IPM strategies to control mycotoxins

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Fusarium head blight

Fungal disease complex of small grain cereals

Important disease on wheat, barley and oats world-wide

Barley and oats are less susceptible in most growing regions

Disease dependent on weather at specific crop growth stages

Range of *Fusarium* species able to infect cereals

Different species produce different mycotoxins

Different species occur on different cereals and in different climates

Mycotoxin profile varies by cereal, region and season

Mycotoxin profile evolves over time

Key Fusarium mycotoxins

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Mycotoxin	Main producers
Deoxynivalenol (DON)	*F. graminearum* and *F. culmorum*
Zearalenone (ZON)	*F. graminearum* and *F. culmorum*
HT2 and T2	*F. langsethiae* and *F. sporotrichioides*
Fumonisins	*F. verticillioides and F. proliferatum*

Fusarium mycotoxins in UK Cereal Crops

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	% greater than limits (2002-2008)		
	DON	ZON	HT2+T2
Wheat	4.0 (0-13)	6.5 (0.3-29)	0.4 (0-1)
Barley	0.3	2.0	0.1 (0-1)
Oats	0.1	0.9	16 (1-30)

DON: 1250 ppb (1750 ppb for oats); ZON: 100 ppb;
HT2+T2: 100 ppb for wheat, 200 ppb for barley, 1000 ppb for oats HT2+T2
Data is for all cereals sampled, not all intended for human consumption

DON and ZON in wheat

Fusarium disease cycle

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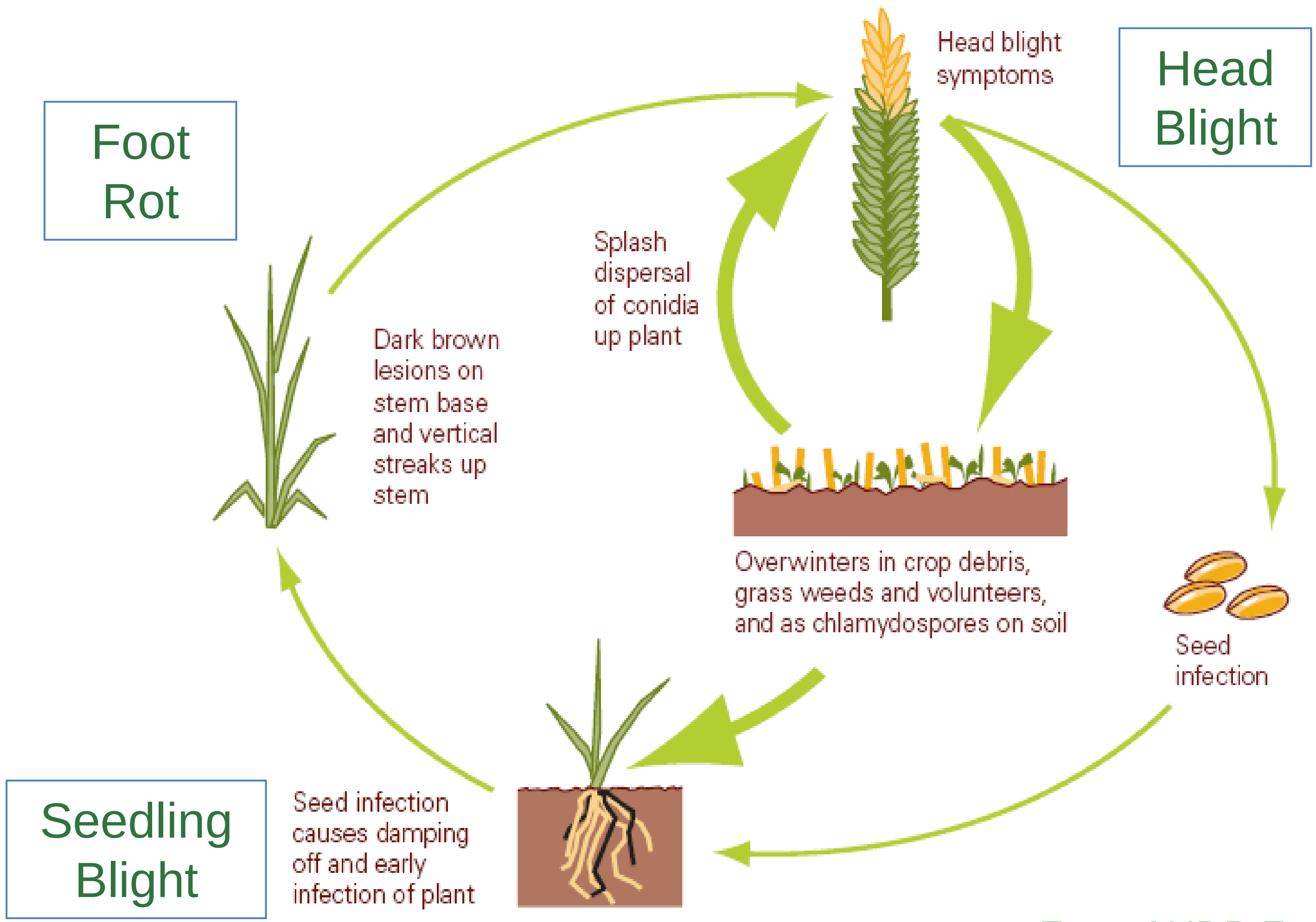

From AHDB Fusarium Guide, Summer 2007

Fusarium Disease Conditions

Warm dry spring induces spore production on crop debris

Heavy rainfall in June splashes spores onto ears

Infection occurs mainly at flowering under warm humid conditions

High rainfall/humidity through summer allows infection to spread, particularly once the crop ripens

Log_{10}DON Accumulated Analysis of Variance

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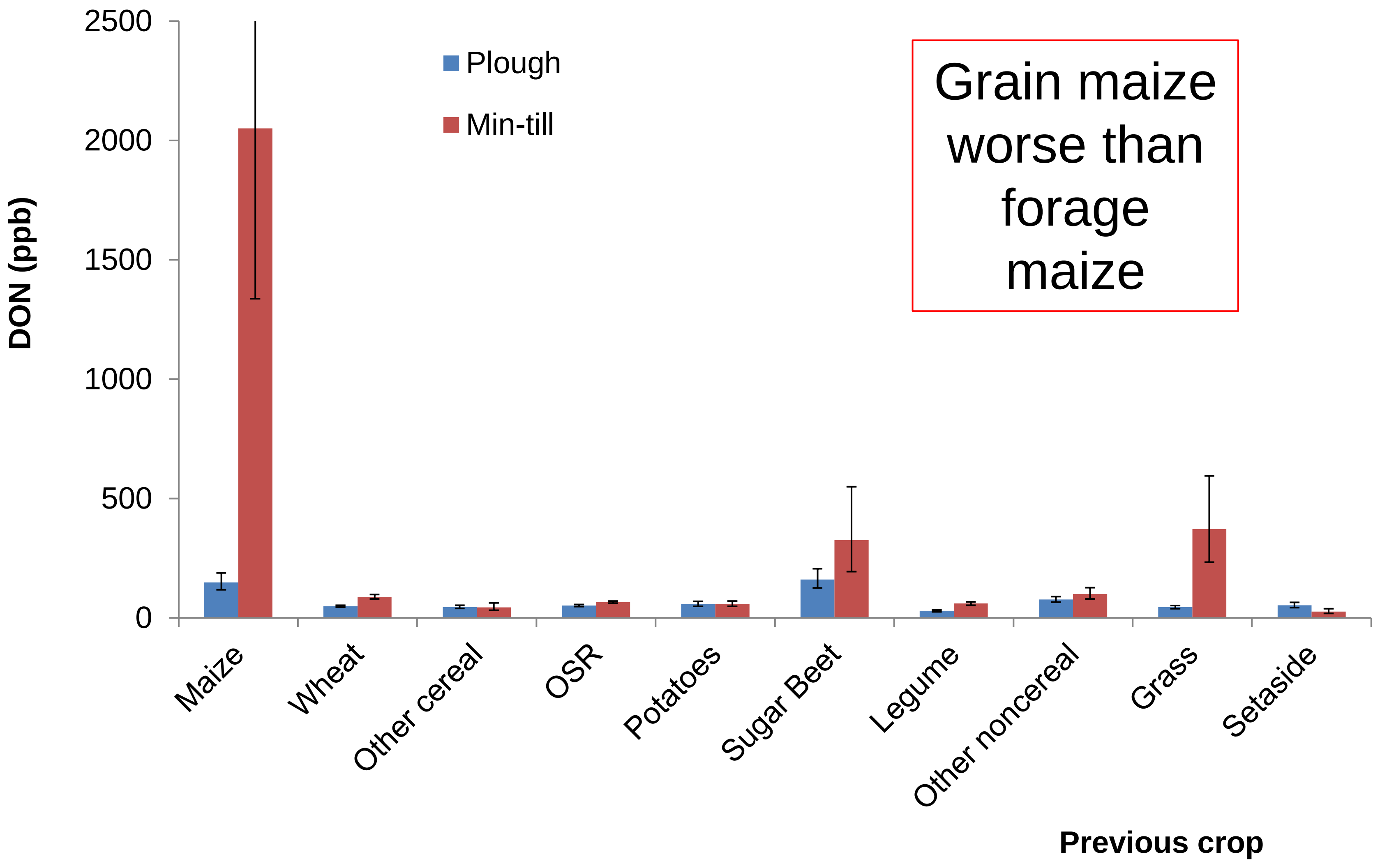
Change	d.f.	s.s.	m.s.	v.r.	F pr.
+ year	4	54.8145	13.7036	37.28	<.001
+ region	5	214.2586	42.8517	116.57	<.001
+ year.region	19	33.3683	1.7562	4.78	<.001
+ previous crop	9	13.7884	1.532	4.17	<.001
+ plough	1	4.9513	4.9513	13.47	<.001
+ pcrop.plough	9	8.2462	0.9162	2.49	0.008
+ varress	5	20.7477	4.1495	11.29	<.001
+ T3	4	3.7296	0.9324	2.54	0.039
Residual	1396	513.1896	0.3676		
Total	1452	867.0943	0.5972		

Most variance (35%) accounted for by temporal and spatial factors (primarily weather)

Agronomy – previous crop, cultivation, variety and T3 fungicide only account for 6% of overall variance

Analysis of wheat by cultivation and previous crop

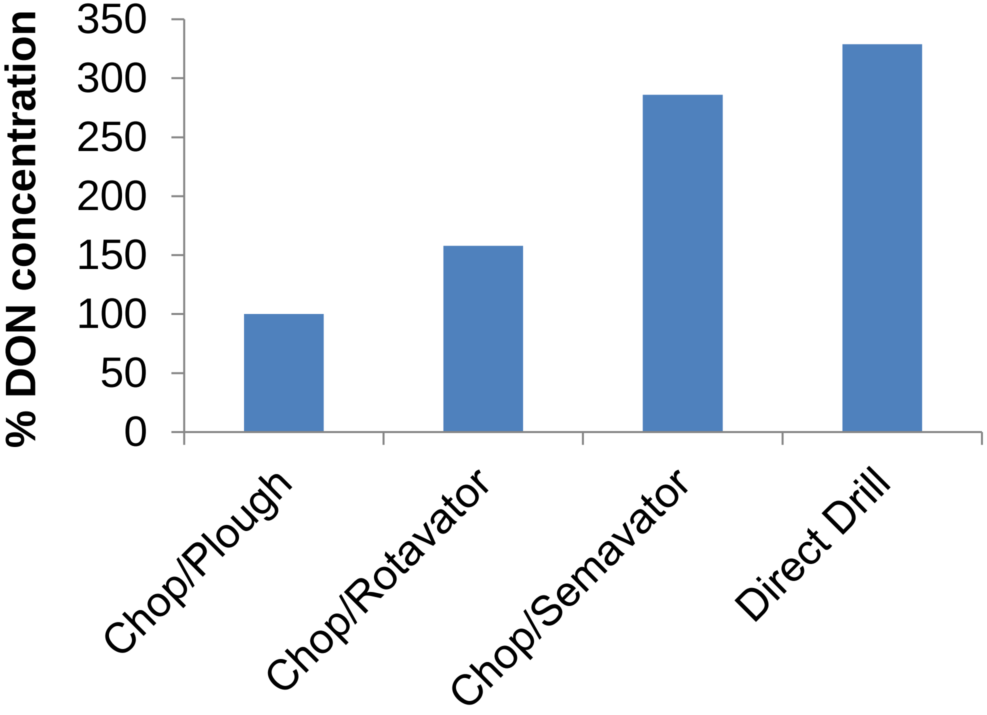


Impact of tillage on DON

Ploughing gives greatest reduction

More intensive chopping and mixing gives greater reduction in DON

Direct drilling worst



Direct drilled after grain maize

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Minimum tillage after forage maize

Wheat varietal resistance

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Winter wheat 2022/23

Yield, agronomy and disease resistance

AHDB RECOMMENDED

	KWS Zyatt	Skyfall	Crusoe	RGT Illustrious
End-use group	UKFM Group 1			
Scope of recommendation	UK	UK	UK	UK
Variety status		C		
Fungicide-treated grain yield (% treated control)				
United Kingdom (10.8 t/ha)	98	97	96	96
East region (10.7 t/ha)	98	97	96	95
West region (11.0 t/ha)	99	96	97	97
North region (11.1 t/ha)	98	96	94	94
Untreated grain yield (% treated control)				
United Kingdom (10.8 t/ha)	76	70	72	81
Agronomic features				
Resistance to lodging without PGR (1–9) - **see note below**	8	8	8	7
Resistance to lodging with PGR (1–9) - **see note below**	8	8	7	8
Height without PGR (cm)	85	84	82	89
Ripening (days +/- Skyfall, -ve = earlier)	0	0	+1	+1
Resistance to sprouting (1–9)	5	5	6	6
Disease resistance				
Mildew (1–9)	7	6	7	7
Yellow rust (1–9)	4	3	9	8
Brown rust (1–9)	6	8	3	6
Septoria tritici (1–9)	6.1	5.3	6.2	5.7
Septoria tritici (1–9) - one-year rating - **see note below**	5.8	5.1	5.9	5.4
Eyespot (1–9)	6@	7@	5	7@
Fusarium ear blight (1–9)	6	7	7	6
Orange wheat blossom midge	-	R	-	-

Limited range in UK (5-7)

Susceptible compared to international genotypes

Polygenic trait

Single QTL only provide small reductions

Fungicide reduction of DON

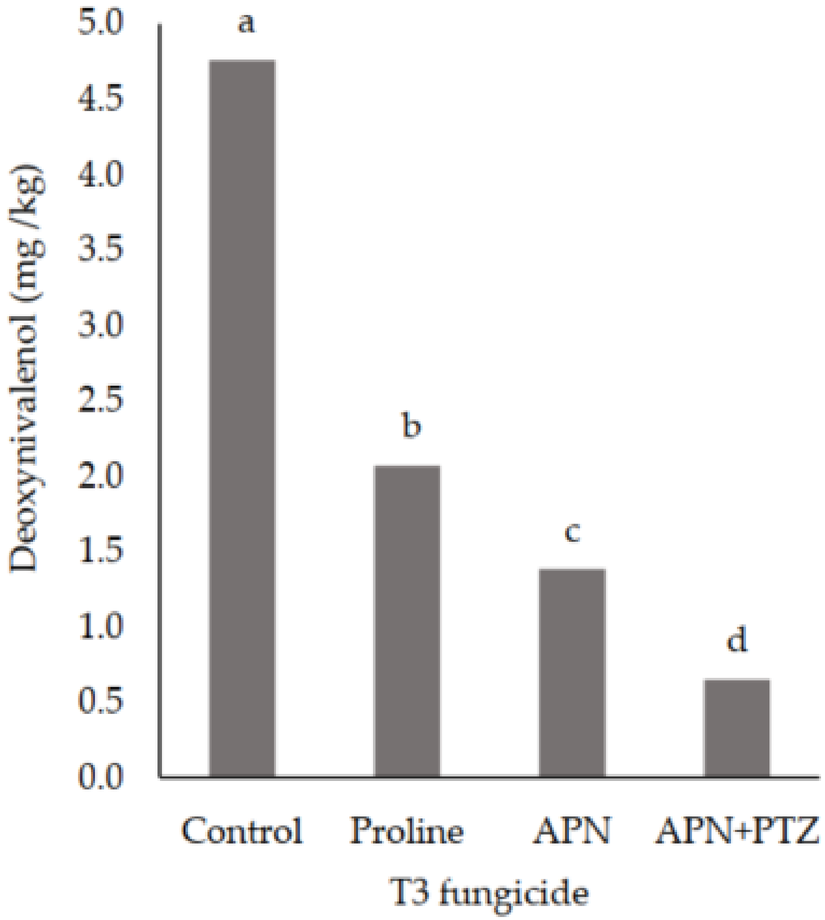
Triazoles: Prothioconazole
Metconazole
Tebuconazole

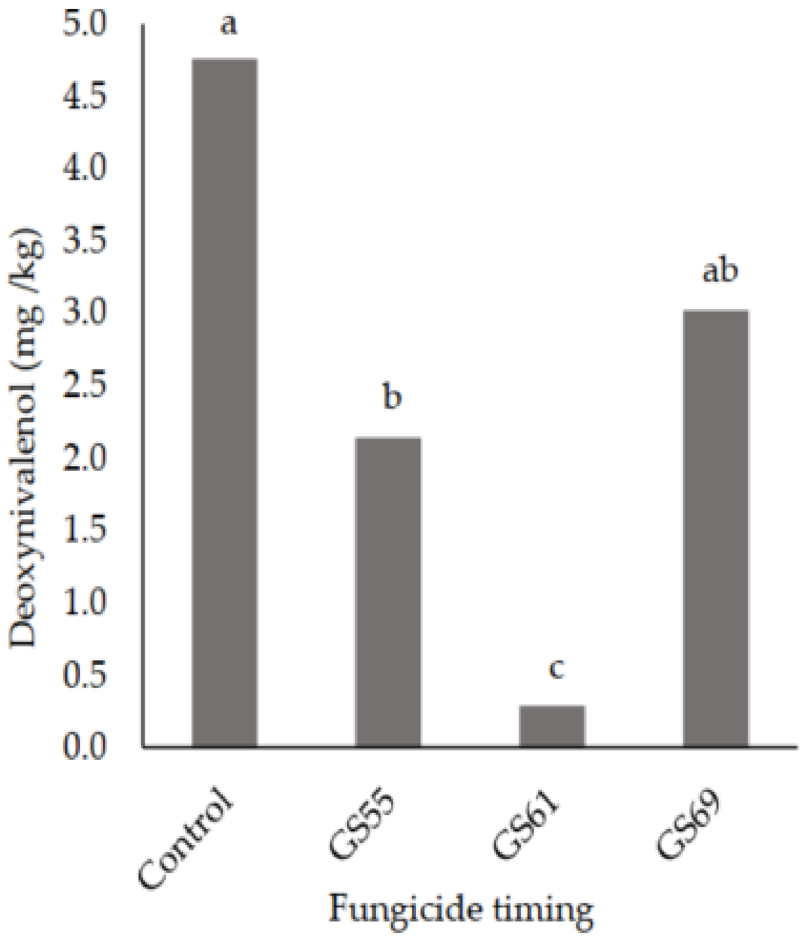
Dithiocarbamate (weak/variable)

Adepidyn (pydiflumetofen, new SDHI not yet registered)

Previously strobilurins could result in increased DON

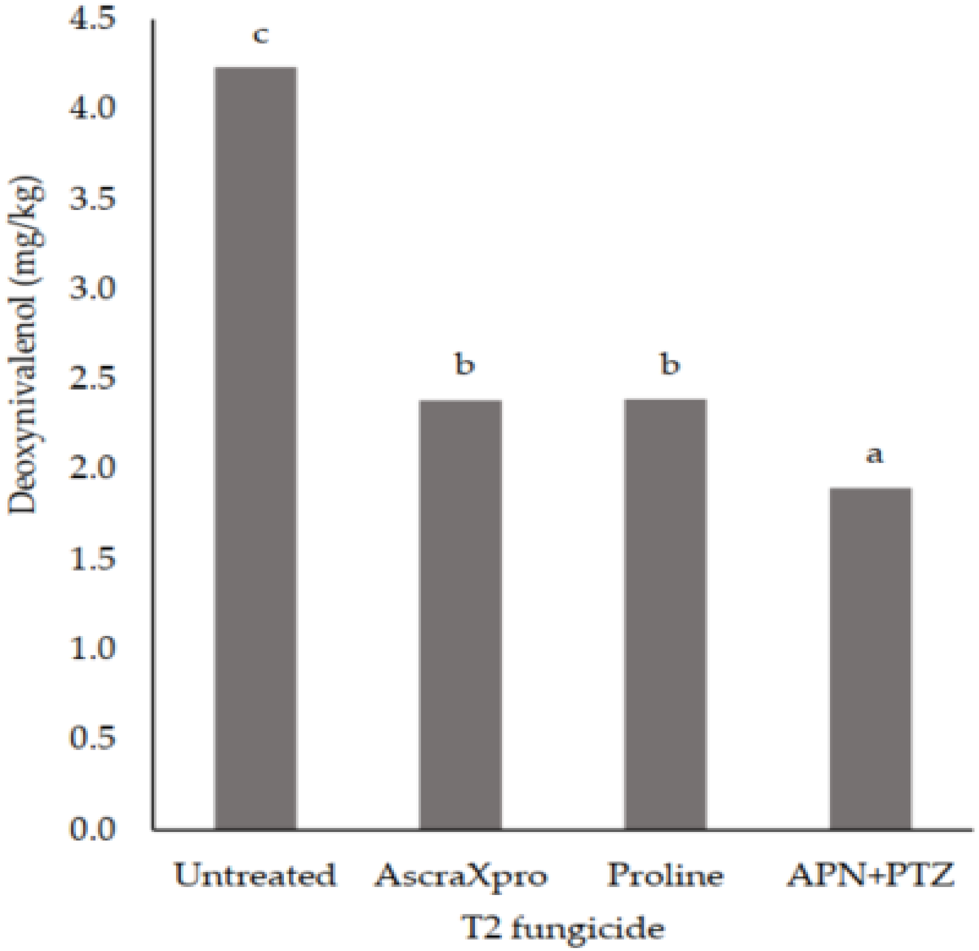
T3 fungicide product and timing



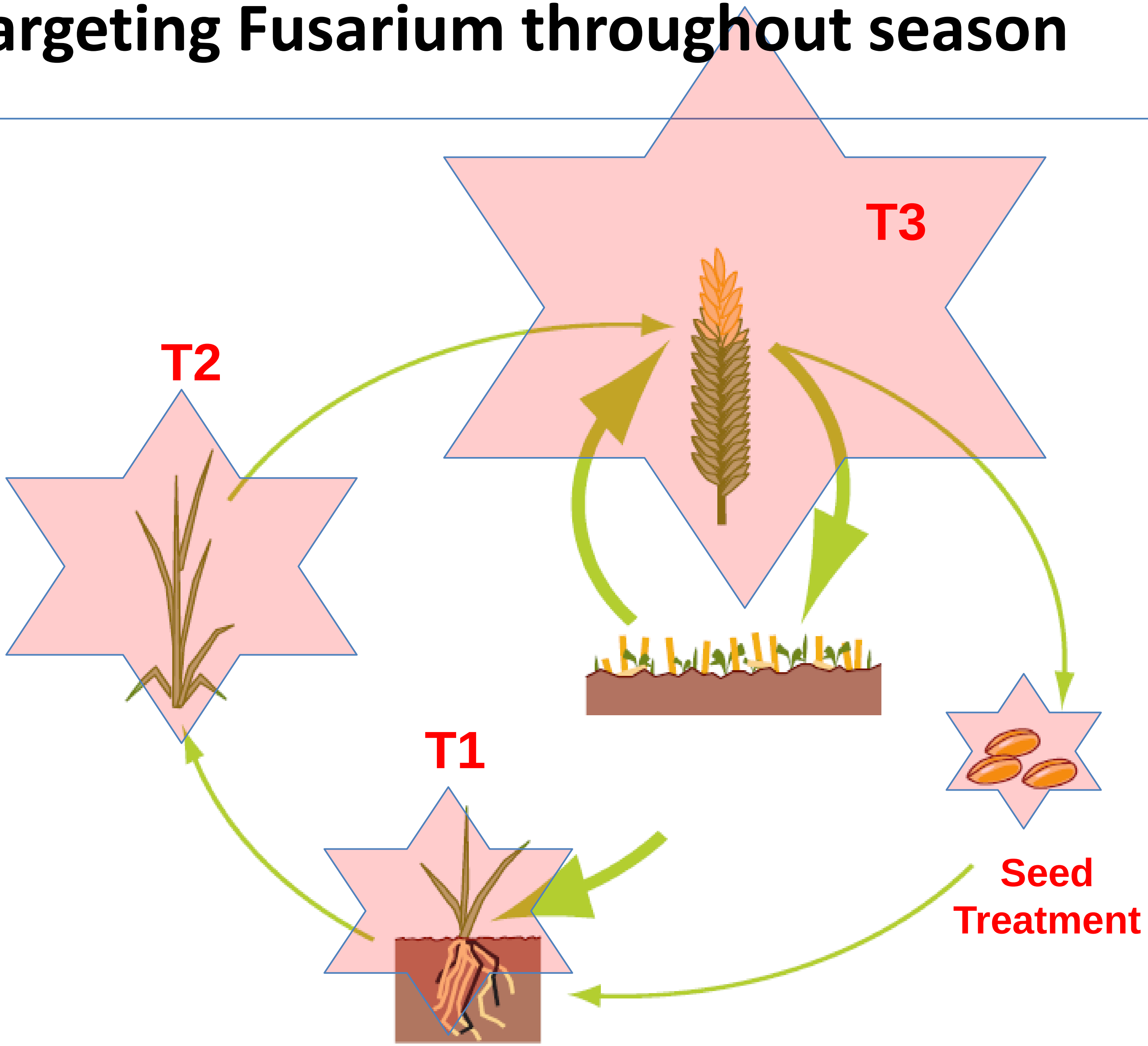


Edwards, S. G. (2022). Pydiflumetofen Co-Formulated with Prothioconazole: A Novel Fungicide for Fusarium Head Blight and Deoxynivalenol Control. *Toxins, 14*(1), 34.

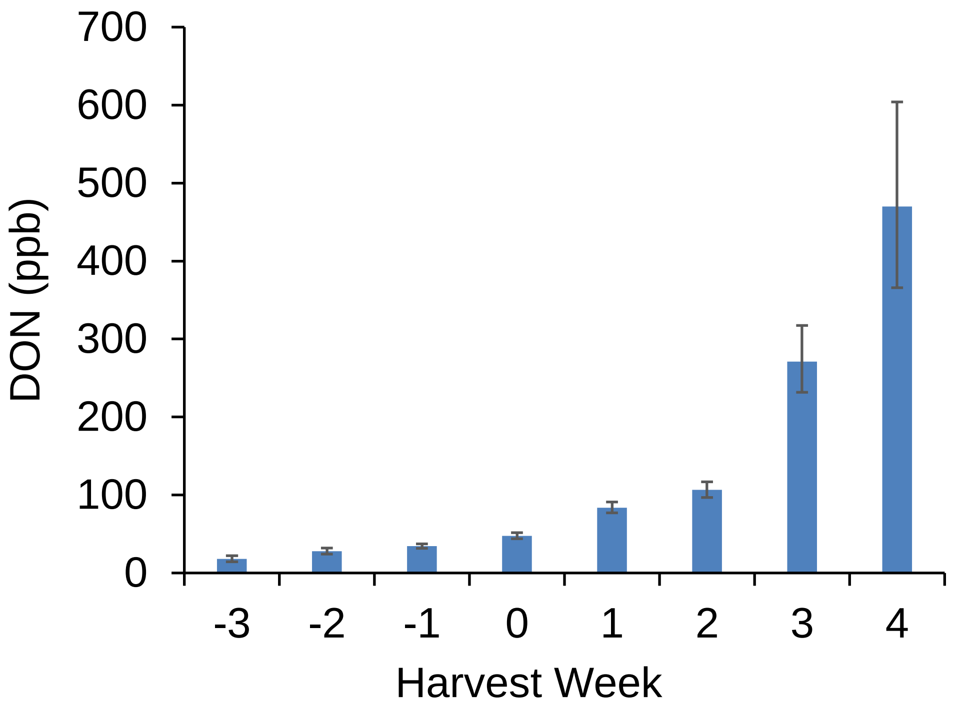
T2 fungicide product

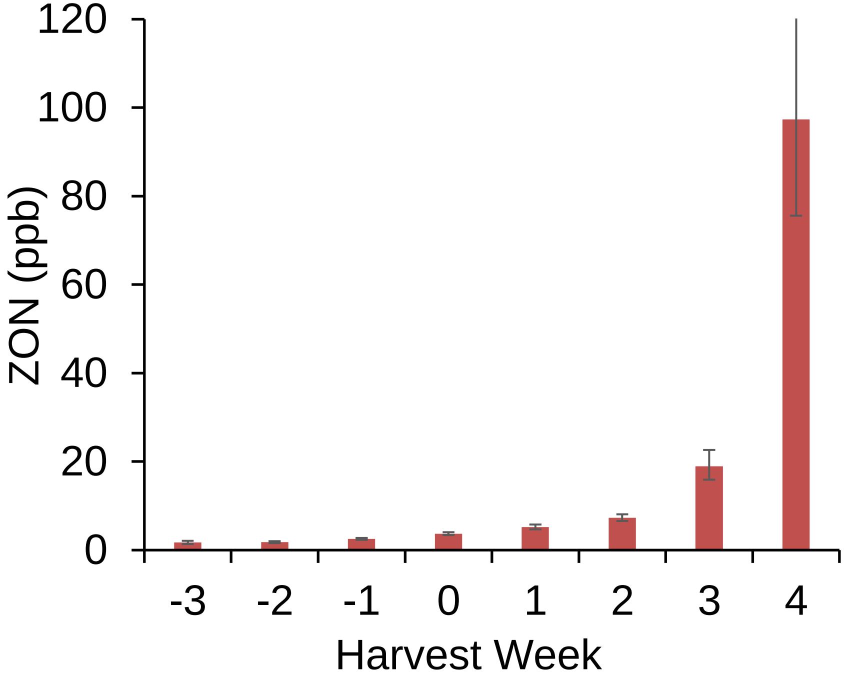


Targeting Fusarium throughout season



Impact of delayed harvest



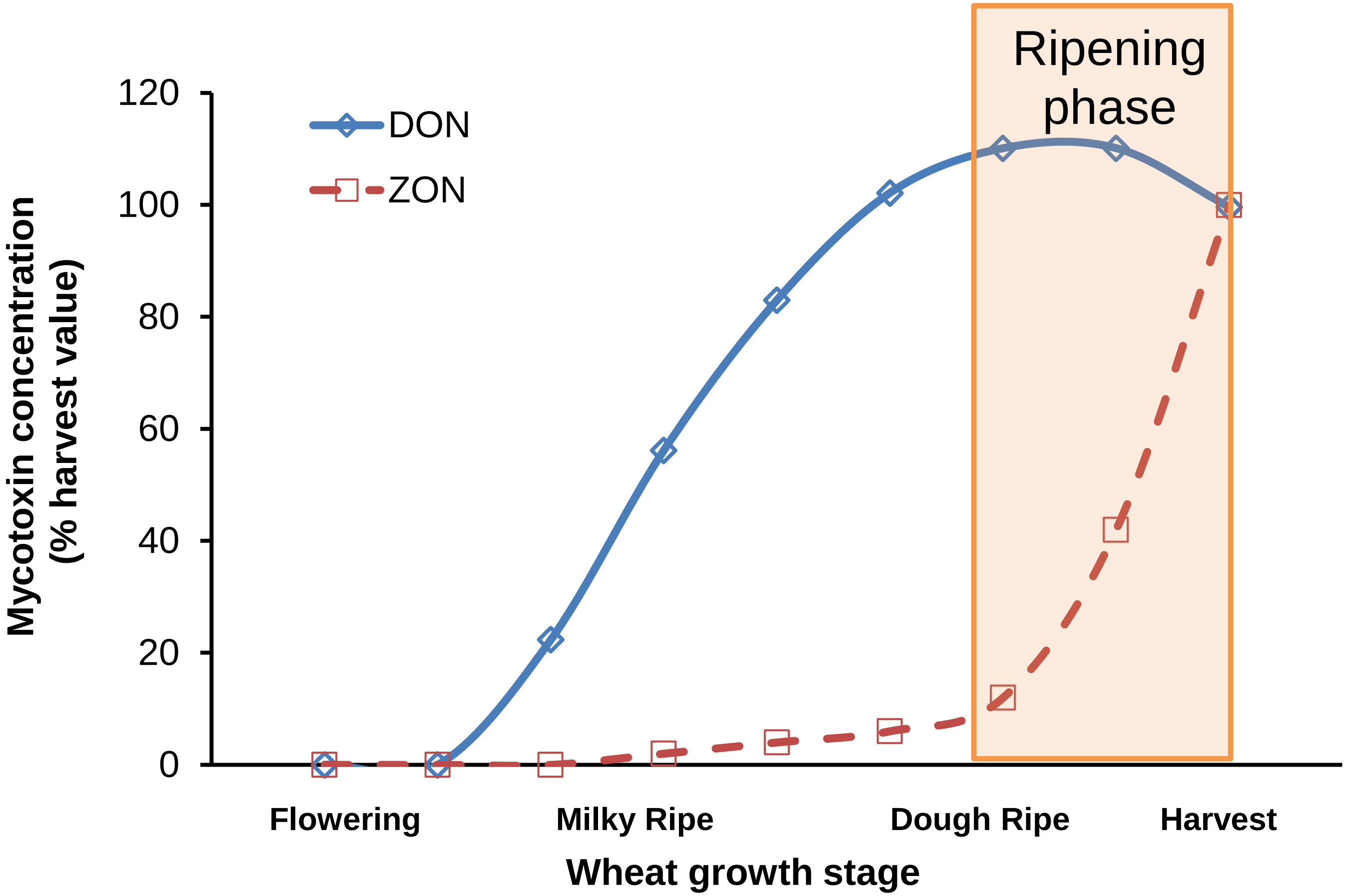


Week 0 is long term average harvest week for county

- values = early harvest

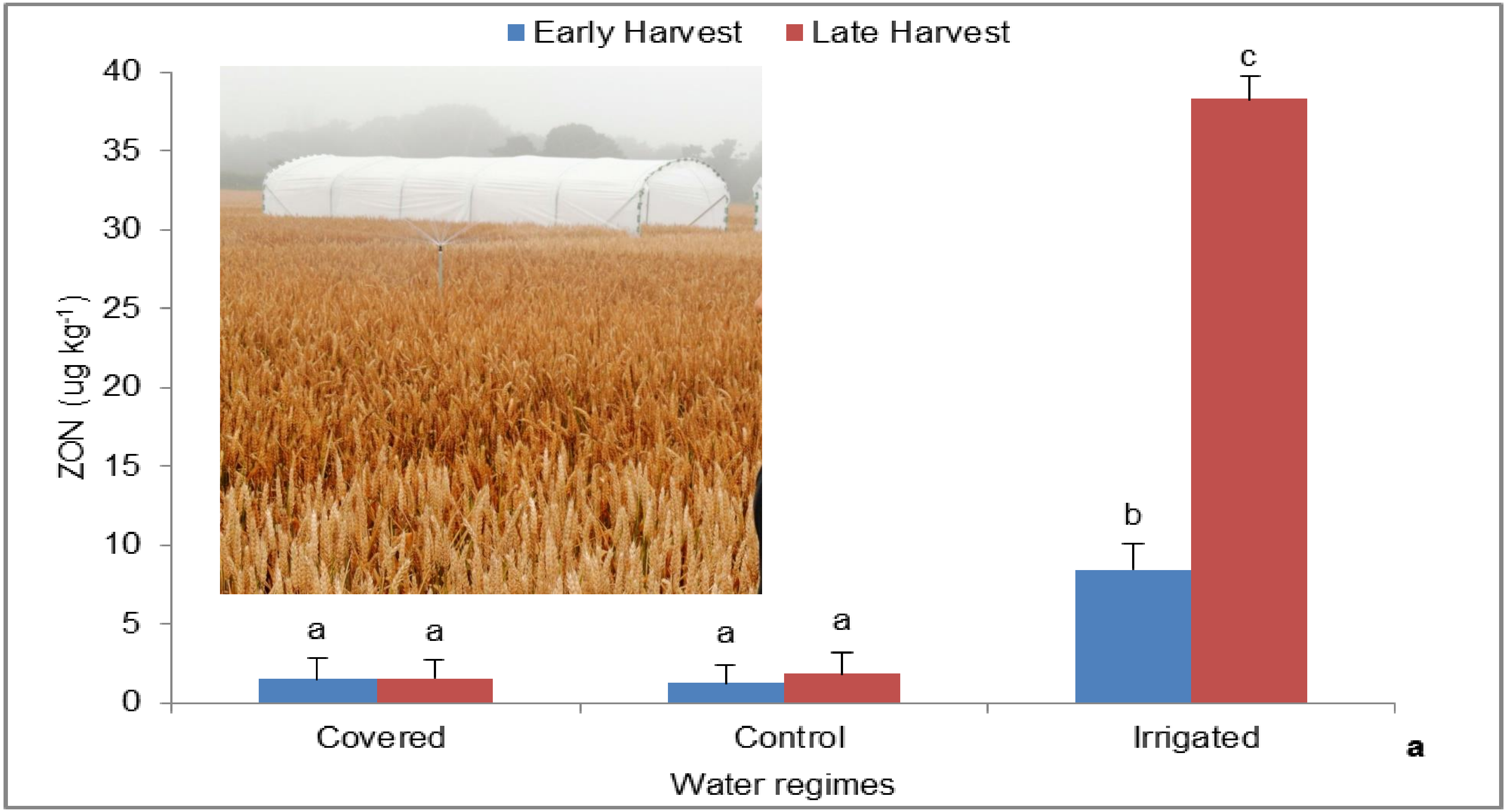
+ values = late harvest

Mycotoxin production during FHB infection



Based on data from Matthaus et al. (2004) Progression of mycotoxin and nutrient concentrations in wheat after inoculation with *Fusarium culmorum*. Archives of Animal Nutrition 58: 19-35.

ZON harvest - Field experimental data



IPM to minimise Fusarium mycotoxins in milling wheat

Fusarium resistant varieties

Good rotation - avoid maize as previous crop

Cultivation – Intense cultivation following a high risk crop (particularly maize)

Use a robust rate of a Fusarium active fungicide at T2 (GS39) and at T3 (GS 59)

Timely harvest

HT2 and T2 in UK oats

Observational studies 2002-2005 and 2006-2008 (n=702)

Conventional oats collected at harvest (food and feed samples)

High season variability in HT2+T2

DON and ZON routinely low in UK oats

	HT2+T2 (%> ppb)		
	> 500	> 1000	> 2000
2002	23	10	3
2003	41	29	8
2004	27	15	6
2005	51	30	10
2006	43	21	9
2007	18	8	5
2008	6	1	0
Overall	30	16	6

Accumulated analysis of variance table for Log_{10}(HT2+T2) concentration for oats

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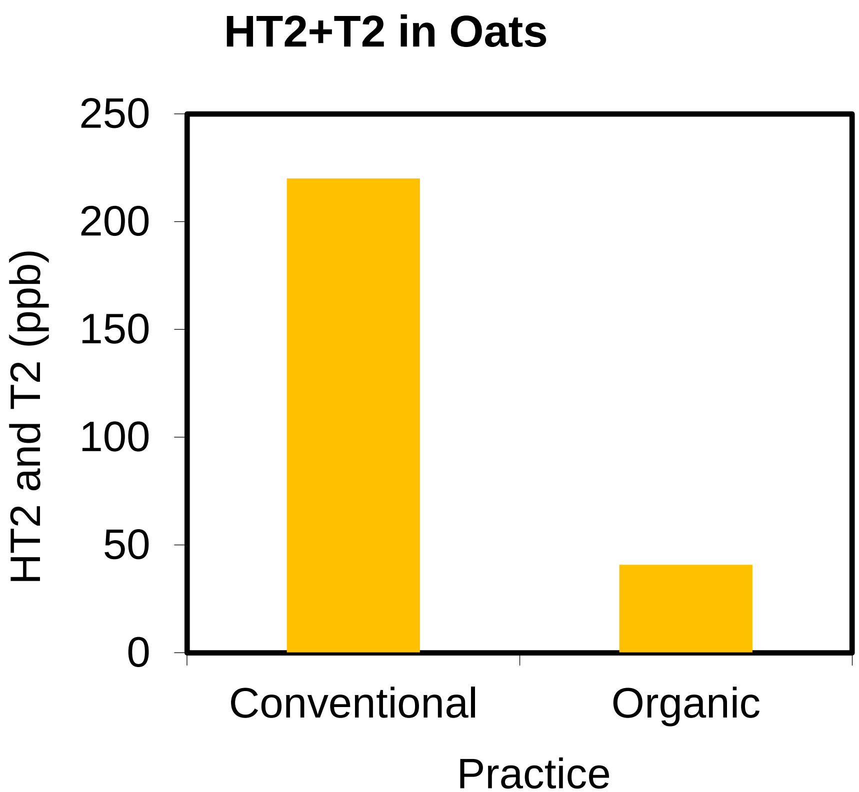
Change	d.f.	s.s.	m.s.	v.r.	F pr.
+year	3	12	3.86	11.4	<.001
+region	5	8	1.66	4.9	<.001
+year.region	15	20	1.32	3.9	<.001
+practice	1	35	35.18	103.8	<.001
+previous crop	4	12	3.04	9	<.001
+plough	1	0	0.01	0.0	0.876
+previous crop.plough	3	3	1.20	3.5	0.015
+variety	5	15	3.07	9.0	<.001
Residual	369	125	0.33		
Total	406	231	0.56		

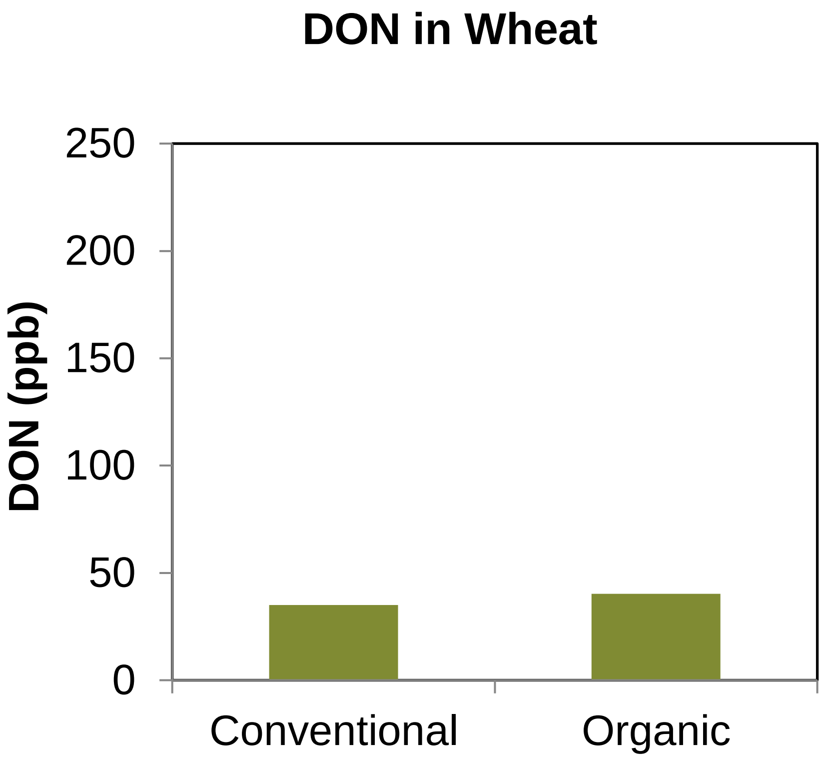
Change	d.f.	s.s.	m.s.	v.r.	F pr.
+ year	3	12	3.86	11.4	<.001
+ region	5	8	1.66	4.9	<.001
+ year.region	15	20	1.32	3.9	<.001
+ previous crop	4	28	6.87	20.3	<.001
+ plough	1	1	0.68	2.0	0.154
+ previous crop.plough	3	5	1.81	5.3	0.001
+ var	5	24	4.89	14.4	<.001
+ practice	1	8	8.25	24.3	<.001
Residual	369	125	0.33		
Total	406	231	0.56		

Organic and conventional UK oats

Oats – Much lower levels in organic oats

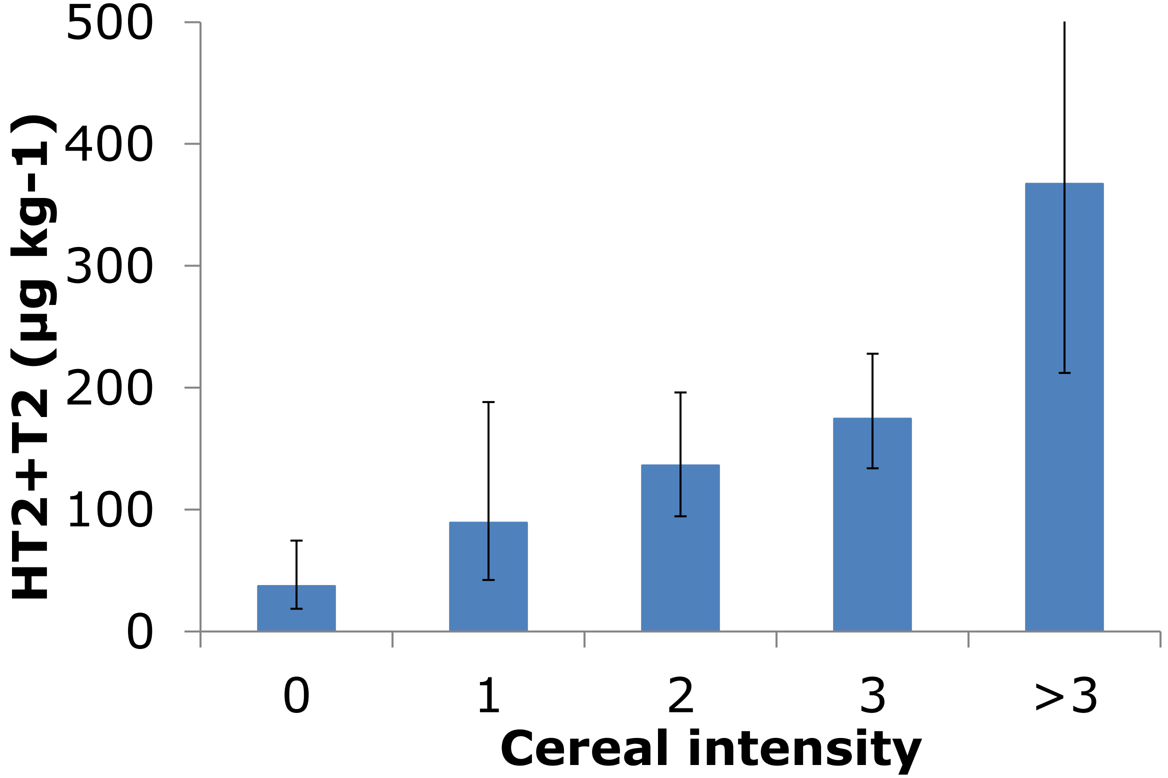
Wheat – No significant difference



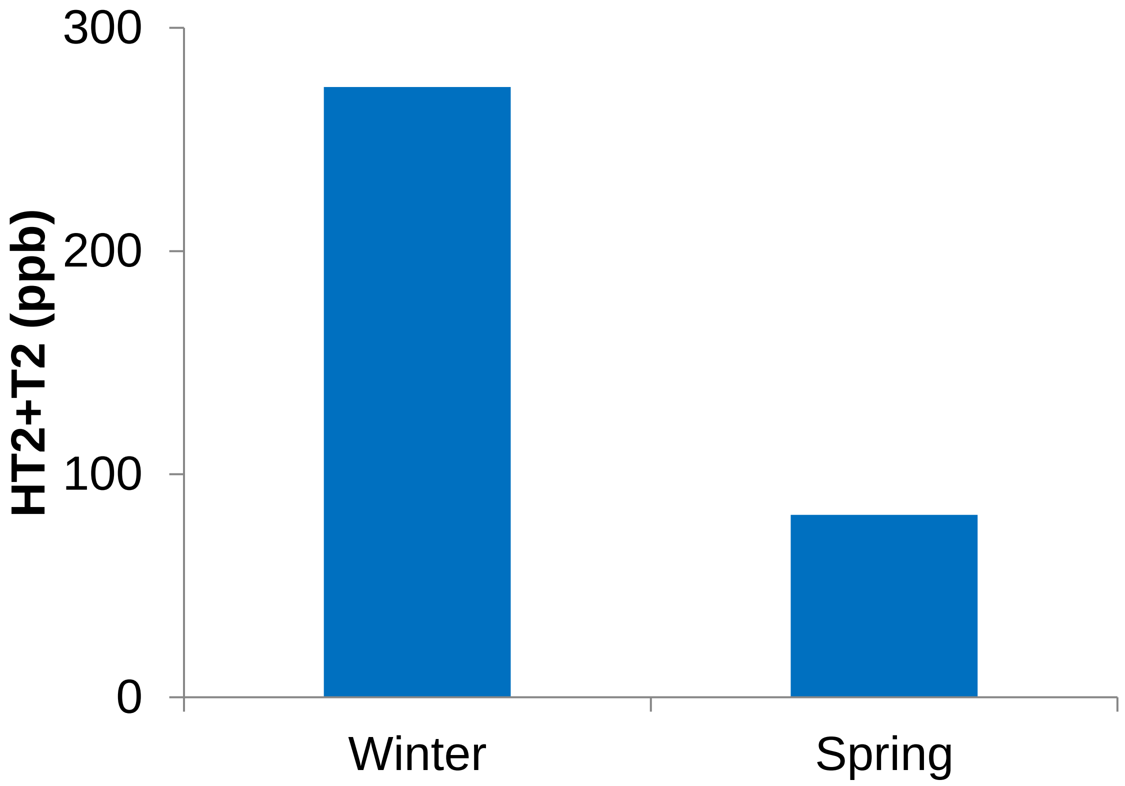


Oat Agronomy - Cereal intensity within rotation

Data based on last four years previous crops
Intensity = number of previous cereal crops



Oat varietal differences to HT2+T2 content



Subsequent studies have shown differences are primarily genetic

Oat Agronomy - Varietal resistance

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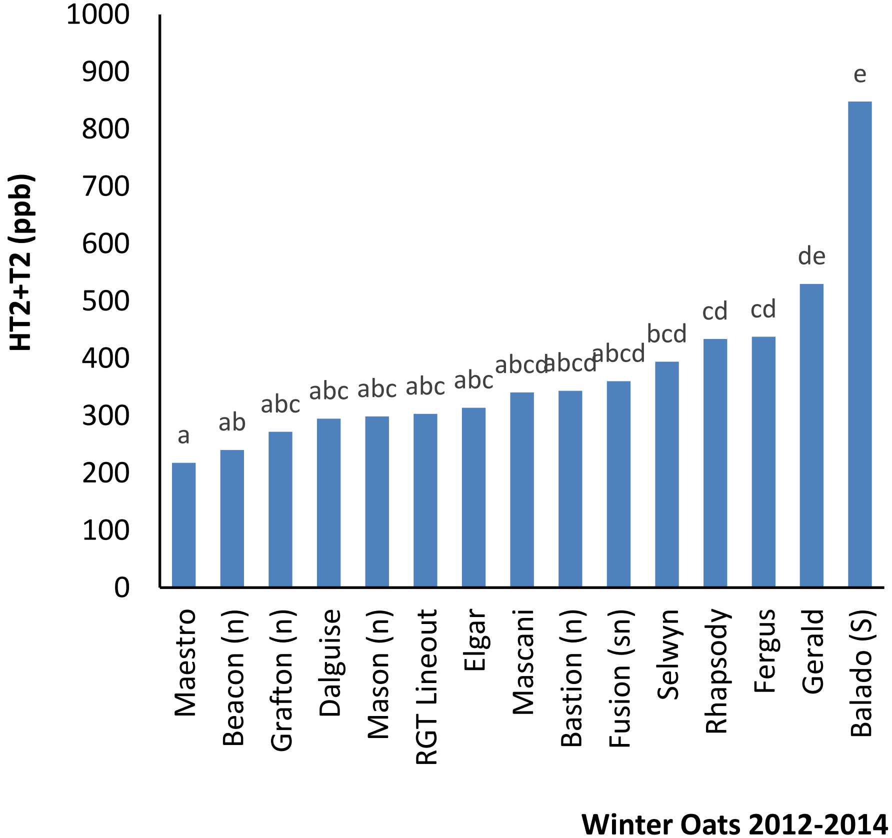

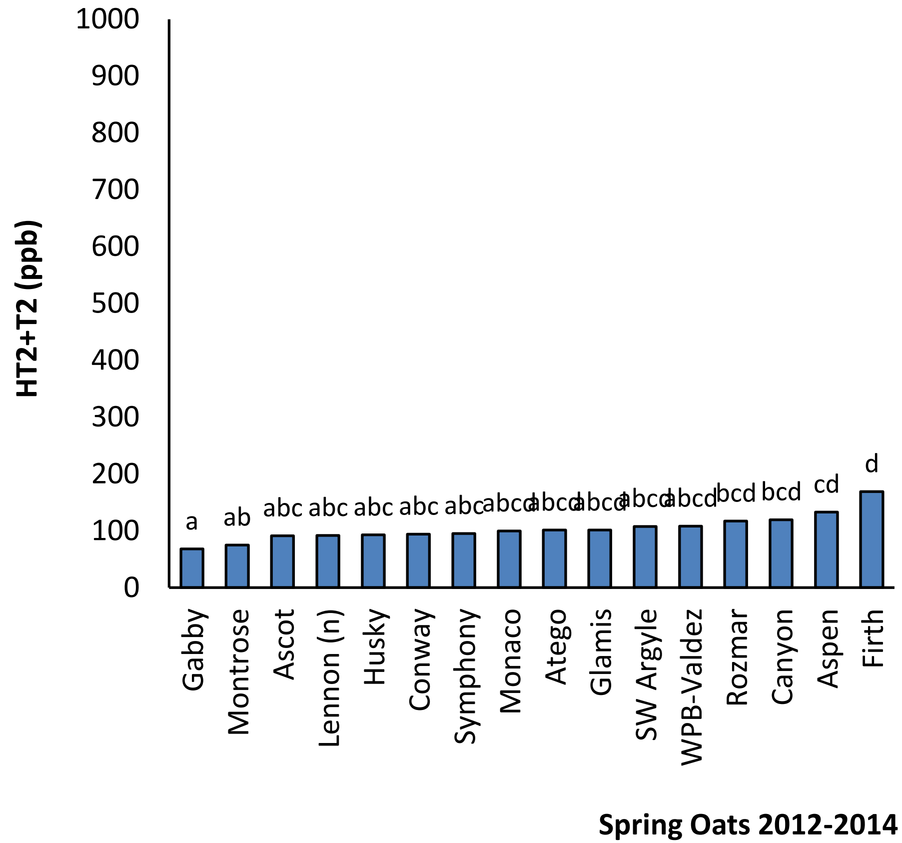

Varieties with same letter are not significantly different (LSD at P=0.05).
After name (n, naked; s, short-strawed).

Other agronomic factors

Mainly studied as part of standard agronomy experiments.

1) Fungicides – generally no effect
2) PGR – no effect/slight effect (height)
3) Nitrogen rate – no effect within commercial ranges
4) Seed rates – no effect

Differences in organic and conventional are partially explained by varietal choice and rotation.

IPM to minimise Fusarium mycotoxins in milling oats

Switch to spring varieties

Broad/long rotation (reduce cereal intensity)

Select Fusarium resistant tall varieties

Cultivation – dependant on rotation, better to plough after cereals and grass

(first two are not economically viable compared to alternative crops)

IPM strategies to control mycotoxins

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IPM for reduction of fusarium mycotoxins identified for wheat and oats

Weather still the key factor dictating risk

Several factors go against current economics and/or sustainability (eg ploughing)

Varietal resistance is primary long term strategy but difficult due to polygenic nature of resistance

Acknowledgements

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