Making historic data available for future challenges: the Rothamsted experience

Korean Long-Term Experiments Symposium
26th October 2023

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ROTHAMSTED RESEARCH

Overview of presentation

- Brief description of Rothamsted and the long-term experiments (LTEs)
- LTE management
- Data archiving
- Data usage

Rothamsted Research Today

- **2 campuses + 2 additional field trial sites**
  830 ha of field environment
  - Harpenden, Woburn and Brooms Barn – arable systems
  - North Wyke – grassland systems and livestock

- **~500 people >35 nationalities**
  + collaborations in over 50 countries
- **>300 publications per year**
  in international scientific journals

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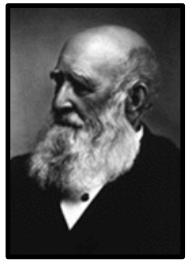
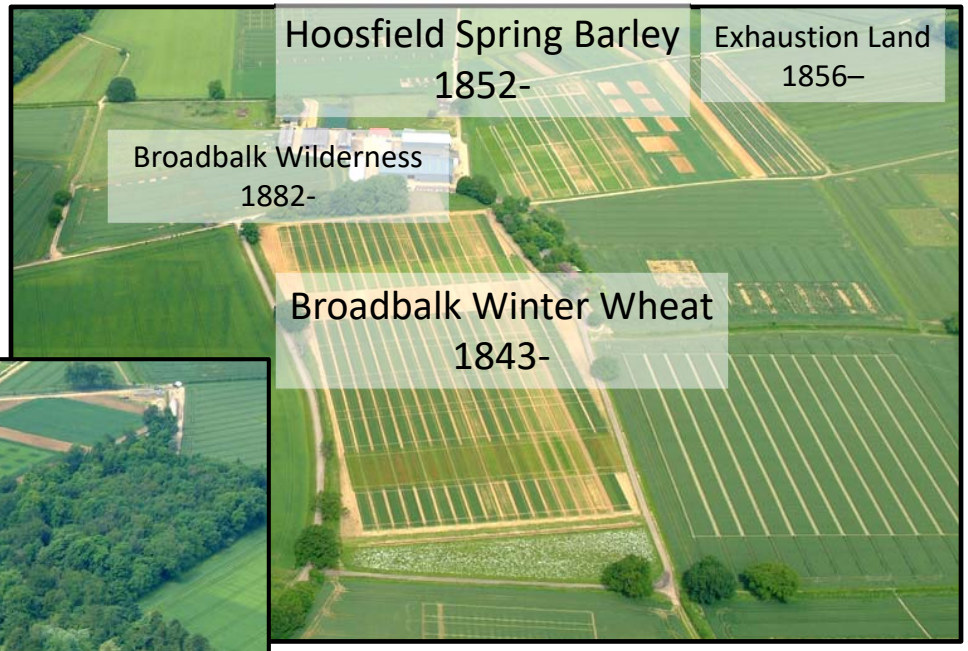
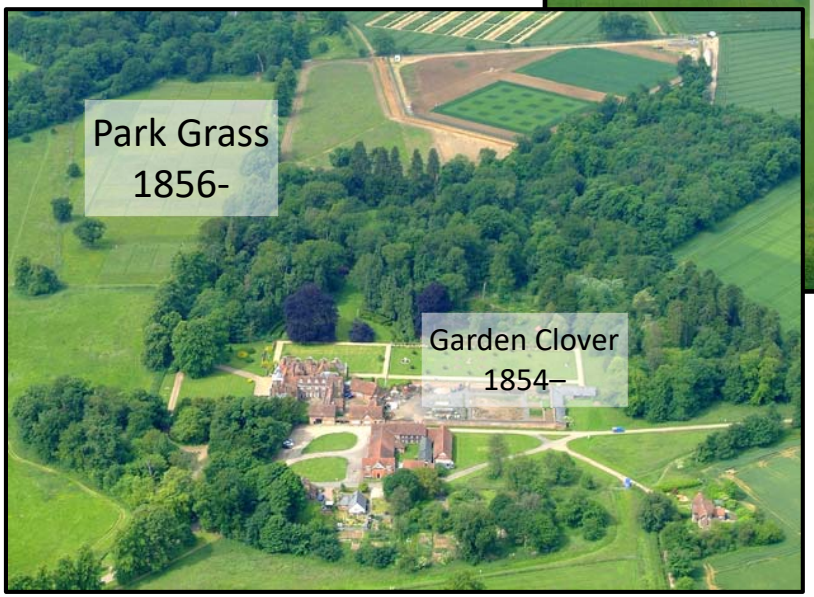
Original Rothamsted LTEs: the “Classicals”

Lawes
1814-1900



Gilbert
1817-1901





- Lawes & Gilbert established the original ‘Classical Experiments’ between 1843 and 1886.
- To test effects of fertilizers supplying N, P, K, Mg and Na on the main crops, wheat, barley, hay, legumes and roots.
- Some discontinued but seven continue today

https://www.rothamsted.ac.uk/long-term-experiments

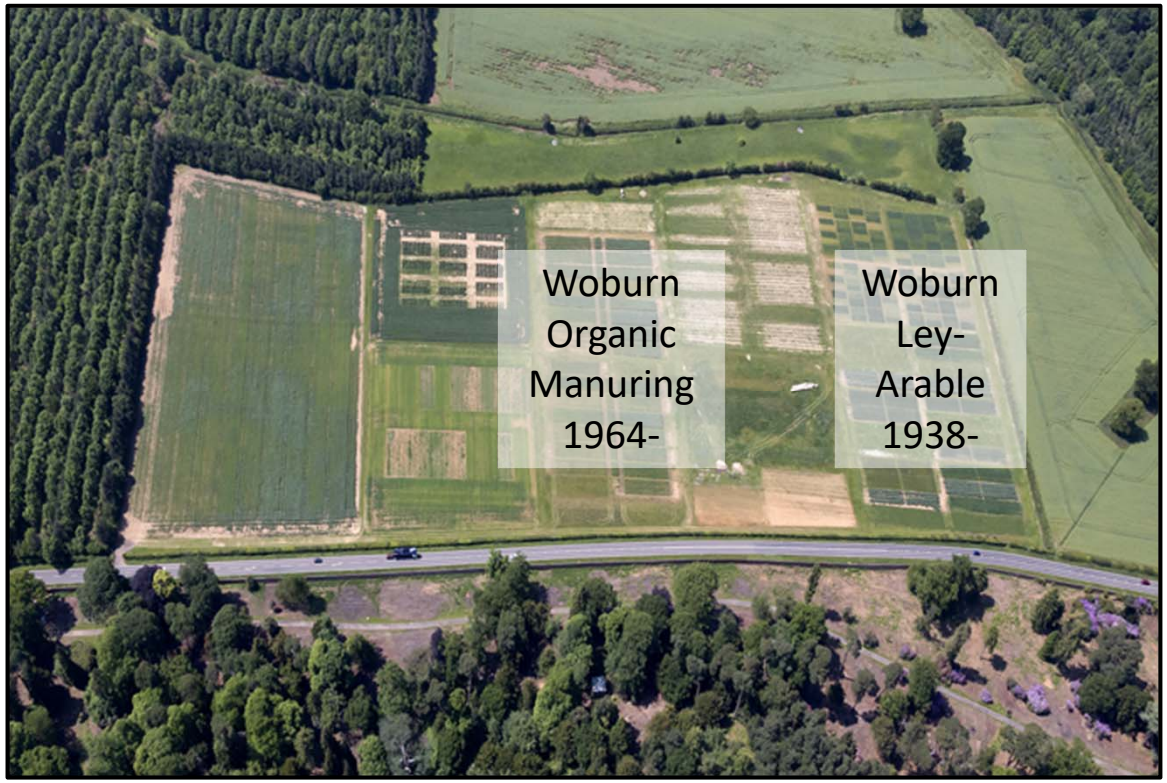
Other LTEs

Harpenden

Harpenden &
Brooms Barn

Large Scale
Rotation
Experiment
2016

Woburn



https://www.era.rothamsted.ac.uk/

Meteorological data

ROTHAMSTED RESEARCH

- Meteorological stations
  - Harpenden (1853-)
  - Woburn (1928-)
  - Broom's Barn (1982-)
- Fully automated
- Real-time daily and yearly weather charts available on-line

https://www.era.rothamsted.ac.uk/

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Management of the LTEs 1 – standard practices

- Managed by standard farm practice - pesticides, liming, ploughing, etc

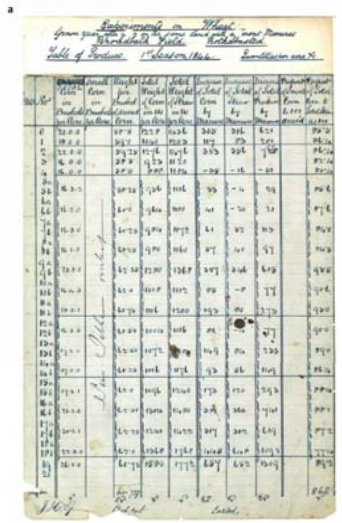
- Large plots:
  - Standard farm machinery for seedbed preparation, field-plot machinery for harvesting
  - Sub-plots to test other treatments - N rates etc

- Baseline and routine soil measurements:
  - %SOC, %N, pH, soil texture, bulk density,
  - Same depth
  - Sub-soil samples

Management of the LTEs 2 – record keeping

- From the start, meticulous record keeping:
  - Crop yields, nutrient uptake, species composition, weeds, disease surveys, etc
  - Key dates – sowing, harvest, ploughing, fertilizer, etc
  - Full details of all treatments (amount, type, date)
  - Full details of crops grown – varieties, seed mix, etc
  - Full details of all management (pesticides, seedbed preparation, etc)

- Soil and crop samples kept from the start



Historical record sheets **a.** Broadbalk Yields 1st Season 1844; **b**. Park Grass hay produce 1856 cut June 25th carted July 1st.

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Rothamsted Sample Archive

- Started by Lawes and Gilbert in 1843
- Comprises over 300,000 dried samples:
  - crop (grain, straw, herbage, etc.)
  - soil
  - inputs (fertilisers, manures, etc.)
- About 1200 crop & 200 soil samples added each year
- Originally analysed for nutrient content
- Now used for many more studies with new analytical techniques
- On-going digitisation and cataloguing of samples and their associated records
- Available for collaborative use
- Key to understanding and interpreting the LTEs

- https://www.rothamsted.ac.uk/sample-archive

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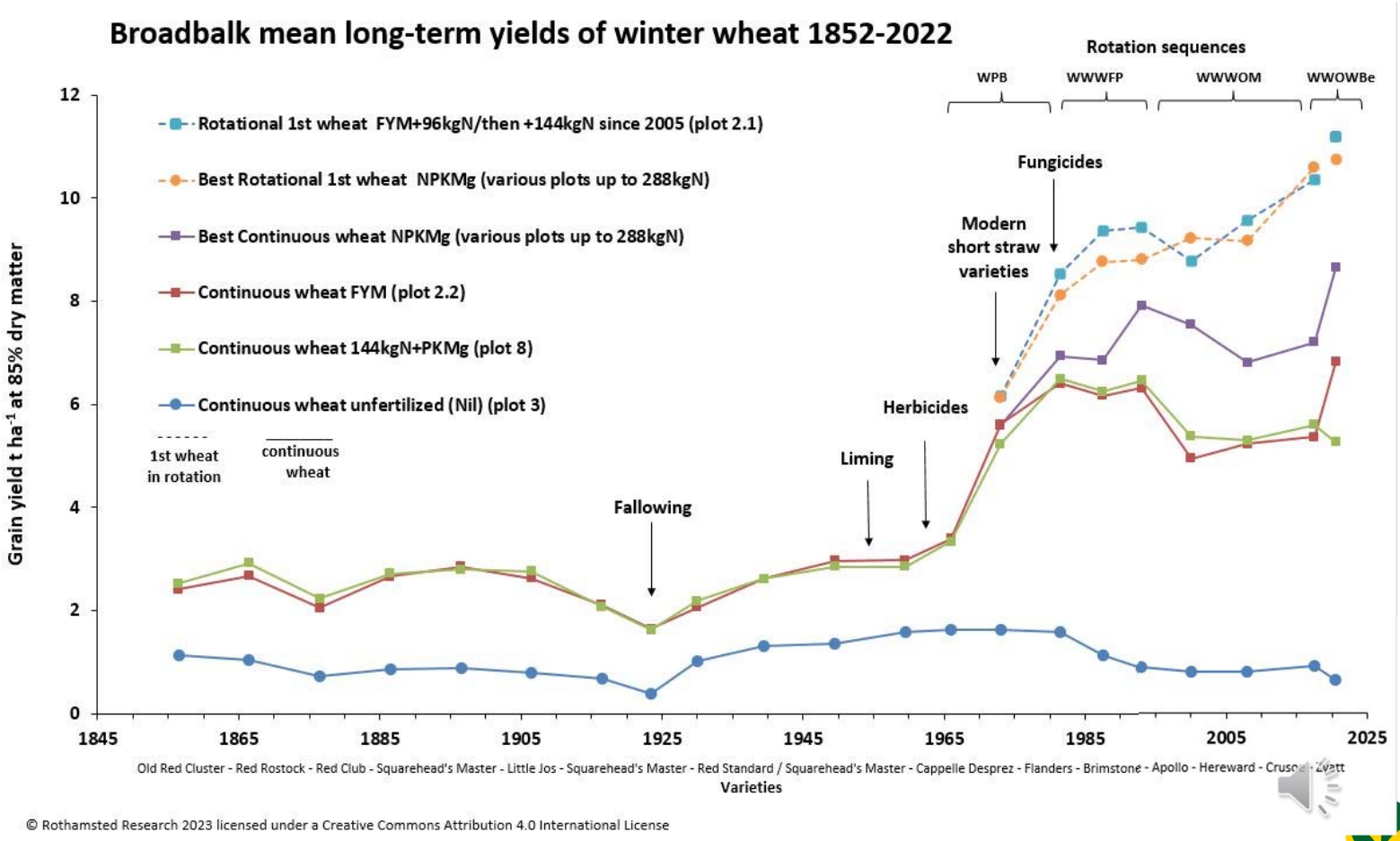
Management of the LTEs 3 – making changes

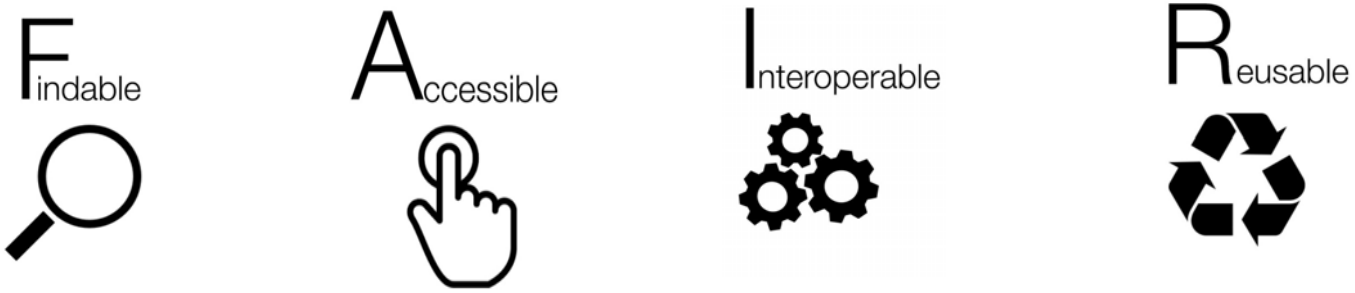
LTEs are not museums – some change is necessary

- To avoid failure: weed control, soil pH
- To keep relevant to current agriculture: modern cultivars, higher N rates, crop protection
- To maintain long-term integrity: keep original treatments, control plots



Data management: Making data more accessible

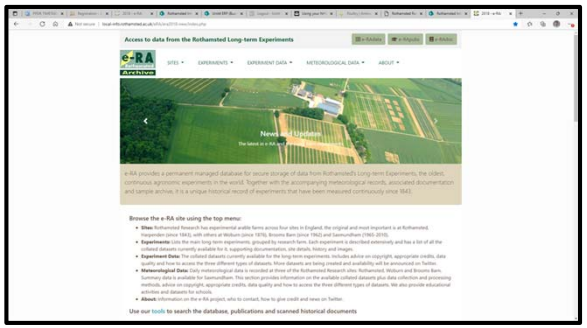
- LTES will have the greatest impact if their data can be found, understood and reused
- Most publicly funded science now requires that data is widely accessible to all
- We are adopting FAIR data principles to make the Rothamsted LTE data:



Wilkinson et al, 2016 The FAIR guiding principles for scientific data management and stewardship *Scientific Data* **3,** 160018 **DOI: 10.1038/sdata.2016.18**

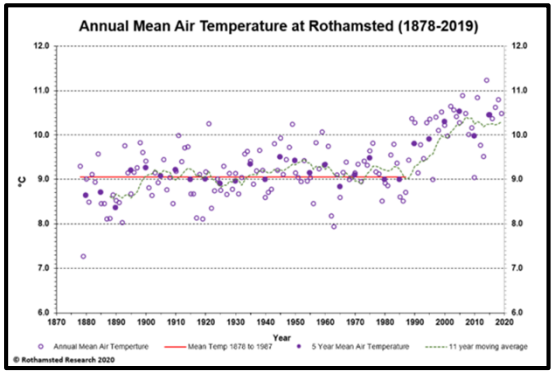
Data archiving 1: e-RA (*electronic* Rothamsted Archive)

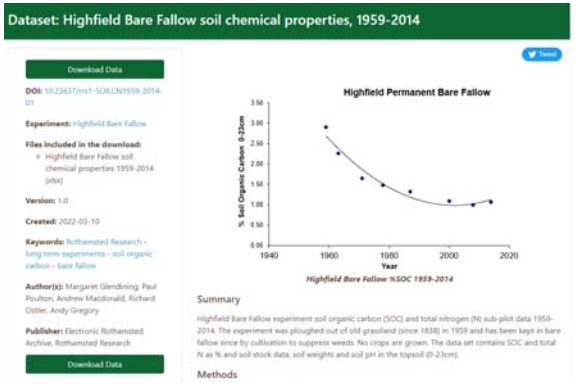
- Permanent managed database for secure storage of data from the LTEs
- Data is free and accessible to all
- First port of call for information on:
  - sites and experiments
  - experimental datasets
  - meteorological datasets
- Types of data
  - Registration datasets (password)
  - Open Access datasets (DOI)
    - Summary
    - Frictionless – full metadata included
- Supported by **e-RA curators**, guide users to appropriate datasets, answer queries



Data extracted from PGHAYEQUIV

plot	cut	year	start_cut	drymatter	drymatterpc	area
				t/ha	%	ha
2-1a	1	2017	20-06-2017	0.848	25.42	0.00156
2-1b	1	2017	20-06-2017	1.443	22.17	0.00191
2-1c	1	2017	20-06-2017	0.845	24.71	0.00178
2-1d	1	2017	20-06-2017	0.522	32.06	0.00191
2-2a	1	2017	20-06-2017	1.632	27.35	0.00156
2-2b	1	2017	20-06-2017	1.717	24.05	0.00191
2-2c	1	2017	20-06-2017	0.929	30.12	0.00178
2-2d	1	2017	20-06-2017	0.882	34.99	0.00191

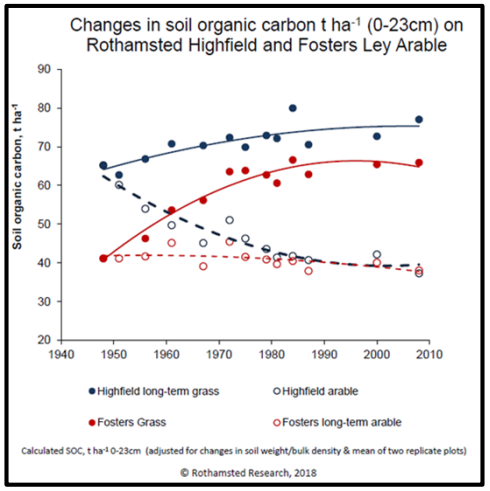


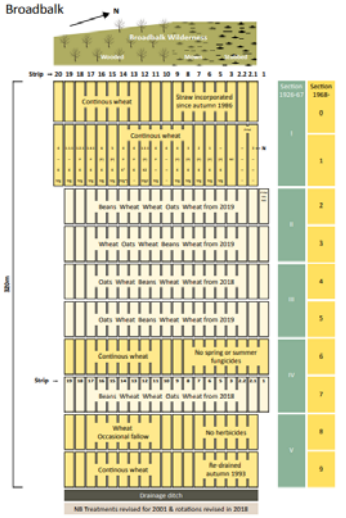


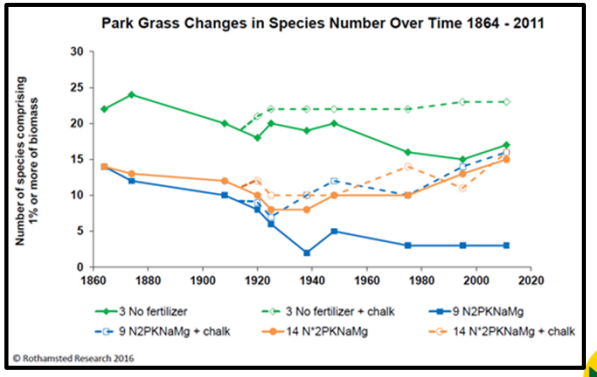
Data archiving 2: data in e-RA

- **Data**: yields, crop nutrients, soil properties, species, disease scores, weed surveys…
- **Background information:** plans, treatments, site details, images…
- **Supporting information**: key references, analytical techniques…

- **e-RApubs** *c*omprehensive bibliography**:** 1,900+ papers relating to the LTEs
- **e-RAdoc:** scanned document archive– DOIs, accessible, searchable
- www.era.rothamsted.ac.uk







Challenges to curation of data from the LTEs

- Conflict between continuity of management and relevance to modern agriculture and environmental issues
- New areas of research
- Changes in methodology
  - Analytical techniques
  - Field measurements
  - Different varieties/crop rotations/fertilizers

➡ Rely on adequate metadata to explain changes

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ROTHAMSTED RESEARCH

Publishing Open Access Datasets

Dataset: Woburn long-term liming experiment grain mineral composition

Download Data

DOI: 10.23637/wcs10-wltlgrain-01

Experiment: Woburn Long Term Liming

Files included in the download:
- Frictionless data package containing the grain data described here (zip)

Version: 1.0

Created: 2021-03-18

Updated: 2021-07-22

Keywords: wheat - Rothamsted Research - soil pH - long term experiments - phosphorous - liming - barley - mineral content - trace elements - oats

Author(s): Lionel Jordan Meille, Jonathan Holland, Steve McGrath, Margaret Glendining, Cathy Thomas, Stephan Haefele

Publisher: Electronic Rothamsted Archive, Rothamsted Research

Download Data

Tweet

Summary

The experiment tests the effects of four different amounts of lime (creating a soil pH range for approximately 4.5 to 7.5) with and without fertilizer P, on the grain mineral compostion of three arable crops. The site is a sandy loam soil at Woburn Experimental Farm, from 1962-1996. There was a parallel experiment on a silty clay loam soil at Rothamsted Experimental Farm. The dataset contains grain mineral compostion for 20 different minerals (mg/kg dry soil), for individual plots, measured in 1978, 1981 and 1995. It includes details of the lime and fertilizer treatments, and crop yield.

Methods

Grain mineral composition was determined, in 2019 and 2020, on archived ground samples grown in 1978 (barley), 1981 (oats) and 1995 (wheat). Macro-nutrients (Ca, K, Mg, Na, P, S) and Al, Fe and Ti were determined by open tube digestion with $HNO_3/HClO_4$ and measured with ICP-OES. Micro-nutrients and trace elements (As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Se, and Zn) were determined with microwave digestion with HNO_3/H_2O_2, then measured with ICP-MS.

Technical Information

Related Documents
- Holland et al. (2019) Paper describing yield response of all crops 1962-1996;
- Woburn long-term liming experiment plans 1962-1996;
- Woburn long-term liming experiments lime and fertilizer treatments 1962-1996;
- Jordan-Meille et al. (2021) Paper describing grain mineral composition;

Related Datasets
- Woburn long-term liming experiment crop yields 1962-1996
- Rothamsted long-term liming experiment grain mineral composition

Contributors
- **Sarah Perryman:** Data curator
- **Margaret Glendining:** Data curator
- **Richard Ostler:** Project manager
- **Ruth Skilton:** Data collector
- **Nathalie Castells:** Data manager
- **Steve McGrath:** Project manager
- **Jonathan Holland:** Researcher
- **Lionel Jordan Meille:** Researcher
- **Cathy Thomas:** Researcher
- **Stephan Haefele:** Project manager
- **Mark Durenkamp:** Data collector
- **Chloe Garwood:** Data collector

Dataset Access and Conditions

Rights Holder

Rothamsted Research

License

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Cite this Dataset

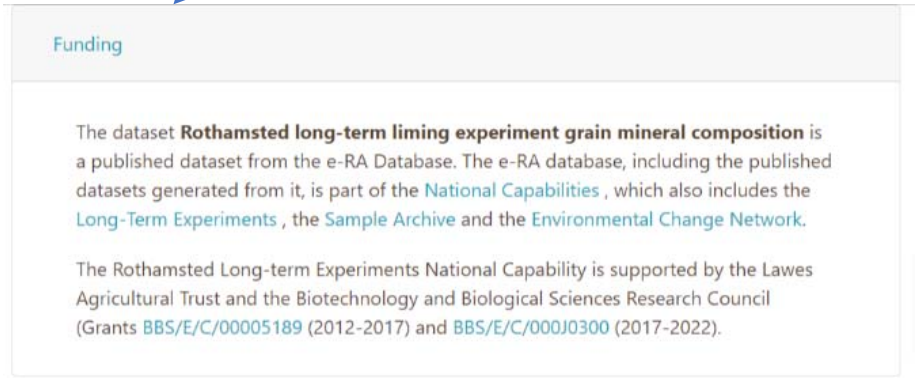
YOU MUST CITE AS: Lionel Jordan Meille, Jonathan Holland, Steve McGrath, Margaret Glendining, Cathy Thomas, Stephan Haefele (2021). Dataset: Woburn long-term liming experiment grain mineral composition *Electronic Rothamsted Archive, Rothamsted Research* https://doi.org/10.23637/wcs10-wltlgrain-01

iew our How to Credit Datasets guidance for more information.

of Use

id relies on the integrity of users to ensure that datasets are used appropriately and Rothamsted Research receives suitable acknowledgment as being the originators of these data. Please review the Conditions of Use before downloading.

- Assigned DOIs
- Published on the Rothamsted LTE data repository (e-RA)
- Related documents & datasets identified
- Keywords
- Technical metadata on sampling and analytical protocols
- Recognizes contributions from all staff involved
- Licence and conditions of use including recommended citation
- Funding information (grant number, funder)



Funding

The dataset **Rothamsted long-term liming experiment grain mineral composition** is a published dataset from the e-RA Database. The e-RA database, including the published datasets generated from it, is part of the National Capabilities , which also includes the Long-Term Experiments , the Sample Archive and the Environmental Change Network.

The Rothamsted Long-term Experiments National Capability is supported by the Lawes Agricultural Trust and the Biotechnology and Biological Sciences Research Council (Grants BBS/E/C/00005189 (2012-2017) and BBS/E/C/000J0300 (2017-2022).

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Data formatting

- Simple tabular CSV format (Tidy Data format- observations as rows, variables as columns)
- Easy to use with R and Python

Positional data, identifies plots in time and space

Treatment factors – what was applied to the plots

Observed and Measured data

sample_year	strip	old_section	section	soil_dep	cropping	straw_incorporation	herbicide	fungicide	n_rate	other_fertiliser_combination	soil_organic_carbon	soil_total_nitrogen	olsen_p	bulk_density	calculated_soc_content
1988	3	Ia	0	0-23	Continuous wheat	S1	H1	F1	N0	Nil	0.93	0.105	6	1.252	26.78
1987	3	Ib	1	0-23	Continuous wheat	S0	H1	F1	N0	Nil	0.98	0.108	4	1.252	28.22
1988	3	II	2	0-23	Wheat in rotation	S0	H1	F1	N0	Nil	0.88	0.088	8	1.252	25.34
1988	3	II	3	0-23	Wheat in rotation	S0	H1	F1	N0	Nil	0.77	0.078	9	1.252	22.17
1987	3	III	4	0-23	Wheat in rotation	S0	H1	F1	N0	Nil	0.79	0.092	9	1.252	22.75
1988	3	III	5	0-23	Wheat in rotation	S0	H1	F1	N0	Nil	0.85	0.082	8	1.252	24.48
1987	3	IV	6	0-23	Continuous wheat	S0	H1	F0	N0	Nil	ns	ns	ns	1.252	ns
1987	3	IV	7	0-23	Wheat in rotation	S0	H1	F1	N0	Nil	0.83	0.090	6	1.252	23.90
1987	3	Va	8	0-23	Continuous wheat	S0	H0	F1	N0	Nil	ns	ns	ns	1.252	ns
1987	3	Vb	9	0-23	Continuous wheat	S0	H1	F1	N0	Nil	0.83	0.095	5	1.252	23.90
1988	5	Ia	0	0-23	Continuous wheat	S1	H1	F1	N0	PKMg	0.97	0.102	102	1.252	27.93
1987	5	Ib	1	0-23	Continuous wheat	S0	H1	F1	N0	PKMg	0.94	0.108	72	1.252	27.07
1988	5	II	2	0-23	Wheat in rotation	S0	H1	F1	N0	PKMg	0.77	0.085	86	1.252	22.17
1988	5	II	3	0-23	Wheat in rotation	S0	H1	F1	N0	PKMg	0.77	0.085	88	1.252	22.17
1987	5	III	4	0-23	Wheat in rotation	S0	H1	F1	N0	PKMg	0.77	0.092	70	1.252	22.17
1988	5	III	5	0-23	Wheat in rotation	S0	H1	F1	N0	PKMg	0.82	0.084	91	1.252	23.61
1987	5	IV	6	0-23	Continuous wheat	S0	H1	F0	N0	PKMg	ns	ns	ns	1.252	ns
1987	5	IV	7	0-23	Wheat in rotation	S0	H1	F1	N0	PKMg	0.87	0.095	67	1.252	25.05
1987	5	Va	8	0-23	Continuous wheat	S0	H0	F1	N0	PKMg	ns	ns	ns	1.252	ns
1987	5	Vb	9	0-23	Continuous wheat	S0	H1	F1	N0	PKMg	0.88	0.099	82	1.252	25.34
1988	6	Ia	0	0-23	Continuous wheat	S1	H1	F1	N1	PKMg	1.02	0.104	102	1.252	29.37
1987	6	Ib	1	0-23	Continuous wheat	S0	H1	F1	N1	PKMg	1.00	0.117	65	1.252	28.80
1988	6	II	2	0-23	Wheat in rotation	S0	H1	F1	N1	PKMg	0.82	0.091	91	1.252	23.61
1988	6	II	3	0-23	Wheat in rotation	S0	H1	F1	N1	PKMg	0.90	0.091	92	1.252	25.92
1987	6	III	4	0-23	Wheat in rotation	S0	H1	F1	N1	PKMg	0.79	0.095	80	1.252	22.75
1988	6	III	5	0-23	Wheat in rotation	S0	H1	F1	N1	PKMg	0.88	0.085	98	1.252	25.34
1987	6	IV	6	0-23	Continuous wheat	S0	H1	F0	N1	PKMg	ns	ns	ns	1.252	ns
1987	6	IV	7	0-23	Wheat in rotation	S0	H1	F1	N1	PKMg	0.90	0.098	85	1.252	25.92
1987	6	Va	8	0-23	Continuous wheat	S0	H0	F1	N1	PKMg	ns	ns	ns	1.252	ns
1987	6	Vb	9	0-23	Continuous wheat	S0	H1	F1	N1	PKMg	1.02	0.108	92	1.252	29.37

GLTEN Metadata portal

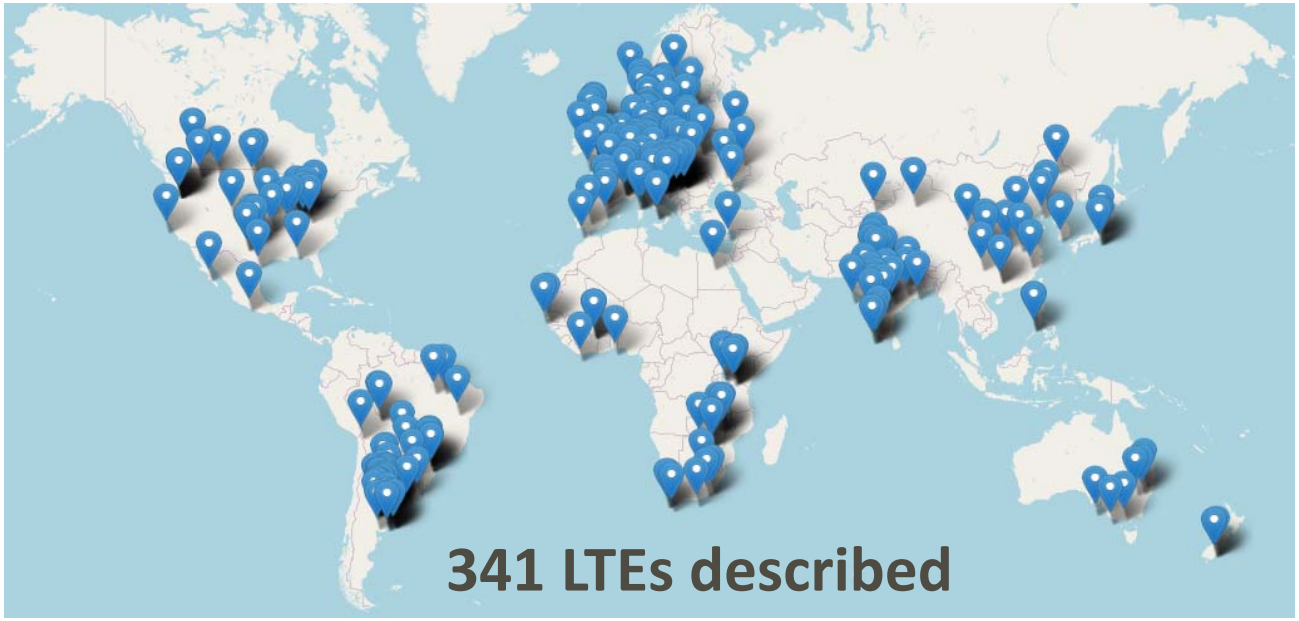
The Global Long-term Agricultural Experiments Network (GLTEN)

Established: 2018 (Rothamsted LTE Conference) with an International Steering Committee

Objectives:

1. Establishing and supporting a collaborative network within the international LTE community.
2. Improve findability of and access to unique and valuable LTE data to address today's societal challenges

Rothamsted LTEs all described in GLTEN, this information feeds into e-RA



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https://www.glten.org

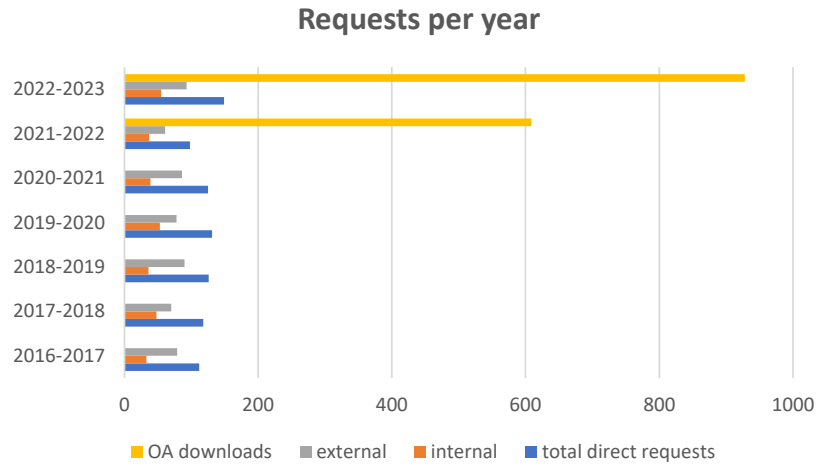
ROTHAMSTED RESEARCH

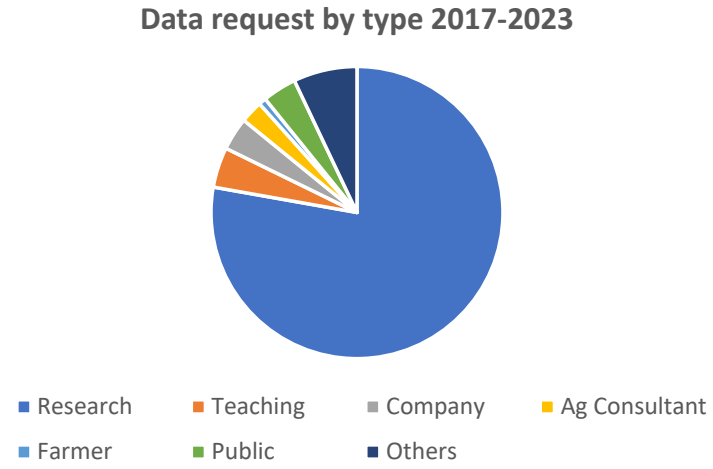
Data usage 1 – data requests and downloads

- Since 2017 over 860 requests for data and information in e-RA
- Around 300 from Rothamsted, 315 from rest of the UK
- 250 from 34 other countries

- Since 2021 we have been recording the number of downloads of our OA datasets.
- Increasing rapidly with datasets downloaded over 900 times in the last year

- Majority requests for research, also teaching, consultants, members of the public





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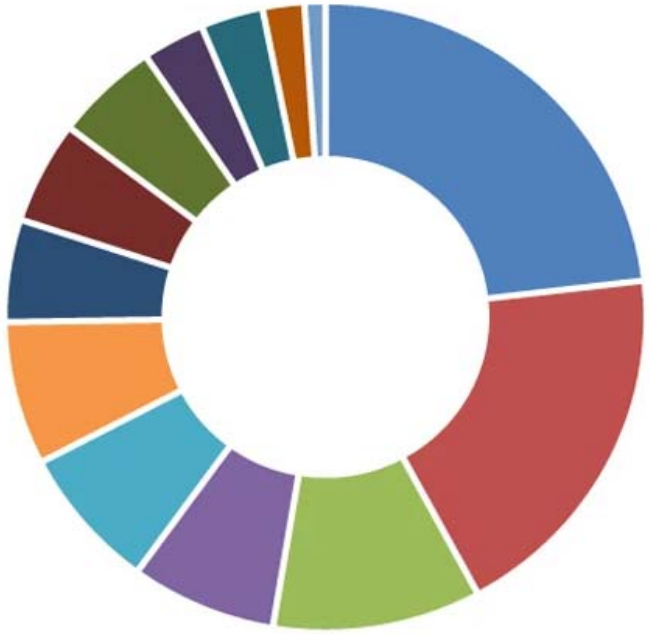
Data usage 2 – publications

Peer-reviewed publications:

2017-2022	27/year
Range	18 - 35



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Conclusions

- The Rothamsted LTEs, the e-RA database and the Rothamsted Sample Archive, continue to be an invaluable resource for scientists worldwide to explore new ideas and future challenges.
- The data is free and accessible to all, and continually being added to
- It is widely used around the world, stimulating new research in a range of scientific disciplines

For further details about e-RA and the Rothamsted LTEs, contact the e-RA curators: era@rothamsted.ac.uk
Or visit our website: www.era.rothamsted.ac.uk

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Acknowledgments

THANK YOU FOR LISTENING

Any comments or questions to era@rothamsted.ac.uk

With thanks to our colleagues Andy Gregory, Tony Scott, Paul Poulton, Chris Hall, Emily Greene, Suzanne Clarke, Melina Velasquez, Wendy Gregory and the many scientific and support staff of current and past generations

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Lawes Agricultural Trust

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