

**Trial Title: Fungicide timing response monitoring in winter wheat at Morley****Centre:** Morley      **Trial Code:** WW22-05501      **Varieties:** KWS Extase and RGT Gravity**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 2022 trial at Morley considered this, by comparing two winter wheat varieties KWS Extase and RGT Gravity across a range of fungicide programmes. On the AHDB Recommended List 2022-23, KWS Extase displays high resistance scores for septoria, mildew, yellow rust, and brown rust; 7.8, 7, 8, and 7 respectively while RGT Gravity, has poor to moderate resistance scores for septoria, mildew, yellow rust and brown rust; 4.7, 5, 6 and 6 respectively, Both had fungicide treated grain yields of 101% of the treated yield control; however they differed dramatically in their untreated yields, with the untreated grain yield of KWS Extase at 93% of the fungicide treated control and RGT Gravity at 77% 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 RGT Gravity 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 RGT Gravity.

Disease levels were low throughout the trial period, with yellow rust and brown rust only evident in untreated plots from early July. Septoria was present on the older leaves throughout the trial period, but powdery mildew was not observed.

In untreated conditions KWS Extase performed better than RGT Gravity, with a 1.36 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 ca. a 0.97 t/ha yield increase over RGT Gravity in a 1 or 2-spray programme and ca. a 1.08 t/ha yield increase in a 3 or 4-spray programme. As expected; KWS Extase also had an overall lower yield response to fungicide programmes, compared to RGT Gravity.

In comparison to the mean fungicide response over the previous 36-year period of this trial, RGT Gravity showed very little response in 2022; the mean yield response of a T0 alone was -0.1 t/ha, the mean yield response to a T1 + T2 spray was 0.18 t/ha and the mean yield response to a T3 spray was 0.14 t/ha which amounted to a total fungicide response of 0.22 t/ha. Taking the 2022 data into consideration, the mean 37-year fungicide response for T1 + T2 is now 1.80 t/ha, and the fungicide response for T3 is 0.33 t/ha. Response to T0 has only been considered since 2005, and the 18-year mean fungicide response to T0 is 0.06 t/ha. The 37-year total fungicide response therefore stands at 2.19 t/ha.

Table 1. Products

Product	Active ingredients and concentration
Revystar XE	47.5 g/l fluxapyroxad and 100 g/l mefentrifluconazole
Univoq	50 g/l fenpicoxamid and 100g/l prothioconazole
Toledo	430 g/l tebuconazole
Talius	200g/l proquinazid

Table 2. Treatments and timings

Variety	Treatment	GS30	GS32	GS39	GS65	Comment
KWS Extase (Treatments 1-5) and RGT Gravity (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	Toledo 0.45 l/ha	T1 + T2+ T3
	5, 10	Toledo 0.3 l/ha + Talius 0.125 l/ha	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Toledo 0.45 l/ha	Complete

## Results

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

Growth stage	GS73-77															
Date	27.06.22															
Disease	Yellow rust %				Brown rust %				Septoria %				GLA %			
Leaf	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Variety																
KWS Extase	0	0	0	0	0.3	0	0	0	0.3	0	0	0	99.3	100	73.3	0
RGT Gravity	7	6.6	4.3	1.6	2	0.6	0.6	1.6	0	1	4.3	3.3	91	91.6	90.6	26.6

Disease levels were low throughout the trial period. Yellow rust and brown rust were only evident on untreated plots from early July onwards and were clearly more evident throughout the RGT Gravity plots compared with KWS Extase. Septoria was present on the older leaves throughout the trial period, but powdery mildew was not observed.

Table 4. Yield (t/ha) of KWS Extase and RGT Gravity at Morley in 2022, with details of each treatment programme and growth stage timing of application.

Treatments	Growth stage timing				KWS Extase Yield (t/ha)	RGT Gravity yield (t/ha)
	GS30	GS32	GS39	GS65		
1, 6	Untreated	-	-	-	10.36 ± 0.1	9.00 ± 0.32
2, 7	-	-	Revystar XE 0.8 l/ha + Tebucur 250 0.5 l/ha	-	10.36 ± 0.32	9.50 ± 0.13
3, 8	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	-	10.26 ± 0.13	9.18 ± 0.09
4, 9	-	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Toledo 0.45 l/ha	10.43 ± 0.19	9.32 ± 0.06
5, 10	Toledo 0.3 l/ha + Talius 0.125 l/ha	Revystar XE 0.8 l/ha	Univoq 1.25 l/ha	Toledo 0.45 l/ha	10.27 ± 0.06	9.22 ± 0.31
<b>LSD</b>					<b>0.54</b>	
<b>CV%</b>					<b>3.2</b>	

Figure 1: Yield (t/ha) ± SE of KWS Extase and RGT Gravity at Morley in 2022

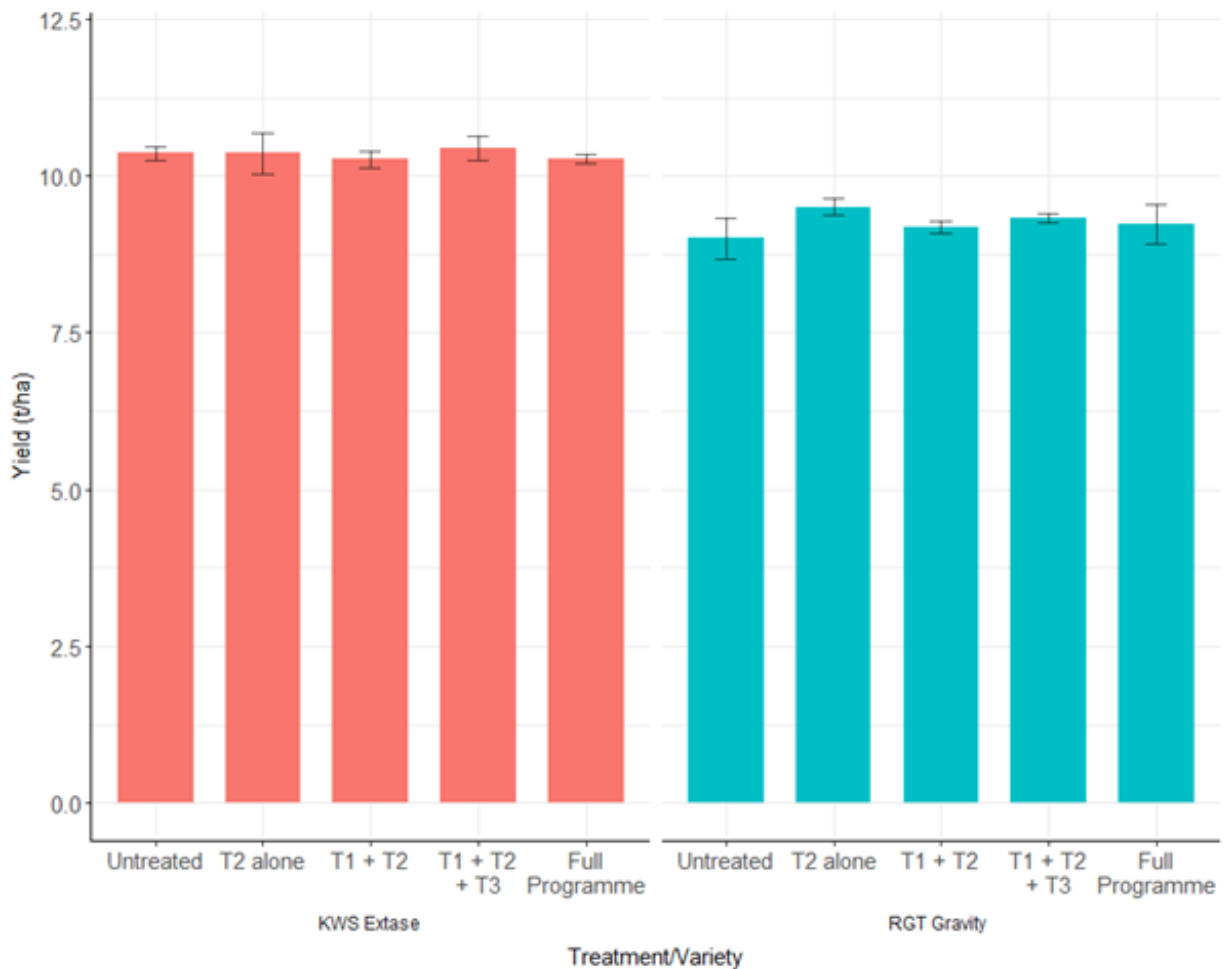


Table 4 and Figure 1 show the yield of each variety under each treatment. In untreated conditions KWS Extase performed better than RGT Gravity, with a 1.36 t/ha yield difference between the two varieties. However, in the fungicide treated programmes, the difference in treated yields between the two varieties narrowed with KWS Extase showing an average 0.97 t/ha yield increase over RGT Gravity in a 1 or 2-spray programme and an average 1.08 t/ha yield increase in a 3 or 4-spray programme. The yield difference between the two varieties was significant across all treatments, with a p-value of <0.05, except in treatments 2 and 7, T2 alone.

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

<b>Comparison</b>	<b>KWS Extase yield response (t/ha)</b>	<b>RGT Gravity yield response (t/ha)</b>
Benefit of T1+T2 vs untreated	-0.10	0.18
Benefit of T3 vs T1+T2	0.17	0.14
Benefit of T0 vs T1+T2+T3	-0.16	-0.10
Benefit of T1 alone vs untreated	-0.09	-0.32
Benefit of T2 alone vs untreated	-0.003	0.50

Table 5 shows the component yield responses for both KWS Extase and RGT Gravity in 2022. Compared to the untreated, KWS Extase showed the highest yield response to the 3-spray programme, with an 0.17 t/ha yield response to a T3 application, whereas RGT Gravity showed the highest yield response to a T2 only application (0.5 t/ha). Neither of these yield responses were significantly different compared to the untreated control of each variety

Table 6 shows the multi-year yield responses to T0, T1 + T2 and T3 applications at Morley, starting in 1986. The 2022 data represents the yield responses for RGT Gravity. This variety was also used in the 2019, 2020 and 2021 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, RGT Gravity showed very little response in 2022. Compared to the untreated, the 2022 RGT Gravity mean yield response of a T0 alone was -0.1 t/ha, the mean yield response to a T1 + T2 spray was 0.18 t/ha and the mean yield response to a T3 spray was 0.14 t/ha which amounted to a total fungicide response of 0.22 t/ha.

Taking the 2022 data into consideration, the mean 37-year fungicide response for T1 + T2 is now 1.80 t/ha, and the fungicide response for T3 is 0.33 t/ha. Response to T0 has only been considered since 2005, and the 18-year mean fungicide response to T0 is 0.06 t/ha. The 37-year total fungicide response therefore stands at 2.19 t/ha.

Table 6: Multi-year fungicide yield responses, starting from 1986 at Morley. The 2019-2022 data represents yield responses for RGT Gravity. Previous years' trials have selected varieties with moderate to high fungicide responses. Response to T0 was first recorded in 2005 and so 18 years of data is available.

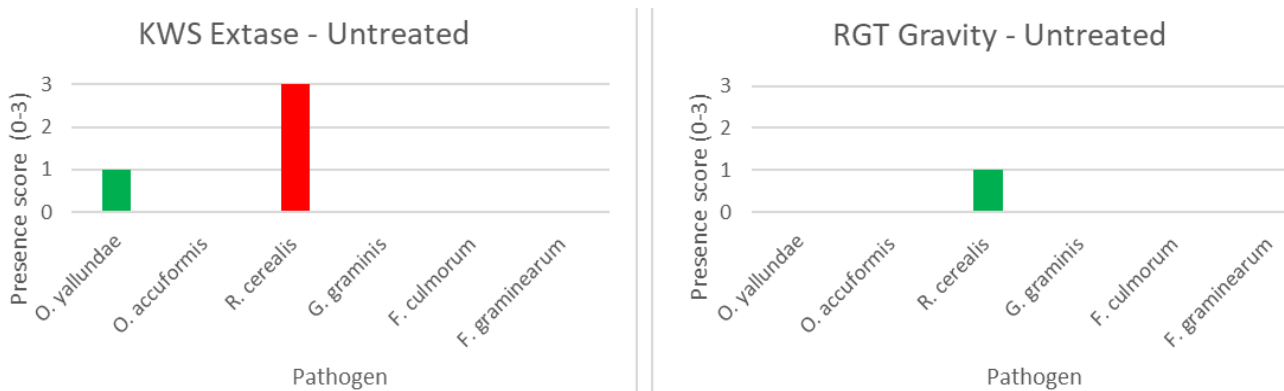
Harvest	Timing		
	T0	T1+T2	T3
1986		0.69	0.05
1987		1.64	0.57
1989		2.98	0.87
1990		1.11	0.25
1991		1.12	0.60
1992		2.08	0.53
1993		1.67	0.50
1994		0.53	0.13
1995		2.06	0.13
1996		0.67	0.54
1997		2.92	1.20
1998		3.94	0.81
1999		4.69	0.41
2000		3.21	1.28
2001		0.75	0.00
2002		3.12	0.39
2003		1.88	0.40
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	3.91	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
<b>Mean response</b>	<b>0.06</b>	<b>1.80</b>	<b>0.33</b>
<b>Mean total response</b>			<b>2.19</b>

**Molecular detection of stem based pathogens**

Eighteen plots consisting of two varieties of winter wheat (KWS Extase and RGT Gravity) 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 was used to compare the resultant bands on the gel of the wheat samples to those of pure fungal cultures (controls). 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*. The 2021 disease screenings were delayed until 2022/23 due to various factors. Samples were in storage for a year before molecular diagnostics were completed.

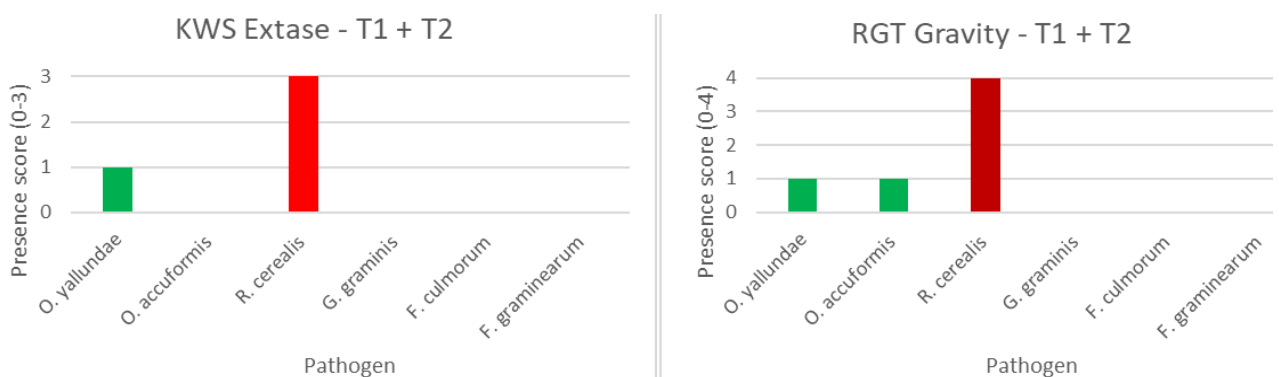
In 2021 very few pathogens were detected in the untreated plots. The only pathogens detected were *O. yallundae* (eyespot) and *R. cerealis* (sharp eyespot). Notably, *R. cerealis* was detected in all three replicates of KWS Extase. There was no significant differences detected between varieties. Take all (*G. graminis* var. *tritici*), *F. culmorum* and *F. graminearum* were not detected throughout any of the assessed treatment programs in 2021 (Figures 2, 3 and 4). This may be due to the growing conditions in 2021 or issues during sample storage.

Figure 2. The presence or absence of stem based pathogens in untreated plots (n=3) of KWS or RGT Gravity in 2021. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.



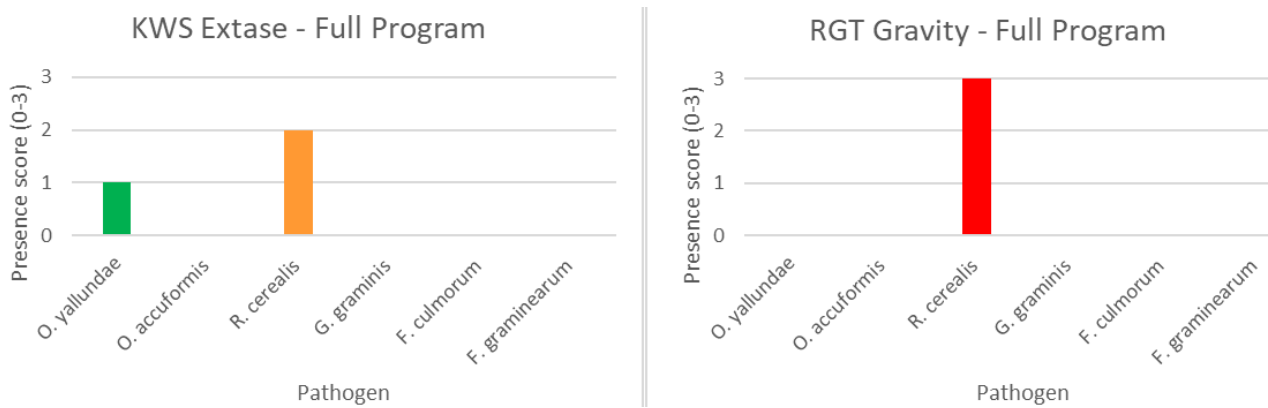
*R. cerealis* was detected in all replicates for both varieties in T1 and T2 treated plots (Figure 3). Both eyespot species (*O. yallundae* and *O. acuformis*) were also detected in the T1 and T2 treated plots but at low levels.

Figure 3. The presence or absence of stem based pathogens in T1 & T2 treated plots (n=3) of KWS or RGT Gravity in 2021. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.



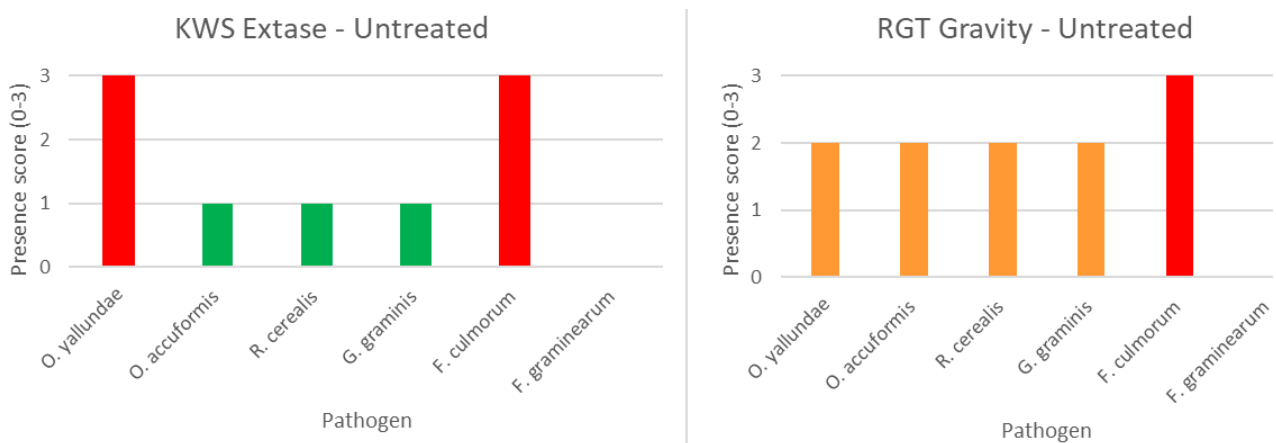
Similar disease levels were also seen in the full fungicide program treated plots (Figure 4). *R. cerealis* was again the most prevalent. No *O. acuformis* was detected in this treatment and *O. yallundae* was only found in one replicate of KWS Extase.

Figure 4. Presence or absence of stem based pathogens in full fungicide program treated plots (n=3) of KWS or RGT Gravity in 2021. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.



In 2022, in both varieties, presence of all screened pathogens was detected with the exception of *F. graminearum*, which was not detected in any samples (Figure 5). This may be due to factors including weather, seasonal conditions or even the lifecycle stage when sampling took place. *F. culmorum* was found in all replicates of both varieties. In RGT Gravity *O. yallundae*, *O. acuformis*, *R. cerealis* and *G. graminis* were found in two out of three replicates. *O. acuformis*, *R. cerealis* and *G. graminis* was detected in one out of three replicates of KWS Extase, but *O. yallundae* was detected in all three replicates.

Figure 5: The presence or absence of stem based pathogens in untreated plots (n=3) of KWS or RGT Gravity in 2022. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.

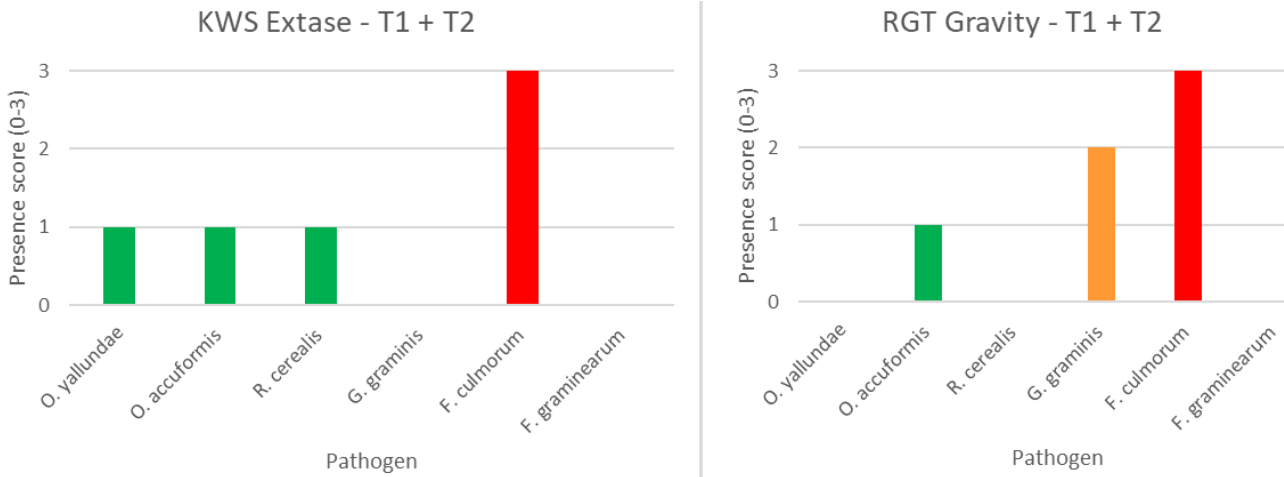


In the T1 and T2 treated plots, *F. culmorum* presence was unaffected and was detected in all replicates from both varieties (Figure 6). *O. yallundae*, *O. acuformis* and *R. cerealis* were detected in one out of three replicates for KWS Extase and only *O. acuformis* was detected in one of three



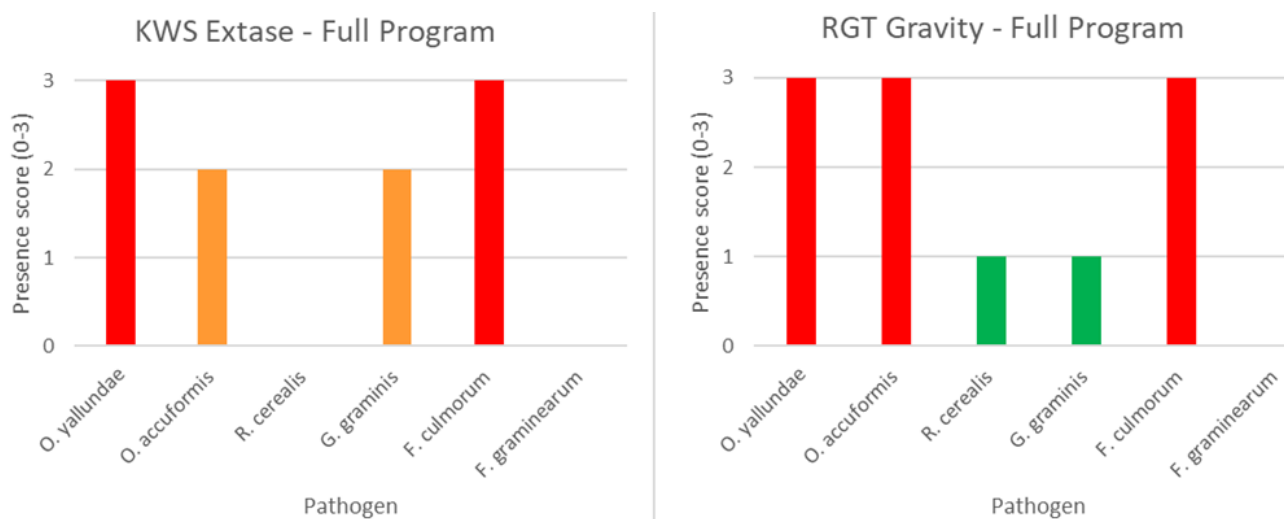
replicates of RGT Gravity. *G. graminis* was not detected in KWS Extase but maintained the same visual score as the untreated plots in RGT Gravity.

Figure 6: Presence or absence of stem based pathogens in T1 & T2 treated plots (n=3) of KWS or RGT Gravity in 2022. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.



In the full fungicide program treated plots (Figure 7), *O. yallundae* and *F. culmorum* were detected in all replicates, for both varieties. *O. acuformis* was detected in all three replicates for RGT Gravity and two out of three replicates of KWS Extase. *R. cerealis* and *G. graminis* was detected in one replicate of RGT Gravity. *G. graminis* was detected in two replicates of KWS Extase. Most noteworthy is that *F. culmorum* presence was unaffected across the treatments and was detected in all samples in 2022.

Figure 7: Presence or absence of stem based pathogens in full fungicide program treated plots (n=3) of KWS or RGT Gravity in 2022. Presence score indicates the number of plots (0-3) where each pathogen was detected at the DNA level.





**Field details**

<b>Trial Code:</b>	WW22-05501
<b>Trial Centre:</b>	Morley
<b>Trial Location:</b>	Morley
<b>Crop:</b>	Winter Wheat
<b>Previous crop:</b>	Vining Peas
<b>Soil type:</b>	Sandy Loam
<b>Total N/ha applied:</b>	213 kgN/ha
<b>Drill Date:</b>	13/10/21
<b>Seed Rate:</b>	300 seeds/m <sup>2</sup>
<b>Drilled plot size:</b>	2m x 12m
<b>Replicates:</b>	3
<b>Harvest date:</b>	27/07/22