Factors affecting weed control in arable crops

Dr Nicola Cannon

Royal Agricultural University Cirencester


rhizomes
germination
SPREAD
SEEDS
SEEDBANK
NUTRIENTS
SHADE
YIELD
DRILLING
water
HOES
rotations
robots
LIGHT
POPULATIONS
fallow
legislation
DIVERSE
SEASONAL
MULCHES
CROPS
competition
density
RESISTANCE
WIND
roots
biology
chemistry
HARROWS
RHIZOMES
environmental
mulches
ROBOTS
technology
QUALITY
ECOLOGY
grasses
knowledge
SPECIES
ADAPTION
YIELD
SEEDBANK
SPREAD
hoes
dicotyledrons
quality
KNOWLEDGE
COMPETITION
resistance
diverse
DISPERSAL
seeds
fallow
DRILLING
GRAZING
CROPS
populations
SEASONAL
cultivates
nutrients
ROTATIONS
LEGISLATION
wind
SHADE
MULCHES
grasses
hoes

Techniques for weed control

1. Understanding weed biology
2. Physical removal
3. Chemical options (if available)

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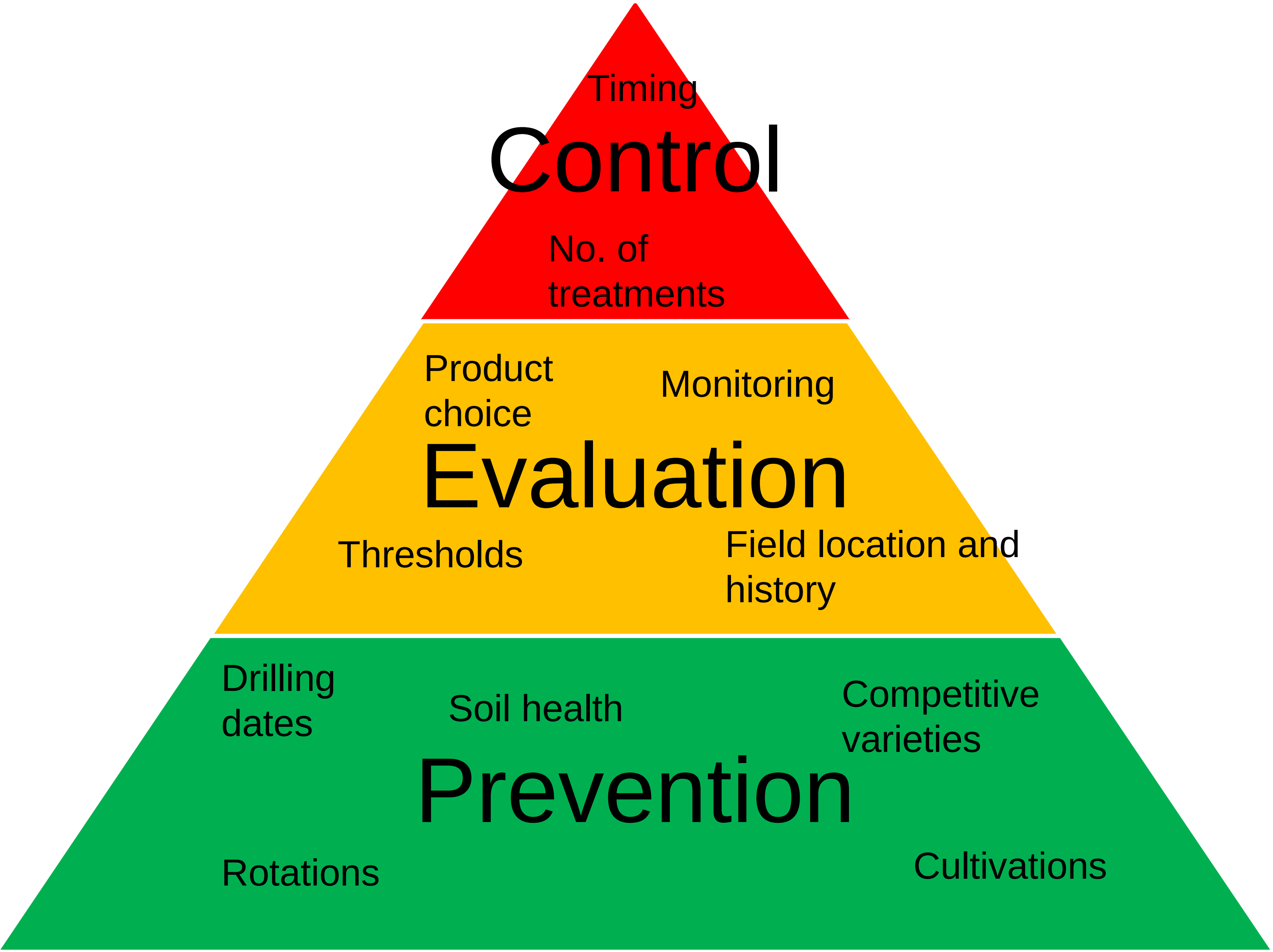
Understanding weeds



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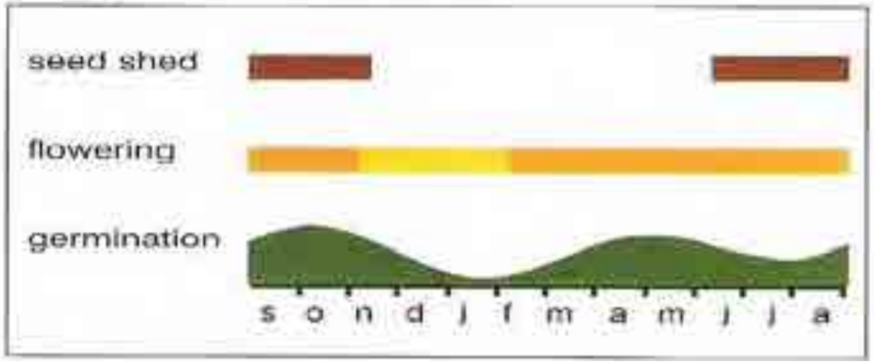
Common field-speedwell

Veronica persica

Competetive in

WW	WOSR	Spring Crops	Resistance	Value to Biodivers
	✓			

Lifecycle



Seed longevity: >5 years

Seed weight: 0.52 mg

Seeds/flower: 7

Seeds/plant: 50 - 10 000

Lifecycle
Plants can overwinter and even flower throughout the year, giving rise to two generations per season. Shoot fragments are able to regenerate and the large seeds are probably dispersed by ants.

Location

- Leaves are broad, triangular and toothed on short stems
- Can grow at low temperatures and have 2 generations a year
- Grows in winter & spring sown crops
- Sprawling growth habit
- Pretty blue flowers on a long stem

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Approaches to weed Control

Broad-spectrum - weeding across the entire area

Inter-row - weed machinery is focused between the crop rows

Intra-row - weeding is carried out in the crop row itself

Patches - specific patches are targeted by hand or machine

Above ground weeding

- Requires physical difference
  - Need to have weeds that are taller than the crops
- Weed wipers
  - Electric
  - Glyphosate????

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DESCRIPTION

TECHNOLOGY

EFFECTIVENESS

SECTORS

SUSTAINABLE

EFFECTIVE

VERSATILE

SAFEGUARDED

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The next step for weed control

- The technology is available:

Automated lawn mowers

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But this is what I need….

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Robotic weeding

http://www.trp.uk.com/carre-farm-machinery/carre-meadow-maintenance/anatis.html

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Agricultural challenges in 2017

Uncertain weather patterns	LARGER MACHINERY
Limited supply of labour	LARGER MACHINERY
Challenges of soil compaction	LARGER MACHINERY
Low resolution of precision farming	LARGER MACHINERY

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Small robotic solutions could offer...

Reduced soil compaction → Increased yields

Better imagery → Improved precision farming → Increased margins?

Swarms of robots → Improved efficiency

https://agribotics.blogs.lincoln.ac.uk/files/2014/03/cropped-boni_rob.png

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Weed mapping

- Works on the chlorophyll content difference between blackgrass and wheat
- Using RedEdge multispectral sensor
- Processing the results into an orthomosaic, DSM and several different vegetation indices.

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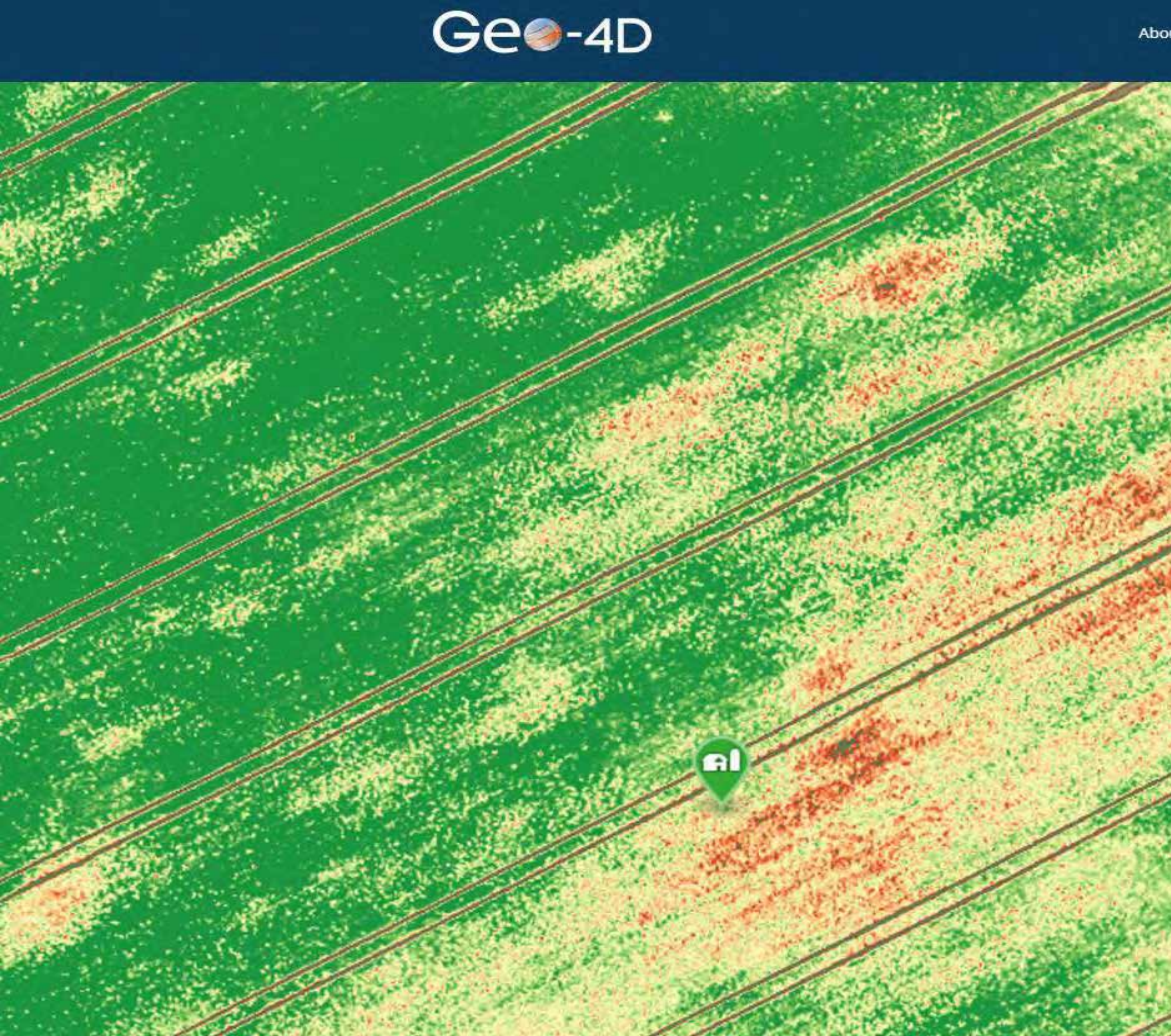

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But what can be done now….

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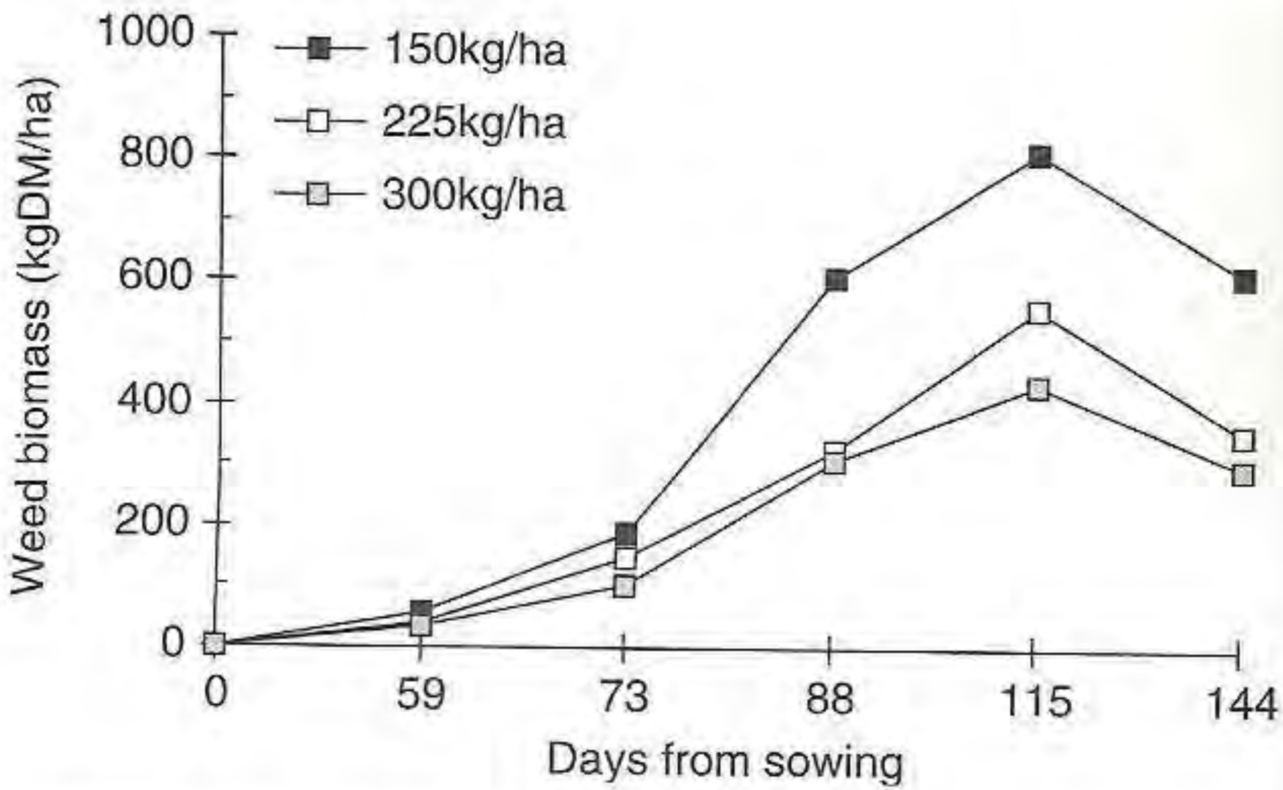

'he effect of oat seed rate on weed development

nie & Taylor, 1995

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Quantifying tools available for weed control

- Crop establishment technique
- Sowing date
- Crop height/variety
- Weed removal
- Sheep grazing
- Undersowing
- Weed seed banks

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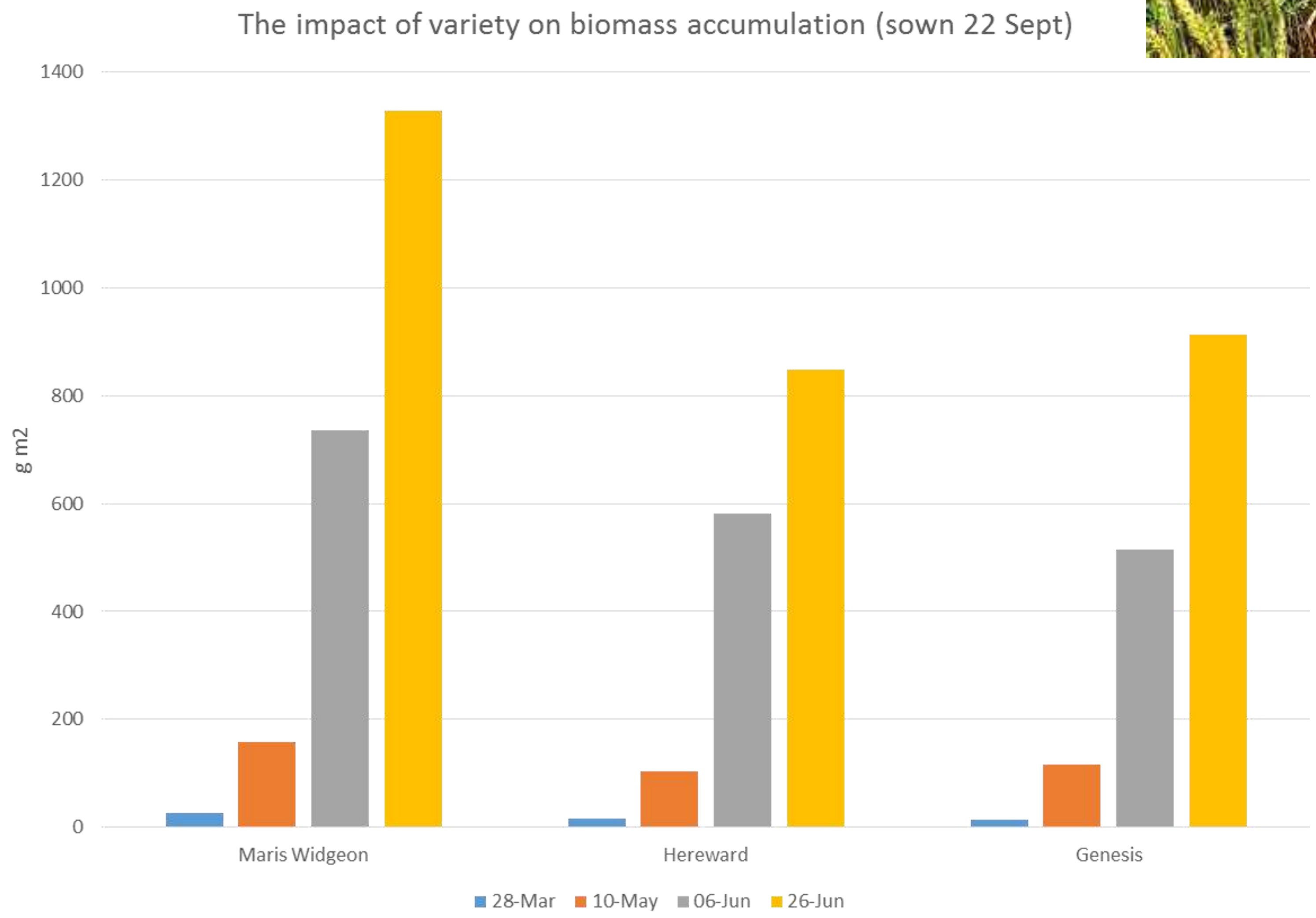
Varieties



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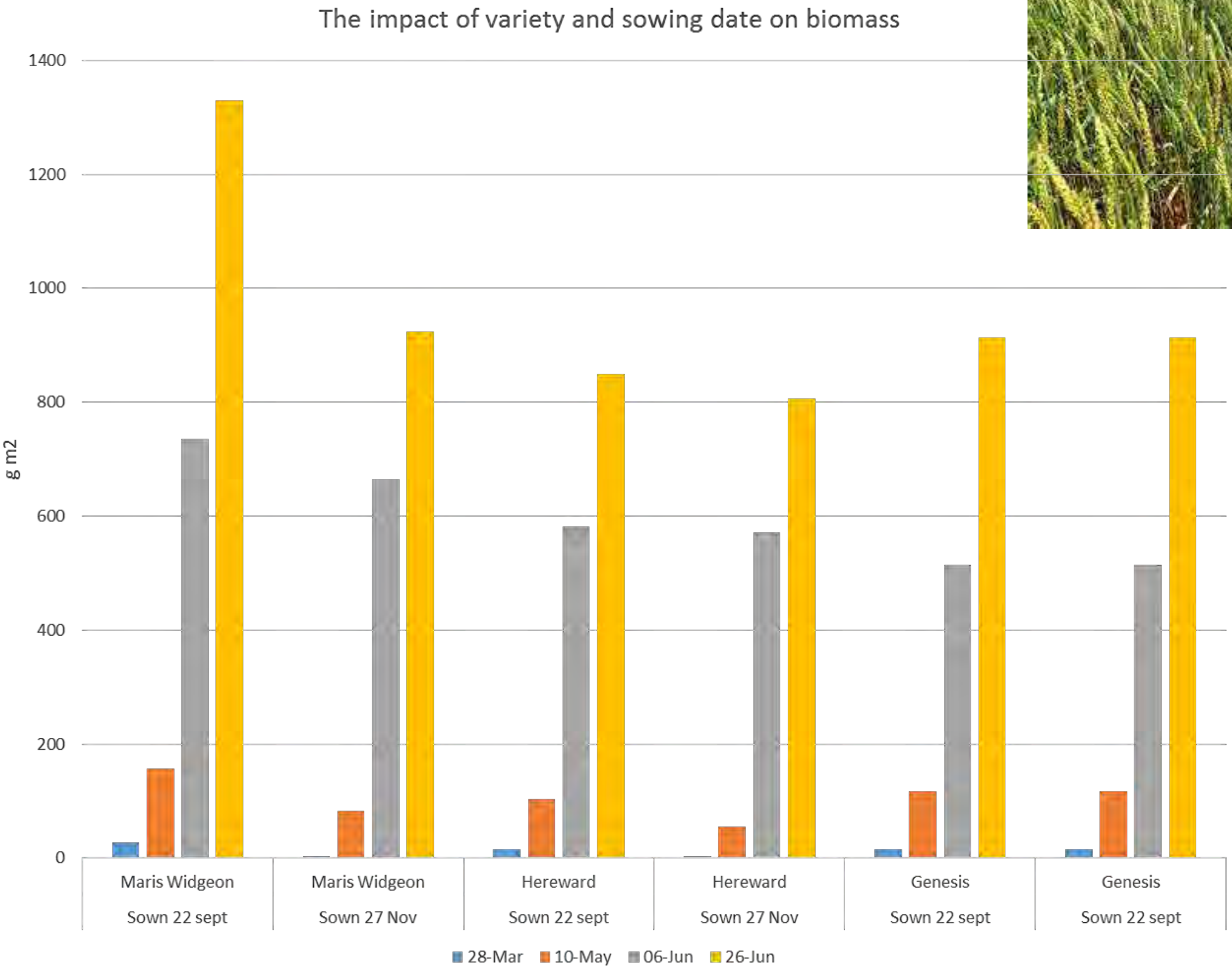
Sowing Date and variety



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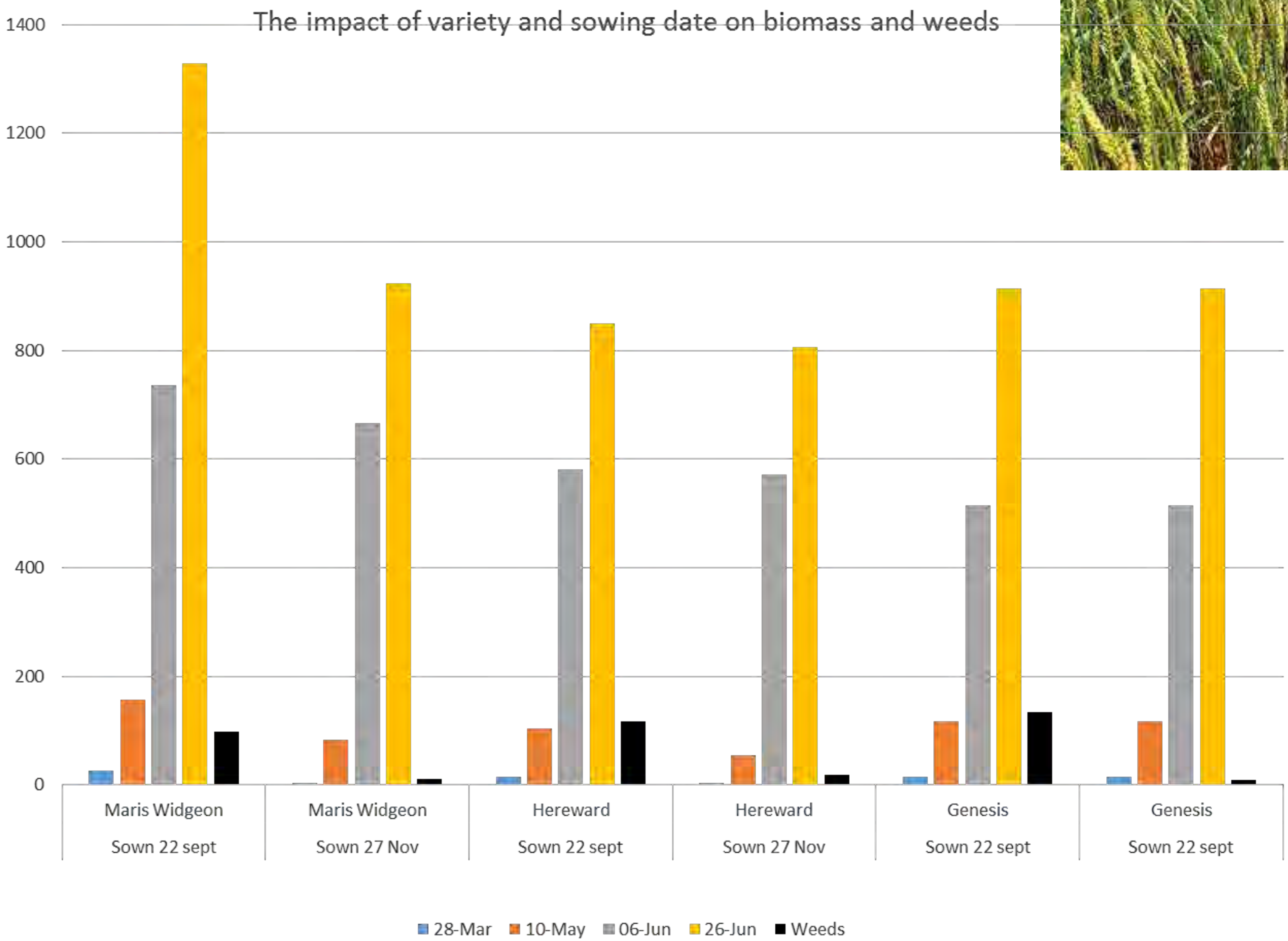
Sowing Date and variety



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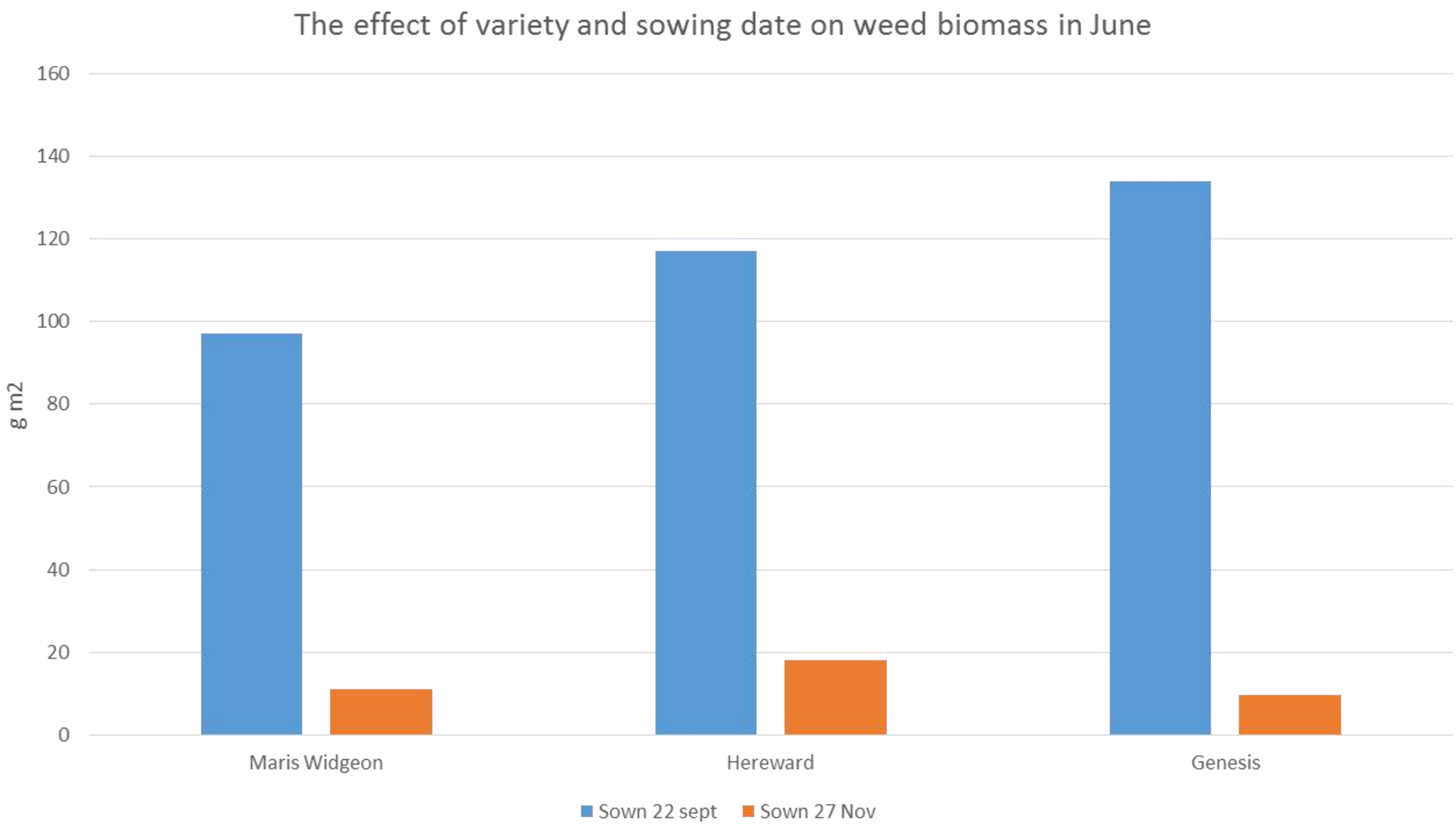

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“The Corn Harvest"
Pieter Bruegel the Elder, 1565

Metropolitan Museum of Art, New York

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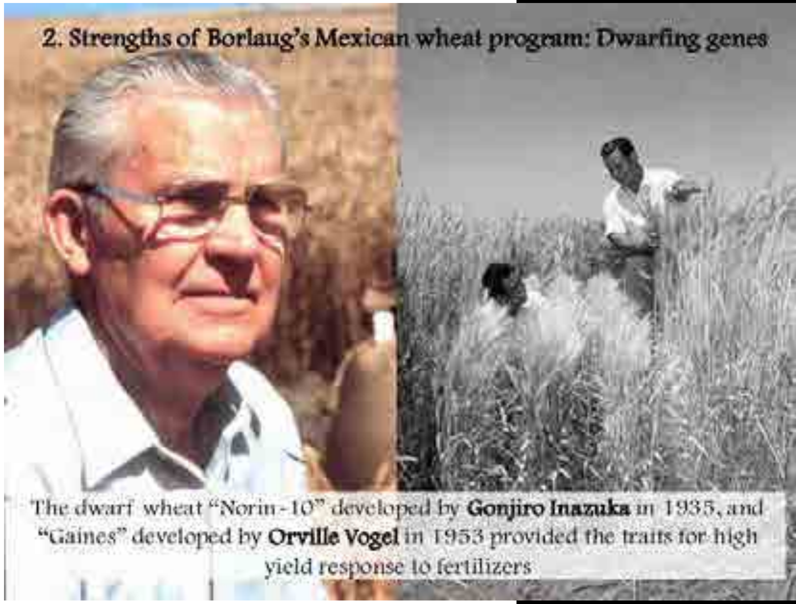
Why the Rht (reduced height) gene was introduced…

- The Green Revolution found that introducing a gene 'Norin 10' from Japanese wheat:
  - Decreased plant height leading to:
    - An increased harvest index
    - Stronger plant and lower lodging risk
  - Capable of:
    - Yielding more
    - Responding to higher levels of crop inputs



https://www.slideshare.net/CIMMYT/norm-and-i-dr-thomas-a

- Worked by making the plant unresponsive to the plant growth hormone, gibberellin, which normally increases stem height

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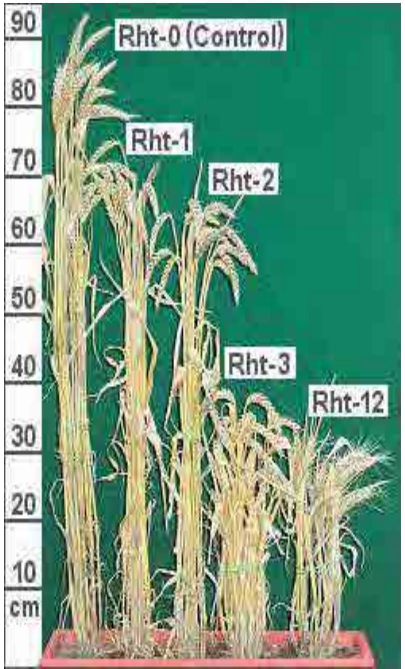
The impact of dwarfing genes on blackgrass

Table 1. The effects of dwarfing genes on *A. myosuroides* head numbers, whole grain yield and yield components of winter wheat cv. Maris Widgeon.

	A. myosuroides No. m^{-2}	Ear No. m^{-2}	Grain No. m^{-2}	TGW g d.m.	Yield t ha^{-1}
No *Rht*	5.7	218	9940	38.1	2.96
*Rht*1	21.1	248	13300	33.2	3.59
*Rht*2	20.8	243	11300	36.4	3.25
*Rht*1+2	30.2	267	14000	30.4	3.30
S.E.D.	8.18	12.02	954	1.98	0.195



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Grazing

The effect of variety and grazing on crop height, weed dry matter and grain yield. Average of 2 sowing dates. 1993-1994

Variety	With (+) & without (-) grazing	Crop height (cm)		Weeds (g DM m^{-2})	Grain yield (t ha^{-1} 85% DM)
		29-Mar	**20-Jun**	**06-Jun**	
Maris Widgeon	-	12.5	119.5	105	5.2
Maris Widgeon	+	7.8	112.3	82	4.9
Hereward	-	9.4	82.4	115	5.3
Hereward	+	5.7	79	83	5.2
Genesis	-	8.2	80.3	99	5.1
Genesis	+	5.5	79	91	5.3
s.e.d. (grazing, same variety)		0.73	1.47	11.5	0.25
s.e.d. (variety ,same grazing)		0.29	1.43	10.7	0.16
<u>Significance levels</u>					
Grazing		*	***	*	-
Variety		***	**	-	-
Grazing X Variety		***	-	-	-

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Gooding *et al*. 1998

Table 1. *The effect of weeding and defoliation method on grain yield and quality*

Weeding	Grazing	Ear Number m^{-2}	Yield ($t\ ha^{-1}$) 85% DM	TGW (g) DM	Crude protein (%) 85% DM	Hagberg falling number
-	-	243	1.53	31.6	10.18	243
+	-	318	2.00	32.7	10.16	243
-	+	223	1.33	31.4	10.18	238
+	+	231	1.53	31.6	10.21	262
SED(9df)		25.0	0.184	1.01	0.314	8.83
SED(same defoliation)		29.0	0.216	0.87	0.217	8.74

Main findings:

- Ear numbers were average, but low TGW resulting in low yield
- Weeding increased:
  - Ear number
  - Grain yield
  - HFN
- Grazing reduced ear number

Cosser *et al*. 1997

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Undersowing

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Table 1. *Effect of undersown legume species on organic spring wheat*

	Plant height (cm)	Ear (numbers m^{-2})	Wheat DM yield (t ha^{-1})	TGW (g)	Grain yield (t ha^{-1})	Legumes DM yield (t ha^{-1}) (a)	Weeds DM yield (t ha^{-1}) (b)	Non-wheat DM yields (t ha^{-1}) (a + b)
Non-undersown	81.52a	372a	9.37a	34.73	3.79a	0.130a	0.172	0.307a
Wheat + WC	81.16a	360a	8.89ab	34.24	3.61ab	0.258b	0.195	0.452ab
Wheat + BM	80.66ab	335ab	8.52ab	34.36	3.51ab	0.264b	0.226	0.489abc
Wheat + BT	80.44ab	328ab	7.34bc	33.70	2.92bc	0.272b	0.245	0.517bc
Wheat + V	79.25b	307bc	7.28bc	33.39	2.84bc	0.293bc	0.278	0.571bc
Wheat + RC	77.17c	290bc	6.75c	33.64	2.62c	0.298bc	0.265	0.563bc
Wheat + CC	76.30cd	286bc	6.60c	32.83	2.52c	0.358bc	0.309	0.667c
Wheat + PC	75.14d	275c	6.26c	32.16	2.27c	0.393c	0.282	0.675c
SED (53 df)	0.86	24.81	0.862	1.319	0.412	0.058	0.084	0.104
Significance	***	**	**	ns	**	**	ns	*

Any two mean within columns not sharing common letters differs significantly. *** significance $P<0.001$, ** significance $P<0.01$, * significance $P<0.05$, ns non-significant.

Bhaskar et al.

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Weed seedbank

Table 1. *The effect of sowing date and grazing on the soil weed seedbank in 1993/4 (Square root transformation)*

	Veronica hederifolia	*Stellaria media*	*Lamium purpureum*	*Poa trivialis*	*Sinapis arvensis*	*Myosotis arvensis*	Broadleaf Total	Total
Early sown								
Ungrazed	11.33	5.45	1.79	13.51	1.70	2.84	14.28	19.82
Grazed	8.77	4.64	1.12	14.10	1.47	2.12	11.56	18.32
Late sown								
Ungrazed	4.79	3.81	1.15	8.05	0.87	1.07	7.36	11.02
Grazed	4.68	4.08	0.86	8.96	1.07	0.90	7.61	11.82
SED(df=4)	1.404	1.125	0.656	1.878	0.355	0.727	0.954	1.906
SED(same grazing)	1.305	0.322	0.172	1.045	0.374	0.302	1.158	1.551

Table 2. *The effect of sowing date and grazing on the soil weed seedbank in 1994/5 (Square root transformation)*

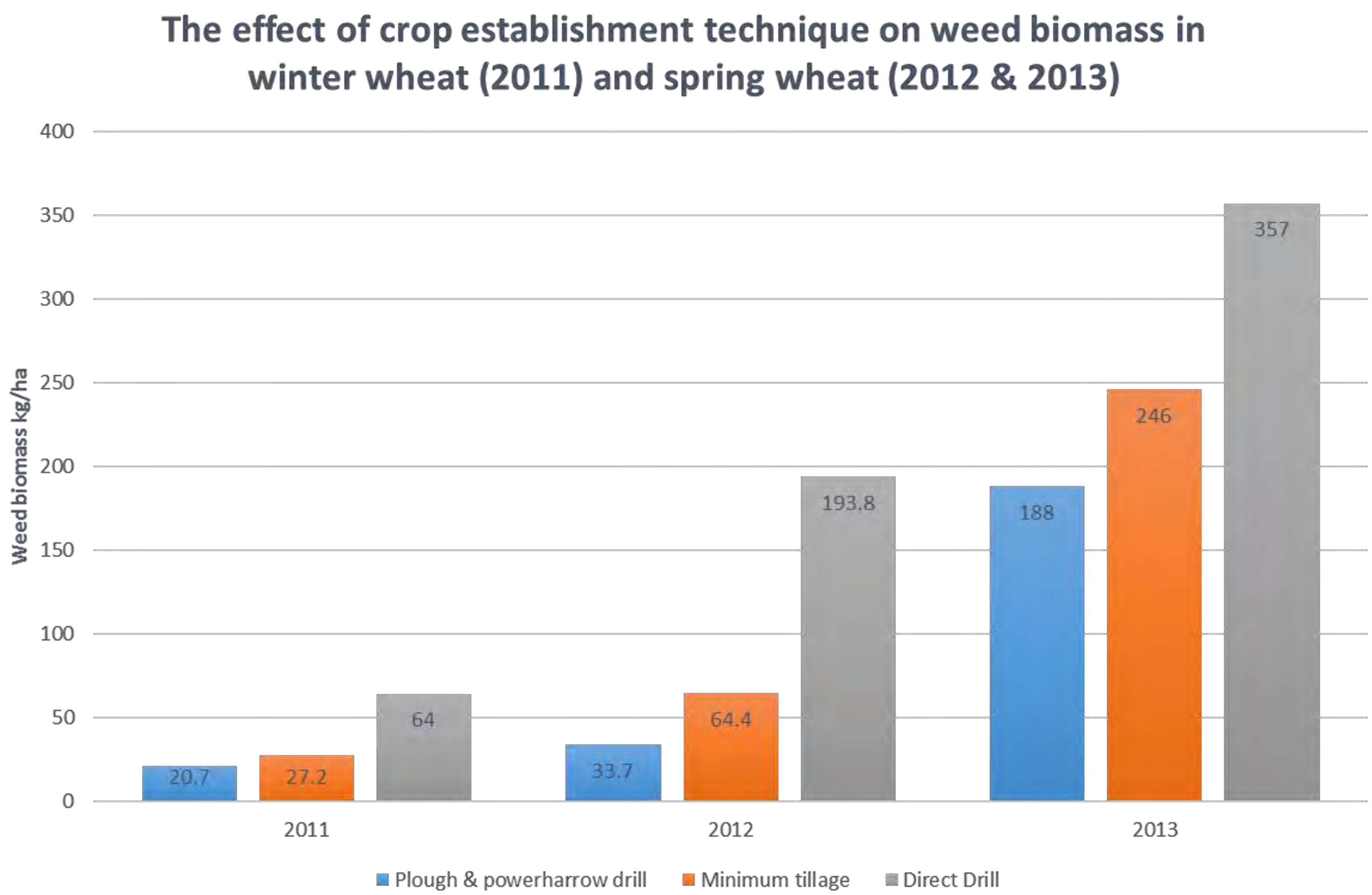
	Veronica hederifolia	*Stellaria media*	*Lamium purpureum*	*Poa trivialis*	*Alopecurus myosuroides*	*Papaver rhoeas*	Broadleaf Total	Total
Early sown								
Ungrazed	11.00	0.69	2.54	10.93	6.08	3.27	14.66	19.49
Grazed	10.44	2.30	3.30	8.44	2.29	5.25	14.33	16.96
Late sown								
Ungrazed	4.48	0.51	2.13	3.03	2.06	1.81	7.31	9.83
Grazed	4.22	0.47	1.73	5.33	0.94	2.55	7.18	9.09
SED(df=4)	1.708	0.334	0.464	0.601	0.552	0.732	1.232	1.068
SED(same grazing)	1.795	0.292	0.574	0.440	0.670	0.930	1.371	1.334

Key findings:

- More weed seeds germinated after early rather than late sown wheat.
- Blackgrass seedlings were much greater in early sown wheat but less so when grazed by sheep in 1995.
- More charlock emerged from plots sown with Maris Widegon (1.70) than Genesis (1.33) or Hereward (0.81).

Cosser *et al*. 1996

Crop establishment technique



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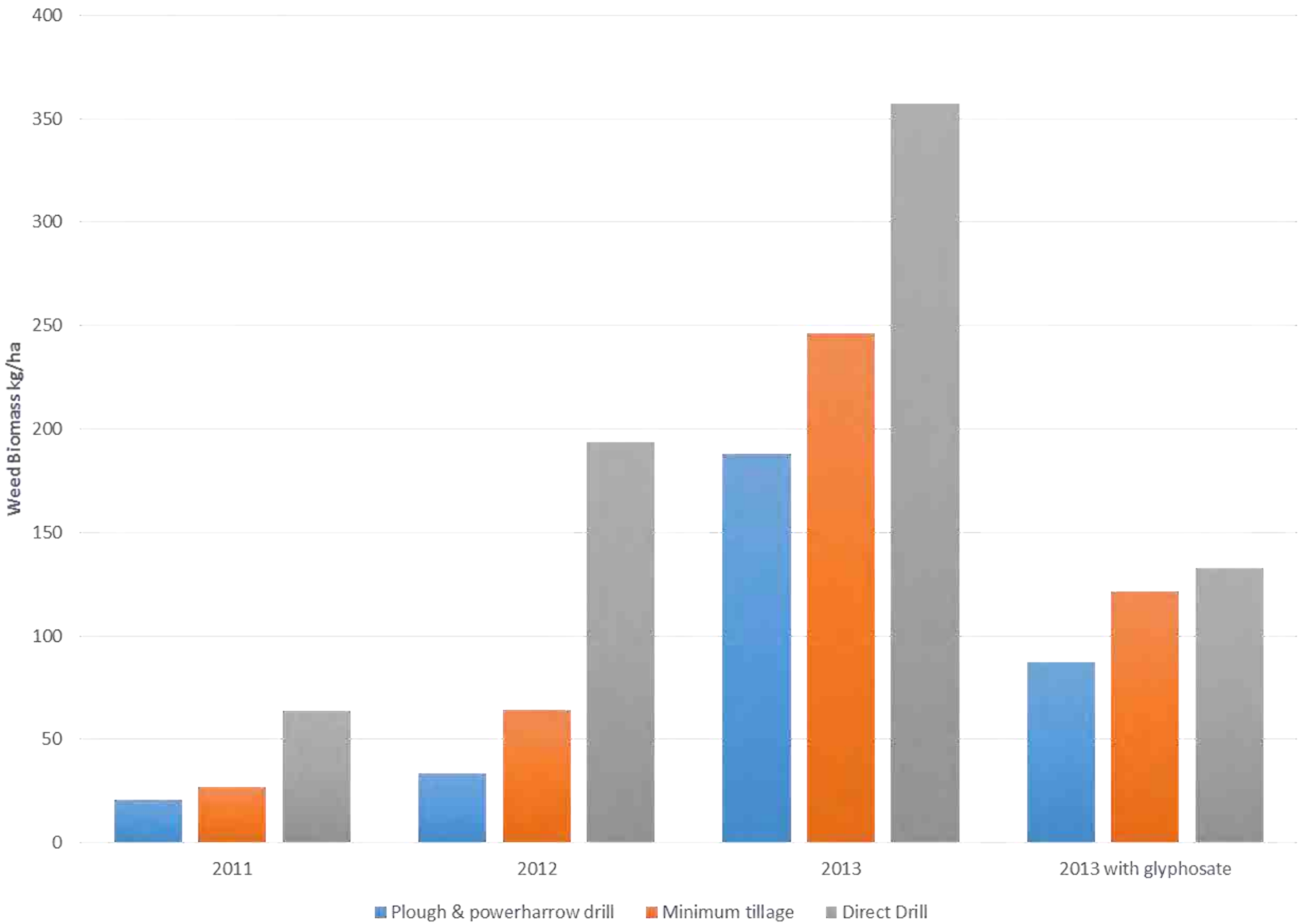
Bhaskar et al. 2014

The effect of crop establishment technique on weed biomass in organic winter wheat (2011), spring wheat (2012 and 2013) and with the addition of a single pre drilling Glyphosate spray



Bhaskar et al. 2014

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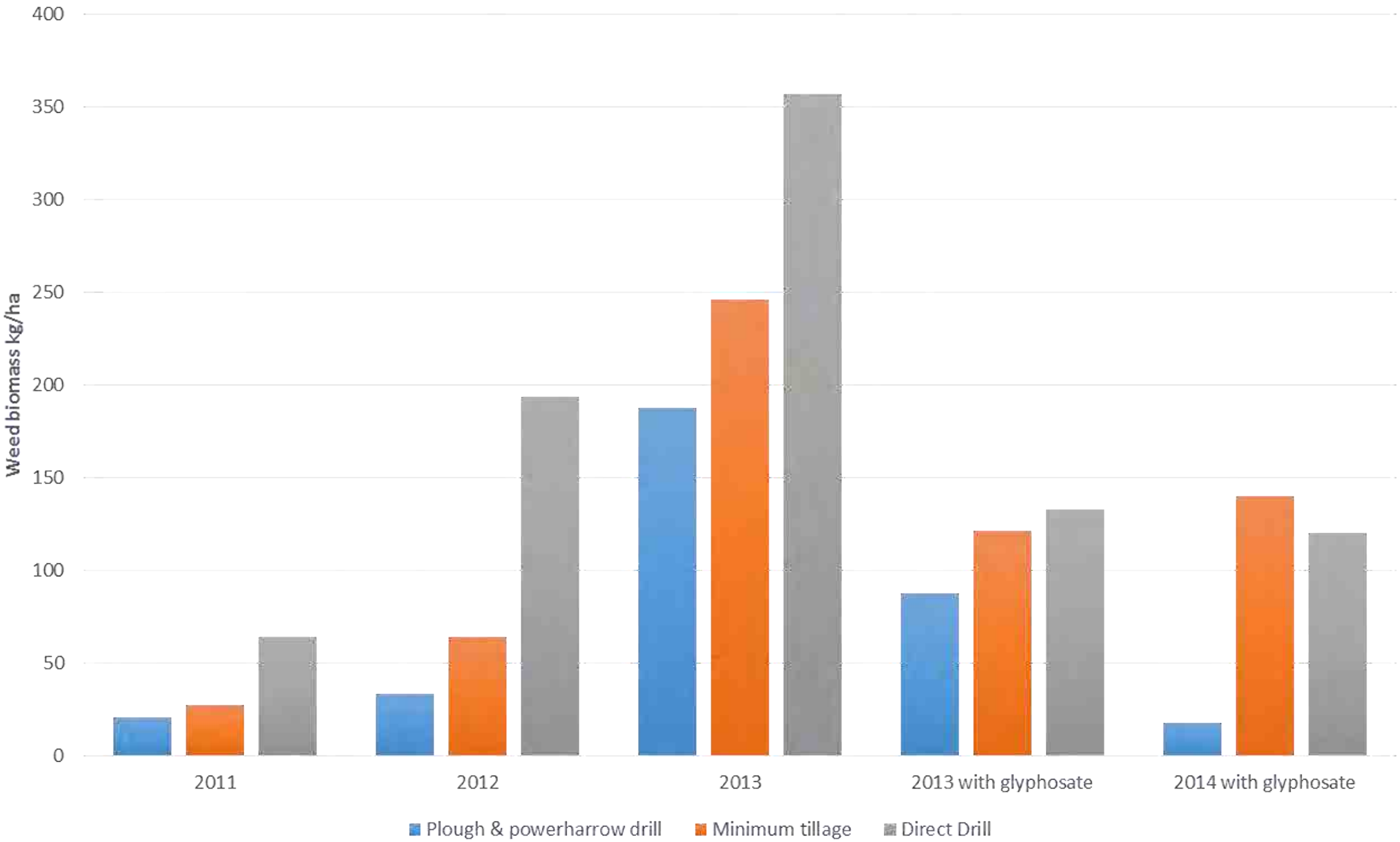
The effect of crop establishment technique on weed biomass in winter wheat (2011) and spring wheat (2012-2014) and later with the addition of a single pre drilling glyphosate spray



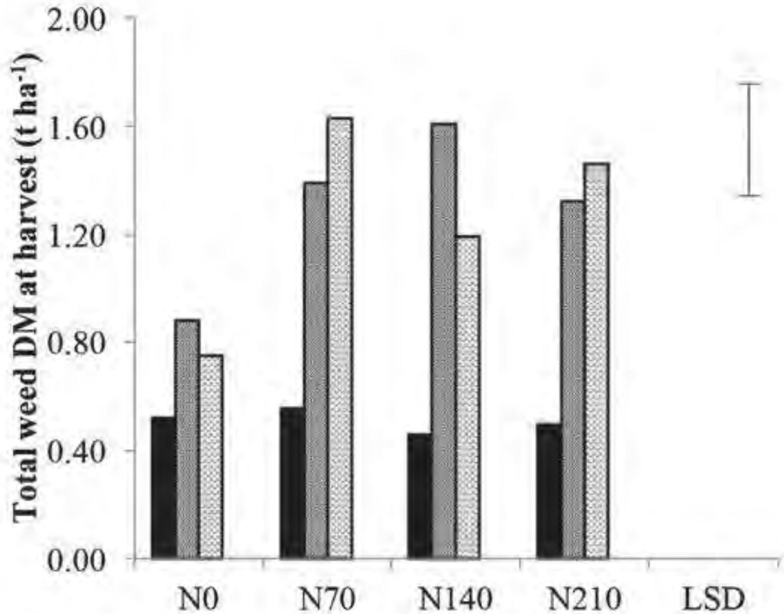
Bhaskar *et al.* 2014
Rial-Lovera *et al.* 2016

Impact of Nitrogen application

Table 3 Analysis of variance for year, tillage and N management effects. Mean values for weed aboveground biomass and spring wheat grain yield parameter

Source	df	Early Total Weed DM (t ha^{-1})	Midseason Total Weed DM (t ha^{-1})	Broadleaf Weed DM (t ha^{-1})	Grass Weed DM (t ha^{-1})	Total Weed DM (t ha^{-1}) at harvest	Grain Yield (t ha^{-1})
Year (Y)	1						
2013		0.0338a	1.438b	1.131b	0.307a	1.140b	5.595b
2014		0.0837b	1.138a	0.816a	0.321a	0.905a	3.701a
SED		*0.01069****	*0.0915****	*0.0700****	*0.0697*^{ns}	*0.0850***	*0.1469****
Tillage (T)	2						
CT		0.0198a	0.528a	0.4468a	0.0812a	0.507a	5.473c
HINiT		0.1186b	1.953c	1.5921c	0.3612b	1.301b	3.833a
LINiT		0.0378a	1.382b	0.8821b	0.5004b	1.259b	4.638b
SED		*0.01309****	*0.1121****	*0.0857****	*0.0854****	*0.1041****	*0.1800****
N rate (N)	3						
N0							4.248a
N70							4.381a
N140							4.945b
N210							5.019b
SED						***	*0.2078****
Y×T	2					***	*0.2545****
Y×N	3					^{ns}	*0.2939*^{ns}
T×N	6					*	*0.3599*^{ns}
Y×T×N	6					^{ns}	*0.5090*^{ns}

Values are mean; df, deg … eractions.
Values followed by same … ificant.



LSD, Fisher's Least Significant Difference at *P*<0.05 for treatments interaction means

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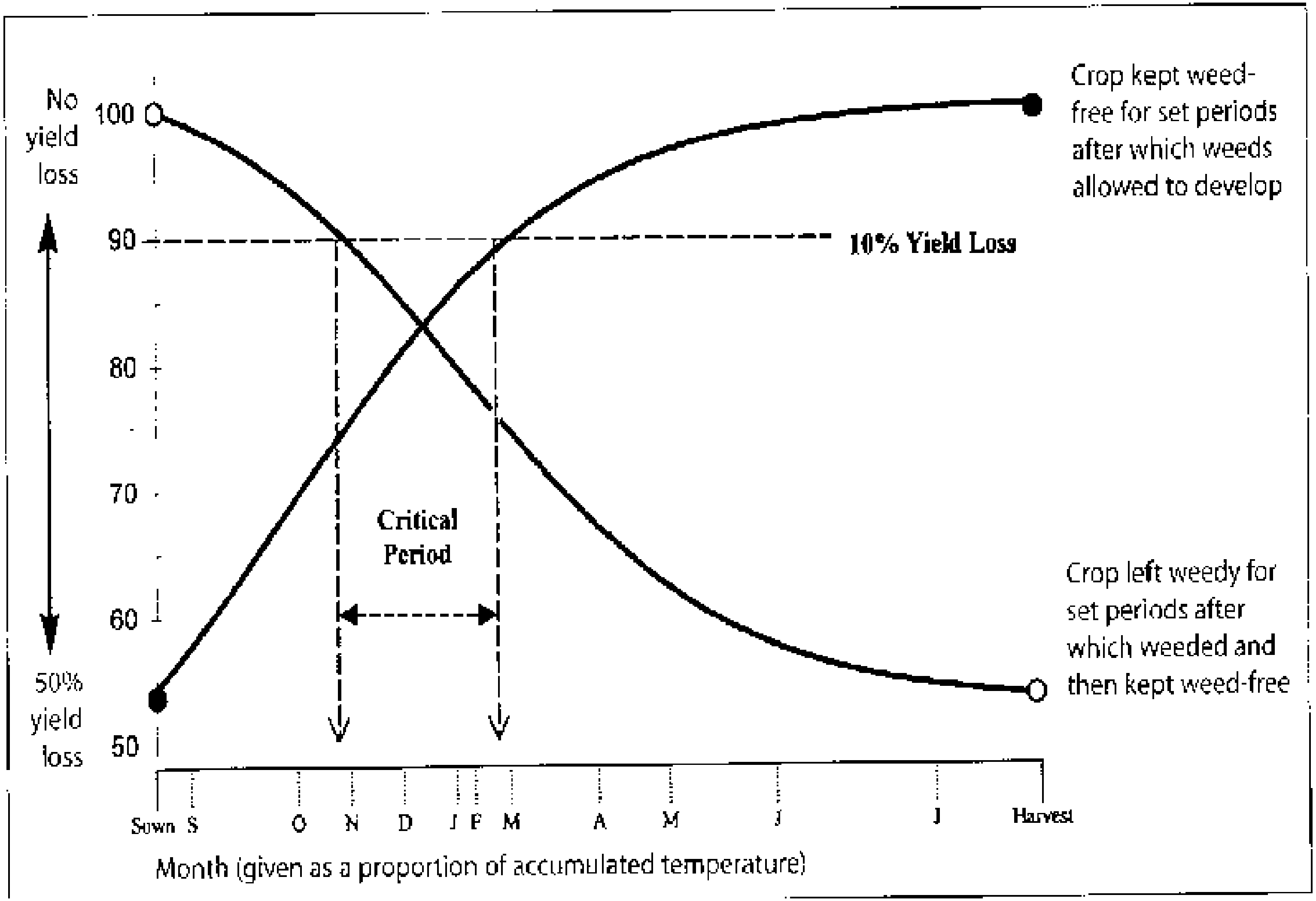
Critical Weed Free Period



Welsh et al. 1999

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Critical Weed Free Periods

<u>Number of weeding operations needed</u>:

Trials with onions and swedes

Weeds had no adverse effects on a crop of bulb onions for up to five weeks after 50 per cent of the onions had emerged. From week five to week seven, however, yields were reduced by 4 per cent for every day that weeds were left uncontrolled. This two-week period was the critical weed-free period for that crop.

Trials with more competitive crops such as swede showed that one single weed removal operation around six weeks after sowing was all that was needed. This gave yields equivalent to that of a crop which was kept weed-free throughout the season.

Conclusions

- Many exciting options on the horizon
- Agronomy decisions can make a big difference on weed competition including
  - Variety
  - Sowing date
  - Grazing
  - Undersowing
- Mechanical weeding is another tool in the toolbox to aid weed control

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