

# Wheat Cultivar Rotation Trial – Take-all root disease

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# Take-all disease of wheat

- *Gaeumannomyces graminis* var. *tritici* (*Ggt*)
- ascomycete soil borne fungus
- *Ggt* infects the roots
- No genetic solution to the control of take-all disease available



Severely take-all infected plant



Typical take-all patch showing stunting and premature ripening of the crop

# Disease development

- **1<sup>st</sup> wheat crop**- very little disease provided break crop is free from take-all carriers
- **2<sup>nd</sup> – 4<sup>th</sup> wheat crop**- severe disease can occur during this period
- **5<sup>th</sup> wheat crop onwards**- take-all severity decreases compared to a crop at its peak. This is known as Take-all Decline (TAD)

**1. Soil core taken angled underneath row**



**THE  
SOIL CORE  
BIOASSAY**

**2. Core inverted into plastic cup**



**3. Ten bait wheat (cv Hereward) seeds sown**



**4. Growth room for 5 weeks**



# Soil core bioassay plants



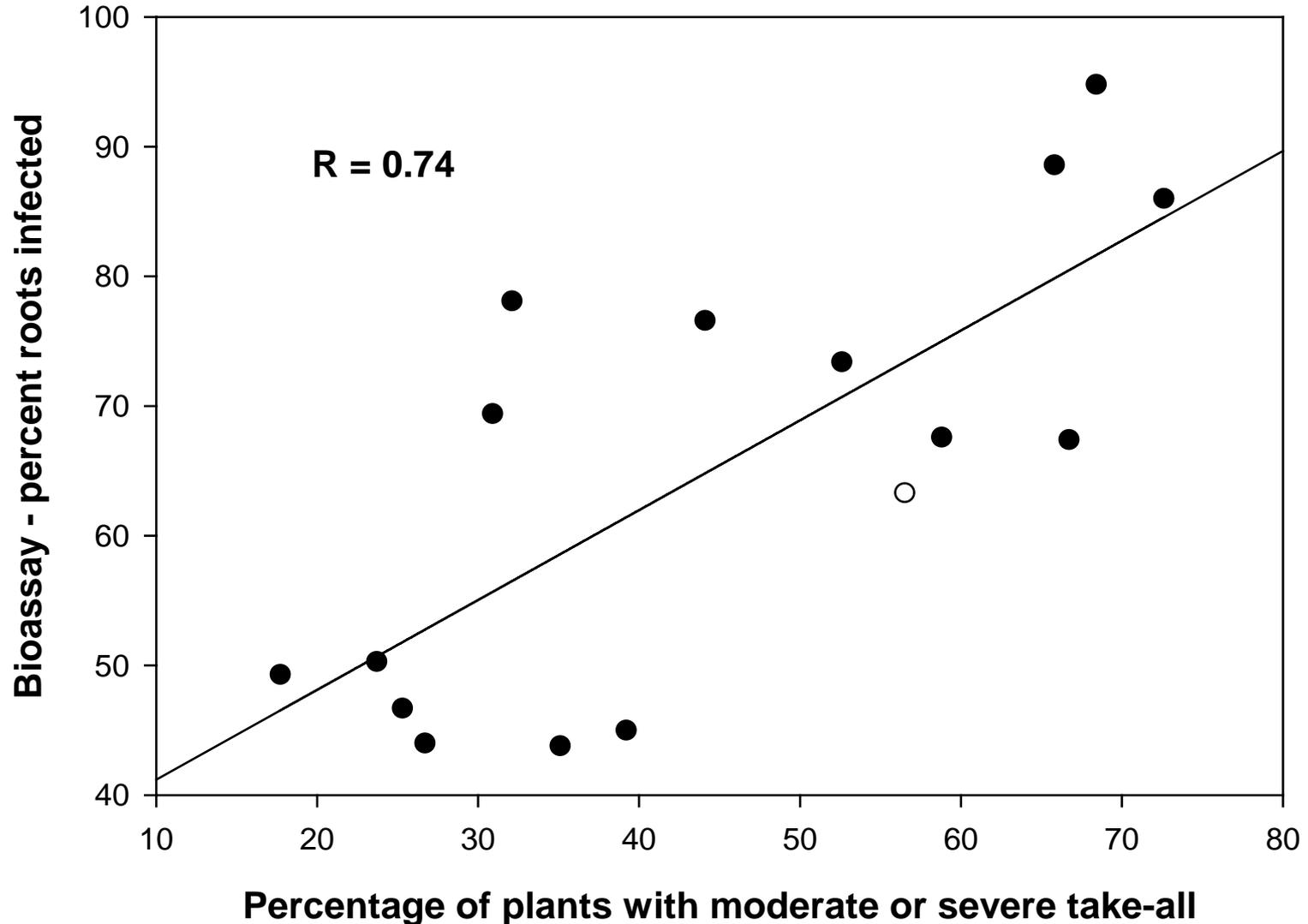
**Severe take-all infection**



**Slight take-all infection**

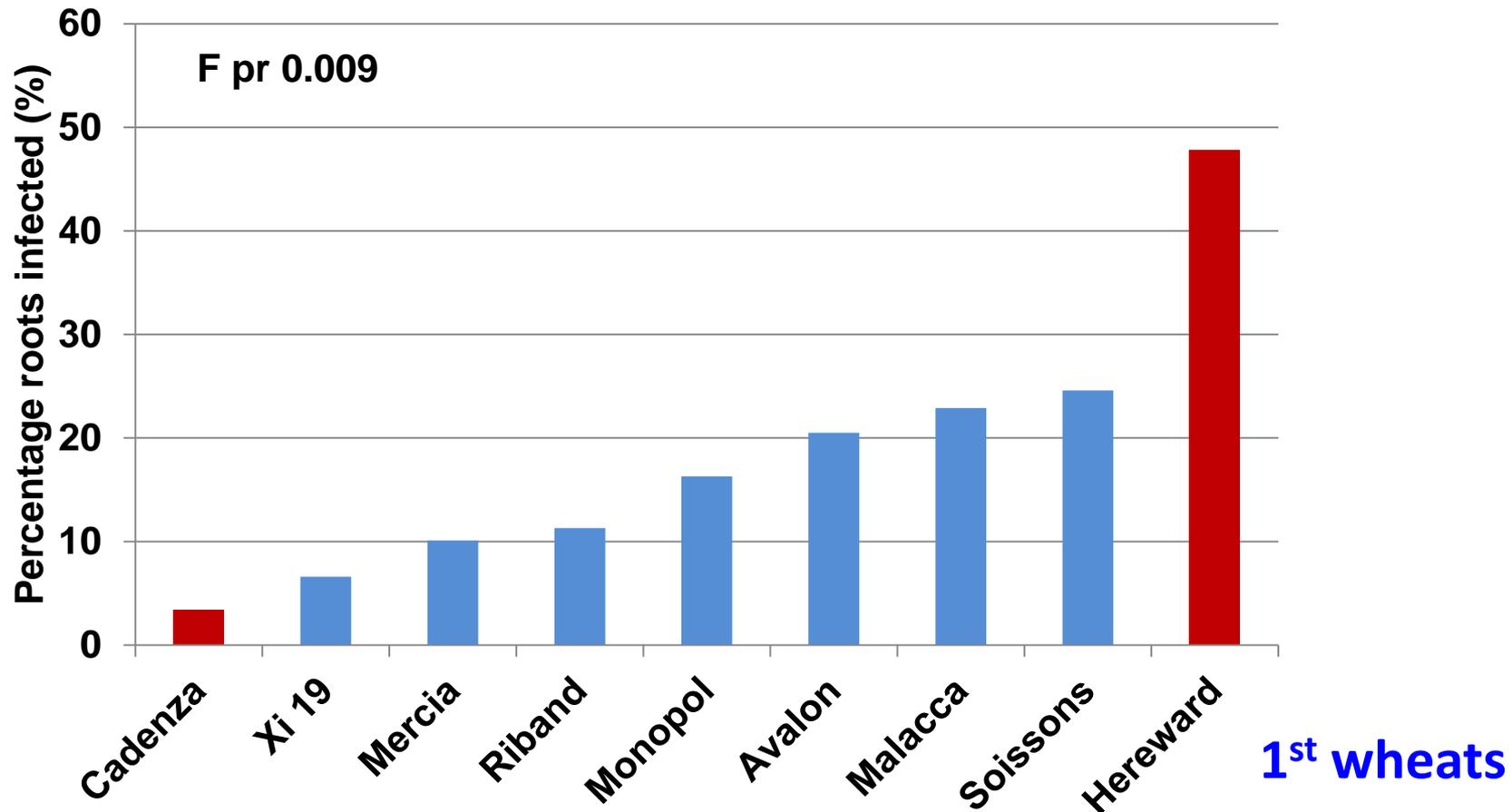
# The relationship between percentage of roots infected in the autumn bioassay and the disease in the following crop

Source - Gutteridge et al. (2008) - HGCA report No 445

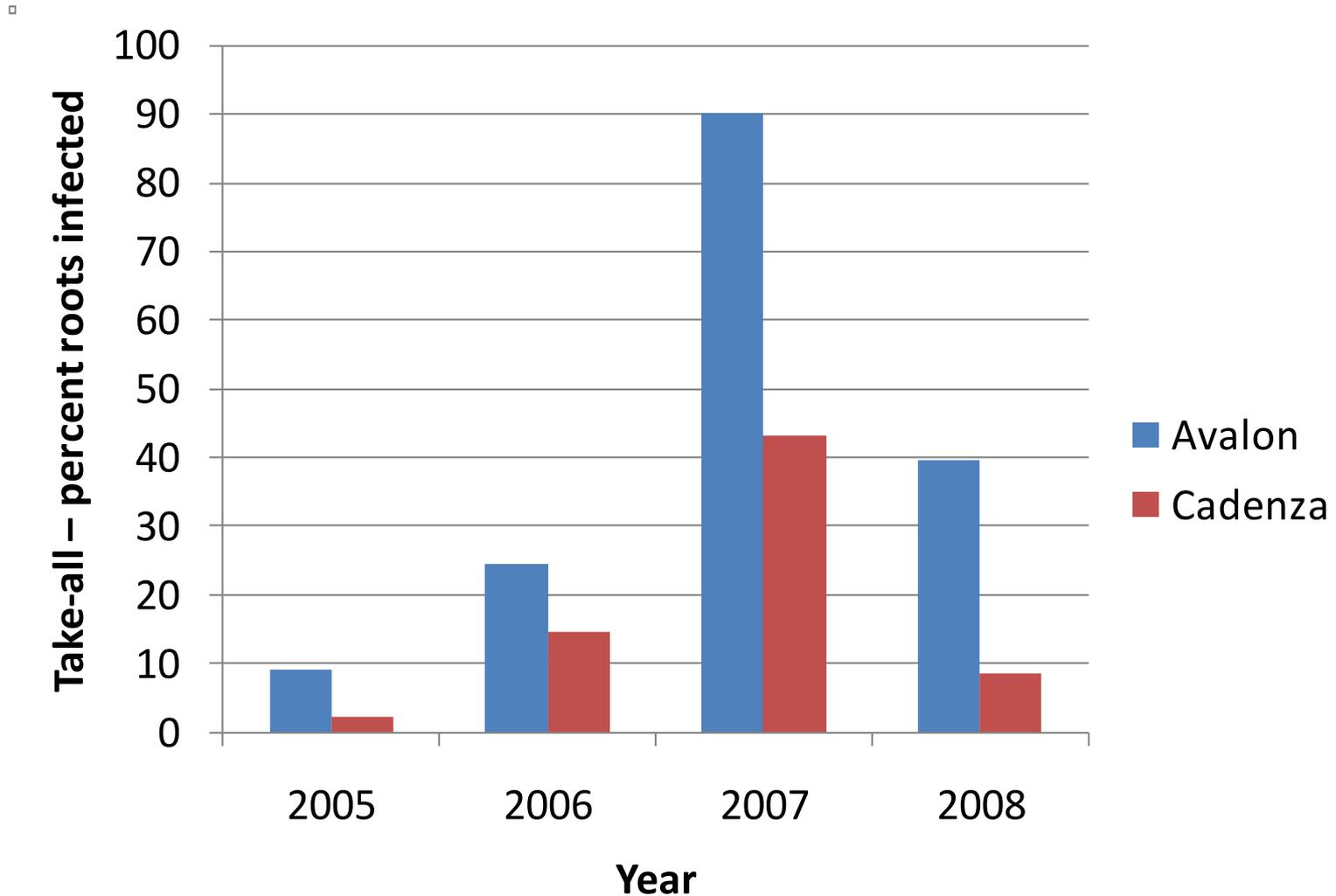


# WGIN winter wheat soil core bioassay (4 year means – 2004-2008)

New trait is called **TAB** (Take-All inoculum Build-up)



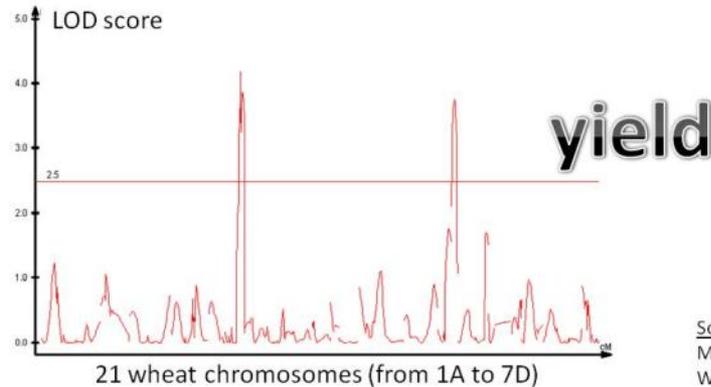
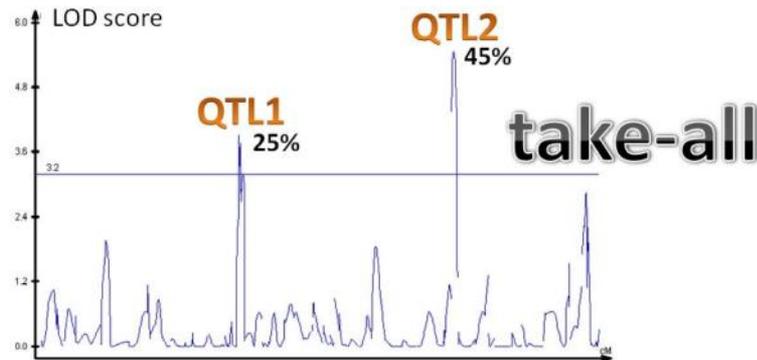
# % roots infected with take-all in a soil core bioassay Avalon and Cadenza 2005 - 2008 WGIN Diversity trials



# Can we genetically analyse and map the trait?

319 markers on the A x C map  
62 DH lines + parents scored

Quantitative Trait Loci (QTL) analysis

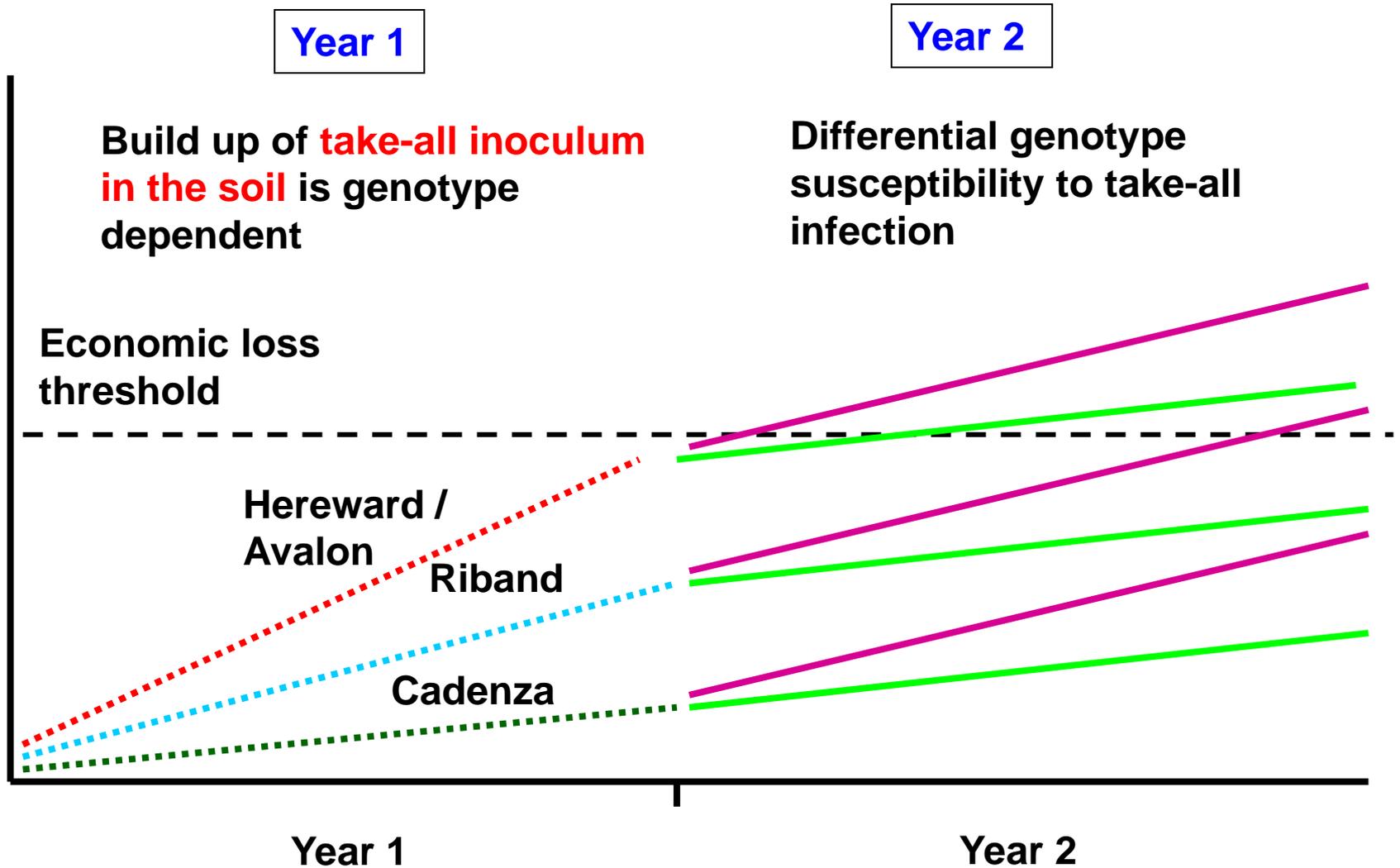


Software used:  
MapQTL5  
Windows QTL Cartographer v2.5

Analysis done by Kostya Kanyuka

# Cultivar rotation trials

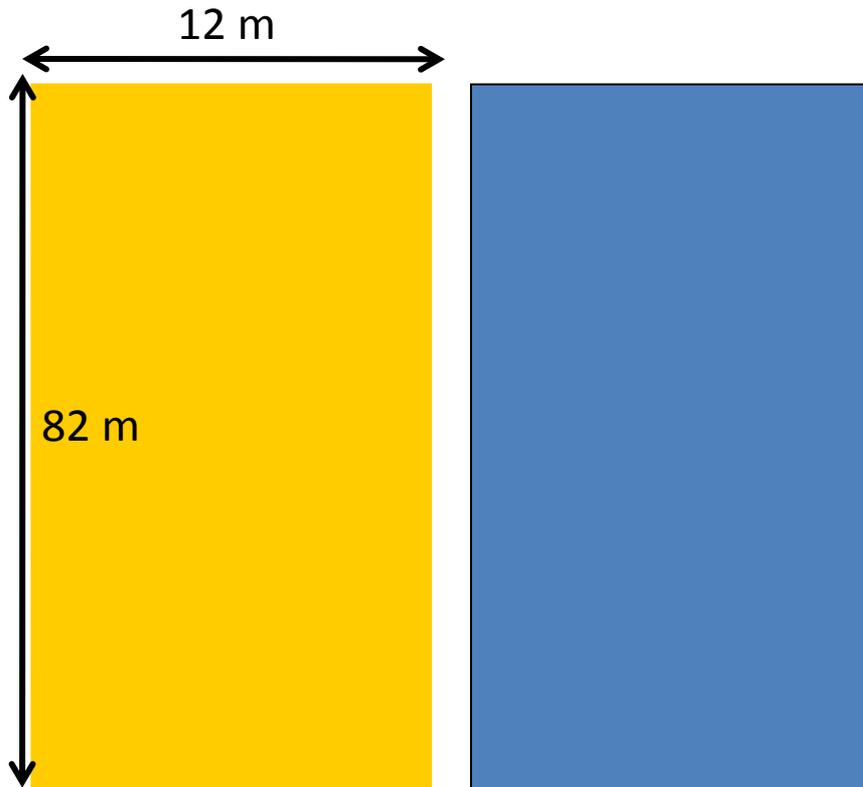
**Overall objective:** Explore the effect of sowing different sequences of cultivars on take-all disease pressure



# Cultivar rotation trials

**Overall objective:** Explore the effect of different cultivar sequences on take-all disease pressure

**Step 1: Year 1** To create different take-all disease pressures in the field using the varieties **Hereward** (high inoculum build up) and **Cadenza** (low inoculum build up)

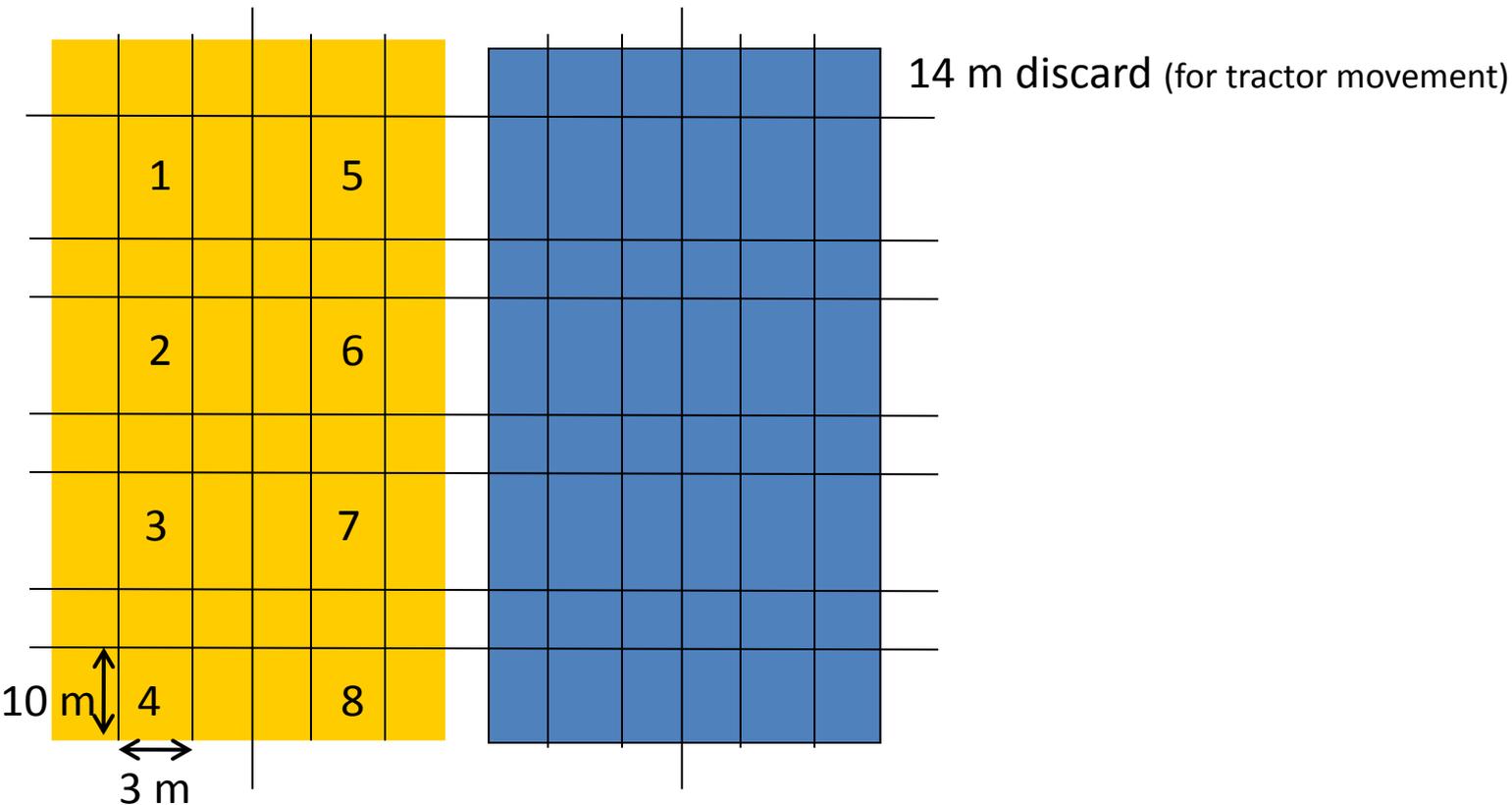


12m x 82m, of each variety  
4 replicates of each

# Cultivar rotation trials

**Overall objective:** Explore the effect of different cultivar sequences on take-all disease pressure

**Step 2: Year 2** Each of the Year 1 large plots **divided into eight 10m x 3m** for the Year 2 field season.

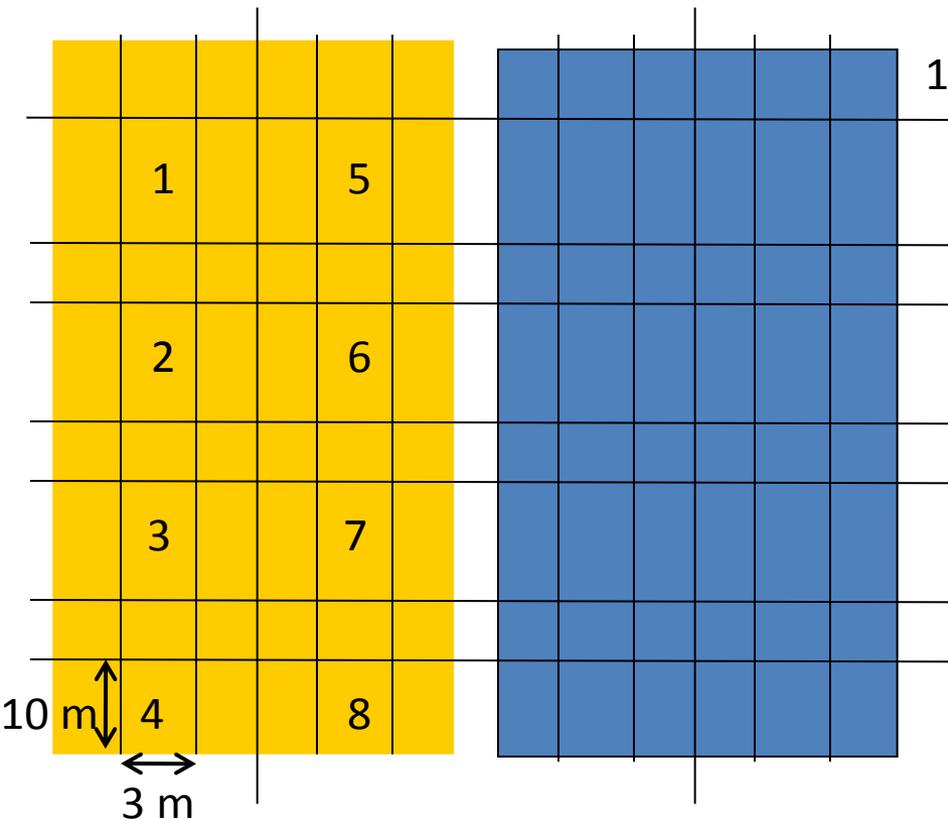


Plan NOT drawn to scale

# Cultivar rotation trials

**Overall objective:** Explore the effect of different cultivar sequences on take-all disease pressure

**Step 2: Year 2** Each of the Year 1 large plots **divided into eight 10m x 3m** for the Year 2 field season.



14 m discard (for tractor movement)

**Year 1:** After harvest of year 1, five soil cores were taken from each of the designated Year 2 plots i.e. 64 plots x 5 = 320 cores.

**Year 2:** Eight different winter wheat cultivars chosen for Year 2. Plant samples taken in spring and summer for take-all disease assessment- Take-all Index calculated (0-100). Yields taken by the Rothamsted farm.

Plan NOT drawn to scale

# The eight selected cultivars for the rotation trial

Drilled as the 2<sup>nd</sup> wheat

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Variety	Nabim group
Hereward	1
Gallant	1
Xi19	1
Solstice	1
Cordiale	2
Einstein	2
Robigus	3
Duxford	4

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# Rotation trial: harvest years 2010 and 2011

## Great Knott 1

Take-all infectivity of the soil after the first wheat source varieties **Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2009-2010)
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots
Source variety	Logit % roots infected (BT means)
Cadenza	-1.87 ( <b>1.8%</b> )
Hereward	-1.72 ( <b>2.6%</b> )
d.f.	3
SED	0.173
F Pr	<b>0.450</b>
Grand mean	-1.79 (2.2)

# Rotation trial: harvest years 2010 and 2011

## Great Knott 1

Take-all infectivity of the soil after the first wheat source varieties **Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2009-2010)	Year 2 (2010-2011)	
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots	Oversow <b>Spring</b> plant samples	
<b>Source variety</b>	Logit % roots infected (BT means)	Logit % plants with take-all (BT means)	Take-all roots per plant
<b>Cadenza</b>	-1.87 ( <b>1.8%</b> )	-1.55 ( <b>3.8</b> )	<b>0.05</b>
<b>Hereward</b>	-1.72 ( <b>2.6%</b> )	-1.37 ( <b>5.5</b> )	<b>0.12</b>
<b>d.f.</b>	3	3	3
<b>SED</b>	0.173	0.039	0.018
<b>F Pr</b>	<b>0.450</b>	<b>0.021</b>	<b>0.039</b>
<b>Grand mean</b>	-1.79 (2.2)	-1.46 (4.7)	0.08

# Rotation trial: harvest years 2010 and 2011

## Great Knott 1

Take-all infectivity of the soil after the first wheat source varieties **Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2009-2010)	Year 2 (2010-2011)			
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots	Oversow <b>Spring</b> plant samples		Oversow <b>Summer</b> plant samples	
<b>Source variety</b>	Logit % roots infected (BT means)	Logit % plants with take-all (BT means)	Take-all roots per plant	Logit % plants with take-all (BT means)	TAI (0-100)
<b>Cadenza</b>	-1.87 ( <b>1.8%</b> )	-1.55 ( <b>3.8</b> )	<b>0.05</b>	-0.56 ( <b>24.2%</b> )	<b>13.49</b>
<b>Hereward</b>	-1.72 ( <b>2.6%</b> )	-1.37 ( <b>5.5</b> )	<b>0.12</b>	-0.38 ( <b>31.5%</b> )	<b>21.07</b>
<b>d.f.</b>	3	3	3	3	3
<b>SED</b>	0.173	0.039	0.018	0.104	2.345
<b>F Pr</b>	<b>0.450</b>	<b>0.021</b>	<b>0.039</b>	<b>0.181</b>	<b>0.048</b>
<b>Grand mean</b>	-1.79 (2.2)	-1.46 (4.7)	0.08	-0.467 (27.9)	17.28

# Rotation trial: harvest years 2010 and 2011

## Great Knott 1

Take-all infectivity of the soil after the **first wheat source varieties Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2009-2010)	Year 2 (2010-2011)				
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots	Oversow <b>Spring</b> plant samples		Oversow <b>Summer</b> plant samples		Oversow Yields
Source variety	Logit % roots infected (BT means)	Logit % plants with take-all (BT means)	Take-all roots per plant	Logit % plants with take-all (BT means)	TAI (0-100)	tonnes/ha
Cadenza	-1.87 ( <b>1.8%</b> )	-1.55 ( <b>3.8</b> )	<b>0.05</b>	-0.56 ( <b>24.2%</b> )	<b>13.49</b>	<b>11.17</b>
Hereward	-1.72 ( <b>2.6%</b> )	-1.37 ( <b>5.5</b> )	<b>0.12</b>	-0.38 ( <b>31.5%</b> )	<b>21.07</b>	<b>10.97</b>
d.f.	3	3	3	3	3	3
SED	0.173	0.039	0.018	0.104	2.345	0.059
F Pr	<b>0.450</b>	<b>0.021</b>	<b>0.039</b>	<b>0.181</b>	<b>0.048</b>	<b>0.043</b>
Grand mean	-1.79 (2.2)	-1.46 (4.7)	0.08	-0.467 (27.9)	17.28	11.07

# Rotation trial: harvest years 2010 and 2011

## Second wheat yields

Main effect of:

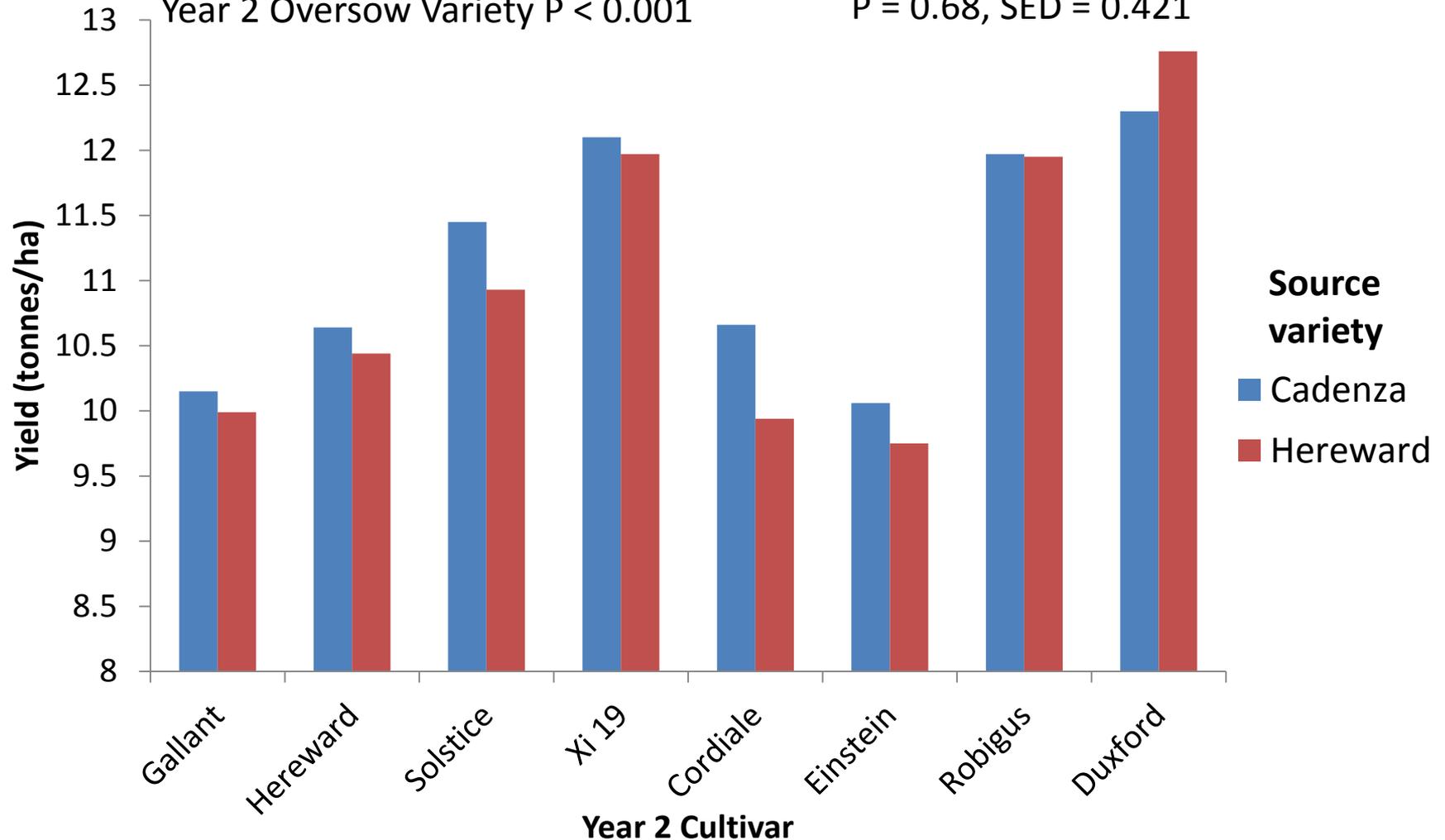
Year 1 Source Variety P = 0.043

Year 2 Oversow Variety P < 0.001

Interaction:

Source\*Oversow variety

P = 0.68, SED = 0.421



# Rotation trial: harvest years 2011 and 2012

## Great Harpenden 2

Take-all infectivity of the soil after the first wheat source varieties Cadenza and Hereward, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2010-2011)
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots
Source variety	Logit % roots infected (Back-transformed means)
Cadenza	-0.73 (18.4%)
Hereward	-0.31 (34.7%)
d.f.	3
SED	0.115
F Probability	0.034
Grand mean	-0.52 (26.6%)

# Rotation trial: harvest years 2011 and 2012

## Great Harpenden 2

Take-all infectivity of the soil after the **first wheat source varieties Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

	Year 1 (2010-2011)	Year 2 (2011-2012)	
	Soil bioassay after harvest of 1 <sup>st</sup> wheat plots	Oversow <b>Spring</b> plant samples (Xi 19 & Hereward plots sampled)	
<b>Source variety</b>	Logit % roots infected (Back-transformed means)	Logit % plants with take-all (Back-transformed means)	Take-all roots per plant
<b>Cadenza</b>	-0.73 ( <b>18.4%</b> )	0.56 ( <b>75.5%</b> )	<b>2.18</b>
<b>Hereward</b>	-0.31 ( <b>34.7%</b> )	1.82 ( <b>97.9%</b> )	<b>4.29</b>
<b>d.f.</b>	3	3	3
<b>SED</b>	0.115	0.216	0.268
<b>F Probability</b>	<b>0.034</b>	<b>0.010</b>	<b>0.004</b>
<b>Grand mean</b>	-0.52 (26.6%)	1.19 (86.7%)	3.23



**X**

**Hereward then Xi19 or Duxford or Solstice**

**27<sup>th</sup> June 2012 - GH2**

A wide-angle photograph of a lush green wheat field. The wheat stalks are tall and dense, with some yellowing at the base. In the center of the field, there is a white square marker containing a black 'X'. The background shows a flat landscape with a few trees, a utility pole, and a building under a cloudy sky.

**X**

**Cadenza then Xi19 or Duxford or Einstein**

**27<sup>th</sup> June 2012 - GH2**

# Rotation trial: harvest years 2011 and 2012

## Great Harpenden 2

Take-all infectivity of the soil after the **first wheat source varieties Cadenza and Hereward**, and take-all disease and yield data in the **subsequent second wheat oversow.**

Year 2 (2011-2012)			
	Oversow Summer measurements		Oversow Summer plant samples
Source variety	Take-all patch score (% area)	Canopy height pre-harvest (cm)	TAI (0-100)
Cadenza	<b>49.4</b>	<b>63.55</b>	<b>73</b>
Hereward	<b>81.3</b>	<b>57.75</b>	<b>94</b>
d.f.	3	3	
SED	3.72	0.818	
F Probability	<b>0.003</b>	<b>0.006</b>	
Grand mean	65.4	60.65	

**N.B. Summer plant samples still to be statistically analysed**

# Rotation trial: harvest years 2011 and 2012

## Great Harpenden 2

Take-all infectivity of the soil after the **first wheat source varieties Cadenza and Hereward**, and take-all disease and yield data in the subsequent second wheat oversow.

Year 2 (2011-2012)					
	Oversow Summer measurements		Oversow Summer plant samples	Oversow Yield	
Source variety	Take-all patch score (% area)	Canopy height pre-harvest (cm)	TAI (0-100)	Grain yield (tonnes/ha)	Straw yield (tonnes/ha)
Cadenza	<b>49.4</b>	<b>63.55</b>	<b>73</b>	<b>8.60</b>	<b>5.57</b>
Hereward	<b>81.3</b>	<b>57.75</b>	<b>94</b>	<b>6.18</b>	<b>4.25</b>
d.f.	3	3		3	3
SED	3.72	0.818		0.338	0.167
F Probability	<b>0.003</b>	<b>0.006</b>		<b>0.006</b>	<b>0.004</b>
Grand mean	65.4	60.65		7.39	4.91

**N.B. Summer plant samples still to be statistically analysed**

# Rotation trial: harvest years 2011 and 2012

## Second wheat yields

Main effect of:

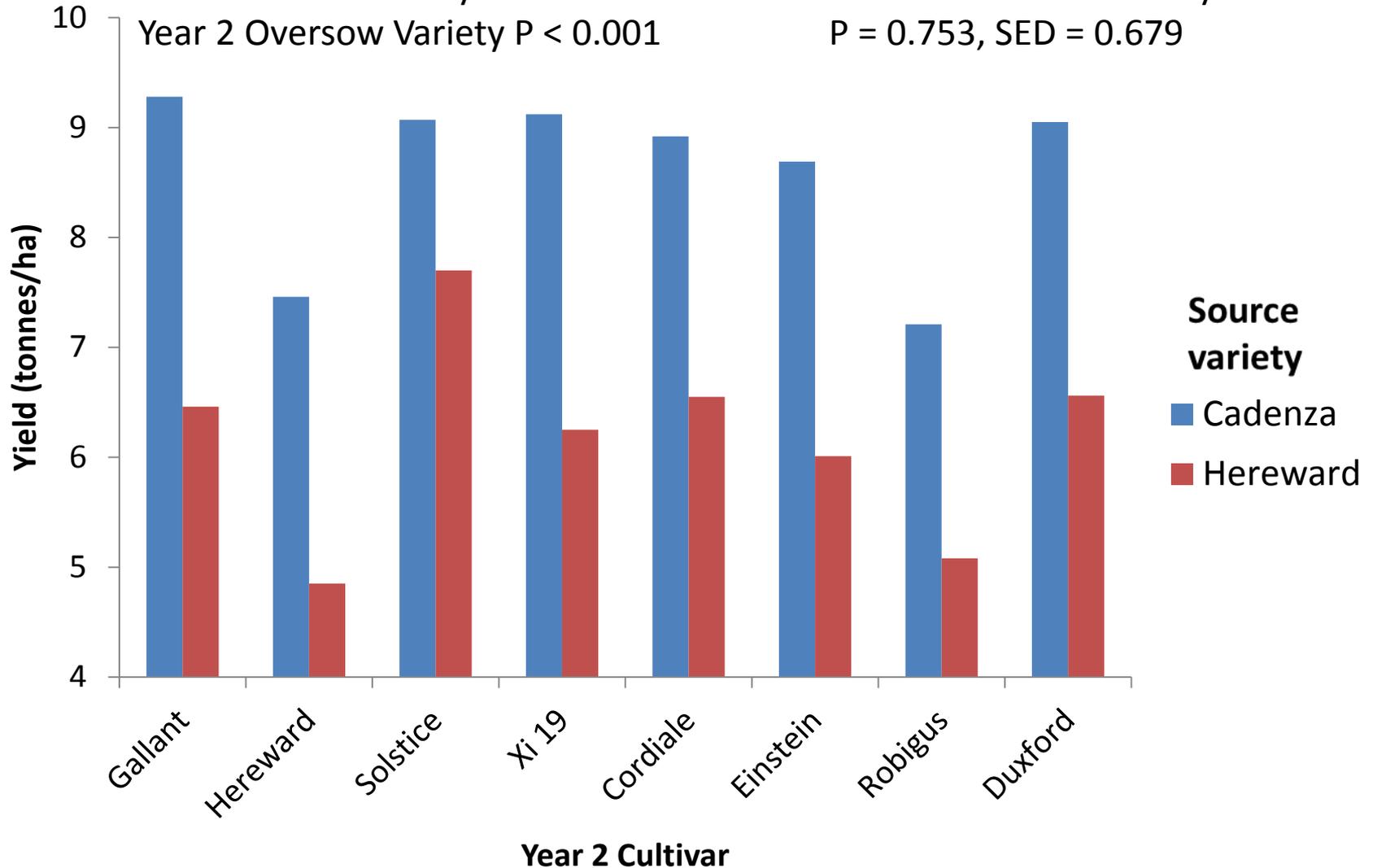
Year 1 Source Variety  $P = 0.006$

Year 2 Oversow Variety  $P < 0.001$

Interaction:

Source\*Oversow variety

$P = 0.753$ ,  $SED = 0.679$



# The current WGIN Cultivar Rotation trial

Rotation trial: harvest years 2012 and 2013

**Field: Drapers**

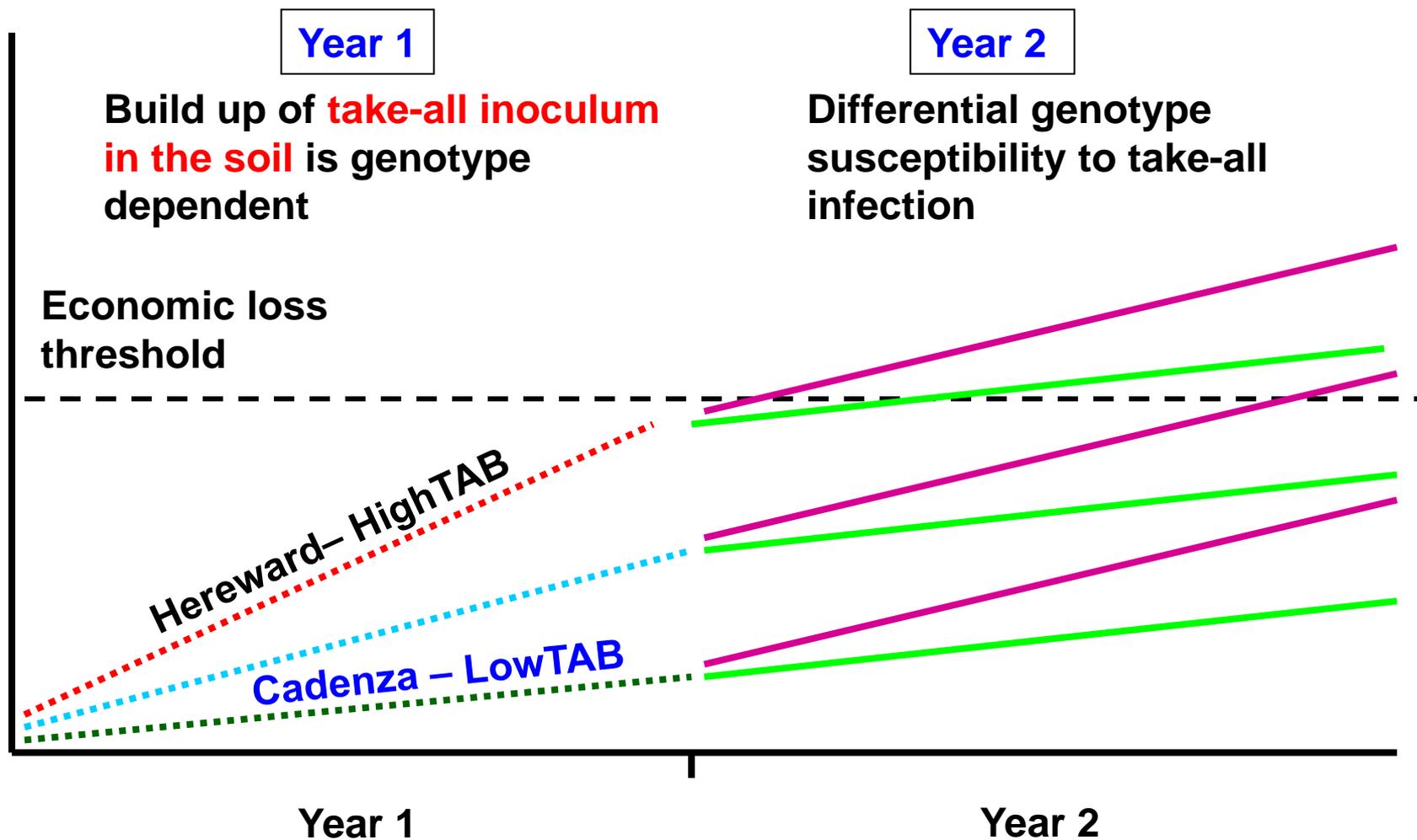
Soil cores taken after harvest in August 2012, still to be processed, expected high take-all inoculum build-up year.

## Summary : Cultivar rotation trials

Using 1<sup>st</sup> wheat genetics to improve 2<sup>nd</sup> wheat crop yield performance

- **Less take-all disease** in a 2<sup>nd</sup> wheat crop when Cadenza is grown as the 1<sup>st</sup> wheat (n = 8 cultivars, 2<sup>nd</sup> wheats)
- **Fewer plants infected and less severe root disease**
- **Grain yield advantage** in the 2<sup>nd</sup> wheat crop
  - 0.2 t /ha (good growing season – 2011)
  - 2.42 t /ha (difficult growing season – 2012)
- **The LowTAB trait is major QTL based**

# New concept : Using wheat cultivar rotations to lower the take-all risk - genetic solution





# Many thanks to



## RRes Farm staff

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Gail Canning

Rodger White (Stats)



## Summer students & casuals

David Franklin (WGIN)  
Martha Jones (WGIN)  
Nicola Phillips (HGCA)  
Joseph Whittaker (BBSRC)  
Adrian Czaban (WGIN)  
Marcin Czaban (WGIN)  
James Bruce (HGCA-BBSRC)  
Steve Freeman (WGIN)  
Carl Halford (WGIN)  
Daniela Izera (WGIN)  
Mike Hammond-Kosack (TSB)  
Mike Hall (TSB-WGIN)