no records of seedborne incidences or seed transmission (CABI – Heterodera avenae). Therefore, seed borne transmission of *H. avenae* is considered unlikely.

Arthropods (insects and mites)

***Author*: Henrik Skovgård**
***Reviewe*r: Henrik Bak Topbjerg**

Species of arthropods mentioned as a major problem on barley by either CABI crop protection compendium (CABI – Hordeum vulgare), EPPO global database (EPPO – Hordeum vulgare), or important handbooks like Compendium of barley diseases (Mathre 1997) and "Markens sygdomme og skadedyr" (Nielsen and Jensen 2022) were checked for presence in Denmark and seed born aspects.

A vast number of major or minor important arthropods pest species can potentially attack barley as a small-grain crop in Denmark (see Appendix E). However, none of these insects or mites are true seed borne pests at harvest in July and August from Danish farmers' fields (Nielsen 2022). A statement further confirmed, July 2023 in an email correspondence by the author, Ghita Cordsen Nielsen (SEGES). On top of this, literature produced by EPPO and CABI on the key pest species, old or new Danish literature (very little), have been consulted without finding, at present, strong and convincing evidence for seed borne arthropods in barley in Denmark.

Weeds

The weed flora in Danish barley fields and evaluation of finding weed seeds in batches of malting barley

Authors: Mette Sønderskov and Johannes Ravn Jørgensen
Reviewer: Bo Melander

Malting barley is a summer annual crop in Denmark that is sown early in spring, typically late March or early April depending on the weather conditions. Weather conditions during the growing season and the variety determine the time of harvest, which is typically from early August until late August. The competitive ability of spring barley is considered high compared to most other crop species, but in general large yield losses are induced by weeds. Oerke (2006) mention a potential loss of up to 34%. But the potential yield loss for individual weed species is not always known. The dominating weed flora is mainly composed of summer annual weed species (e.g. *Chenopodium album*, *Sinapis arvensis*, *Galeopsis tetrahit*) and species that exhibit both summer annual and winter annual germination behavior (e.g. *Stellaria media*, *Veronica persica*, *Capsella bursa-pastoris*) (Håkansson, 2003). Perennial weed species also infest barley fields, but the number of species is much lower than for annual weeds. *Elytrigia repens* and *Cirsium arvense* are the principal perennials found in barley fields (Andreasen & Stryhn, 2008).

A broad range of weed species can be observed in Danish barley fields, although their frequencies varies from very frequent to rare (Appendix F). Barley growth and yield are affected differently by the weed species depending on their abundance, competitive ability, growth structure, and ease of control. For example, *Poa annua, Stellaria media*, *Veronica persica* and *Polygunum aviculare* occur frequently in barley fields but have low statures and compete weakly with barley. Furthermore, the low growing nature of these weeds decrease the likelihood of collecting the seeds with the harvester and adding them to the harvested crop batches. Elongating and tall growing species, reaching the same height of barley or taller, are most detrimental to barley growth and more likely to find in the harvested seed batches; examples are *Sinapis arvensis*, *Cirsium arvense*, *Tripleurospermum inodorum* and the majority of grasses infesting barley such as *Elytrigia repens*, *Lolium perenne* and *Bromus sterilis*. Although species like *Chrysantemum segetum*, *Centauria cyanus* and *Raphanus raphanistrum* are competitive and harmful, their importance for barley production in Denmark is negligibly due to less widespread populations.

Seeds of some weed species and cultivated species can be found in batches of malting barley including those for export. The Danish seed companies Nordic Seed and DLG report that the most frequently found species are other cultivated cereals in certified seed lots of barley (Tables 3, 4). Dicotyledonous crop species are also found, but much less frequently. Cultivated species occur in spring barley fields as volunteer weeds when they are included in the crop rotation, but rarely become persistent weed problems in cropping systems, where they are relatively easy to control with common weed management strategies. Volunteer oilseed rape (*Brassica napus*), however, can become problematic in crop rotations because of its persistent seeds that are long-lived in the soil seed bank (Vaughan et al., 1976; Ward et al., 1985). Of the weed species, *Elytrigia repens* and *Galium aparine,* are the most frequently identified weed species in barley seed batches. The annual grass species, *Bromus sterilis*, and the cultivated grass species, *Lolium perenne*, have also been found. Other species, mainly dicotyledonous species, have been observed in much lower frequencies.

Table 3. Frequency of seeds of non-barley species found in 957 seed samples (each sample was 1 kg) of certified spring barley grain analysed by DLG (www.dlg.dk) in 2021, 2022 and 2023.

	Frequency (% of samples)	Species detected
2021 (335 samples)		
Other cereals	30%	*Triticum aestivum*, *Secale cereale* and *Avena sativa*
Other cultivated plants	1%	*Spinacia oleracea*, *Pisum sativum*
Monocot weeds	0.5%	*Elytrigia repens*
Dicot weeds	2.5%	*Galium aparine*
2022 (335 samples)		
Other cereals	25%	*Triticum aestivum*, *Secale cereale* and *Avena sativa*
Other cultivated plants	0%	*Brassica napus*, *Pisum sativum, Vicia villosa*
Monocot weeds	1%	*Elytriga repens*
Dicot weeds	3%	*Galium aparine*
2023 (287 samples)		
Other cereals	25%	*Triticum aestivum*, *Secale cereale* and *Avena sativa*
Other cultivated plants	2%	*Brassica napus*, *Pisum sativum, Vicia villoca*
Monocot weeds	5%	*Elytrigia repens, Bromus sterilis, Lolium perenne*
Dicot weeds	5%	*Chenopodium album*, *Fallopia convolvulus*, *Galium aparine*,

Table 4. Frequency and number of seeds of non-barley species found in 1004 seed samples (each sample was 1 kg) of certified spring barley grain analysed by Nordic Seed (nordicseed.dk) July 2021 - June 2022).

Species	Batches	Frequency (% of samples)	Seeds detected in total
Other cereals			
Triticum aestivum	206	21%	359
Secale cereale	55	5%	107
Avena sativa	25	2%	27
Triticosecale	6	1%	8
Other cultivated plants			
Brassica napus	8	1%	12
Pisum sativum	1	0%	1
Spinacia oleracea	3	0%	4
Lupinus luteus	1	0%	1
Raphanus sativus	1	0%	1
Vicia sativa	7	1%	15
Vicia villosa	2	0%	2
Monocot weeds			
Elytrigia repens	10	1%	11
Dicot weeds			
Vicia hirsuta	12	1%	26
Galium aparine	10	1%	11
Tripleurospermum perforatum	5	0%	5
Raphanus raphanistrum	3	0%	4
Anchusa officinalis	1	0%	4
Capsella bursa-pastoris	1	0%	1
Matricaria discoidea	1	0%	1
Centaurea cyanus	1	0%	1
Rumex crispus	1	0%	1

Description of some of the most relevant weed species

The importance of weed species was determined by the frequency in spring barley and the occurrence in seed samples (Table 3, 4). Weed species occurring in spring crops, incl. spring barley, have been surveyed in Denmark (Andreasen and Stryhn, 2008, Andreasen and Streibig, 2011) and in Northern Europe (Hofmeijer et al. 2021). Furthermore, the most common weed species in Denmark is covered by a handbook of weeds (incl. online material from Crop Protection online, plantevaernonline.dlbr.dk), which describe weed species, their habitats and importance (Ukrudtsbogen, 2011). Only common weed species observed in 10 or more batches reported by the Danish seed companies, Nordic seeds and DLG, are described in detail in the following text. In Appendix F, the species found in seed batches are marked as "seed transmitted". Additional information on importance in spring barley, life span, thousand kernel weight and descriptions of seeds are included in Appendix F for weed species occurring in spring barley or other spring crops. To confirm that the list contains the relevant weed species, plant protection advisors from SEGES

(Poul Henning Petersen and Carsten Fabricius) was consulted. No changes were made to the list during this exchange.

Elytrigia repens (couch grass) is a perennial and rhizomatous grass weed that is widespread all over Denmark. It infests all types of crops and is very competitive (Melander, 1994). *E. repens* reduces crop yields significantly, contaminates grasses for grass seed production and its rhizomes can interrupt tillage and harvest operations of root crops. The perennial grass propagates vegetatively by expanding its rhizomes, which can increase by a factor of 5 in spring barley (Permin, 1982). Seed production is up to 50 seeds per spike, but spreading from seeds is less important except when introducing the species to new fields and regions (Holm et al., 1991a).

Bromus sterilis (barren brome) is a competitive and common annual grass weed occurring in all parts of Denmark. It mainly infests annual crops and is mostly seen close to hedges and in headlands. It exhibits both summer and winter annual germination behaviors, hence occurring in both winter and summer crops. Non-inversion tillage systems in combination with frequent cropping of winter wheat can boost *B. sterilis* populations, reaching heavy and detrimental infestation levels (Melander et al., 2013). It produces approx. 200 seeds per plant and the seeds can contaminate grass seeds (Melander, 2011). Seeds of *B. sterilis* have short longevity in soil and shallow cultivation shortly after seed shedding stimulates the seeds to germinate for later termination by another cultivation event or herbicide treatment (Clarke et al., 2000).

Lolium perenne (perennial ryegrass) is a perennial cultivated grass species used for fodder and grass seed production. It is the most commonly grown grass species in grass-clover mixtures and the greatest commodity of the Danish export of grass seeds. The species occurs all over Denmark both on arable land and in non-cropped areas. It mainly becomes a weed problem in spring barley in crop rotations that also include fodder grasses or where *L. perenne* is grown for grass seed production. The grass produces approx. 150 seeds per spike and seeds are short-lived in soils (1-2 years) similar to many other grass species. Due to its elongating growth reaching the height of barley or even taller, it can reduce crop yields significantly (Melander, 2011).

Galium aparine (cleavers) is an annual dicotyledonous weed species that demonstrates both summer and winter annual germination behavior (Håkansson, 2003). It is found in arable crops all over Denmark plus non-cropped areas. Its seeds are relatively large and can germinate from soil layers deeper (5-6 cm) than most other weed species commonly observed in Denmark (Holm et al., 1991b). It germinates in cohorts often separated by several weeks, which makes timing of weed control difficult. Late establishing cohorts can establish populations with large biomasses in the latter part of the growing season. *G. aparine* expand quickly by its climbing growth habit, sometimes resulting in crop canopies heavily infiltrated by cleaver stems, which can strongly interrupt harvest operations. Even a few *G. aparine* plants per m^2 can reduce crop yields markedly and generally there is a high weed control demand. Non-inversion tillage systems are known to proliferate *G. aparine* populations and together with annual grass weeds, the principles weed problems in non-inversion tillage systems are often constituted of *G. aparine* and perennials such as common couch and thistles (Melander et al., 2013). *G. aparine* produces up to 400 seeds per stem and seeds are short-lived in soils (Holm et al., 1991b; Melander, 2011).

Chenopodium album (Lamb's quarters/fat-hen) is an annual dicotyledonous weed species with a summer annual germination behavior in Scandinavia (Håkansson, 2003), but its dormancy and germination characteristics varies across the globe (Holm et al., 1991c). *C. album* occurs in any spring-sown annual crop in Denmark and is among the most common dicot weeds across the country (Andreasen & Stryhn, 2008). The seed production of *C. album* can be substantial with up

20.000 seeds per plant and the seeds usually demonstrate strong innate dormancy after seed shedding (Melander, 2011). *C. album* seedlings emerge in cohorts over several weeks in spring, which sometimes make timing of weed control difficult. The weed is competitive in spring barley, although its growth vigor may vary considerably between growing seasons. The species also acts as an alternate host of several crop pests (Bajwa et al., 2019). *C. album* matures relatively late compared to barley and high infestations with *C. album* can complicate harvest operations.

Fallopia convolvulus (Black bindweed) is a summer annual dicotyledonous weed species that belongs to the collection of dicot weed species most commonly found across Denmark (Andreasen & Stryhn, 2008). *F. convolvulus* has a climbing growth habit, but is rarely causing significant problems in barley and other cereals unless the weed occurs in very high numbers. The seeds are usually dormant when shed from the maternal plant and only germinate after a period of exposure to cold conditions, although some seeds can remain dormant for long periods. Seed longevity in soil is great and seedling cohorts typically emerge over long periods in spring and early summer (Holm et al., 1991d).

Vicia hirsuta (Hairy vetch) is an annual dicotyledonous weed species occurring in spring barley fields across the country. V. hirsuta is not among the most common dicots infesting Danish barley fields and is not reported particular problematic. Due to the climbing growth habit of V. hirsuta, the crop can be tangled up by the stems of the weed making harvest operations difficult. Generally, very little is known about the weed biology of V. hirsuta.

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Appendix A: Points 14, 15, 16 and 17 of the questionnaire from the Mexican plant health authority.

14. Major phytosanitary problems of the crop in the production area designated for export and if there are differences, other major phytosanitary problems in other producing areas.

15. In each of the pests associated with the crop in question, submit the following information:
    a. Name(s) of the pest in Spanish or local language (s).
    b. Taxonomic classification (that includes at least the order, family, genus and species).
    c. Geographical distribution of the pest in the country, if it is a quarantine pest and if is present.
    d. Period of attack (for example, the percentage of infested plants or fruit infested) with the time (eg. During different phenological stages of crops and/or times of the year);
    e. The biology of the pest or disease etiology or epidemiology, and
    f. From each of the biological stages of the pest (insects, mites) indicate what part of the plant is associated and describe their attack, either external or internal.
    g. In the case of a pathogen (fungus, bacteria, viruses, phytoplasma and nematodes), explain the form and type of infection.
    h. In the case of weeds or any other organism, describe its association and damage.
    i. Economic losses associated with pests associated with the product of interest in the country of origin or source.
    j. Bibliographies of the information presented in paragraph 21 with the technical and scientific support (photocopies of the literature cited).

16. List of important pests per crop phenological stage, emphasizing the pests associated with the part of the plant to be exported.

17. List of pests of quarantine importance according to what is established in the lists of quarantine pests

18. of each country.

Appendix B: Seed transmitted bacterial and viral pathogens known to infect barley that were considered for presence on barley in Denmark.

Organisms	Pest - latin name	English name	Main source to establish as a seed borne disease	Present on barley in DK	Main reference for presence or absence on barley in DK
Bacteria	*Acidovorax avenae*	bacterial leaf blight of grasses	CABI compendium crop protection	No records	CABI crop protection compendium
Bacteria	*Pseudomonas syringae* pv. *atrofaciens*	Basal: wheat glume rot	Compendium of barley diseases	No records	CABI crop protection compendium
Bacteria	*Pseudomonas syringae* pv. striafaciens	Bacterial black node	Compendium of barley diseases	No records	CABI crop protection compendium; Nicolaisen et al. 2019b
Bacteria	*Pseudomonas syringae* pv. *syringae*	Bacterial kernel blight	Compendium of barley diseases	Yes, worldwide	CABI crop protection compendium; Nicolaisen et al. 2019a
Bacteria	*Xanthomonas translucens* pv. *cerealis*	bacterial leaf streak of grasses	CABI compendium crop protection	No records	CABI crop protection compendium; EPPO Global database
Bacteria	*Xanthomonas translucens* pv. *translucens*	bacterial leaf streak of barley	Compendium of barley diseases	No records	CABI crop protection compendium EPPO Global database; Nicolaisen et al. 2019a
Bacteria	*Xanthomonas translucens* pv. *undulosa*	bacterial leaf streak of wheat and barley	CABI compendium crop protection	No records	CABI crop protection compendium; EPPO Global database; Nicolaisen et al. 2019b
Virus	Arabis mosaic virus	hop bare-bine	CABI compendium crop protection	No records	CABI crop protection compendium
Virus	Barley stripe mosaic virus	Stripe mosaic of barley	CABI compendium crop protection	Yes	CABI crop protection compendium; EPPO Global database; Nicolaisen et al. 2019b
Virus	Brome mosaic virus	Brome mosaic virus	Compendium of barley diseases	No records	CABI crop protection compendium
Virus	High plains wheat mosaic emaravirus	High plains disease	CABI compendium crop protection	No records	CABI crop protection compendium; Nicolaisen et al. 2019b
Virus	Wheat streak mosaic virus	Wheat streak mosaic virus	CABI compendium crop protection	No records	CABI crop protection compendium; Nicolaisen et al. 2019a

Appendix C: Seed borne fungal and oomycete pathogens of barley that were considered for presence on barley in Denmark.

Organism	Pest - Latin name	English name (s)	Main source to establish as a seed born disease	Present on barley in DK	Main reference for presence or absence on barley in DK
Fungus	*Alternaria spp.*	Black point or Kernel blight	Compendium of barley diseases	Yes	Andersen et al. 1996
Fungus	*Alternaria triticina*	Black point or Kernel blight	CABI compendium crop protection	No	Nicolaisen et al. 2019 (del 3)
Fungus	*Athelia rolfsii*	Southern blight	Nicolaisen et al. 2021	No	No records found for barley in DK
Fungus	*Bipolaris sorokiniana*	Spot blotch of barley	Compendium of barley diseases	Yes	Jørgensen et al. 2013
Fungus	*Cladosporium spp.*	Black point or Kernel blight	Compendium of barley diseases	Yes	Andersen et al. 1996
Fungus	*Claviceps purpurea*	Ergot	Compendium of barley diseases	Yes	CABI compendium crop protection
Fungus	*Colletotrichum graminicola*	Anthracnose	Compendium of barley diseases	No	No records found for barley in DK
Fungus	*Epicoccum nigrum*	Red blotch of grain	Bretträger et al. 2022	Yes	Andersen et al. 1996
Fungus	*Fusarium avenaceum*	Fusarium head blight	Compendium of barley diseases	Yes	Nielsen et al. 2011
Fungus	*Fusarium cerealis*	Fusarium head blight	Castañeras et al. 2013	No	CABI compendium crop protection
Fungus	*Fusarium culmorum*	Fusarium head blight	Compendium of barley diseases	Yes	Nielsen et al. 2011; CABI compendium crop protection
Fungus	*Fusarium langsethiae*	Fusarium head blight	Imathiu et al. 2013	Yes	Nielsen et al. 2011
Fungus	*Fusarium tricinctum*	Fusarium head blight	Kulik 2008	Yes	Nielsen et al. 2011
Fungus	*Fusarium poae*	Fusarium head blight	Compendium of barley diseases	Yes	Nielsen et al. 2011
Fungus	*Fusarium graminearum*	Fusarium head blight	Compendium of barley diseases	Yes	Nielsen et al. 2011
Fungus	*Fusarium pseudograminearum*	Fusarium crown rot of wheat	Bragard et al. 2022	No	Bragard et al. 2022
Fungus	*Fusarium sporotrichioides*	Fusarium head blight	CABI compendium crop protection	Yes	Nielsen et al. 2011
Fungus	*Hymenula cerealis*	Cephalosporium stripe	CABI compendium crop protection	Yes	Nicolaisen et al. 2021
Fungus	*Magnaporthe oryzae*	Rice blast	CABI compendium crop protection	No	CABI compendium crop protection
Fungus	*Magnaporthe oryzae pa. Wheat*	Wheat blast	CABI compendium crop protection	No	CABI compendium crop protection
Fungus	*Microdochium nivale*	Snow mould, Fusarium head blight	Compendium of barley diseases	Yes	Nielsen et al. 2011
Fungus	*Parastagonospora nodorum*	Glume blotch	Compendium of barley diseases	Yes	Pedersen 2022 and 2023
Fungus	*Pseudoseptoria donacis*	Halo spot	Dugan and Lupien 2003	No	Nicolaisen et al. 2019 (del 3)
Fungus	*Pyrenophora graminea*	Barley leaf stripe	Compendium of barley diseases	Yes	Justesen et al. 2008
Fungus	*Pyrenophora teres*	Net blotch	Compendium of barley diseases	Yes	Pedersen 2022 and 2023
Fungus	*Pyrenophora tritici-repentis*	Tan spot	Compendium of barley diseases	No	No records found for barley in DK

Fungus	*Ramularia collo-cygni*	Ramularia	Havis et al. 2014	Yes	Pedersen 2022 and 2023
Fungus	*Rhynchosporium graminicola*	Scald	Compendium of barley diseases	Yes	Pedersen 2022 and 2023
Fungus	*Tilletia controversa*	Dwarf bunt of wheat	Compendium of barley diseases	No	Nicolaisen et al. 2019 (del 1)
Fungus	*Ustilago hordei*	Barley covered smut	Compendium of barley diseases	Yes	Nicolaisen et al. 2021
Fungus	*Ustilago nuda*	Loose smut of barley	Compendium of barley diseases	Yes	Nielsen et al. 2006
Fungus	*Ustilago avenae*	Loose smut of oats	Compendium of barley diseases	No	Nicolaisen et al. 2019 (del 3)
Oomycete	*Sclerophthora macrospora*	Downey mildew	CABI compendium crop protection	No	No records found for barley in DK

Appendix D: Frequency of ergot (*Claviceps purpurea*) sclerotia found in seed samples (1kg) of certified spring barley analysed by the Danish seed companies DLG and Nordic Seeds A/S in the years 2021-2023

Seed Company	Year	Number of samples	Frequency
DLG	2021	335	2,5 %
DLG	2022	335	1 %
DLG	2023	287	1 %
Nordic Seeds A/S	2021-2022	1004	1 %

Appendix E: Arthropods in relation to field grown Barley known to occur in Denmark, including and estimation of their importance on Danish barley

Organism	Pest - latin name	English name	Danish name	Order:Family	Seed transmitted	Present in DK	Importance on barley in Denmark Major/minor/none
Arthropoda	*Agrotis ipsilon*	Black cutworm	Ypsilonugle	Lepidoptera: Noctuidae	No	Yes	Minor
Arthropoda	*Agrotis segetum*	Turnip moth	Agerugle	Lepidoptera: Noctuidae	No	Yes	Minor
Arthropoda	*Aulacorthum solani*	Foxglove aphid	Kartoffelbladlus	Hemiptera: Aphidoidae	No	Yes	Not relevant
Arthropoda	*Cephus pygmeus*	European wheat stem borer	Halmhveps	Hymenoptera: Cephidae	No	Yes	Minor
Arthropoda	*Contarinia tritici*	Wheat yellow blossom midge	Gul hvedegalmyg	Diptera: Cecidomyiidae	No	Yes	Major/Minor
Arthropoda	*Delia coarctata*	Wheat bulb fly	Brakflue	Diptera: Anthomyiidae	No	Yes	Major/Minor
Arthropoda	*Diuraphis noxia*	Russian wheat aphid	Diuraphis noxia	Hemiptera: Aphidoidae	No	Yes	Not relevant
Arthropoda	*Dolerus aericeps*	Dolerus aericeps	Dolerus aericeps	Hymenoptera: Tenthredinoidae	No	Yes	Minor
Arthropoda	*Euxoa (Agrotis) tritici*	White-line dart	Hvedeugle	Lepidoptera: Noctuidae	No	Yes	Minor
Arthropoda	*Haplodiplosis (equestris) marginata*	Saddle gall midge	Sadelgalmyg	Diptera: Cecidomyiidae	No	Yes	Minor
Arthropoda	Haplothrips aculeatus	Grass thrips	Akstrips	Thysanoptera: Phlaeothripidae	No	Yes	Minor
Arthropoda	Helicoverpa armigera	Cotton bollworm	Kriger træk-ugle	Lepidoptera: Noctuidae	No	Yes/No	Not relevant
Arthropoda	*Hydraecia micacea*	Rosy rustic	Kartoffelborer	Lepidoptera: Noctuidae	No	Yes	Minor
Arthropoda	*Hydrellia griseola*	Rice leaf miner	Kornbladflue	Diptera: Ephydridae	No	Yes	Minor
Arthropoda	Laodelphax striatellus	Small brown planthopper	Laodelphax striatellus	Hemiptera: Delphacidae	No	Yes	Not relevant
Arthropoda	*Limothrips cerealium*	Corn thrips	korntrips	Thysanoptera: Thripidae	No	Yes	Minor
Arthropoda	*Limothrips denticornis*	Barley thrips	Rugtrips	Thysanoptera: Thripidae	No	Yes	Minor
Arthropoda	*Metopolophium dirhodum*	Rose grain aphid	Græsbladlus	Hemiptera: Aphidoidae	No	Yes	Major
Arthropoda	*Myzus persicae*	Green peach aphid	Ferskenbladlus	Hemiptera: Aphididae	No	Yes	Minor
Arthropoda	*Opopyza florum*	Yellow cereal fly	Gul græsflue	Diptera: Anthomyiidae	No	Yes	Minor
Arthropoda	*Oscinella frit*	Frit fly	Almindelig Fritflue	Diptera: Chloropidae	No	Yes	Minor
Arthropoda	*Oulema lichenis*	Cereal leaf beetle	Sortblå kornbladbille	Coleoptera: Chrysomelidae	No	Yes	Major/Minor
Arthropoda	*Oulema melanopus*	Common cereal leaf beetle	Alm. kornbladbille	Coleoptera: Chrysomelidae	No	Yes	Major/Minor
Arthropoda	Petrobia latens	Brown wheat mite	Brun hvedemide	Acarida: Tetranychidae	No	Yes/No	Major/minor

Arthropoda	*Rhopalosiphum padi*	Bird cherry-oat aphid	Havrebladlus	Hemiptera: Aphidoidae	No	Yes	Major
Arthropoda	*Sitobion avenae*	Grain aphid	Kornbladlus	Hemiptera: Aphidoidae	No	Yes	Major
Arthropoda	*Sitophilus mosellana*	Orange wheat blossom midge	Orangegul hvedegalmyg	Diptera: Cecidomyiidae	No	Yes	Major/minor
Arthropoda	*Thrips angusticeps*	Cabbage thrips	Kåltrips	Thysanoptera: Thripidae	No	Yes	Minor
Arthropoda	Thrips flavus	Honeysuckle thrips	Thrips flavus	Thysanoptera: Thripidae	No	Yes	Minor
Arthropoda	*Zabrus tenebrioides*	Corn ground beetle	Aksløber	Coleoptera: Carabidae	No	Yes	Not relevant

Appendix F: Weed species that can be observed in Danish barley fields

Organims	Weed - latin name	Family	English name	Danish name	Seed transmitted	Present in DK	Importance in barley: Major (1) Intermediate (2) Minor (3)	Quarantine pest in Mexico	Grass (G) or dicotyledon (D)	Lifespan: annual/ biannual/ perennial	Thousand Kernal Weight (g)	Seed shape	Mentioned in Hofmeijer et al. 2021	Mentioned in Andreasen and Streibig 2011	Mentioned in Andreasen og Stryhn 2008	Described in a book of common weeds in DK (Ukrudtsbogen)
Weed	Aethusa cynapium	Apiaceae	Fool's parsley	Hundepersille		Yes	3	No	D	annual/biannual	1.7	Almost egg-shaped in circumference. Crescent-shaped cross section. The surface has strong veins on the curved side and 2 red oil tubes on the flat side.			Yes	Yes
Weed	Alopecurus myosuroides	Poaceae	Blackgrass	Ager-Rævehale	Yes	Yes	1	No	G	annual	2	Oval outline, very compressed, with kneed awn from the bract under the outer awns. Oval cross section. The highly compressed, very firmly attached outer awns are fused at the bottom, but separate at the top with a sharp angle. The surface is rough, finely granular and hairy on the sharp-edged veins. Oval, compressed and naked seeds occur				Yes
Weed	Amsinckia micrantha	Boraginaceae	Fidddleneck	Gulurt		Yes	2	No	D	annual	NA	Beetle- or slipper-shaped with drop-shaped outline. The surface is sinuately nodose and granular.				Yes
Weed	Anagallis arvensis	Myrsinaceae	scarlet pimpernel	Rød Arve		Yes	2	No	D	annual	5	Pyramidal. The base of the pyramid may be oval, 3-, 5- or 6-sided. The surface is scaly rough or hairy.	Yes	Yes	Yes	Yes
Weed	Anchusa arvensis	Boraginaceae	small/annual bugloss	Krumhals		Yes	2	No	D	annual	6.3	Shaped like a child's shoe with oval cross section. The surface is very folded and nubbly.			Yes	Yes
Weed	Anchusa officinalis	Boraginaceae	Common bugloss	Lægeoksetunge	Yes	Yes	2	No	D	biannual	NA	NA				
Weed	Anthemis arvensis	Asteraceae	corn chamomile	Ager-gåseurt		Yes	3	No	D	annual	0.5-1.2	Two types of seeds: Ray seed and disc seed. Ray seed: Oblong and often slightly curved with rounded 4-5-sided cross section. The surface has 10 rounded, somewhat rough longitudinal ribs. Disc seed: As the ray seed, but smaller and with less conspicuous ribs.			Yes	Yes

Weed	Apera spica-venti	Poaceae	Loose silky-bent	Vindaks		Yes	2	No	G	annual	0.1	Lancet-shaped with a very long, thin awn. Kidney-shaped cross section. The bract is strongly domed and short, sparsely barbate on the upper part, but with fine hairy Bristles at the base. Very thin and short rachilla.	Yes		Yes	Yes
Weed	Aphanes arvensis	Rosaceae	Field Parsley-piert	Almindelig dværgløvefod		Yes	3	No	D		NA	oval pointed glabrous			Yes	
Weed	Arenaria serpyllifolia	Caryophyllaceae	Thyme-leaf sandwort	Markarve		Yes	2	No	D	annual	0.6	Approx. 1 mm			Yes	
Weed	Artemis vulgaris	Asteraceae	Mugwort	Grå bynke		Yes	1	No	D	perennial	0.1	Rod-shaped, broadest towards the top, which has a thin ring-shaped collar. The base is slightly pointed and often a little curved. The cross section is circular. The surface is slightly glistening with longitudinal, silvery stripes.	Yes	Yes	Yes	Yes
Weed	Atriplex patula	Amaranthaceae	Spear saltbush	Svinemælde		Yes	1	No	D	annual	1.4	Roundish, flattened seed, which is very similar to the seed of Fat Hen. The surface is coated with a greyish-white layer of wax, which can easily be rubbed off. The seed is often surrounded by remnants of a sPear tip-like perianth			Yes	Yes
Weed	Avena fatua *(Note: by law the farmer has to remove this species from the fields)*	Poaceae	common wild oat	Flyve-havre		Yes	1	No	G	annual	22.5	Lancet-shaped to elliptical with a long, twisted, kneed awn, which emerges from about the middle of the domed bract. Kidney-shaped cross section. The base of ventral side has a horseshoe-shaped stigma. Sparsely to densely hairy surface. The hairs appear as stiff tufts, especially near the base, and usually hide the rachilla in the more or less slender ventral furrow. Naked, downy grains occur.				Yes
Weed	Avena sativa	Poaceae	Culture crop, spring oat	vårhavre	Yes	Yes	1	No	G	annual	30-32	Typical cereal shape				

Weed	Brassica campestris	Brassicaceae	Wild turnip	Agerkål		Yes	1	No	D	annual	2	Almost spherical. The surface is slightly pitted.				Yes
Weed	Brassica napus	Brassicaceae	Culture crop, Oilseed rape	Raps	Yes	Yes	1	No	D	annual	5	Ball-shaped. Very finely pitted surface.				Yes
Weed	Bromus hordeaceus	Poaceae	Soft brome	Blød hejre		Yes	1	No	G	annual	3.6	Elliptical with a "feed shovel"-shaped commissural surface and an approx. 5-8 mm long awn. The bract is 7-9-veined, convex with open lateral edges on the upper third. The rachilla is approx. 1 mm long, slightly curved with a bowl-shaped head. The ventral furrow is broad and flat-bottomed with a narrow longitudinal groove. The surface is short-haired on the rachilla and bract.				Yes
Weed	Bromus secalinus	Poaceae	Rye brome	Rughejre		Yes	3	No	G	annual	7	Elongated				
Weed	Bromus sterilis	Poaceae	Barren brome	Gold hejre		Yes	1	No	G	annual	6.4	Long, very slim, often hollow-backed with a 15-25 mm long awn and a pointed, nail-shaped edge at the base of the back. The bract is highly domed, 7-veined, of which the middle veins are the most prominent. The rachilla is approx. 3 mm long. The ventral furrow is deep, gull-shaped with a narrow, deep longitudinal groove. The surface has short barbate hairs on the bract and rachilla.				Yes
Weed	Capsella bursa-pastoris	Brassicaceae	Shepherd's purse	Hyrdetaske	Yes	Yes	1	No	D	annual	0.1	Almost oval in outline. A slender, oval furrow along the seed can be seen on both sides. Slightly rough surface	Yes	Yes	Yes	Yes
Weed	Centauria cyanus	Asteraceae	cornflower	kornblomst	Yes	Yes	2	No	D	annual	4.5	Pitcher-shaped with oval cross section. A tuftlike accumulation of reddish brown hairs is seen at the top. A tilted stigma is found near the base.	Yes			Yes
Weed	Cerastium fontanum	Caryophyllaceae	Common mouse-ear	Alm. hønsetarm		Yes	3	No	D	annual	0.1	Lopsidedly kidney-shaped in outline with a trilateral cross section. The surface is granulated in			Yes	

												irregular, curving rows.				
Weed	Chamomilla recutita	Asteraceae	Scented mayweed	Vellugtende Kamille		Yes	2	No	D	annual	0.05	Shaped like a slightly curved, truncated 3-4-sided cone. The surface has 3-4 longitudinal, light veins.				
Weed	Chenopodium album	Chenopodiaceae	Lamb's quarters/fat-hen	Hvidmelet Gåsefod		Yes	1	No	D	annual	1.2	round, flattened often with a edge taper	Yes	Yes		Yes
Weed	Chrysanthemum segetum	Asteraceae	Corn marygold	Gul okseøje		Yes	2	No	D	annual	2.2	Two types exist: ray seed and disc seed. Disc seed: Cylindrical, slightly curved; the diameter decreases at one end. The surface has 8-10 longitudinal ribs. Thousand grain weight approx. 1.5 g. Ray seed: Cylindrical with two opposite ribs, which resemble broad edges of wings. The surface has many ribs.				Yes
Weed	Cirsium arvense	Asteraceae	creeping thistle	Ager-Tidsel		Yes	1	No	D	perennial	1.2	jar-shaped with a collar at one end and peg-shaped stylus residue	Yes	Yes		Yes
Weed	Cirsium vulgare	Asteraceae	bull thistle	Horse-Tidsel		Yes	3	No	D	biannual	NA	NA			Yes	
Weed	Convolvulus arvensis	*Convolvulaceae*	Field bindweed	Ager-Snerle		Yes	1	No	D	perennial	NA	Seed ovate, trigonous with the hilum at the narrow end	Yes			
Weed	Conyza canadensis	Asteraceae	Canadian fleabane	Canadisk Bakkestjerne		Yes	3	No	D	annual	NA	Rod-shaped with lancet-shaped to elliptical cross section. At one end 2-3 mm long pappus hairs can be seen, which fall off easily, however. Otherwise, the surface is smooth with sparse hairs				Yes
Weed	Dactylis glomerata	Poaceae	Cocksfoot	hundegræs		Yes	3	No	G	Perennial	1.2	Lancet-shaped and with a 5-nerved lemma with a sharp, stiff keel-shaped midrib. Triangular cross-section. The rachilla is 0.6-1.2 mm long and adjoining.				Yes
Weed	Echinochloa crus-galli	Poaceae	Cockspur	Alm. hanespore		Yes	2	No	G	annual	0.9	Egg-shaped outline. Domed dorsal side and flat to slightly domed ventral side with no rachilla or ventral furrow. The bract and bracteole are gristly, stiff and				Yes

												inflexible. The surface is finely granular with a regular weaving pattern, except on the two slim and bright side edges of the bracteole. The colour varies, usually dark-spotted.				
Weed	Elytrigia repens	Poaceae	Couch grass	Almindelig kvik	Yes	Yes	1	No	G	perennial	3.9		Yes		Yes	Yes
Weed	Equisetum arvense	Equisetaceae	Field horsetail	Ager-Padderok		Yes	2	No	D	Perennial	NA	Reproduced by spores and vegetatively	Yes		Yes	Yes
Weed	Erodium cicutarium	Geraniceae	Common stork's-bill	Hejrenæb		Yes	2	No	D	annual	2.7	Round, cone-shaped, often with a whorled awn at the top. The surface densely hispid.	Yes			Yes
Weed	Euphorbia helioscopia	Euphorbiaceae	Sun spurge	Skærm-Vortemælk		Yes	1	No	D	annual	2.9	Egg-shaped to oval in circumference with a small tilted disc at one end	Yes		Yes	Yes
Weed	Fallopia convolvulus/Polygonum convolulus	Polygonaceae	Black bindweed	Snerle-Pileurt		Yes	1	No	D	annual	5	Almost triangular with three-sided cross section, where the sides often are somewhat concave. The surface is smooth to slightly rough, often covered with remnants of the perianth	Yes	Yes	Yes	Yes
Weed	Fumaria officinalis	Fumariaceae	Common fumitory	Læge-Jordrøg		Yes	1	No	D	annual	3.4	Round to slightly heart-shaped. Almost circular cross section. The surface is granulated to wrinkled	Yes			Yes
Weed	Galeopsis spp	Labiatae	Hemp-nettle	Hanekro		Yes	1	No	D	annual	5	Compressed egg-shaped with a somewhat sharp-edged periphery. The lower part of the ventral side is shaped like a round roof. The surface is slightly warty	Yes			Yes
Weed	Galinsoga spp.	Asteraceae	Soldier	Kortstråle		Yes	3	No	D	annual	0.2 for both types	Two types of seeds exist: Ray seed and disc seed. Ray seed: Curved, cone- or pin-shaped with almost triangular cross section. Hairy surface with longitudinal stripes. Disc seed: Like ray seed, but straighter and with square cross section.				Yes
Weed	Galium aparine	Rubiaceae	Cleavers	Burresnerre	Yes	Yes	1	No	D	annual	3.7	Ball-shaped to slightly oval with a depression on the commissural surface.	Yes	Yes	Yes	Yes

												The surface is hedgehog-like due to stiff, hooked Bristles, which can be more or less broken				
Weed	Geranium spp	Geraniceae	Cranes-bill	Storkenæb		Yes	1	No	D	annual	depending on species 1.1 -2.5	Generally, plumb egg-shaped, but varies among species	Yes		Yes	Yes
Weed	Gnaphalium uliginosum	Asteraceae	Marsh Cudweed	sumpevighedsblomst		Yes	2	No	D	annual	NA	No information			Yes	
Weed	Lamium spp	Labiatae	Death-nettle	Tvetand		Yes	1	No	D	annual	Depending on species 0.6-0.9	Inverted Beetle-shaped. Dorsal side domed. Ventral side roof-shaped with 2 slightly convex sides and a smaller, triangular top side	Yes			Yes
Weed	Lapsana communis	Asteraceae	Nipplewort	Haremad		Yes	3	No	D	annual	1.1	Club-shaped and somewhat curved. The cross section is almost triangular. The surface has many light longitudinal veins	Yes		Yes	Yes
Weed	Lolium multiflorum	Poaceae	Italian ryegrass	Italiensk Rajgræs	Yes	Yes	1	No	G	primarily annual	2.3	Oblong, almost rectangular in circumference. 1-7 mm long awn. The lemma is 5-nerved, slightly domed and tough. The rachilla is short (1-2 mm), adjoining and with a diagonally cut and bowl-shaped top. Naked seeds occur.				Yes
Weed	Lolium perenne	Poaceae	Perennial ryegrass	Alm. rajgræs		Yes	1	No	G	perennial	2	Oblong, almost rectangular in outline. Awnless. The bract is 5-veined, slightly domed. The rachilla is short, flat and densely compressed and often sparsely toothed.	Yes			Yes
Weed	Lupinus luteus	Fabaceae	Annual yellow-lupin	Gul lupin	Yes	Yes	1	No	D	annual	52-226 depending on variety	Slightly oval rounded				
Weed	Matricaria discoidea	Asteraceae	Disc mayweed	Skive kamille	Yes	Yes	1	No	D	annual	0.3	Oblong jar-shaped, slightly crooked, surface ribbed	Yes	Yes	Yes	Yes
Weed	Medicago lupulina	Fabaceae	Black medick	Humle sneglebælg		Yes	3	No	D	annual/biannual	1.6	Slightly kidney shaped light brown seeds			Yes	
Weed	Myosotis arvensis	Boraginaceae	Field forget-me-not	Mark forglemmigej		Yes	2	No	D	annual	0.3	Almond-shaped to compressed drop-shaped with a sharp peripheral suture. The surface is smooth and very shiny.	Yes		Yes	Yes
Weed	Papaver rhoeas	Papaveraceae	Common poppy	Korn-Valmue		Yes	1	No	D	annual	0.1	Kidney-shaped with egg-shaped cross	Yes		Yes	Yes

												section. Net-like, pitted surface				
Weed	Pisum sativum	Fabaceae	Culture crop, field pea	markært	Yes	Yes	1	No	D	annual	250	Large round with a cave on one side				
Weed	Plantago Major	Plantaginaceae	Greater Plantain	Glat vejbred		Yes	3	No	D	perennial	0.3	Oval outline, but somewhat angular. The surface is longitudinally furrowed.	Yes	Yes		Yes
Weed	Poa annua	Poaceae	Annual meadow-grass	Enårig rapgræs		Yes	1	No	G	annual	0.4	Plumb with a sharply keeled, rough bract of which the side edges bend outwards at the top. Triangular cross section. Round and thin rachilla. Low and broad ventral furrow. Shelled seeds occur frequently	Yes		Yes	Yes
Weed	Poa pratensis	Poaceae	Smooth meadow-grass	Eng-rapgræs		Yes	1	No	G	annual	0.3	Lancet-shaped, resembles an oblong boat due to a distinct u- or v-shaped groove (ventral furrow). Triangular cross section. Cellophane-like, 5-nerved lemmas with a sharp midkeel. Thin, slightly protruding, approx. 1 mm long rachilla. Naked seeds may occur, with a boat-like appearance like covered seeds				Yes
Weed	Polygonum aviculare	Polygonaceae	Knotgrass	Vej-Pileurt		Yes	1	No	D	annual	2.7	Almost triangular with a slender, slightly curved top. Triangular cross section. Slightly granular surface. The seed is usually surrounded by remnants of the perianth	Yes	Yes	Yes	Yes
Weed	Polygonum lapathifolium	Polygonaceae	Pale Persicaria	Bleg pileurt		Yes	1	No	D	annual	3.6	Almost heart-shaped and flattened from the sides. The surface is smooth, often showing remnants of the perianth.	Yes		Yes	Yes
Weed	Polygonum persicaria	Polygonaceae	Redshank	Ferskenpileurt	Yes	Yes	1	No	D	annual	2.7	Two types. The main type like Pale Persicaria, but plumper. The other type is somewhat triangular with rounded edges. The surface of both types is almost smooth, often showing remnants of the perianth				Yes

Weed	Raphanus raphanistrum	Cruciferae	Wild radish	Kiddike	Yes	Yes	2	No	D	annual	7.9	The naked seeds are round to egg-shaped. The surface is finely netted. The seed is often hidden in the hard articulate silique.				Yes
Weed	Raphanus repens	Ranunculaceae	Creeping buttercup	Lav ranunkel		Yes	3	No	D	perennial	NA	NA			Yes	
Weed	Raphanus sativus	Brassicaceae	Radish	Radise	Yes	Yes	1	No	D	annual	0.9	Oval with irregular surface				
Weed	Rumex acetosella	Polygonaceae	Common dock	Rødknæ		Yes	3	No	D	perennial	NA	NA		Yes	Yes	
Weed	Rumex crispus	Polygonaceae	Curled dock	Kruset skræppe	Yes	Yes	2	No	D	perennial	1.4	Triangular with seam-shaped edges. Triangular cross section. Smooth surface.	Yes		Yes	Yes
Weed	Scleranthus annuus, ssp annuus	Caryophyllaceae	German knotweed	enårig knavel		Yes	2	No	D	annual	NA	NA		Yes	Yes	
Weed	Secale cereale	Poaceae	Culture crop, winter rye	vinterrug	Yes	Yes	1	No	G	annual	40-42	Typical cereal shape				
Weed	Senecio vulgaris	Asteraceae	Groundsel	Alm. brandbæger		Yes	1	No	D	annual	0.3	Rod-shaped, longitudinally ribbed with round cross section. The surface is rough with dense rows of hairs between the ribs			Yes	Yes
Weed	Setaria pumila	Poaceae	Yellow foxtail	Blågrøn Skærmaks		Yes	3	No	D	annual	0.9	Egg-shaped/ beetle shaped				
Weed	Setaria viridis	Poaceae	Green foxtail/green bristle-grass	Grøn Skærmaks		Yes	3	No	D	annual	0.9	Egg-shaped/beetle-shaped				Yes
Weed	Silene noctiflora	Caryophyllaceae	Night-flowering Catchfly	Nat limurt		Yes	1	No	D	annual	1.1	Kidney-shaped and plumb. The surface is densely covered with flat warts in broad, parallel rows.	Yes		Yes	Yes
Weed	Sinapis arvensis	Cruciferae	Charlock	Agersennep		Yes	1	No	D	annual	1.3	Spherical in both cross section and circumference. The surface is finely pitted	Yes		Yes	Yes
Weed	Solanum nigrum	Solanaceae	Black nightshade	Sort natskygge		Yes	2	No	D	annual	0.8	Compressed almond-shaped to oval with a quite sharp peripheral edge. The surface is netted and pitted in a weaving pattern.				Yes
Weed	Sonchus arvensis	Asteraceae	Perennial sow-thistle	Ager-Svinemælk		Yes	2	No	D	perennial	0.5	Perennial sow-Thistle: compressed staff- to oblong almond-shaped and slightly pointed at both ends. Oval cross section. On each side of the surface are 3-5 longitudinal ribs, which are jagged across.	Yes		Yes	Yes

Weed	Spergula arvensis	Caryophyllaceae	Corn spurrey	Spergel		Yes	1	No	D	annual	0.5	Round and a little flattened with a light, narrow membraneous margin. The surface has small pointed peaks	Yes	Yes	Yes	Yes
Weed	Spinacia oleracea	Chenopodiaceae	culture crop, spinach	spinat	Yes	Yes	1	No	D	annual	10	Oval in circumference, but compressed from the side.				
Weed	Stellaria media	Caryophyllaceae	Common chickweed	Almindelig Fuglegræs		Yes	1	No	D	annual	0.6	Almost circular and somewhat flattened. The surface is finely nubbly with the burls in curving rows. One notch in the peripheral edge.	Yes	Yes	Yes	Yes
Weed	Taraxacum Officinale	Asteraceae	Dandelion	Mælkebøtte		Yes	1	No	D	perennial	0.7	Cone-shaped and slightly curved. Oval cross section. The top ends in a stalk with a pappus umbrella; the stalk can easily be broken off. The surface has several longitudinal ribs, which are covered with patulous teeth at the top	Yes		Yes	Yes
Weed	Thlaspi arvense	Cruciferae	Field penny-cress	Almindelig Pengeurt		Yes	1	No	D	annual	1.8	Oval in circumference, but compressed from the side. The surface is furrowed in parallel, curving rows	Yes			Yes
Weed	Trifolium dubium	Fabaceae	white clover	fin kløver		Yes	3	No	D		0.5	Egg-shaped			Yes	
Weed	Trifolium repens	Fabaceae	White clover	Hvidkløver		Yes	1	No	D				Yes		Yes	
Weed	Tripleurospermum inodorum	Asteraceae	Scentless mayweed	Lugtløs kamille	Yes	Yes	1	No	D	annual	0.35	Shaped like a slightly curved, truncated 3-4-sided cone. The surface has 3-4 longitudinal, light veins. Two types can be found: broad ray seeds and more slender disc seeds	Yes	Yes	Yes	Yes
Weed	Triticosecale	Poaceae	Culture crop, triticale	Triticale	Yes	Yes	1	No	G	annual	45	Typical cereal shape				
Weed	Triticum aestivum	Poaceae	Culture crop, winter wheat	Vinterhvede	Yes	Yes	1	No	G	annual	45-50	Typical cereal shape				
Weed	Tussilago farfara	Asteraceae	Coltsfoot	følfod		Yes	1	No	D	annual	0.3	Oblong, somewhat bent, with circular cross section. A collar-shaped top is seen at one end. The surface is longitudinally furrowed.	Yes		Yes	Yes
Weed	Urtica urens	urticaceae	Annual nettle	Liden nælde		Yes	3	No	D		0.5	Almond- or inverted heart-shaped with compressed, oval cross section. Smooth, slightly				Yes

												glistening surface. The seed is sometimes surrounded by the perianth				
Weed	Veronica spp	Scrophulariaceae	Speedwell, more species	Ærenpris		Yes	1	No	D	annual	0.04 depending on species	V. arvensis: Flattened, oval, lenticular to lozenge-shaped with an oval, central, darkish ventral stigma. The surface is smooth or very slightly sinuately furrowed V. persica: Varying, asymmetrically mussel-shaped. The surface has irregular, sinuate lines across the dorsal side, which usually faces downwards, and an uneven, toothed edge.	Yes	Yes	Yes	Yes
Weed	Vicia hirsuta	Fabaceae	Tiny vetch	tofrøet vikke	Yes	Yes	1	No	D	annual/biannual	NA	NA				
Weed	Vicia sativa	Fabaceae	Common vetch	smalbladet vikke	Yes	Yes	1	No	D	annual/biannual	NA	NA				
Weed	Vicia villosa	Fabaceae	Hairy vetch	Sandvikke	Yes	Yes	1	No	D	annual	6.7	Large round blackish seeds	Yes			
Weed	Viola arvensis	Scrophulariaceae	Field pansy	Agerstedmoder		Yes	1	No	D	annual	0.4	Inverted drop-shaped with a whitish yellow bulge at the base margin. Smooth and shiny surface	Yes	Yes	Yes	Yes
Weed	Vulpia myosuroides	Poaceae	Annual fescue/ rat's tails fescue	Væselhale		Yes	1	No	G	annual		longated, slender , with a cavage on one side, with spike				Yes

* Defined as the weed species found in seed batches by the seed companies (DLG & Nordic Seed) or evaluated as a risk by national advisory service (SEGES)

** The weed species have got a score from 1-3, where 1 is the most common in spring barley and considered the major weeds on field level