Title: WW23-05501 Fungicide timing response monitoring in winter wheat at Morley.

Trial Code: WW23-05501
Centre and (Trial Site): Morley
Crop: Winter Wheat
Variety: KWS Extase and Gleam
Report Author: Nathan Morris

Objective:

To record and monitor the yield responses to each of the component spray timings within a fungicide programme on wheat.

Background:

The site is part of a long-term experiment that has run at Morley, Norfolk for 37 years (supported by The Morley Agricultural Foundation). The experiment records a snapshot of the yield response to fungicide input and spray programme components in winter wheat each year. Varieties with similar fungicide-treated yields can have very different fungicide requirements. The 2023 trial at Morley considered this, by comparing two winter wheat varieties KWS Extase and Gleam across a range of fungicide programmes. On the AHDB Recommended List 2023-24, KWS Extase displays high resistance scores for septoria, mildew, yellow rust, and brown rust; 7.8, 7, 8, and 6 respectively. While Gleam has poor to moderate resistance scores for septoria, mildew, yellow rust and brown rust; 5.7, 7, 5 and 6 respectively. KWS Extase and Gleam had fungicide-treated grain yields of 102% and 101%, respectively, of the treated yield control. However, they differed dramatically in their untreated yields, with the untreated grain yield of KWS Extase at 97% of the fungicide-treated control and Gleam at 84% of the fungicide-treated control. This indicates that although both varieties have good treated grain yields, they get to that yield in very different ways, with Gleam responding well to fungicide use and KWS Extase less responsive to fungicide use. The strong untreated yield of KWS Extase also means that the fungicide spend could thus be half that of disease-susceptible varieties, such as Gleam.

Summary:

In untreated conditions, KWS Extase performed better than Gleam, with a 1.09 t/ha yield difference between the two varieties. However, in the fungicide-treated programs, the difference in treated yields between the two varieties narrowed with KWS Extase showing ca. a 0.18 t/ha yield increase over Gleam in a 1 or 2-spray programme and ca. a 0.33 t/ha yield decrease in a 3 or 4-spray programme. As expected; KWS Extase also had an overall lower yield response to fungicide programmes, compared to Gleam. In comparison to the mean fungicide response over the previous 36-year period of this trial, in Gleam in 2023, the mean yield response to the T0 alone was -0.21 t/ha, the mean yield response to a T1 + T2 spray was 1.77 t/ha and the mean yield response to a T3 spray was 0.54 t/ha which amounted to a total fungicide response of 1.74 t/ha. Taking the 2023 data into consideration, the mean 37-year fungicide response for T1 + T2 is now 1.77 t/ha, and the fungicide response for T3 is 0.34 t/ha.

Treatments:

Table 1: Treatment list with comments and description.

Variety	Treatments	GS30	GS32	GS39	GS65	Comment
KWS Extase (Treatments 1- 5) and Gleam (Treatments 6-10)	1,6	Untreated	-	-	-	Untreated
	2,7	-	-	Revystar XE 0.8 l/ha + Tebucur 250 0.5 l/ha	-	T2 Alone
	3,8	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	-	T1 + T2
	4,9	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Tesoro 0.774 l/ha	T1 + T2+ T3
	5,10	Tesoro 0.516 l/ha + Talius 0.125 l/ha	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Tesoro 0.774 l/ha	Full Programme

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Table 2: Products and active ingredients.

Product	Active ingredient and concentration
Revystar XE	fluxapyroxad 47.5 g/l + mefentrifluconazole 100 g/l
Talius	proquinazid 200 g/l
Tesoro	tebuconazole 250 g/l
Univoq	fenpicoxamid 50 g/l + prothioconazole 100 g/l

Results

Disease levels were low throughout the trial period. Septoria was present at a low incidence from early spring (GS61). Septoria was only evident at higher levels on untreated plots from mid-June onwards and was clearly more evident throughout the Gleam plots compared with KWS Extase. Yellow rust was present on the older leaves throughout the trial period, and powdery mildew was rarely observed.

Table 3. Mean disease scores on untreated plots (n= 3 replicate plots per treatment x variety combination).

Growth Stage	GS61								
Date	19.06.23								
Disease	Yellow Rust (%)			Septoria (%)			GLA		
Leaf / Variety	1	2	3	1	2	3	1	2	3
KWS Extase	0	0	0	0	7	8	96	83	37
Gleam	10	2	0	0	12	20	80	70	20

Table 4. Yield (t/ha) of KWS Extase and Gleam at Morley in 2023, with details of each treatment programme and growth stage timing of application.

Treatments	Growth Stage Timing				KWS Extase Yield (t/ha)	Gleam Yield (t/ha)
	GS30	GS32	GS39	GS65		
1,6	Untreated	-	-	-	9.26 ± 0.23	8.16 ± 0.18
2,7	-	-	Revystar XE 0.8 l/ha + Tebucur 250 0.5 l/ha	-	9.63 ± 0.07	9.46 ± 0.16
3,8	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	-	9.75 ± 0.25	9.57 ± 0.07
4,9	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Tesoro 0.774 l/ha	10.00 ± 0.08	10.11 ± 0.32
5,10	Tesoro 0.516 l/ha + Talius 0.125 l/ha	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Tesoro 0.774 l/ha	9.34 ± 0.23	9.90 ± 0.34
				LSD	**0.63**	
				CV %	**3.9**	

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Figure 1: Yield (t/ha) ± SE of KWS Extase and Gleam at Morley in 2023.

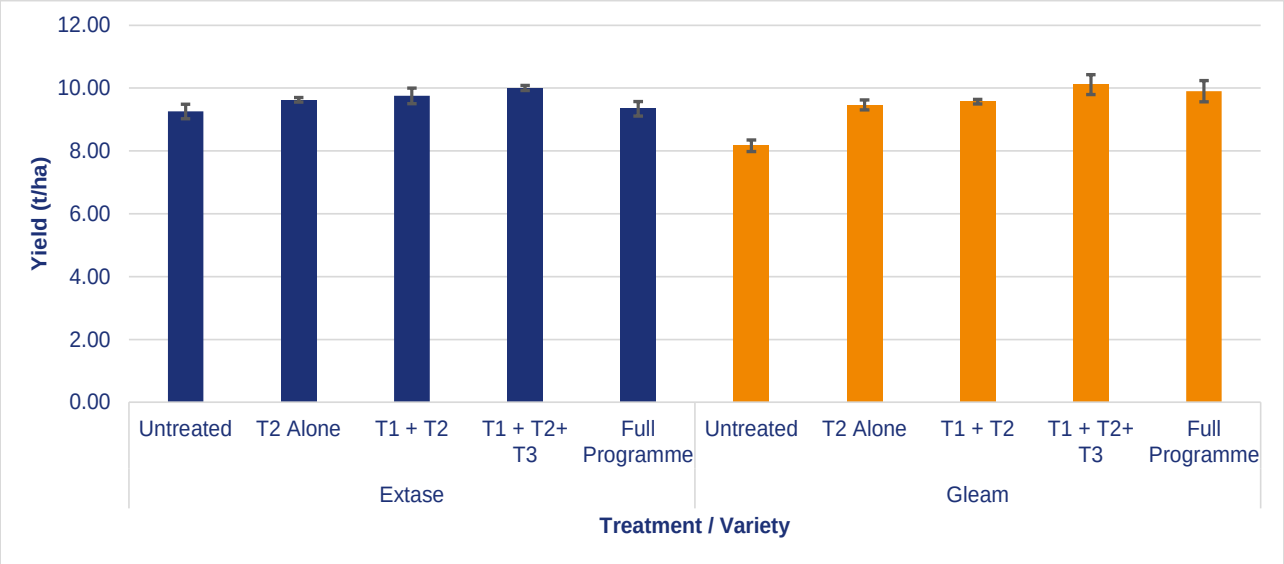

Table 4 and Figure 1 show the yield of each variety under each treatment. In untreated conditions, KWS Extase performed better than Gleam, with a 1.09 t/ha yield difference between the two varieties. However, in the fungicide-treated programmes, the difference in treated yields between the two varieties narrowed with KWS Extase showing an average 0.18 t/ha yield increase over Gleam in a 1 or 2-spray programme and an average 0.33 t/ha yield decrease in a 3 or 4-spray programme. The yield difference between the two varieties was significant across untreated, with a p-value of <0.05 but not between treated.

Table 5. Component yield responses (t/ha) of KWS Extase and Gleam.

Comparison	KWS Extase yield response (t/ha)	Gleam yield response (t/ha)
Benefit of T1+T2 vs untreated	0.50	1.41
Benefit of T3 vs T1+T2	0.25	0.54
Benefit of T0 vs T1+T2+T3	-0.66	-0.21
Benefit of T1 alone vs untreated	0.12	0.10
Benefit of T2 alone vs untreated	0.37	1.30

Table 5 shows the component yield responses for both KWS Extase and Gleam in 2023. Compared to the untreated, KWS Extase showed the highest yield response to the 2-spray programme, with a 0.50 t/ha yield response. This was the same for Gleam which showed the highest yield response to the 2-spray programme, with a 1.41 t/ha yield response. Gleam showed the highest yield response to a T2-only application (1.30 t/ha) compared to untreated.

Table 6 shows the multi-year yield responses to T0, T1 + T2 and T3 applications at Morley, starting in 1986. The 2023 data represents the yield responses for Gleam. This variety is the more responsive variety, similar to RGT Gravity which was used in the 2019, 2020, 2021 and 2022 trials. Some of these fungicide responses were negative, and both negative and positive figures have been used to calculate the multi-year means for each timing, shown at the bottom of Table 6. In comparison to the mean fungicide response over the previous 36-year period of this trial, Gleam showed a reasonable response in 2023. Compared to the untreated, the 2023 Gleam mean yield response of a T0 alone was -0.21 t/ha, the mean yield response to a T1 + T2 spray was 1.77 t/ha and the mean yield response to a T3 spray was 0.54 t/ha which amounted to a total fungicide response of 1.74 t/ha. Taking the 2023 data into consideration, the mean 37-year fungicide response for T1 + T2 is now 1.77 t/ha, and the fungicide response for T3 is 0.34 t/ha. Responses to T0 have only been considered since 2005, and the 19-year mean fungicide response to T0 is 0.04 t/ha. The 37-year total fungicide response therefore stands at 2.15 t/ha.

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Table 6: Multi-year fungicide yield responses, starting from 1986 at Morley. The 2019-2023 data represents yield responses for RGT Gravity (2019-2022) or Gleam (2023). Previous years' trials have selected varieties with moderate to high fungicide responses. Response to T0 was first recorded in 2005 so 19 years of data is available.

Harvest	Timing		
	T0	T1+T2	T3
1986		0.69	0.05
1987		1.64	0.57
1989		2.98	0.87
1990		1.11	0.25
1991		1.12	0.60
1992		2.08	0.53
1993		1.67	0.50
1994		0.53	0.13
1995		2.06	0.13
1996		0.67	0.54
1997		2.92	1.20
1998		3.94	0.81
1999		4.69	0.41
2000		3.21	1.28
2001		0.75	0.00
2002		3.12	0.39
2003		1.88	0.40
2004		2.53	0.00
2005	0.14	2.26	0.23
2006	0.15	1.11	0.00
2007	0.19	1.05	0.64
2008	0.06	1.64	0.13
2009	0.00	0.91	0.22
2010	0.00	3.19	0.09
2011	0.06	0.64	-0.09
2012	0.20	3.76	0.59
2013	0.10	0.21	-0.03
2014	-0.09	3.97	-0.26
2015	0.14	0.33	-0.14
2016	0.10	2.39	0.12
2017	0.17	0.63	-0.19
2018	0.01	-0.30	0.75
2019	0.11	0.59	0.17
2020	-0.10	1.50	0.40
2021	-0.15	2.51	0.60
2022	-0.10	0.18	0.14
2023	-0.21	1.41	0.54
Mean response	**0.04**	**1.77**	**0.34**
Mean total response			**2.15**

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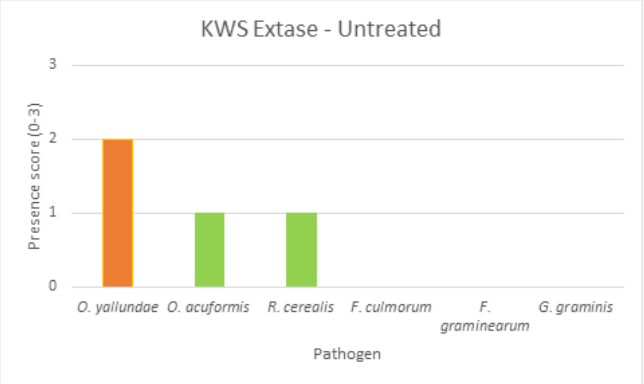
Molecular detection of stem-based pathogens

Eighteen plots consisting of two varieties of winter wheat (KWS Extase and Gleam) with different fungicide treatment programs were harvested from the field. In the lab, the very base of the stem was ground up and DNA was extracted using a Qiagen Plant Soil Pro kit. From these extractions, polymerase chain reaction (PCR) and gel electrophoresis were used to compare the resultant bands on the gel of the wheat samples to those of pure fungal cultures (controls). The presence/absence of the following species within a plot was determined; *Fusarium culmorum, Fusarium graminearum, Gaeumannomyces graminis var. tritici, Rhizoctonia cerealis, Oculimacula acuformis* and *Oculimacula yallundae*.

In 2023, there was no significant difference between the two varieties. Take all (*Gaeumannomyces graminis* var. *tritici*), *Fusarium culmorum* and *Fusarium graminearum* were not detected throughout any of the assessed treatment programs. This may be due to the conditions of the growth season in 2023, however, it does mimic the 2021 samples. The presence of *Oculimacula yallundae* (eyespot, W-type), *Oculimacula acuformis* (eyespot, R-type) and *Rhizoctonia cerealis* (sharp eyespot) is consistent in both varieties, however, very little eyespot lesions were physically visible on the stem samples. The conditions of the 2023 season were favourable for the progression of eyespot.

All three of the present pathogens were detected in the untreated plots (Figure 2). *Oculimacula yallundae* was the most prevalent, being detected in 2 out of 3 replicates in both varieties. *O. acuformis* was in one rep of both varieties, *Rhizoctonia cerealis* (sharp eyespot) was detected in one rep of KWS Extase and 2 replicates of Gleam.

Figure 2. The presence or absence of stem-based pathogens in untreated plots (n=3) of KWS Gravity or Gleam in 2023. The presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.



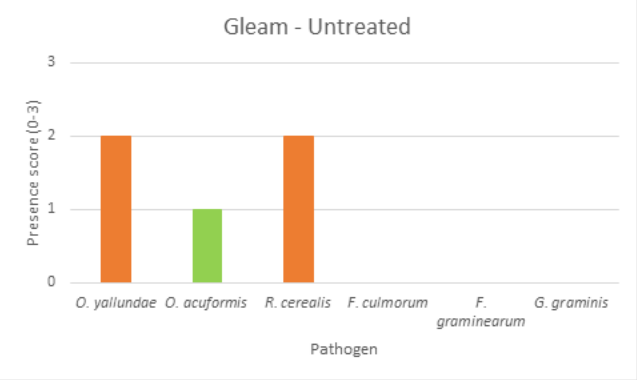
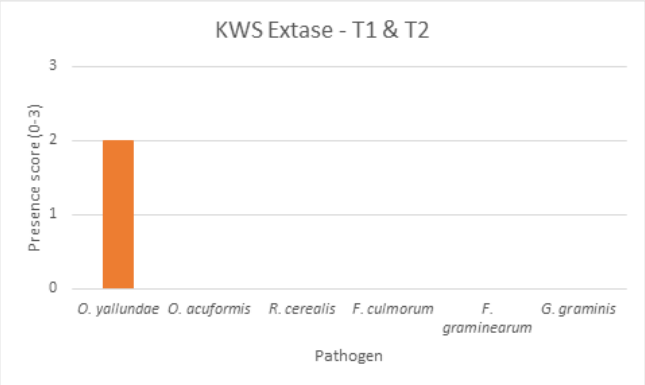
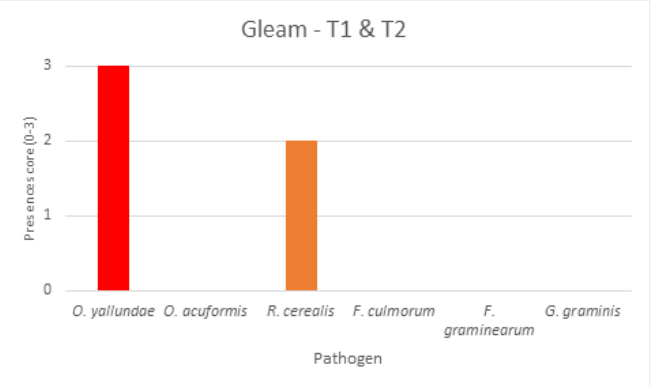


Figure 3. The presence or absence of stem-based pathogens in T1 & T2 treated plots (n=3) of KWS Extase or Gleam in 2023. The presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.





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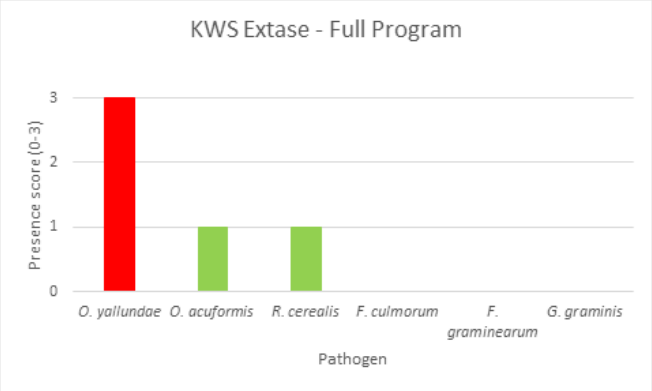
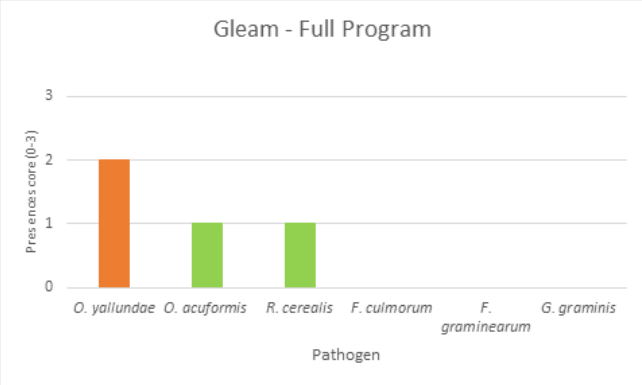
O. yallundae was also the most prevalent pathogen for both varieties in T1 and T2 treated plots (Figure 3). Both varieties show high levels of *O. Yallundae*; present in 2 out of 3 of the KWS Extase replicate plots, and all three replicates of Gleam were infected. *O acuformis* was not present in T1 and T2 treated plots in both varieties and *R. cerealis* (sharp eyespot) was not present in KWS Extase but was present in 2 out of 3 replicates in Gleam.

Figure 4. Presence or absence of stem-based pathogens in full fungicide program treated plots (n=3) of KWS Extase or Gleam in 2023. The presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.





O. acuformis and *R. cerealis* were present in both varieties of winter wheat treated with a full fungicide program with DNA detected in one replicate out of three for both varieties (Figure 4). *O. yallundae* remained the dominant pathogen present, with all three replicates of KWS Extase infected and two out of three replicates of Gleam infected.

Appendix

Field details

Trial Code	WW23-05501
Trial Centre	Morley
Trial Location	McLean's
Crop	Winter wheat
Previous Crop	Peas
Soil Texture	Sandy Loam
Soil Series	Ashley
Soil Analysis	N/A
Soil Mineral Nitrogen	0-30cm 16KgN/ha, 30-60cm 7KgN/ha, 60-90cm 4 kgN/ha
Total N/ha applied	190 kgN/ha
Drill Date	17/10/22
Seed Rate	300 seeds/m^2
Drilled Plot Dimensions	2m x 12m
Replicates	3
Harvest Date	01/08/23

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