# KWS UK

## Hybrid Rye Guide

SEEDING
THE FUTURE
SINCE 1856

# Content

# Introduction

## Our aim is to develop market opportunities, with farmers, processors and end users - we look forward to working together with you!

Your reading KWS UK's new brochure on Hybrid Rye (*Secale cereale*).

KWS Group is the leading breeder of Hybrid Rye, offering varieties for wholecrop (as silage, or AD / biogas feedstock) or grain production (for feed grain, flour and distilling) with a long term hybrid breeding programme established since the mid 1980's.

Today Hybrid Rye is grown on over 5 million hectares worldwide in Europe, Russia, Canada and the United States.

For the UK and Ireland, KWS believes this highly productive cereal offers new perspectives for farmers and end users alike!


If you have any questions, or would like any further information on our varieties, please do not hesitate to contact us.

(see back page for details)

## Did you know?

In June 2017, KWS filed a patent for the Rfp1 gene, an important restorer gene used in Hybrid Rye.

By incorporating the Rfp1 gene isolated from an ancient Iranian rye landrace in PollenPlus hybrids, KWS Hybrid Rye's produce immense quantities of pollen. The Rfp1 gene is important because it is the most effective of all restorer genes. With the stigma closed, the ear is no longer vulnerable to ergot infection.

**Find out more on the KWS website.**

# BREEDING

# What does Hybrid Rye offer farmers?

Hybrid Rye delivers a range of rotational and management benefits, including:

The yield benefit of hybrid over conventional rye cultivars types has increased to almost 20% since the early 2000's and by over 45% since the 1980's – the start of Hybrid Rye breeding activities.

Continued yield progress through higher harvest index (grains/ear) – a key feature of modern hybrids

## High Grain Yields

Typical yields of 10-13t/ha are commonplace, and many growers have found it out-performs wheat and barley as a second or third cereal. A focus on breeding is delivering yield gains of about 1-2% each season.

## Spreads Seasonal Workload

A fast-growing crop with a long drilling window that spans mid-September through to early November means it can be sown when conditions suit, and time allows. Harvest is typically early too. For grain, maturity falls after winter barley, but before winter wheat making it an attractive choice ahead of oilseed rape. Alternatively, it can be made into whole-crop silage, typically in June.

## High Straw Yield

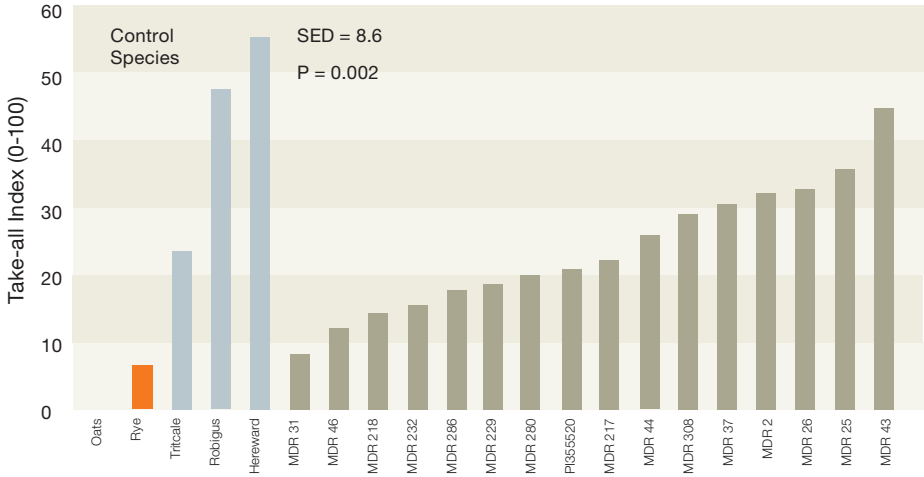
Modern hybrids are being selected for shorter stem lengths in exchange for a higher harvest index, however straw yield remains around 25 – 30% higher than wheat or barley – a useful additional income on farm.

## Exceptional Drought Tolerance

A water requirement of around 25% less than wheat or barley of only 300 litres (400 for wheat) of water per tonne of grain / per hectare makes hybrid rye better suited to light land or drought prone regions.

## High Take-all Resistance

Rye is highly resistant to take-all and is considerably better than triticale and significantly better than wheat. Only oats have zero take-all carryover.




Source: Rothamsted Research

## High Black-grass Competitiveness

Hybrid rye moves through stem elongation faster than any other cereal. Trials have shown that the intense competition of Hybrid Rye against black-grass reduced the viability of black-grass seed by 60% compared with that in wheat.

## Minimal Ergot Risk With PollenPlus

KWS Hybrid Rye's produce immense quantities of pollen cutting the time needed for fertilisation to occur from several days to a matter of hours. The effect of this has been to significantly reduce the risk of ergot infection. Since the introduction in modern hybrids ergot infections has been virtually eliminated. KWS produces only 100% F1 seed to maximise ergot defence.

A black-grass ear produced under competition from hybrid rye (right) compared with that produced in winter wheat (left)

PollenPlus: The amount of pollen released by PollenPlus hybrids (right) v a competitor Hybrid (left)

The benefit of PollenPlus: (On the left) is KWS Magnifico (100% F1 hybrid with PollenPlus), compared with (right) SU Mephisto (90% Hybrid) + Dukato (10% to serve as male restorer)

Source: KWS 2012

# Why hybridise Rye?

Although rye is a cereal just as wheat and barley is, there is a significant difference: Rye is a cross-pollinator while wheat and barley are self-pollinators.

During the time the flower is open it is susceptible to ergot infection. Ergot sporangia over-winter in the field and germinate in the spring leaving the crop vulnerable to infection.

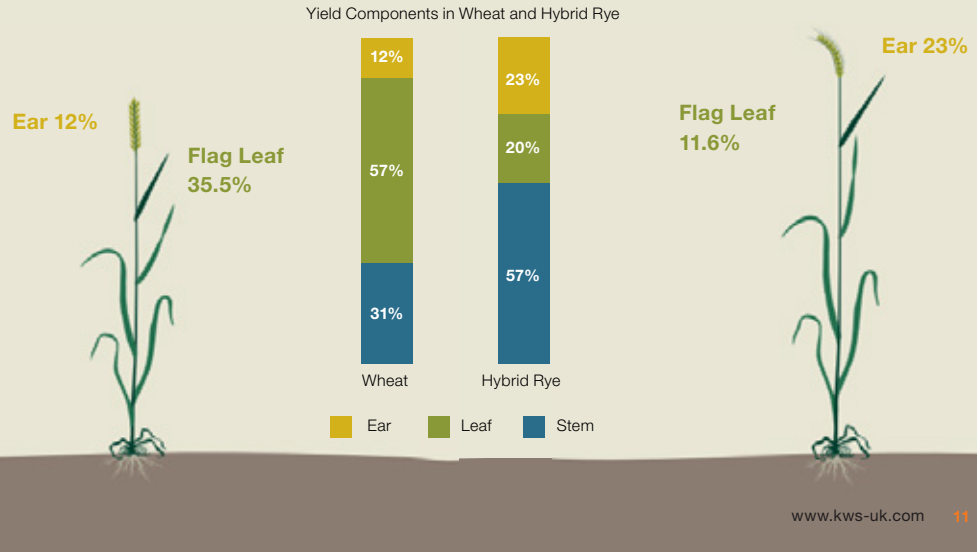
Making rye into a hybrid was the most effective means of addressing this problem. While the process involved is complex, it is less so than in the case of wheat or barley because Rye has a shorter DNA sequence.

By hybridising rye, KWS was able to influence several important aspects of the crop. First, it was able to rapidly increase yield potential through influencing the number of grains produced per ear to the extent that the yield progression of hybrid rye outstrips that of conventionally bred cereals; and second, it could reduce the risk of ergot infection occurring through a reduction in the time taken for fertilisation to occur.

Hybrid Rye (left) v Winter Wheat (right)

Combining Hybrid Rye – yields of 10 – 13 t/ha are typical even when grown as a 2nd or 3rd cereal in the rotation

## Rye differs substantially from wheat in terms of its yield components with the stem contributing close to 60% of final yield



# AGRONOMY

# Hybrid Rye - Seed rates & drilling

To get the best establishment with Hybrid Rye - ensure optimum drilling depth when drilling

- 2cm - 3cm
- Yield is suppressed at depths < 4cm – 6cm

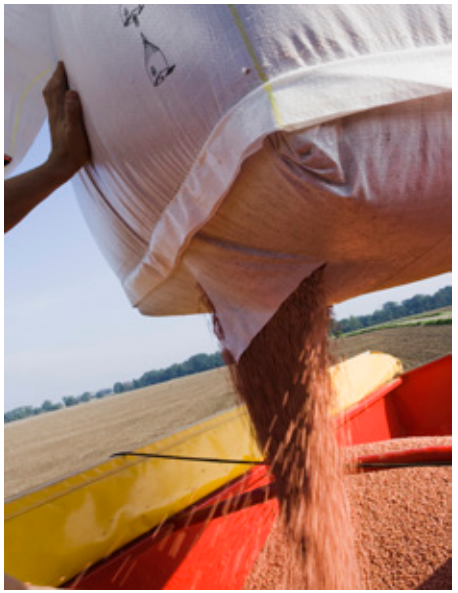


Image supplied courtesy of Vaderstad®

Hybrid Rye seed is supplied in 12 Un. (12 Mio) Bulk Bags ONLY. *1 Unit = 1 Mio. Viable Seeds – packed in multiples of 12 Un. (Equivalent to approx. 500 kg bulk bag) dep on TGW (~30 – 40g)

Suggested seed rates:

- Sept: 175 – 200 seeds / $m^2$
- Oct: 220 – 260 seeds / $m^2$
- Nov: 300 + seeds / $m^2$

## Online Seed Rate Tool

Use KWS' online seed rate tool to find your ideal seed rate:

- Enter your seed rate/$m^2$
- Enter your pack weight (see label) dep. on TGW
- Your drilled weight kg/ha is automatically calculated

## Hybrid Rye - Key rotational advantages:

- High grain yields of 10 – 13 t/ha exceeding 2nd wheat
- Early harvest (wholecrop) or grain (typically between Winter Barley and Wheat)
- Ultra low take – all carry over (2nd lowest compared to oats) *
- High black grass suppression
- High straw yield (around 30% higher than Wheat or Barley)
- Ideal option for OSR establishment to ensure volunteer control

Combing hybrid rye – grain maturity is typically between winter barley and winter wheat

Rye stubble (with straw removed) makes for an ideal entry to OSR

## Blackgrass suppression - a key attribute of Rye

- Light reduction
- Reduced maturity
- Less seed shed
- Blackgrass seed - 60% less viable than those from wheat plots

Blackgrass heads from Wheat (left) v. Rye (right)
Source: Agrovista Lamport (2013)

## Sowing Depth

The seedbed must be firm and clod free to ensure an even drilling depth and even germination.

- Drilling depth must be uniform at a depth approximately equal to 10 times the diameter of the seed being drilled.
- Consider trash volumes and depth. The seed needs to be in good contact with the soil.
- Adequate soil cover and consolidation is essential if soil-acting herbicides are to be used.
- Surface tilth should not be too fine. On weak structured soils 'capping' can occur after heavy rainfall.
- Potential slug damage can be minimised by ensuring seed is placed precisely at an adequate depth and into moisture. This makes the seed harder to access and ensures faster germination.

## Drill Settings

Correct drill set-up helps ensure that it performs to its full potential. Always consider:

- Crop type to be established, along with the seed rate
- Seedbed before drilling
- Type of finish required
- Available horsepower
- Subsequent operations

| | KWS BONO | KWS SERAFINO | KWS ETERNO | KWS EDMONDO | KWS PROPOWER |
|---|---|---|---|---|---|
| Variety Type | Hybrid 100% F1 | Hybrid 100% F1 | Hybrid 100% F1 | Hybrid 100% F1 | Hybrid 100% F1 |
| Use / End Market | AD, Grain [Feed / Flour], Distilling | AD, Grain [Feed / Flour], Distilling | AD, Grain [Feed / Flour], Distilling | AD, Grain [Feed / Flour], Distilling | AD |
| **Reccomendations** | | | | | |
| Seed Rate | Sept 200 - 220 / $m^2$, Oct 250 + / $m^2$ | Sept 200 - 220 / $m^2$, Oct 250 + / $m^2$ | Sept 200 - 220 / $m^2$, Oct 250 + / $m^2$ | Sept 200 - 220 / $m^2$, Oct 250 + / $m^2$ | Sept 200 - 220 / $m^2$, Oct 250 + / $m^2$ |
| Drilling Depth | 2 - 3 cm | 2 - 3 cm | 2 - 3 cm | 2 - 3 cm | 2 - 3 cm |
| Unit / Pack Size | 12 Mio. Seed Unit | 12 Mio. Seed Unit | 12 Mio. Seed Unit | 12 Mio. Seed Unit | 12 Mio. Seed Unit |
| **Characteritics** | | | | | |
| Development to reach GS31 | Medium | Medium | Medium | Fast | Fast |
| Development to reach GS51 | Medium | Medium | Medium | Medium | Fast |
| Wholecrop Silage Maturity | 30 - 40% DM | 30 - 40% DM | 30 - 40% DM | 30 - 40% DM | 30 - 40% DM |
| Grain Harvest (Moisture %) | 13 - 15% | 13 - 15% | 13 - 15% | 13 - 15% | n/a |
| Grain Yield | 9 - 11 t/ha | 11 - 13 t/ha | 10 - 13 t/ha | 10 - 13 t/ha | n/a |
| Drought Tolerance | High | High | Medium | Medium | Medium |
| Harvest Index (Grains / Ear) | Medium | Very High | High | High | Medium |
| Lodging † (1-10 scale, 1 = low risk) | 1- 2 | 2 | 1- 2 | 1- 2 | 2- 3 |
| Straw Length (cm) | 125 - 138 cm | 128 - 136 cm | 122 - 136 cm | 125 - 140 cm | 125 - 148 cm |
| **Disease Resistance** | | | | | |
| Mildew | High | High | High | High | High |
| Brown Rust | Medium | High | High | High | High |
| **Grain Quality (Dep. On Cultivation)** | | | | | |
| Hagberg | 150 - 260 | 120 - 240 | 150 - 260 | 150 - 240 | n/a |
| Protein % | 8% - 11% | 8% - 11% | 9% - 10% | 8% - 11% | n/a |

Data source(s): Danish Farmer Union Trials, KWS UK Obs, KWS Lochow Breeder Obs, Bundessortenamt
Breeder: KWS Lochow GmbH - a subsidury of KWS SAAT SE, UK Distubution Licence via KWS UK LTD

# Agronomy, Fertiliser, Trials Data and Disease Profile

Hybrid Rye has relatively simple agronomy, requiring less fertiliser, and fungicide compared to wheat or barley.

The reason for this lies in its powerful root system, thanks to which rye can make good use of winter moisture and survive long dry periods.

The key success to rye yield performance are a focus on the principle Fertiliser requirements, adequate PGR programs and control of brown rust – the principle disease of the rye species.

KWS Trials data together with our UK partner's including Scottish Agronomy, BASF and Syngenta over the last 2 seasons has focused on optimizing grain yields and developing an N response curve.

Hybrid rye requires around **25% less water / ton of grain yield** (300 ltr / t) than winter wheat (400 ltr / t).

# Fertiliser Management

| Main crop | Crop Offtake | Nutrient content kg t/FM N | P2O5 | K2O | MgO |
|---|---|---|---|---|---|
| Hybrid Rye | **Grain (86% DM)** | **15** | **8** | **6** | **1** |
| | Straw (86% DM) | 5 | 3 | 20 | 2 |

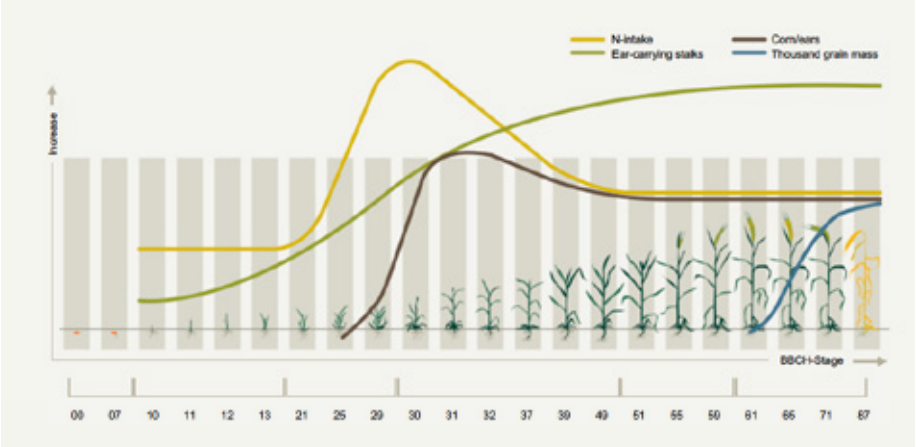
- Fertiliser rates should be based around **RB209**, and must be attained from a **FACTS** qualified advisor. The above crop offtake figures are an indicative example only.
- Rye straw volumes are large and **P & K** offtakes are higher than those listed in **RB209** for other cereals.
- Specific nutrient removal figures for **P, K, Mg0** and **Sulphur** are not currently published in RB209.

## Typical N Application - Second Cereal Slot Winter Wheat v Hybrid Rye

The table below demonstrates the possible application differences between second wheat and hybrid rye.

| | Min N Kg / Ha | Max N Kg / Ha |
|---|---|---|
| **Second Wheat - (Milling Spec)** | 260 | 280 |
| **Second Wheat - (Feed Spec)** | 220 | 240 |
| **Hybrid Rye (Grain)** | **120** | **150** |
| **N Input Difference v Hybrid Rye** | 100 - 140 | 80 -130 |

# Nitrogen Uptake in Hybrid Rye




## Total Nitrogen Recommendations

N applications can be split into 2 – 3 timings based on growth stage, site and season.

Current RB209 recommendations are based on a 6 t/ha grain yield.*

Data used to calculate this may be largely historical, as modern hybrids are capable of producing grain yields in excess of 13 t/ha. As such there must evidence based reasoning to raise total N rates higher than current legal levels.

Continental recommendations for hybrid rye are in the range of 160 - 170kg/ha N.

*Source: Nutrient Management Guide (RB209), Jan 2018

# Hybrid Rye Grain Yield Data - KWS

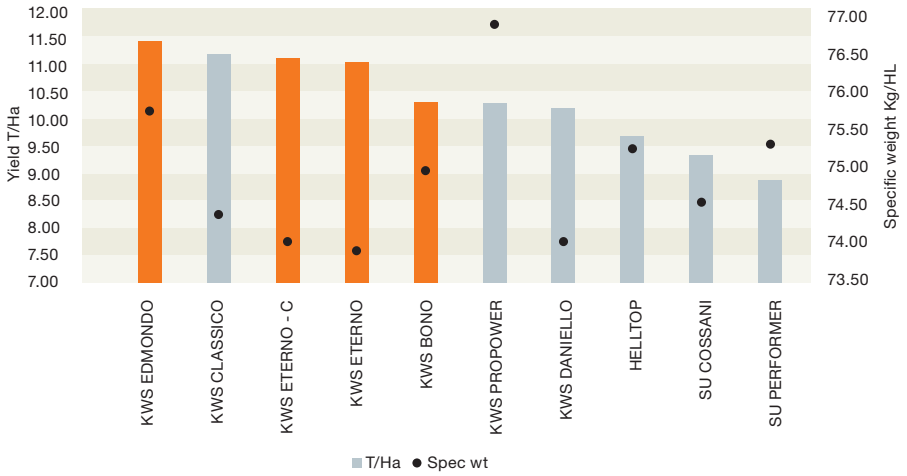
## Grain rye agronomy trials in Cambridge have concentrated on variety comparisons

Presented below are the 2018 grain yield and spec weight (Kg/HL) from Hybrid Rye grown as a **second cereal** following winter wheat;

- Sowing date 30th September 2017 – Seed Rate 200 seeds / m2
- Yield Range: 8.91 – 11.44 t/ha (min – max), Spec Weight: 73.9 – 76.8 Kg/HL
- Split PGR program: CCC 1.0l/ha, Moddus 0.2 l/ha @BBCH 30, Canopy 0.6l/ha @BBCH 31 – 32 and Terpal 1.5l/ha@ BBCH 39
- Fertiliser 150kg/ha N across three splits Second applications includes SO3 @ 50kg/ha

CV 8, LSD: 1.23

**Second cereal variety trial - 2018, Herts KWS PDF Development Trails**

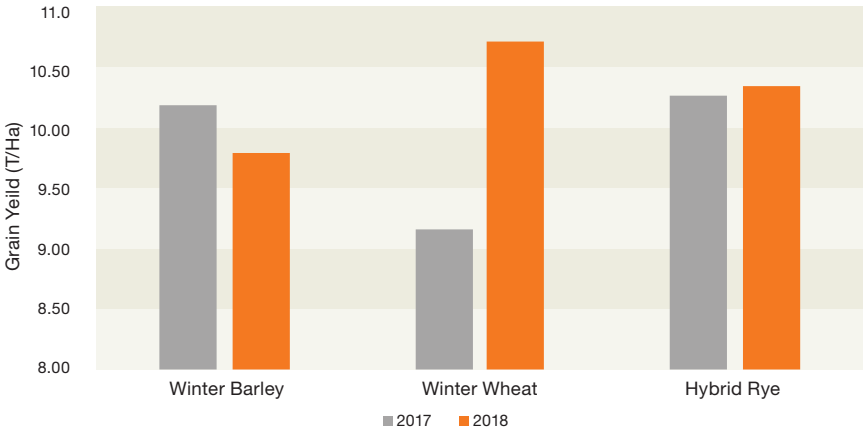



Since 2017 KWS UK have compared the average trial yields of all winter wheat, winter barley and hybrid rye yields.

Seasonal variations lead to one crop type being more successful in annual yield performance, with a developing level of consistency from hybrid rye not seen in other cereals.

(see overleaf)

**2nd Cereal Variety Trials - Hybrid Rye, Winter Barley and Winter Wheat**



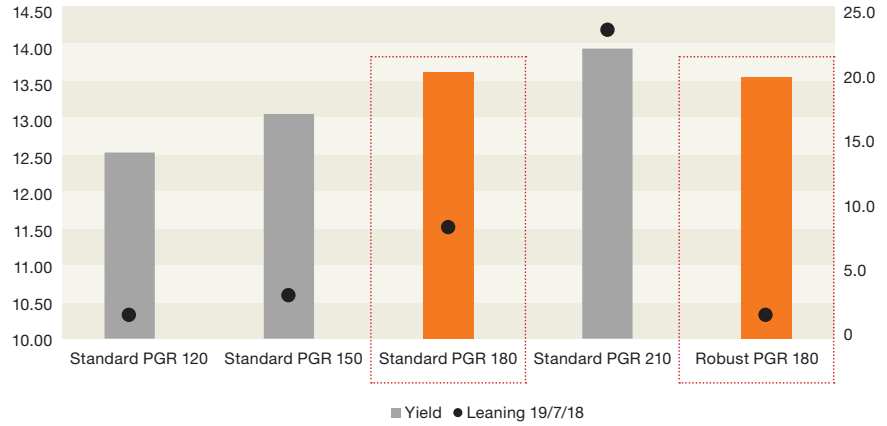

Data Source(s): KWS UK Development Trials 2018

# Hybrid Rye Grain Yield Data - Scottish Agronomy

Presented below are the 2018 grain yield and spec weight (Kg/HL) from Hybrid Rye grown for grain yield test data, using a higher seed rate of **300 seeds / m²** – and varying PGR programs typical of drilling practice in Scotland;

CENTRAL WINTER RYE KWS EDMONDO PROGRAMMES TRIAL - KWS EDMONDO

**Nitrogen Response, Standard vs. Robust PGR - KWS EDMONDO**




Hybrid rye responds to increasing levels of nitrogen well in Scotland. However as levels increase the issues with lodging and brackling increase also making it unadvisable on a commercial scale. The base line yield with the lowest input levels is still very competitive against other cereals.

The inclusion of a higher level of PGR is also advised at higher nitrogen rates. Standard PGR 1x 3C 1.75L & Moddus 0.2L / Robust PGR = 3C 0.5l & Moddus 0.1L FB 3C 1.5l & Moddus 0.15l

# Disease Profile

Hybrid rye is far less susceptible to most leaf diseases compared to other cereals. The most important disease in rye cultivation is brown rust.

## Brown Rust

Rye suffers from a specific strain of brown rust (*puccinia recondita*) – this strain is not known to cross infect with wheat or barley and rye is not affected by *sp. tritici* or s*p. hordei* either.

Despite loss of some active ingredients the fungicide spectrum of products available for brown rust in rye is very strong; some of the newer SDHI's available are very effective, providing an alternative to a strobulurin / triazole programme.

- **T1 (GS29 – 30)** Early season control is essential given the autumn infections the susceptibility to secondary infections
- **T2 (GS39 – 47)** Flag leaf, this is the most important time to maximize protection
- **T3 (GS 51 – 59)** Flowering and grain fill
- Brown rust in the late season can be exacerbated by high temperatures (20 - 26°C and warm nights (15°C) causing yield losses in rye - grain yield (number of grains per ear and thousand-grain weight)
- Infection also impairs grain quality by reducing the protein content

## Mildew

Rye is attacked by a special form of mildew - Blumeria graminis f.sp. secalis and despite being relatively easy to control in rye, mildew can cause yield losses of up to 25% in extreme cases.

Temperatures between 18°C - 20°C and high relative humidity (but no rain) are required for heavy sporulation. Under unfavorable conditions however, the infestation can stagnate, since the spores can only survive for a few days.

- Many fungicide labels include rye and there may be EAMU's in place for others
- Farmers and agronomists are advised to check the latest information directly with chemical manufacturers

## Rhynchosporium

Rhynchosporium is one of the main diseases of winter barley, but rye is also affected by this pathogen. On winter hybrid rye, the lower leaves are usually affected. However, epidemic spread to upper leaves rarely takes place, since rye expresses a powerful stem elongation and is able to outgrow any leaf damage caused.

Rye can also be affected by **Snow Mould** (*Microdochium nivale*) but this is not typical under UK conditions.

**The potential for rye in the rotation to help on farm control of two of the most topical diseases in UK cereal cropping**

## Septoria tritici

Septoria tritici is the most important foliar disease on winter wheat in the UK - however there is growing concern around the loss of some key active ingredients and slippage in performance of others.

- Chlorothalonil (CTL) and its removal from use
- Concern about the continued slippage in triazole and SDHI performance
- Limited new or replacement chemistry available to date although new actives could become available in 2020
- Growers are making use of  more resistant wheat varieties to underpin septoria control

Evidence to date indicates that hybrid rye offers an alternative but complementary option to septoria control that may help spread the workload, especially in a difficult spraying season.

Hybrid rye is a completely different species and does not seem to suffer significantly from septoria (either *tritici* or *nodorum*) thus offering an extra benefit to those considering growing the crop.

## Ramularia

Chlorothalonil (CTL) and its removal from use also concerns barley growers worried about controlling ramularia (*ramularia collo-cygni*) without future multi-site fungicide activity in the future becoming a possibility – so called “evolved resistance” may increase to the disease especially affecting barley production, although newer actives with more specific modes of action may offer some “ramularia relief”.

Rye is not immune but does not suffer to the same extent as barley, as the leaf area (20%) is not so important for yield-generation in rye compared to the stem (57%) and ear (23%) which might be an extra benefit to rye in the rotation.

Given the regulatory pressures on existing fungicides including those responsible for control of both septoria and ramularia  – hybrid rye can offer an opportunity for extended rotational control and more diversity in the on farm cereal rotation.

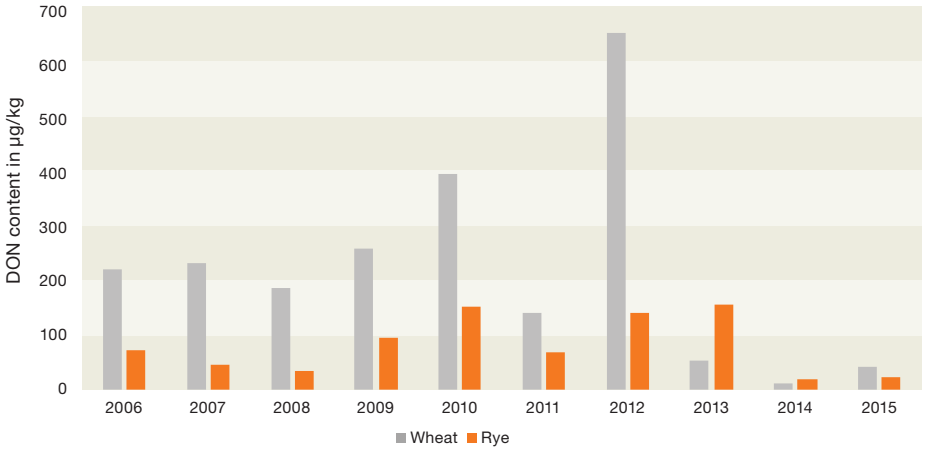
Fusarium free (left) and infected (right) rye grain

## Fusarium

Fusarium ear blight is a fungal disease of all cereals, including wheat, barley, oats, rye and triticale and affects both the yield and feeding quality of the harvested grain.

- It is often associated with contamination by mycotoxins, and can result in high levels of DON (deoxynivalenol) present in the harvested grain.
- Over several harvests measuring the average DON content in harvested wheat and rye samples between 2006 -2015, it has been determined that rye has significantly lower DON values compared to wheat. (see graph)

**Average DON content in harvested wheat and rye samples 2006 -2015 (Bavarian State Institute for Agriculture (2017)**

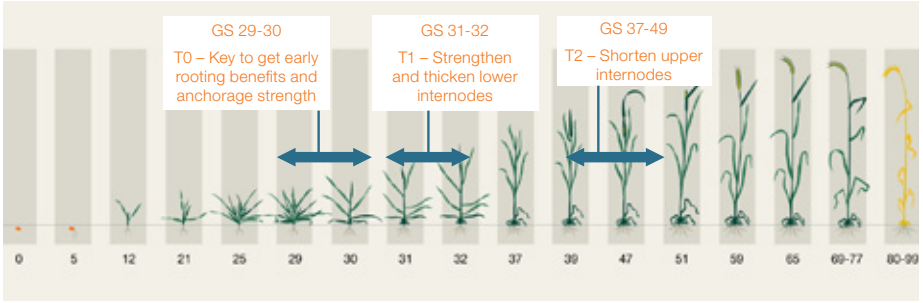



Source: Average DON content in harvested wheat and rye samples 2006 -2015 (Bavarian State Institute for Agriculture (2017)

# PGR Recommendation from BASF in Rye Crops

Rye varieties are renowned for being tall crops with early vigorous growth. Both of these attributes require PGR management to ensure full yield potential can be achieved and maintained through to harvest.

As a tall crop with a large ear, Rye can exert a large leverage force on the stem and root plate. This can lead to root lodging if no control measures are taken. Most anchorage strength develops between growth stages 30-39. It is between these stages that applying a robust PGR to the crop will increase the root plate spread, providing better anchorage against root lodging, and shorten the internodes, which will reduce plant height, and therefore reduce the leverage force which can be exerted. PGRs at this timing will also thicken the stem wall, strengthening the stems to further assist in the management of lodging.




Rye crops move through the growth stages earlier than other winter cereals in the UK. When rye is at GS30 it can still be early in the spring and conditions may be cool and cloudy. Products that contain prohexadione-calcium (BASF Canopy® or Medax® Max) are ideally suited to applications in these conditions as the prohexadione-calcium starts to work immediately within the crop irrespective of light and temperature.

The prohexadione-calcium containing products are co-formulated with a second active ingredient such as trinexapac-ethyl or mepiquat chloride that provides long lasting efficacy, complementing the immediate availability of the prohexadione-calcium.

Medax® Max treated stems on the top are thicker and will therefore provide greater resistance to lodging than the untreated stems on the bottom.

Taken from a 2017 commercial Rye crop.

| T0 – GS29-30 | | T1 – GS31-32 | | T2 – GS 39-49* | |
|---|---|---|---|---|---|
| Canopy® Or Medax® Max | +/- 3C Chlormequat 750 | Canopy® Or Medax® Max | +/- 3C Chlormequat 750 | Canopy® Or Medax® Max | Terpal® |
| Prohexadione-calcium containing products can start to work immediately in the plant to promote tiller retention and provide improved root anchorage. | | With applications still early for UK conditions, prohexadione- calcium containing products provide reliable performance in shortening and thickening lower internodes. | | A robust dose of a late season PGR will help to strengthen the upper stem. | |

*Please read the product labels for guidance on dose rates and application timings



Canopy® contains prohexadione-calcium and mepiquat chloride, Medax® Max contains prohexadione-calcium and trinexapac-ethyl, Terpal® contains 2-chloroethylphosphonic acid and mepiquat chloride, 3C Chlormequat 750 contains chlormequat chloride.

| | | | |
|---|---|---|---|
| **T0 GS 29-30** | Canopy® Or Medax® Max | +/- 3Chlormequat 750 | Prohexadione-calcium containing products can start to work immediately in the plant to promote tiller retention and provide improved root anchorage. |
| **T1 GS 31-32** | Canopy® Or Medax® Max | +/- 3CChlormequat 750 | With applications still early for UK conditions, prohexadione-calcium containing products provide reliable performance in shortening and thickening lower internodes. |
| **T2 GS 39-49*** | Canopy® Or Medax® Max | Terpal® | A robust dose of a late season PGR will help to strengthen the upper stem. |

# Vibrance® Duo in Hybrid Rye

Following very successful trials in Germany, Syngenta have been investigating the effects of different seed treatments on Hybrid Rye in the UK. Vibrance® Duo contains the new active ingredient, sedaxane, plus fludioxonil. This seed treatment has been shown to increase plant emergence, root length and root weight when compared to a standard seed treatment: triticonazole + prochloraz.

Syngenta carried out trials in 2016 and assessed the plant population from the early stages of establishment. The Vibrance® Duo treatment showed 238 plants/ $m^2$ compared with 225 plants/$m^2$ in the triticonazole + prochloraz treated plot.

One month later, the Vibrance® Duo treated Hybrid Rye continued to show advantages in both root and shoot dry weight with added root length advantages of 40mm. This allows the crop to scavenge for nutrients more effectively. The image below shows the Hybrid Rye plants treated with Vibrance® Duo looking healthy with improved tillering.

Triticonazole + prochloraz (GS 21-23)

Vibrance® Duo (GS 23-24)

# 2018 Seed Rate and Vibrance Trial KWS & Syngenta

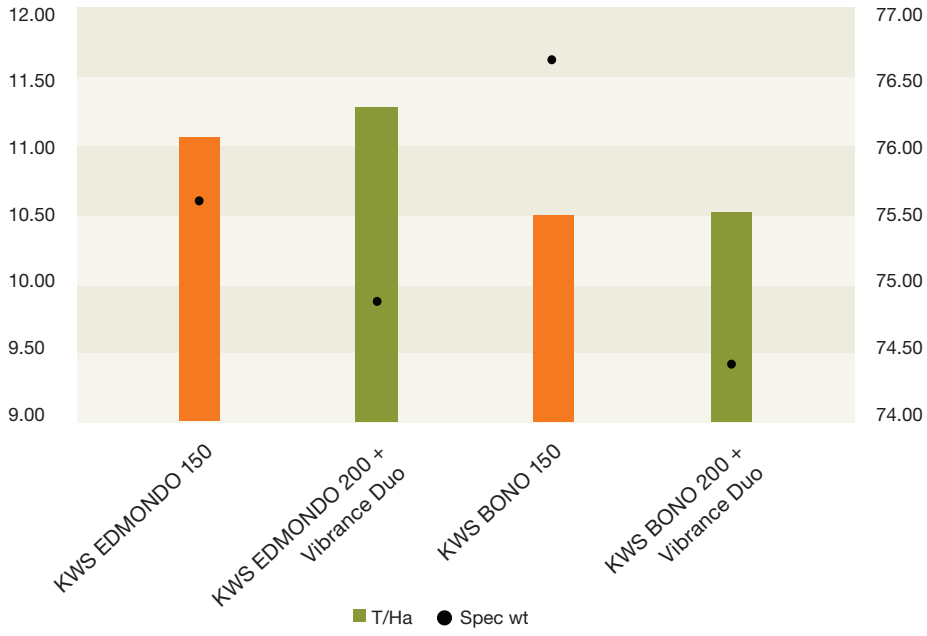
During 2018 KWS in partnership with Syngenta performed a number of grain yield trials on two hybrid rye cultivars, KWS EDMONDO - a relatively fast developing hybrid and KWS BONO - a slower developing hybrid.

Both grain yield and specific weight were analysed at three varying seed rates, Low – 150 seeds / $m^2$ , Medium 200 seeds / $m^2$ and 200 seeds / $m^2$ + Vibrance® Duo (fludioxonil + sedaxane)

**Notes:** LSD = 1.2 T/Ha, CV = 8.0  Trial Location Fowlmere, Herts, Drill Date 30.09.17 Harvest 22.08.18

Trial work is on-going during the 2019 season.

**2018 PDF East Seed Rate Trial 150 and 200 + Vibrance® Duo**



# WHOLECROP OR CRIMPED GRAIN

# Hybrid Rye for biogas (AD) or wholecrop silage

The development of dedicated varieties meant Hybrid Rye rapidly attracted the interest of those with anaerobic digestion (AD) plants. These operators quickly identified Hybrid Rye's potential to complement wastes and other cellulose-based feed stocks. Attracted by yields of more than 35t/ha fresh weight, the area of Hybrid Rye grown for AD in the UK comfortably exceeds 20,000 hectares.

Hybrid Rye for wholecrop also offers potential for inclusion in ruminant rations for beef finishing or dry cows in modern year round calving dairy systems.

## Agronomic advantages of Hybrid Rye:

- High yield potential (35 – 50 t/ha fresh)
- DM content (30 – 40%)
- Starch content (20 – 25%)
- Spreads storage (clamp) utilization and harvest workload
- Ideal co-feedstock - comparable biogas yield / FM tonne to maize silage (200 cu/m$^3$)
- Suitable for dry cow ruminant feeding in areas of silage shortfall

**The advantages of Hybrid Rye include:**

## High starch yield

The ear contributes roughly 50 - 55% of the final wholecrop yield so by producing varieties with more grains per ear KWS has been able to make unrivalled gains in yield. At 30-40% dry matter content, fresh weight yields of 45t/hectare and more have been achieved.

## Favourable dry matter content

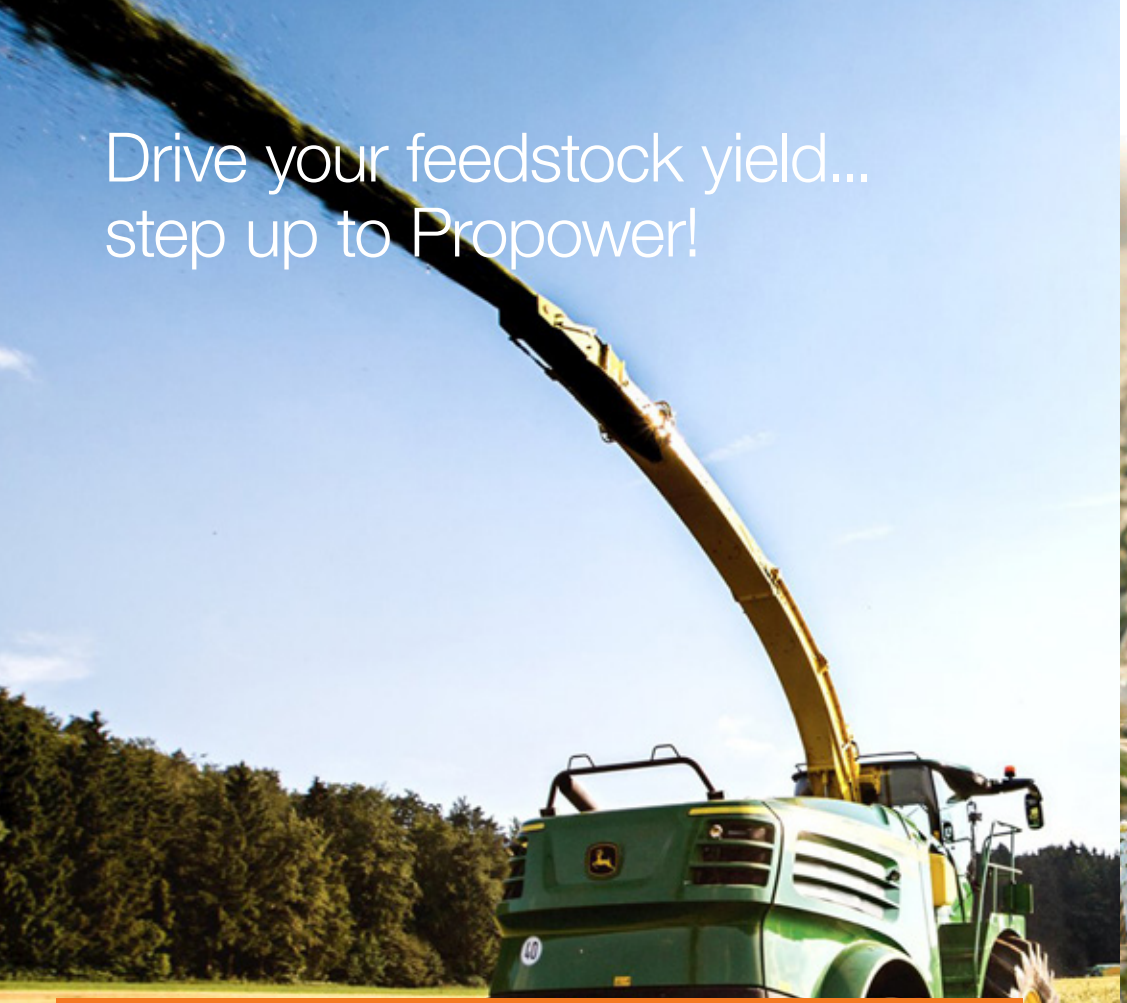
Most growers favour a dry matter content of 30 to 40%, but for some this is not sufficiently accurate. Fortunately, as a whole-crop cereal typically harvested in June it is easy to achieve a more precise dry matter content by influencing harvest date.

## Universal soil type and geographic potential

An autumn-sown cereal that is best suited to light land sites, Hybrid Rye poses little risk to soils as it is sown into good ground conditions and harvested in good weather.

## Hassle-free storage and mixing

Hybrid Rye is an ideal co-feedstock. It spreads the harvest workload between maize and energy beet, is easy to clamp and can be easily substituted for other feedstocks as it has a biogas yield comparable to maize silage of 200 cubic metres per tonne of fresh weight.



# Drive your feedstock yield... step up to Propower!

## KWS PROPOWER

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- High wholecrop yields (45 t/ha +)
- Biogas yield/tn similar to maize (200 $m^3$)

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# New horizons for Hybrid Rye!

## KWS EDMONDO

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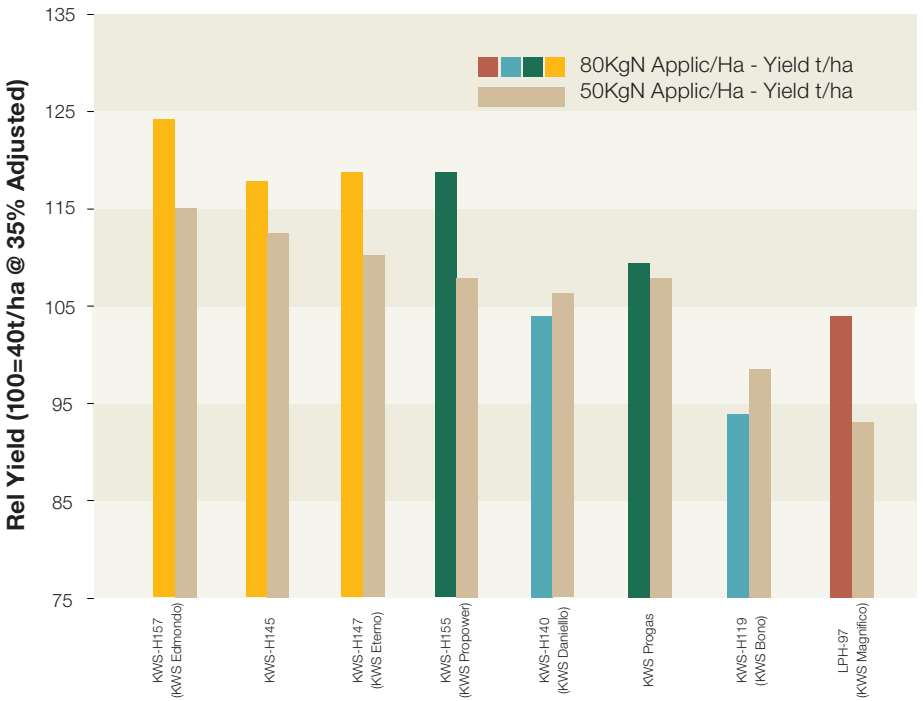
# KWS UK Wholecrop Trial Results 2017

KWS UK trial results 2017 – total N application (150 kg/ha) rate split 50 kg N v 80 kg N between GS 29 - 32




Reference AD/Silage Hybrid

Reference Grain Hybrid (KWS Daniello)

Reference AD/Silage Hybrid (KWS Progas, KWS Propower)

New Candidate Hybrid *tested only in 2015 & 2016

The greater starch content that comes from a higher harvest index (more grains per ear) means a higher gas output for AD purposes or more metabolisable energy (ME) per hectare for ruminant rations.

# Hybrid Rye as a Crimped Grain

Hybrid Rye, just like barley, triticale or wheat presents an alternative crop to be crimped and stored as a valuable ruminant feed, or co-feedstock for biogas.

Image courtesy Kelvin Cave Ltd

Rye grain yield, which is higher than other cereals especially in dry land conditions, can give even higher yields of digestible dry matter if combine-harvested, crimped and ensiled.

If the harvest window for taking the crop as wholecrop silage (30 – 40% DM) has been missed the straw loses digestibility and gas yield potential is significantly reduced.

The crimping process allows cereals to be harvested from 45% down to 25% moisture content (55 – 75 % DM).

Crimping has several benefits, producing a higher starch and ME (MJ/Kg) content as a co-feedstock, together with lower DM losses, compared to silage.

Rye can be crimped, treated with an effective preservative and ensiled in indoor or outdoor clamps. Feed-out rates are lower compared to wholecrop silage and the digestate produced has a higher DM%. The straw can be baled and sold for use on livestock farms or in biomass burners.

## Other benefits of crimped grain compared to silage

- Reduced grain losses and less potential for volunteer contamination
- Harvesting is less weather dependent
- Reduces bought-in feed requirement
- Higher Starch %, ME (MJ/Kg) and methane content for AD/Biogas use

Rye has the potential to be crimped and stored in a similar way to other cereals

Image courtesy Kelvin Cave Ltd

# FEED GRAIN
# (Pigs)

# Hybrid Rye as a Monogastric Feed Grain - Unique Attributes to Pig Feeding

In Denmark, Germany, Russia, Poland and Spain, rye is already rapidly becoming an established component of pig rations.

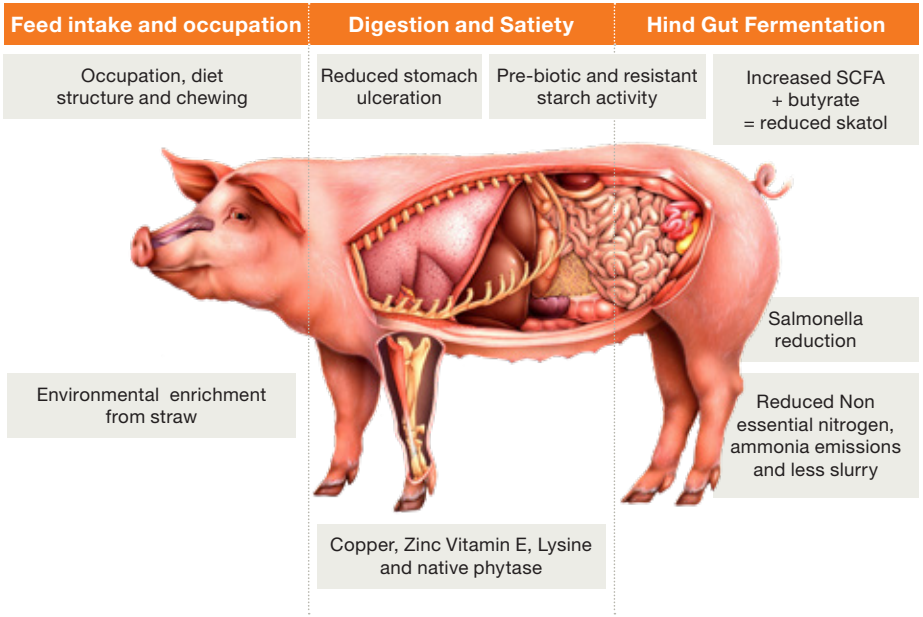
KWS in partnership with farmers and feed experts are now extending hybrid rye uptake in the USA and Canada with strong interest in what rye can offer;

Several factors facing the pig industry worldwide have promoted rye uptake;

## Key advantages for monogastric feed - pigs:

- Positive behavioral effects via satiety inducement (esp. in finishers and dry sows)
- Decreased gut ulceration and promotion of hind gut and colon health
- Low non essential nitrogen and reduced faecal losses - for lower ammonia emissions
- Naturally high dietary fibre, lysine and native phytase levels
- Prebiotic and resistant starch activity
- High straw yield for environmental enrichment
- Similar mineral content to wheat, barley and oats (Copper, Zinc) and higher Vitamin E content
- Lower input and production costs (25% less water requirement, up to 100 Kg less N / hectare compared to wheat, less fungicide requirement)

## Nutritional Roadmap – Hybrid Rye in Pig Feeding




## Feed Intake and Occupation

| Environmental enrichment and welfare | | Benefits from hybrid rye |
|---|---|---|
| Fattening pigs need around **400 – 500 grams / straw per pig / per day** to fully meet their **behavioral and exploration** needs in non-feeding occupation *<br>Straw provision acts as a **novel stimuli** - a lack of which can express itself in aberrant **aggressive behavior** especially among finishing pigs causing **ear, tail and flank biting** | Secondary benefits linked to straw provision;<br>✓ A significant linear decrease of pigs with tail injuries when allocating increasing amounts of straw*<br>✓ Significantly fewer pigs with gastric ulcers when allocating 500 g - 1000 g of straw per pig / per day* | ✓ Rye straw is an ideal crop constituent and by-product for pig production<br>✓ Hybrid rye has a straw yield of around 4 – 5 t/ha – around 1 – 1.5 t/ha more than wheat of barley making it more cost effective |

| Occupation, diet structure and chewing | | Benefits from hybrid rye |
|---|---|---|
| **Diet structure and particle size** has a clear link to the level of **occupation** and **chewing** of finishing pigs, dry sows and piglets<br>Rye can be processed as meal based or pellet based feed similar to barley and wheat | Secondary considerations for particle size;<br>✓ Liquid feed should contain no more than ca. 35% of particles less than 0.2 mm to avoid ulceration**<br>✓ In meal based home mixing systems limiting the fraction of very fine particle sizes avoids gut ulceration or respiratory problems from dusty feed | ✓ Rye is high in water absorbent digestible fibre which demands more active chewing, and more saliva uptake – this can reduce the acidity of the feed as it enters the stomach<br>✓ Rye is suitable for both liquid and dry feeding systems<br>✓ Possibility for extended welfare standards based on post slaughter carcass quality |

Source: *DCA - Danish Centre for Food and Agriculture, Aarhus University 2013,
** Impact of physical form of animal diets, Kamphues, 2018

A comparison of post slaughter gut condition– healthy (left) and ulcerated (right)

Source: Danish Pig Research Centre | SEGES

## Digestion and Satiety

| Pre-biotic and resistant starch (RS) activity | | Benefits from hybrid rye |
|---|---|---|
| A **pre-biotic** feed acts to induce growth or activity of **beneficial microorganisms** in the hind gut<br>Similarly, **resistant starch is starch that bypasses or is unavailable for enzymatic digestion** in the stomach and then passes to the hindgut where it can be fermented by microorganisms | Secondary benefits linked to pre-biotic activity;<br>✓ Probiotic bacteria are able to consume oligofructan as an energy source which can positively impact the gut microbiome<br>✓ Resistant starch can help to improve overall gut health and immunity* | ✓ Rye has a high level of resistant starch owing to its higher **dietary fibre**** levels, leading to more even glucose degradation and blood sugar levels<br>✓ Rye feeding thus promotes **higher satiety** linked to diet, environment and feeding frequency |

| Copper, Zinc, Vitamin E, Lysine and native phytase | | Benefits from hybrid rye |
|---|---|---|
| **Copper, Zinc,** and **Vitamin E** are key components of pig nutrition and are linked to anti-oxidant activity and digestive health<br>**Lysine** and **native phytase** play equally important roles as the key amino acid and enzyme components for weight gain and phosphorus metabolism | Secondary benefits linked to Copper and Zinc;<br>✓ Diet based inclusion in the longer term will be needed to reduce supplemented zinc or copper<br>✓ Native phytase from feed reduces the need for synthetic phytase and the cumulative cost benefits that can result from higher natural inclusion | ✓ Rye has a slightly higher level of vitamin E compared to oats, barley or wheat<br>✓ Rye has higher native phytase levels than wheat – upto 2 times greater by content in u/Kg fed |

Source: *Carbohydrates in pig nutrition - Recent advances. Aarhus University, Department of Animal Science, Denmark, 2016 **Analyzed energy and nutrient composition of cereal grains (as-fed basis) - Comparative digestibility of energy and nutrients and fermentability of dietary fiber in eight cereal grains fed to pigs. Cervantes-Pahm, Liu, Stein – 2013

## Hind Gut Fermentation

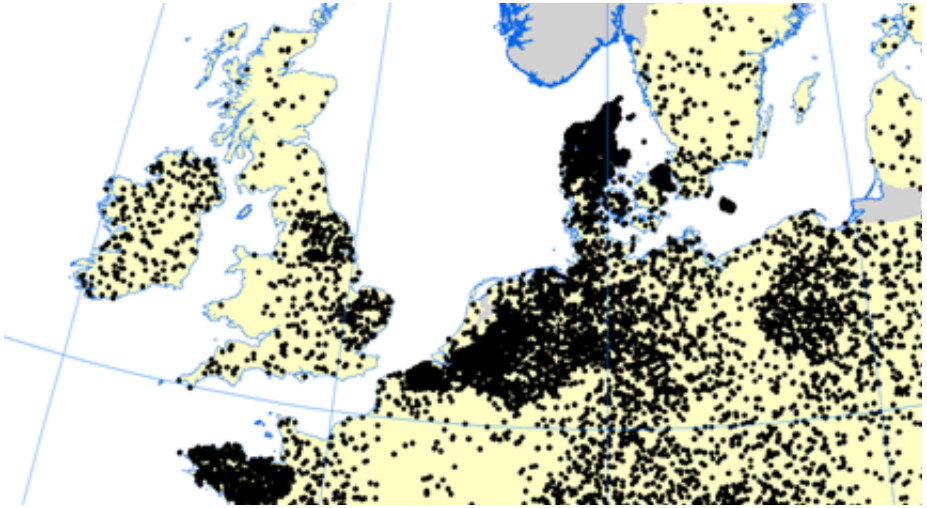
| Increased SCFA + butyrate production – reduced skatol | | Benefits from hybrid rye |
|---|---|---|
| The intestine is critical for nutrient absorption, but also is the largest immune organ in the pig.<br>Inflammation can be induced by numerous factors, such as infection, mucosal dysfunction and weaning stress.<br>Dietary fatty acids including short chain (SC)FA's play a critical role in intestinal development and immune function | Secondary benefits linked to SCFA formation;<br>✓ Enhanced butyrate levels in the hind gut<br>✓ Limitation of synthetic butyrate requirement | ✓ **Rye supports a higher level of fructan** in comparison to wheat or barley – fructan acts as a pre-cursor to butyrate formation<br>✓ **SCFAs' derived from rye** feeding can boost immunity via gut microflora development and reduce **salmonella** gut wall attachment<br>✓ **Natural butyrate production** limits skatol release, and a reduced risk of carcass taint and low consumer acceptability |

| Reduced non-essential nitrogen and slurry | | Benefits from hybrid rye |
|---|---|---|
| Dietary protein must be supplied at adequate levels in order to optimized essential amino acid supply and LWG (live weight gain in finishers) or maintenance for dry sows<br>**Unnecessary** protein can contribute to wasted nitrogen and phosphate levels in slurry<br>Amino acid availability from cereals with a **higher ratio of amino acids**: protein can help optimize this balance | Secondary benefits linked to lower protein and non-essential nitrogen;<br>✓ Less water usage in feeding – the secondary benefit of which is a higher DM% in slurry<br>✓ Lower requirement for land disposal<br>✓ Reduced ammonia, fecal N and phosphate losses | ✓ Rye has a lower protein content than wheat and barley, this directly reduces non-essential nitrogen<br>✓ Rye has a higher lysine:protein ratio**<br>✓ Rye crude protein content is around 8 – 9 % compared to wheat at 11 – 12% this is a net reduction of 3% can give a significant total reduction of slurry production* |

*Calculated on assumed reduction of 1% Protein is equal to 6% lower slurry production. Example: Using 100% wheat as the primary cereal grain - crude protein (CP) forms 15% of the total diet. In comparison inclusion at up to 50% hybrid rye allows total crude protein (CP) to fall to 13.5% of the total diet. Source: Gülleanfall bei unterschiedlicher Proteinversorgung der Mastschweine, LWK Niedersachsen, Germany 2018

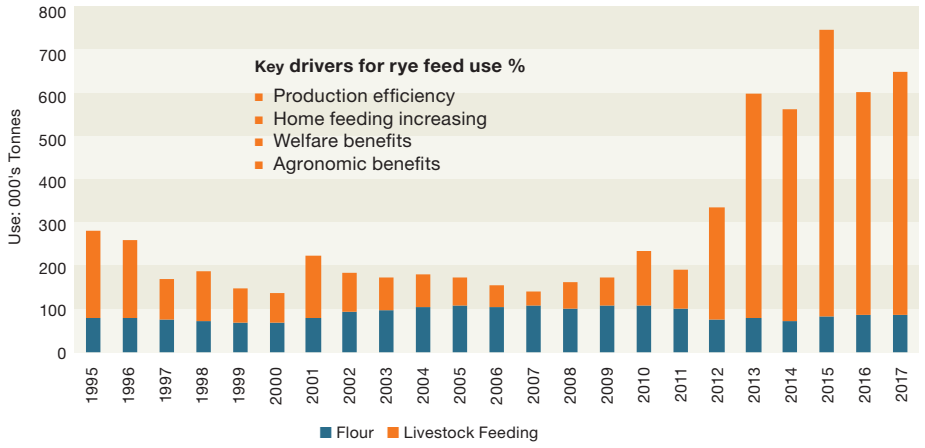
**Source: Precaecal digestibility of lysine g/Kg pcD Lys, 3) Rodehutscord et al - 2016, DLG 2014

**Pig production (sows by region) in Europe**



Source: Eurostat: Pig farming sector - statistical portrait 2014

**Rye usage in Denmark (1995 - 2017)**




Source: Statistics Denmark

# Rye nutritional composition and benefits in pig rations

Hybrid rye is inherently high in fructan, native phytase and together with its highly digestible lysine profile, offers excellent properties for pig nutrition.

## Fructan

Fructan is a storage carbohydrate digested in the pig's hind gut, it supports butyrate production which promotes intestinal health.

## Phytase

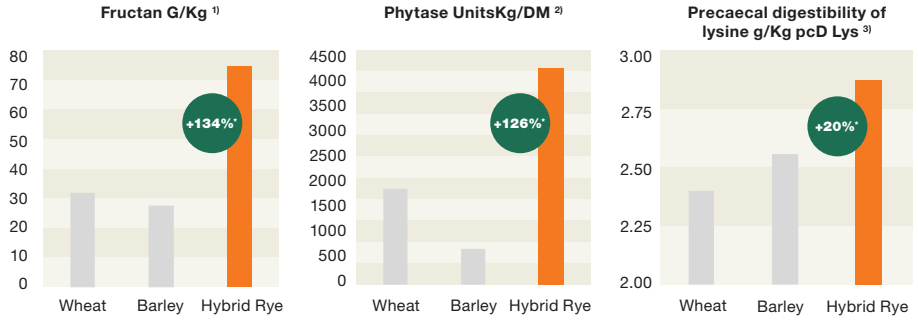
All common cereals contain an intrinsic level of the enzyme phytase, which acts as to break down phosphorus in the ration.

Over the past 10-15 years, phytase supplementation has increased in pig diets to lower the need for mineral phosphate inclusion. Lower levels of phosphorus in slurry are both a benefit to the soil indices remaining manageable, and reducing eutrophication of water courses.

## Precaecal digestibility of Lysine

Lysine digestibility can be defined as either total tract or precaecal, depending on whether the undigested nitrogen is measured in the feces (total tract) or ileal (precaecal) content.

Lysine from rye has a higher precaecal digestibility compared to wheat, leading to reduced non-digested nitrogen and ammonia loss.




Data sources:

1) HPLC LfL Sachsen - 2017 (measurement of native phytase activity) at 88% DM
2) Rodehutscord et al – 2016
3) Rodehutscord et al - 2016, DLG 2014

*Graph percentages are percentage increase vs. wheat

Other references:

Application of resistant starch in swine and poultry diets with particular reference to gut health and function. A. Regassa, C. Nyachoti, Department of Animal Science, University of Manitoba, Winnipeg, Canada – 2018

Apparent and standardized ileal digestibility of AA and starch in hybrid rye, barley, wheat, and corn fed to growing pigs

McGhee, Stein. Department of Animal Sciences, University of Illinois - 2018

## Data Tables

**Fructan and Native Phytase and Precaecal digestibility of lysine: Hybrid Rye v Wheat and Barley**

| | Fructan G/Kg [1] | Phytase Units Kg/DM [2] | Precaecal digestibility of lysine g/Kg pcD Lys [3] |
|---|---|---|---|
| **Wheat** | 32 | 1850 | 2.39 |
| **Barley** | 28 | 693 | 2.55 |
| **Hybrid Rye** | 75 | 4177 | 2.87 |

Data sources:

1) HPLC LfL Sachsen - 2017 (measurement of native phytase activity) at 88% DM

2) Rodehutscord et al - 2016

3) Rodehutscord et al - 2016, DLG 2014

**Trace mineral content of common cereals**

| | Wheat | Oats | Rye | Barley |
|---|---|---|---|---|
| Copper, mg/Kg | 2.9 | 3.6 | 3.0 | 3.1 |
| Zinc, mg/Kg | 18.9 | 13.0 | 19.1 | 18.3 |
| Vitamin E, mg/Kg | 12.3 | 9.6 | 13.0 | 9.0 |

Source: DIN EN 15621, LUFA NORD-WEST AA 1/3-029 Analysis, (mg/Kg at 88% DM)

## Recommended rye inclusion rates for pig feeding (based on live weight)

Rye can be included in both liquid or dry feeding systems to supplement wheat.

Rye inclusions can be progressively increased with live weight - from 10-20% at the piglet stage right up to 50% rye in the finisher stage (from 60kg bodyweight to the desired slaughter weight (105-140Kg).

| Weight and Recommended Inclusion | | |
|---|---|---|
| Fattening Pigs | 28-40Kg (preparatory ration) | 30% Rye |
| | 40-60Kg (initial fattening stage) | 40% Rye |
| | 60-90Kg + (medium and finisher ration) | 50% Rye |
| Sows | Upto 25% Rye | |
| Piglets | 10-15Kg + | 10-20% Rye |

1) When foaming appears in liquid feeding rye proportions should be reduced. Adding vegetable oil might minimise the problem. With additional use of triticale the possible rye proportion should be reduced by an amount of one third of the added triticale amount, due to the high NSP content (e.g. with 30% triticale the maximum recommended rye proportion is 40% in the finishing ration).

Source: DLG 2006

# Notes

# HYBRID RYE FOR HUMAN NUTRITION

# Hybrid Rye - Food products & benefits in human nutrition

Rye is one of the healthiest cereal grains – known in the Nordic countries for being "heart healthy" – Rye is versatile ingredient in baked goods, breakfast cereals and food ingredients too!

## Key advantages for baking and food use:

- High dietary fibre content
- Increased satiety – stable glucose and insulin balance
- Rye grain expresses the lowest glycemic Index (GI) values of all cereal grains
- Lower postprandial insulin response compared to wheat four
- Improve bowel function – lower risk of constipation
- Long term cardiovascular health – Rye based diets are linked to decreased incidence of myocardial infarction and beneficial effects in lipid metabolism

## Example end use products from Rye:

**Milling Products:**

- Whole grain Rye, steel cut rye, Malted Rye kernels, Whole grain Rye flour, Rye bread mix with sourdough, Rye bran, Rye flakes, breakfast cereals (muesli, others)

**Bread products:**

- Sourdough Rye bread, Crispbread, thin crispbread, rolls, buns and breads

**Other Rye products:**

- Rye porridge, pastries, Rye pasta, snack products

Source: NORDIC RYE FORUM

## High Fibre

Rye is rich in water-soluble and insoluble dietary fibres, located in the outer layers of the kernel and in the bran.

Since rye is mainly consumed as whole grain bread, it is an important source of dietary fibre. Rye is also a source of iron and magnesium, zinc and Vitamin E.

The main components in rye fibre;

- Arabinoxylan
- Fructan
- ß-glucan
- Cellulose and resistant starch

Nutritionists disagree on many aspects of diet and health, but most agree on one key topic; dietary fibre. The consensus view is that we need to eat more of it, to reach the recommended fibre intake* of 30 grams / day.

Source: NORDIC RYE FORUM

## Rye as a Pre-biotic

A prebiotic is simply a compound (like fructan or resistant starch) that induces growth or activity of beneficial gut microorganisms.

- Whilst rye exhibits lower starch and crude protein content than wheat, it is far higher in free sugars.
- Fructan is the single largest free sugar component of rye, making it possible to class rye as a pre-biotic.
- Probiotic bacteria are able to consume the resulting oligofructan as an energy source which can positively impact the gut microbiome.

*Recommendation source(s): Scientific Advisory Committee on Nutrition (SACN) report on Carbohydrates and Health (2015), Public Health England

# Rye alcohol products

Rye can be used to add a distinct spicy character and unique colour to brewing, distilling and grain neutral spirit applications. Its use in both craft and commercial sized producers is increasing rapidly.

Rye often has a slower processing throughput owing to its higher residue viscosity compared to wheat and barley – this necessitates the careful control of mash filters, temperatures and handling in the production process.

## Key characteristics of rye:

- Spicy and earthy flavor and texture
- New market options as a novel ingredient compared to maize, wheat, hops and barley
- Alcohol yield is comparable to current soft wheat standards (within 7 - 10% *) work is currently on going to compare rye alcohol yield to spring barley standards
- Environmentally friendly in the supply chain – rye uses far less nitrogen, fungicide and water to grow and produce than most other cereals
- Versatile uses as rye whisky, rye malt, pot still rye, crystal rye, rye IPA and lager, gin, vodka and others

## Malt whisky

- **Scotland** - Scotch whisky's protected designation and origin standards state that only malted barley can be used as the major raw material – using a Low N High Extract (ie: alcohol yield) standard typical of malting barley. Enzyme use is prohibited.
- **Ireland and England** - Rye in Irish and English malt production is allowed owing to differing regulations on grains used for distilling and marketing standards allowing true rye malt to be produced using upto 100% rye mash. Enzyme use is permitted to allow for enhanced diastatic power (DP) in production.

## Grain whisky

- In the UK any cereal grain (up to 90%) (wheat, barley, maize or rye) can be used in grain distilling as a mix with other cereal grains or standalone + 10% high enzyme (high DP) malted barley.
- Wheat and maize are generally used for the production of Scottish grain whisky currently, however rye use is beginning to see a resurgence with the first grain rye whisky brands launched in 2017.

## Gin or Vodka

Rye can supplement any other cereal and there are no restrictions on this – being classed as a grain neutral spirit.

## Beers, Pale Ale and Lager

Beers, IPA, lager and traditional pale ales can be brewed to bring added flavor using traditional barley malt together with rye.

**Note:** spelling: Whisky usually denotes Scotch whisky and whiskey denotes the Irish and American liquors.

*Source SWRI (Scotch Whisky Research Institute ) work undertaken for KWS, 2017

# 2 in 1 Hybrid Rye from KWS!

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- Strong brown rust resistance compared to older hybrids
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RECIPES

# Rye bread & butter pudding

## You will need:

- 450g peeled and chopped apple
- 1-2 tbsp xylitol or Sugar
- 1 loaf rye bread approx 450g*
- Butter
- 250ml oat cream, plus more to serve - I use regular single cream
- 1-2 tsps cinnamon
- 200ml almond milk or whole milk
- 3 eggs
- 80g maple syrup

*Needs to be a “doughy” loaf, not a dense one.

## Method:

**1** Preheat the oven to 180 degrees celsius.

**2** Place the peeled and chopped apple in a saucepan with 1 -2 tbsp xylitol or sugar. Pour in enough water to partially cover the apples. About 60-90ml is ok depending on the size of the pan. Cover and leave to stew on a medium heat for approx 15 minutes or until soft.

**3** In a large bowl whisk the oat cream, eggs, almond milk, maple syrup and cinnamon.

**4** Slice the bread in slices roughly 2cm thick. You can either cut off the crusts of leave them on. Personally it looks prettier with crusts on, although tastes better without them – I sold out for the insta pic!

**5** Toast the bread and spread both sides generously with coconut oil. Layer the bread in an oven proof dish. A cake or loaf tin would also work. Just manoeuvre the bread so it all fits whatever shape.

**6** Spoon the stewed apple around the bread using your hands to pick pieces up if you need to get under slices. You may not want to use all the apple so don’t worry if there’s some left over.

**7** Pour the egg mixture around the bread making sure it’s all submerged as best as possible. You may have to push the bread right down into the egg mixture if it’s a shallow dish.

**8** Bake in the oven for approximately 20 minutes until set. It’s best to keep checking just incase the top of the bread burns. In this case, cover with foil and continue cooking.

Serve warm or cold with plenty more cream and drizzlings of peanut butter.



# Rye pancakes with apple-maple compote

## What you will need:

**For Compote**

- 2 tablespoons unsalted butter
- 1 apple, cored and diced into ⅛-inch thick pieces
- 1 tablespoon Grade B maple syrup
- ¼ teaspoon cinnamon

**For Pancakes**

- ¾ cup rye flour
- ¾ cup (3¾ ounces) all purpose flour
- ½ teaspoon salt
- 1 tablespoon baking powder
- 1½ tablespoons sugar
- 1 egg, lightly beaten
- ½ cup plus 1 tablespoon milk
- Butter, for skillet

## Method:

**1 For Compote:** Melt butter in a small saucepan over medium heat. Add diced apple and cook until tender, stirring occasionally, about 6 minutes. Take off heat, stir in maple syrup and cinnamon, cover and set aside.

**2 For Pancakes:** In a medium bowl, whisk together rye flour, flour, salt, baking powder, and sugar. Whisk in egg and milk until just combined.

**3** Heat griddle or large non-stick skillet over medium heat for 5 minutes, then add a little butter and swirl to coat pan. Ladle 1/4 cup batter into pan and when bubbles have appeared and bottom has set, flip carefully with a spatula. Let cook until just cooked through, another 1-2 minutes. Serve immediately with warm sauce.

# Notes

# Notes

# Notes

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