ROTHAMSTED RESEARCH

University of Nottingham
UK | CHINA | MALAYSIA

Soil-based biofortification to alleviate selenium deficiency

An isotopic study to investigate sulphur and selenium competition for ryegrass uptake

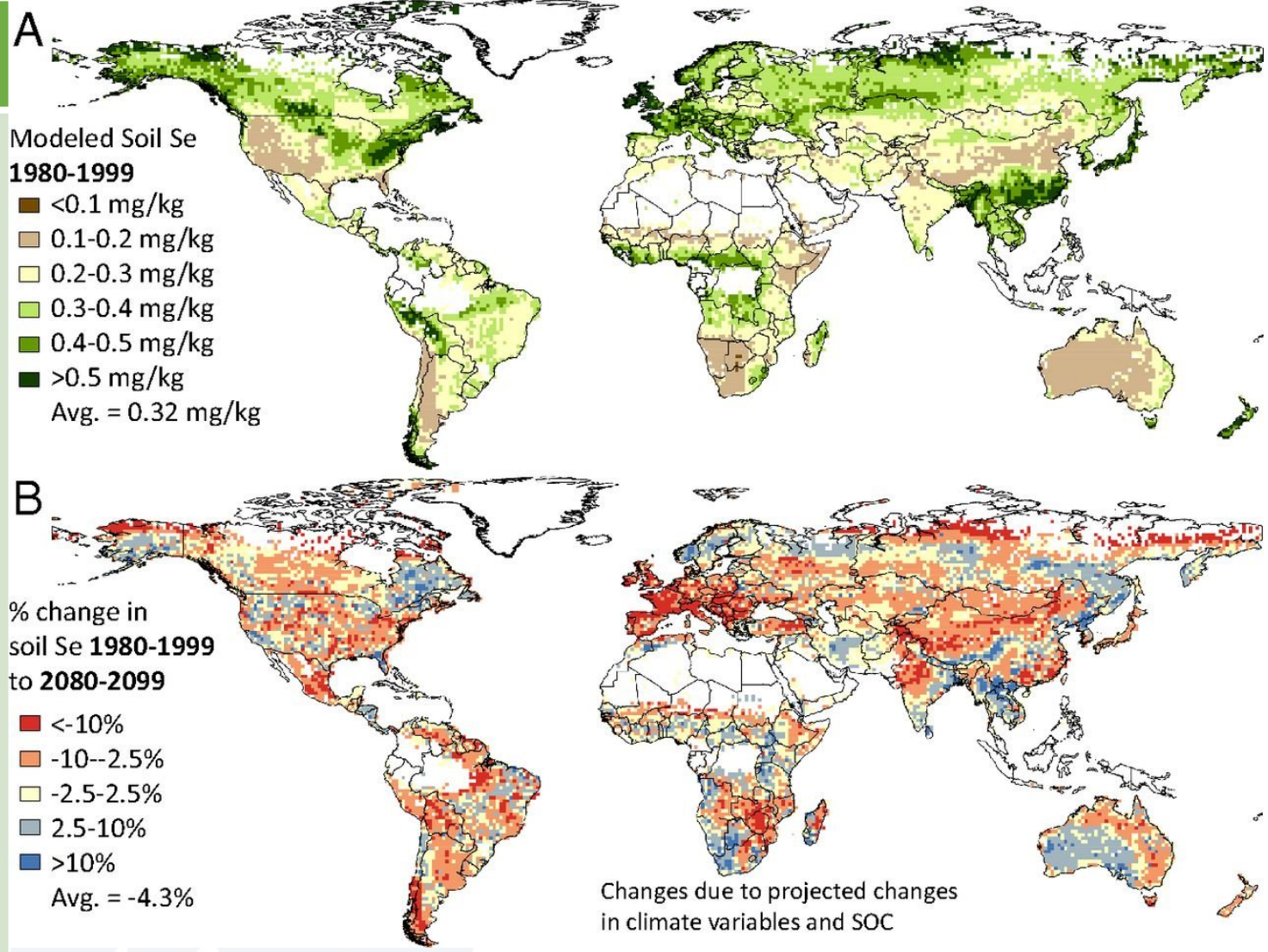
Dr. Linxi Jiang

SOILS: WHERE FOOD BEGINS

Global Symposium on Soils for Nutrition | 26-29 July 2022

Selenium

- One seventh of the global population has low Se intake
- Vital constituent of antioxidant, glutathione peroxidase (GPx)
- Se deficiency in animals results in muscular diseases and reduced reproductive capacity
- Se deficiency in humans has been linked to problems with
  - the heart & cardiovascular system
  - bones and joints
  - thyroid function
  - immune system function
  - the reproductive system
- Soil-based Agronomic Biofertification

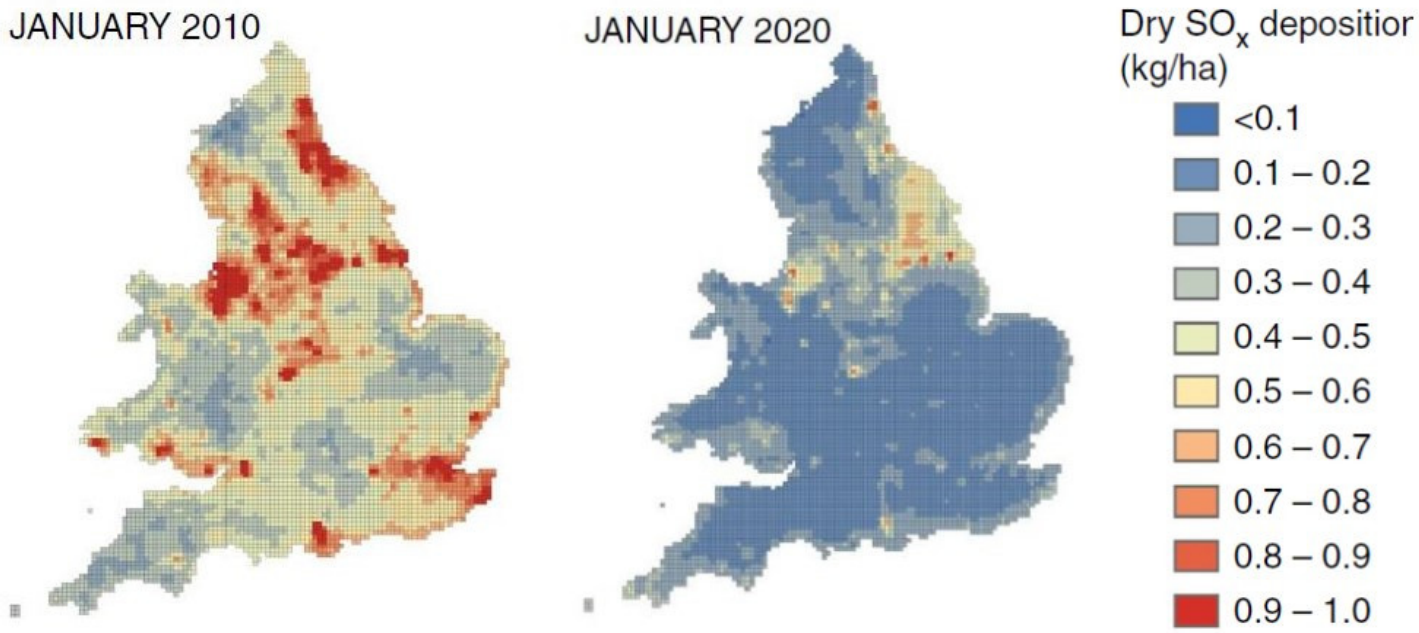


Jones G.D etc, 2017, PNAS

Sulphur

- Component of plant protein and chlorophyll; important for crop yields.

- Atmospheric SO_2 emissions and S deposition has decreased over recent decades; Sulphur co-product fertilizers are not widely used; SO_4^{2-} is easily leached.
  - requirement for increased S fertilizer application.



Sulphur dioxide decreased by 94% between and 1970 and 2010

And predicted to decrease by another 50% by 2020

Webb etc, 32, 3-16, SUM, 2016

Background

- S (SO_4^{2-}) and Se (SeO_4^{2-}) are both taken up by plants through the SO_4^{2-} transporters therefore if S is released when Se is applied less Se will be taken up by the plant.
- S:Se = 1000:1
- TIMING of S release is therefore important to Se uptake which is to be maximized
- Practice prefers to add fertilizers at same **time** & **growth stage** to minimize costs and optimize elements uptake and distribution.

Objective

- Test differences of S release rates on its competition to Se for uptake
- Develop technologies to use enriched stable isotopes to distinguish between fertilizer-Se and indigenous-Se
- Review Se agronomic methods on biofortification efficiency
- Investigate Se biofortification residual effects in plant-soil systems

Treatments Design

Tested *S* fertilizers:

- Gypsum (Slowest) - **Gypsum**
- Polysulphate™ (Slow) - **Poly**
- PotashpluS37™(Middle) - **Potash37**
- PatentKali® (Fast) - **SMP**
- $MgSO_4$ (Fastest) - **$MgSO_4$**

S: 60 kg ha^{-1} (Other Fertilizers)
1.3 t ha^{-1} (Gypsum)

Tested *Se* fertilizers:

$^{74}Se^{VI}$

Fertigation (**FG**)

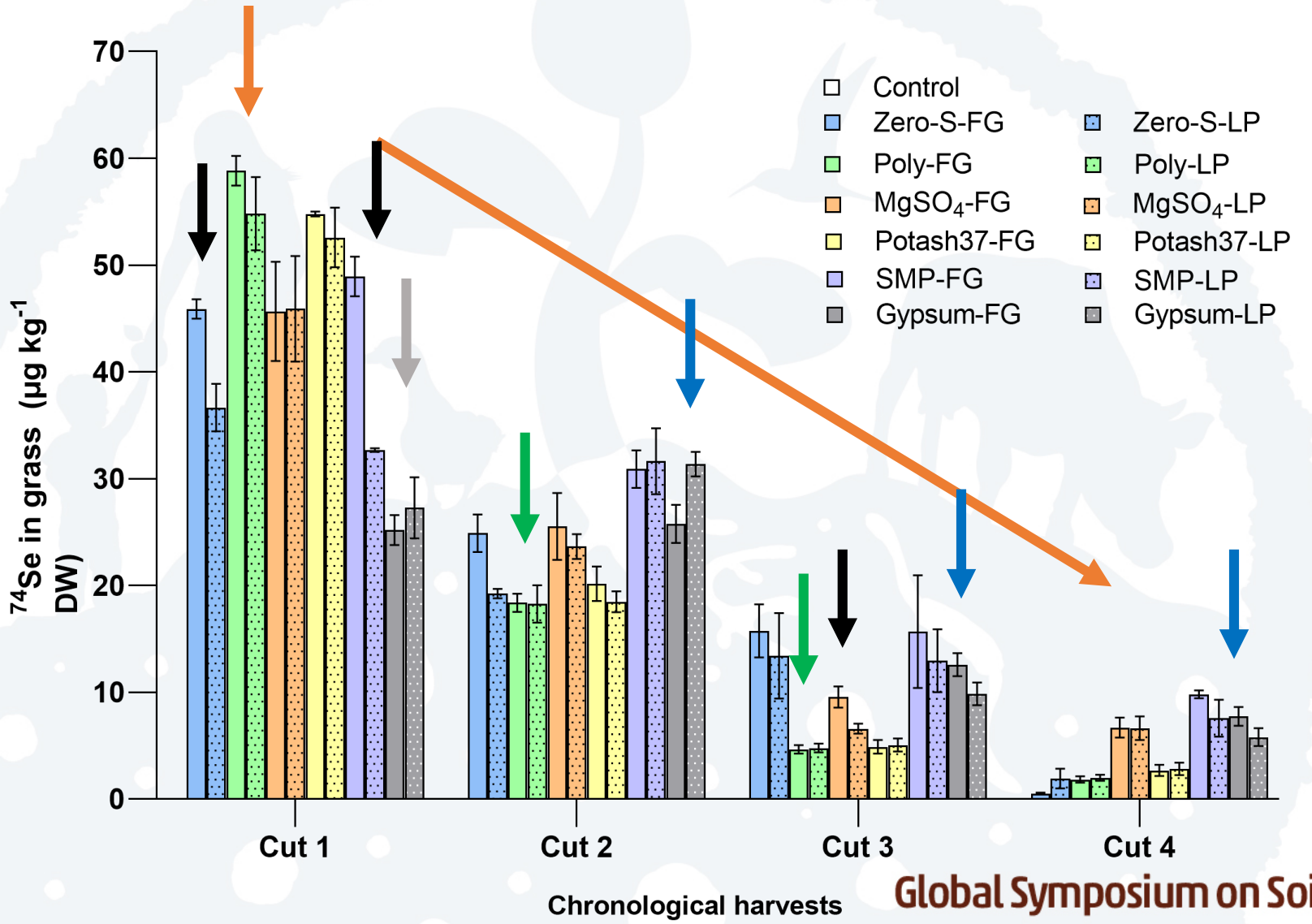
Liquid Placement (**LP**)

Se: 20 g ha^{-1}

- 4 sequential harvests of the ryegrass every each 30 days

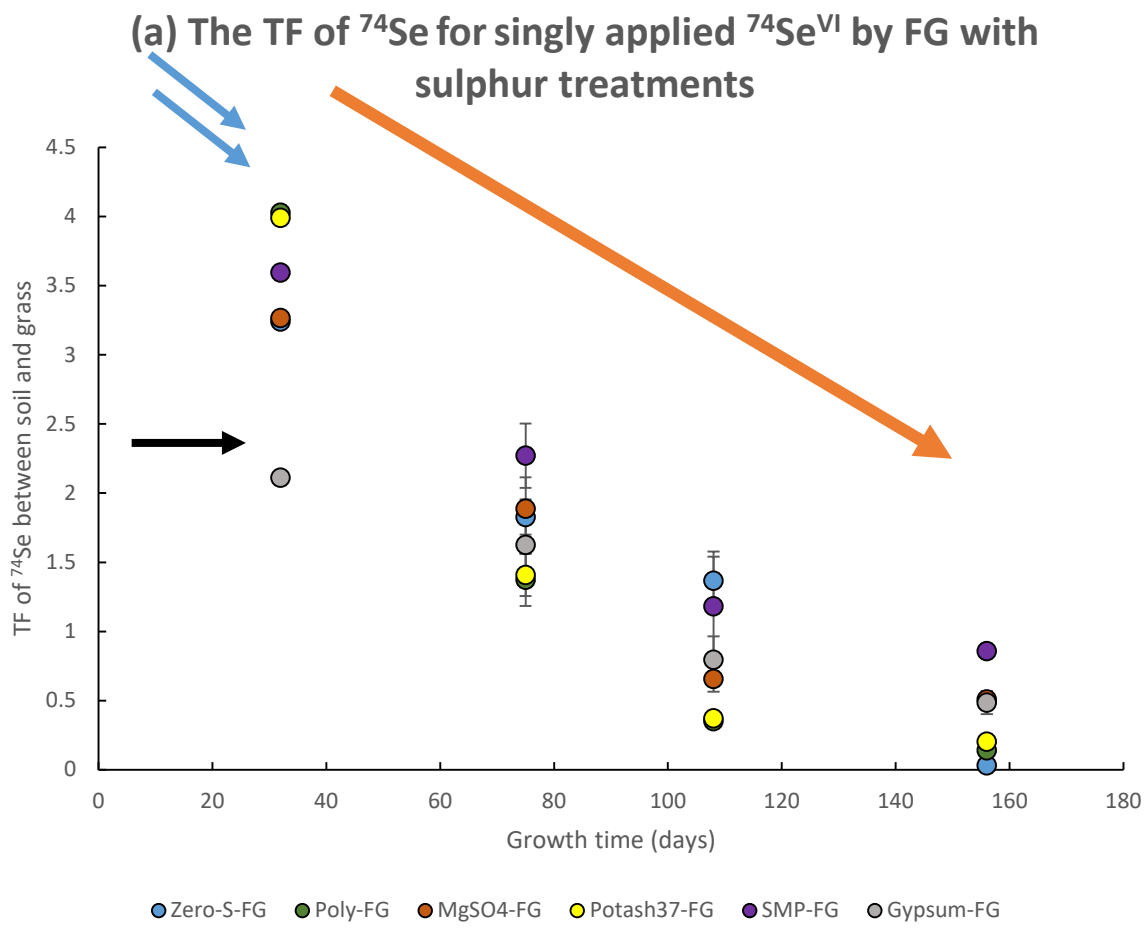
- 20 ml syringe
- Soil top 10 cm

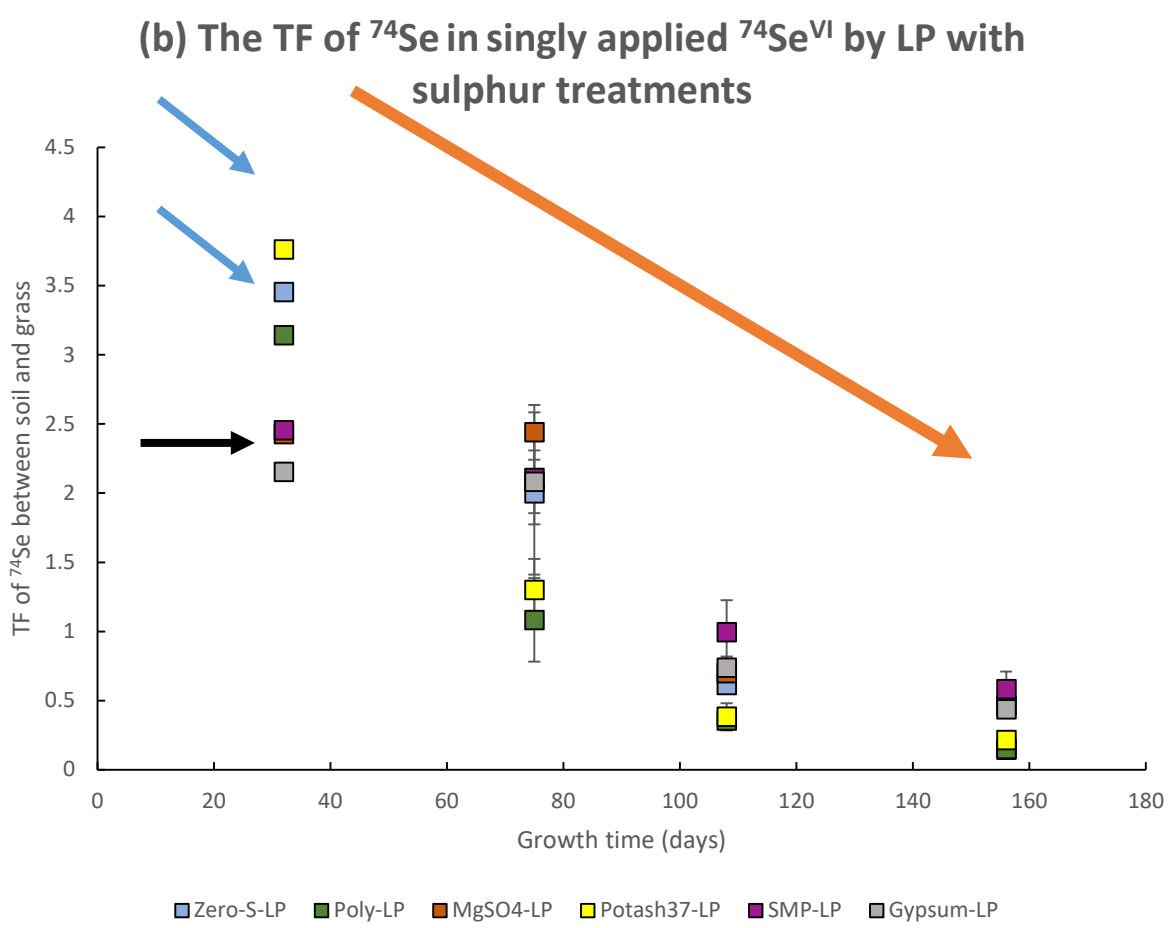
Effect of S on uptake of applied ^{74}Se by grass



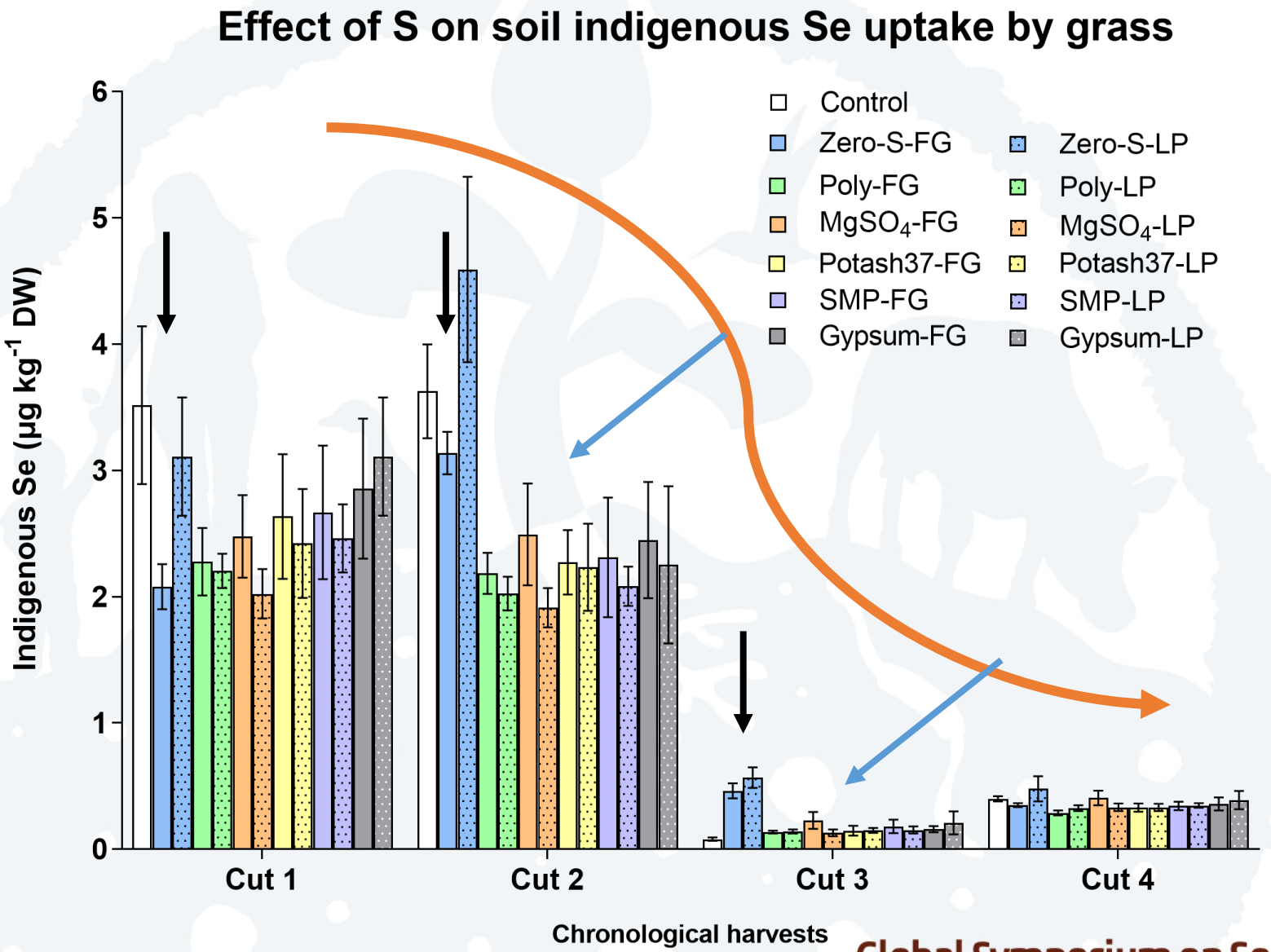
Source	DF	Mean Square	F	p value
S fertilizer	3	10696	528.19	$p < 0.05$
harvest time	5	139	6.89	$p < 0.05$
Se methods	1	251	12.39	$p < 0.05$
S fertilizer x harvest time	15	550	27.17	$p < 0.05$
harvest time x Se methods	3	59	2.90	$p < 0.05$
S fertilizer x Se methods	5	46	2.28	$p < 0.05$
S fertilizer x harvest time x Se methods	15	39	1.95	$p < 0.05$

- Polyhalite encourages Se uptake at Cut1 but suppresses in the rest cuts
- Gypsum suppresses Se uptake at Cut1 but mildly in following cuts
- FG > LP in Zero-S (Cut 1 – 2), SMP (Cut 1), $MgSO_4$ (Cut 3)





- **Transfer Factor** (**TF**) of Poly and Potash37 are greater than others in Cut1.
- TF of gypsum was lower than Zero-S at Cut1.
- **TF** in most S forms under FG was greater than for LP in Cut1 and Cut2.



Source	DF	Mean Square	F	p value
S fertilizer	5	2.23	4.84	p < 0.05
harvest time	3	107.89	233.94	p < 0.05
Se methods	1	0.02	0.04	p > 0.05
harvest time * S fertilizer	15	0.93	2.02	p < 0.05
harvest time * Se methods	3	0.10	0.21	p > 0.05
S fertilizer * Se methods	5	1.27	2.75	p < 0.05
harvest time * S fertilizer * Se methods	15	0.35	0.76	p > 0.05

- Indigenous Se concentrations are greater in Cut1 and 2 than the rest two cuts
- S application suppresses soil indigenous Se uptake
- $^{74}Se^{VI}$ in Zero-S suppresses soil indigenous Se uptake in Cut1-2, reversely in Cut 3

Summary

- **Se isotopes are reliable to investigate uptake of fertilized and indigenous soil Se by grass**
- **Plant physiological and soil chemical and biological processes affects Se fertilizer efficiency.**
- **S fertilizers suppress soil indigenous Se uptake by grass, and the release rate of S fertilizer does not show difference**
- **Slow-release S fertiliser with selenate can ideally satisfy the sulphur requirement of grass but also promote selenate uptake through reduced physiological competition immediately after Se application and possibly by increasing phytoavailable selenate later in the post-fertilized period.**

Acknowledgements

The University of Nottingham

ROTHAMSTED RESEARCH

- Scott Young
- Liz Bailey
- Neil Graham
- Martin Broadley
- Steve McGrath

Dr. Linxi Jiang ; JINGZHI.JIANG@FOXMAIL.COM