FACULTY OF BIOSCIENCE ENGINEERING (FBE) invites you for...

Inspiring Mornings @ UGent FBE

"Creating nutrient-enriched foods through biofortification"

Martin R. Broadley
Professor of Plant Nutrition

The University of Nottingham

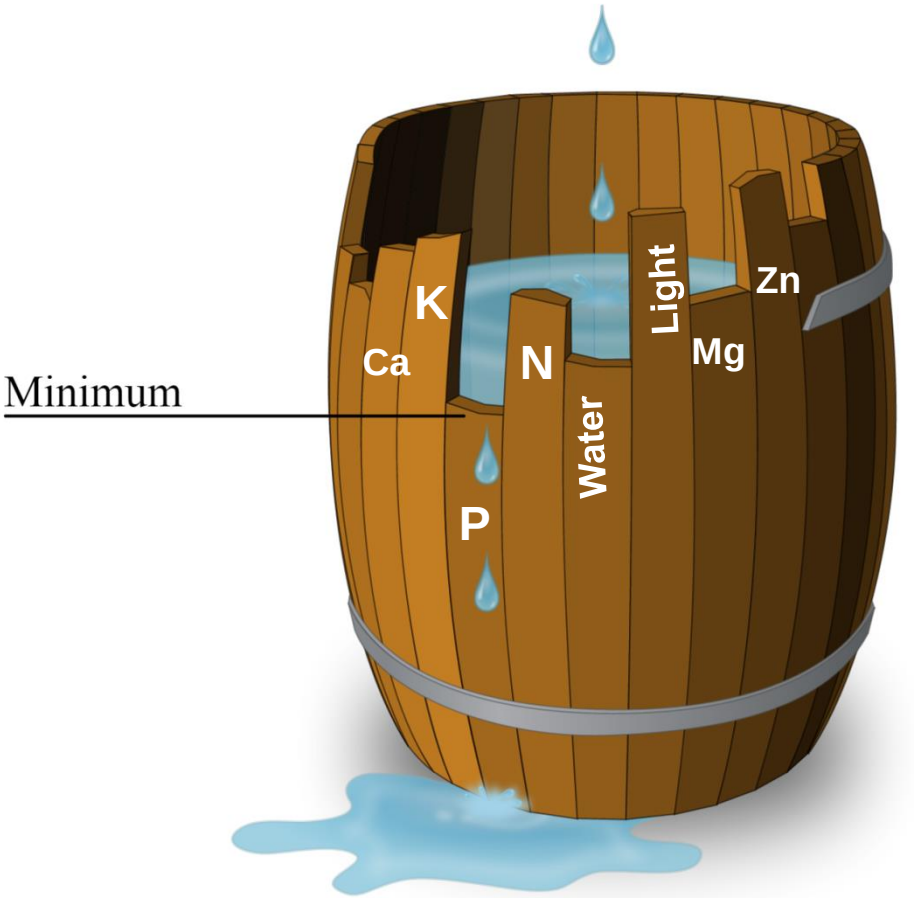
International Food & Nutrition Research Dissemination Conference
Food and Nutrition Security for a Healthier and Productive Nation
'You are what you eat'
October 26th-27th 2016
Bingu International Conference Centre, Lilongwe, Malawi

Progress in quantifying mineral micronutrient deficiencies in Malawi through Agriculture-Nutrition links

The Law of the Minimum

Justus von Liebig (1803-1873)

Liebig's Law of the Minimum



http://en.wikipedia.org/wiki/Justus_von_Liebig

http://upload.wikimedia.org/wikipedia/commons/1/1c/Minimum-Tonne.svg

Selenium

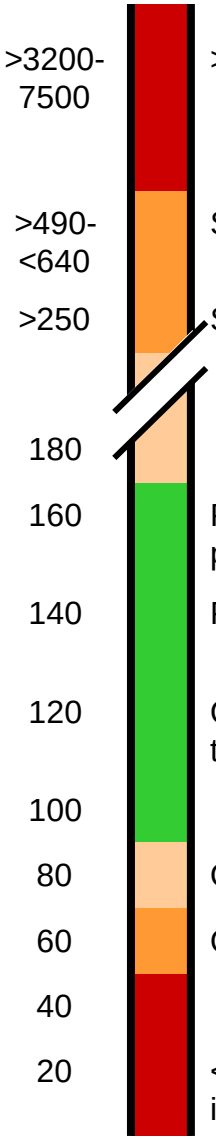
Essential for animals (but not plants)

25 selenoprotein genes in mammals

Many roles in health:

- **immune function**
- **thyroid function / iodine metabolism**
- **cardiovascular health**
- **fertility**
- **cancer ?**

Selenium biomaker



>3200-7500 ng/ml toxicity - death/mortality

Selenium related side-effects; no serious toxicity

Selenium related side-effects; hair loss, dermatitis

Protection against some cancers; [increased risk of diabetes, high blood pressure and hypertension]

Protection against some cancers; reduction in total mortality

Optimisation of selenoprotein P, protection against some cancers, reduction in total mortality

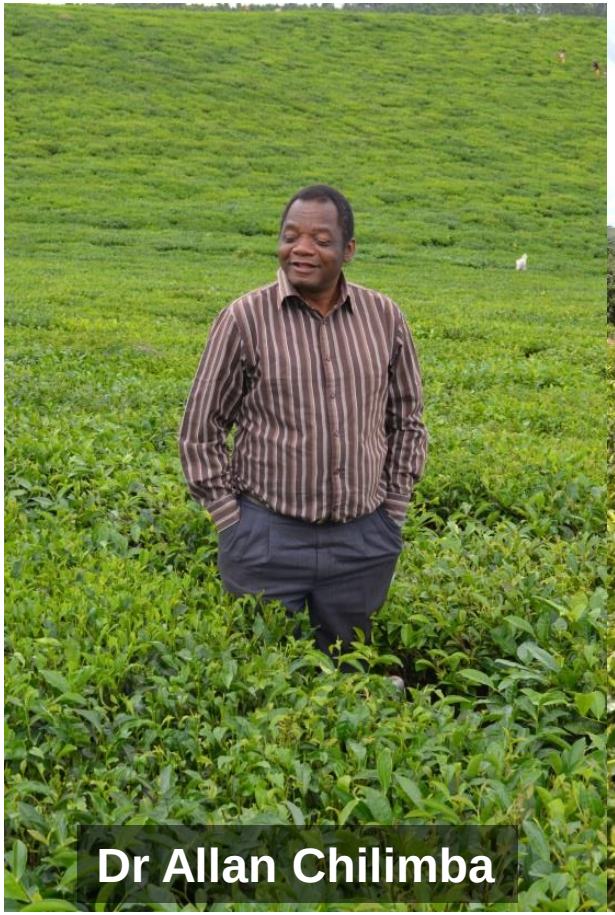
Optimisation of glutathione peroxidase

Optimisation of iodothyronine deiodinases

< 20-40 ng/ml Se deficiency diseases, Keshan, Kashin-Beck, cretinism (with iodine deficiency)

Fairweather-Tait SJ et al. (2011). Selenium in human health and disease. Antioxidant & Redox Signaling, 14: 1337-83.

Selenium supply in Malawi: soil and grain surveys (2008-10)



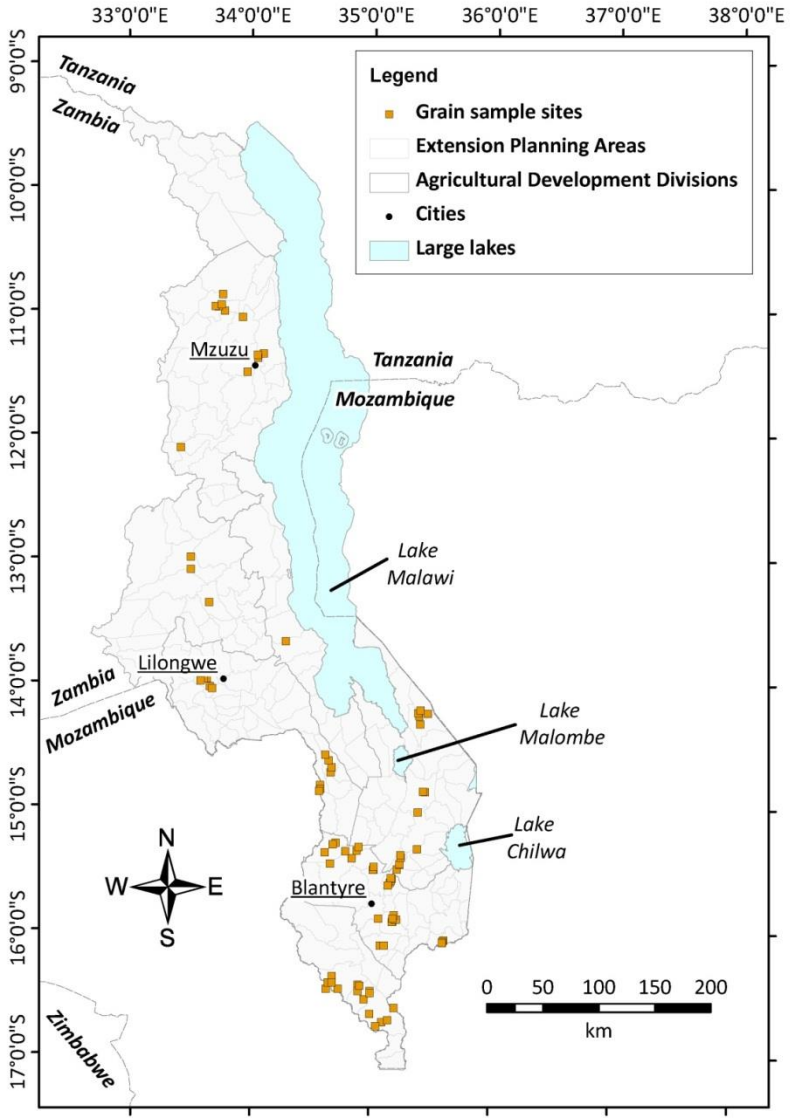
YARA

UNITY and FREEDOM

BGS 1835 British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

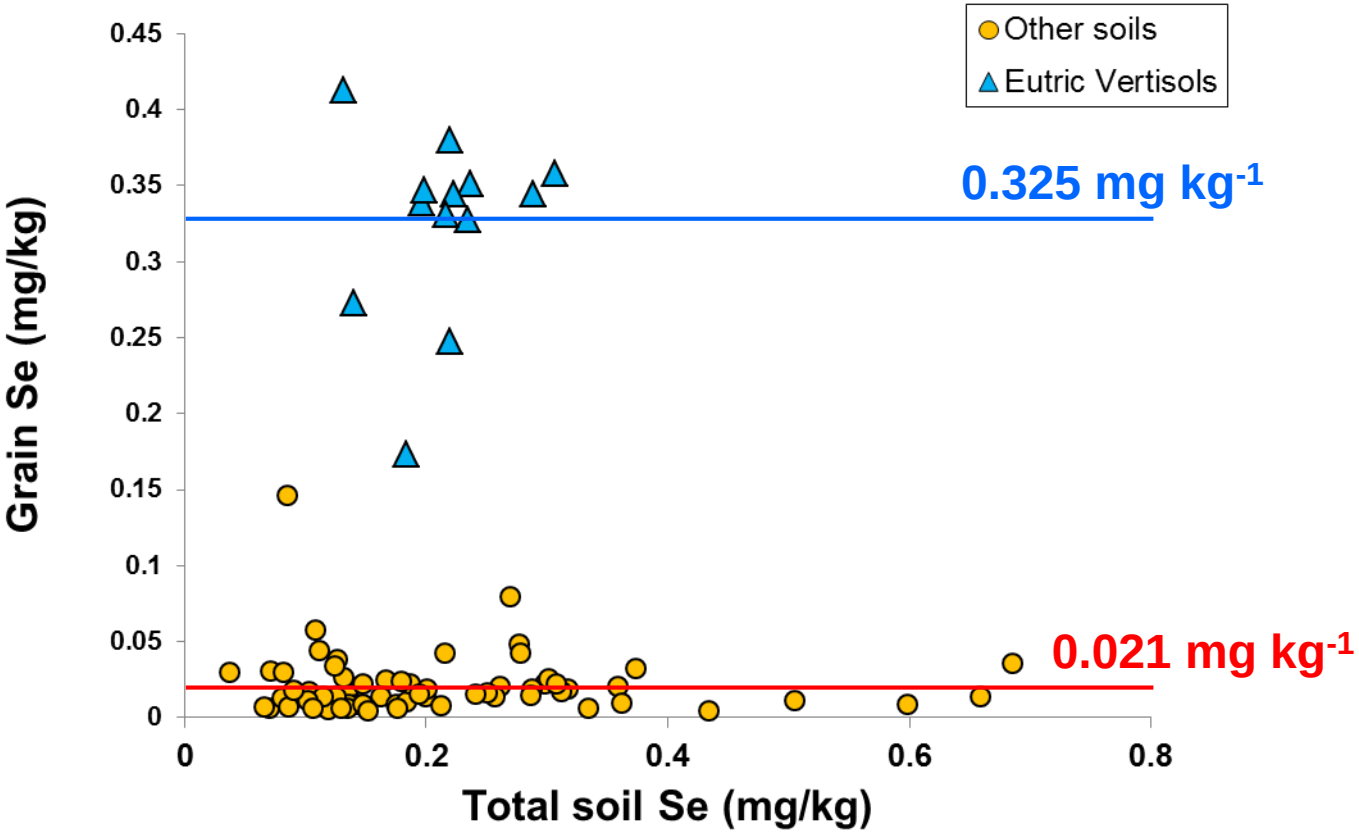
The University of Nottingham

Selenium supply in Malawi: maize-grain survey (2008-10)



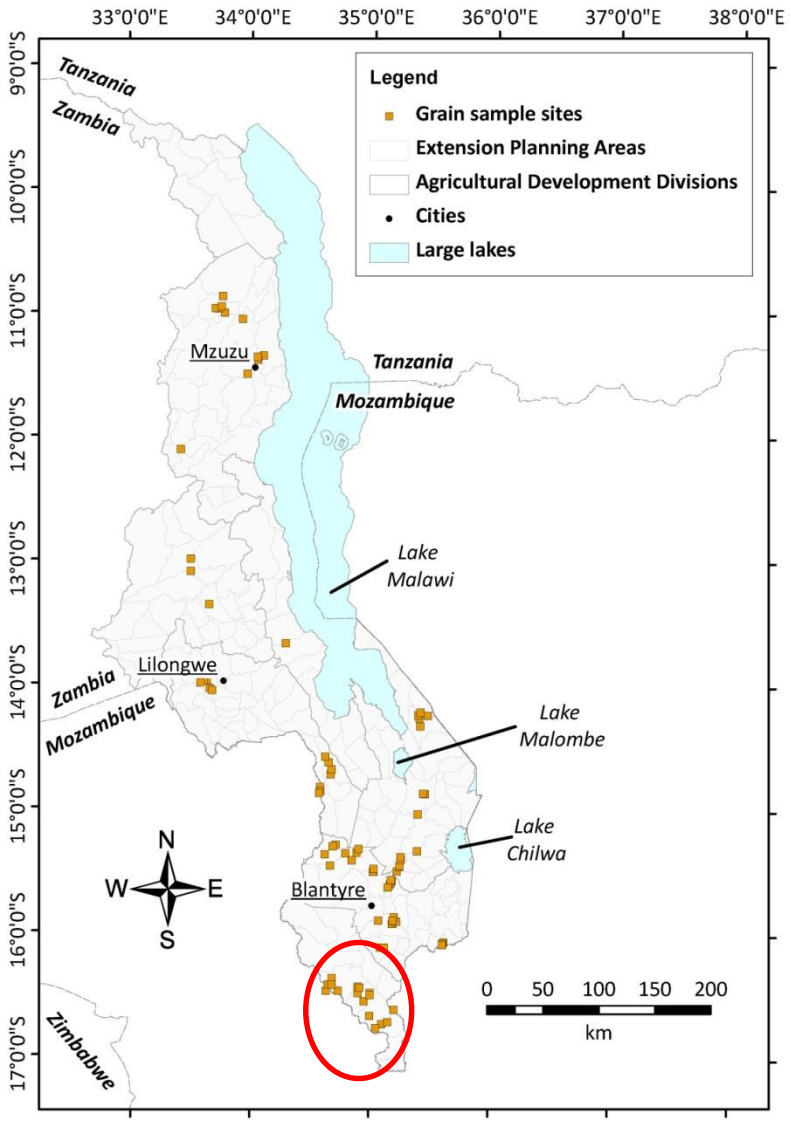
Chilimba ADC, Young SD, Black CR, Rogerson KB, Ander EL, Watts M, Lammel J, Broadley MR (2011). Maize grain and soil surveys reveal suboptimal dietary selenium intake is widespread in Malawi. *Scientific Reports*, 1, 72.

Selenium supply in Malawi: maize-grain survey (2008-10)



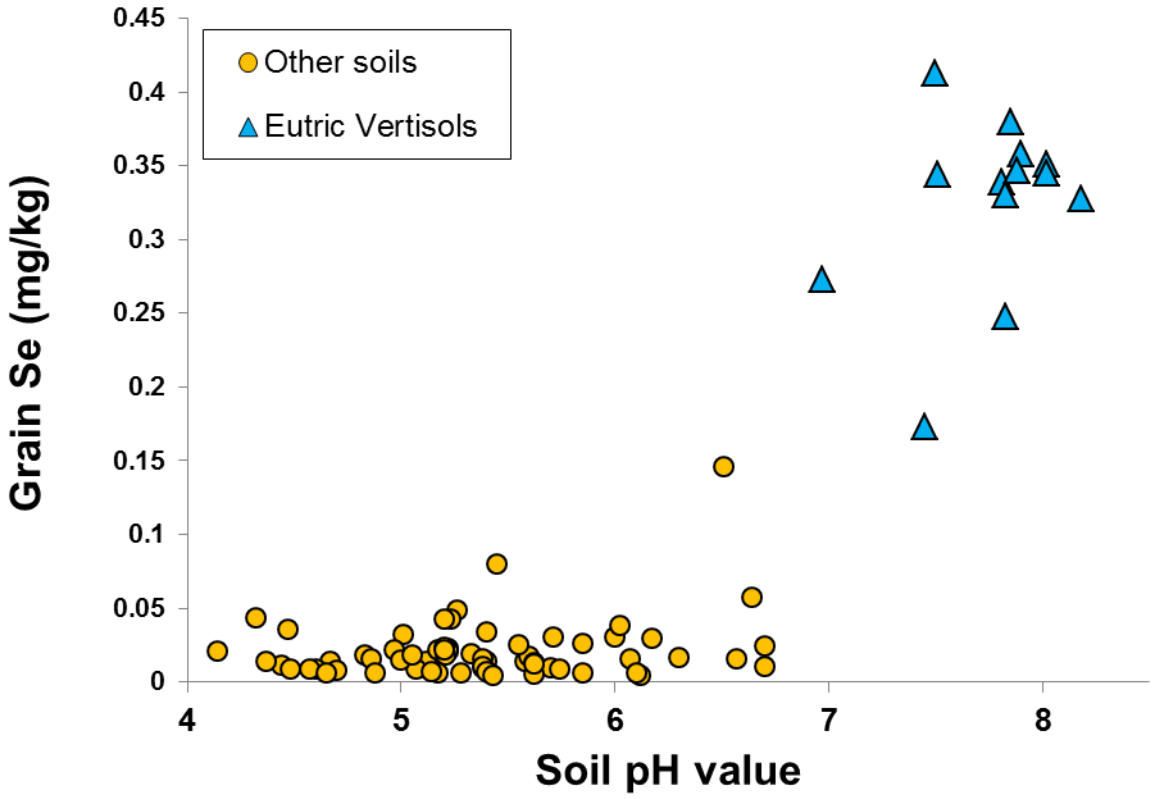
Chilimba ADC, Young SD, Black CR, Rogerson KB, Ander EL, Watts M, Lammel J, Broadley MR (2011). Maize grain and soil surveys reveal suboptimal dietary selenium intake is widespread in Malawi. *Scientific Reports*, 1, 72.

Selenium supply in Malawi: maize-grain survey (2008-10)

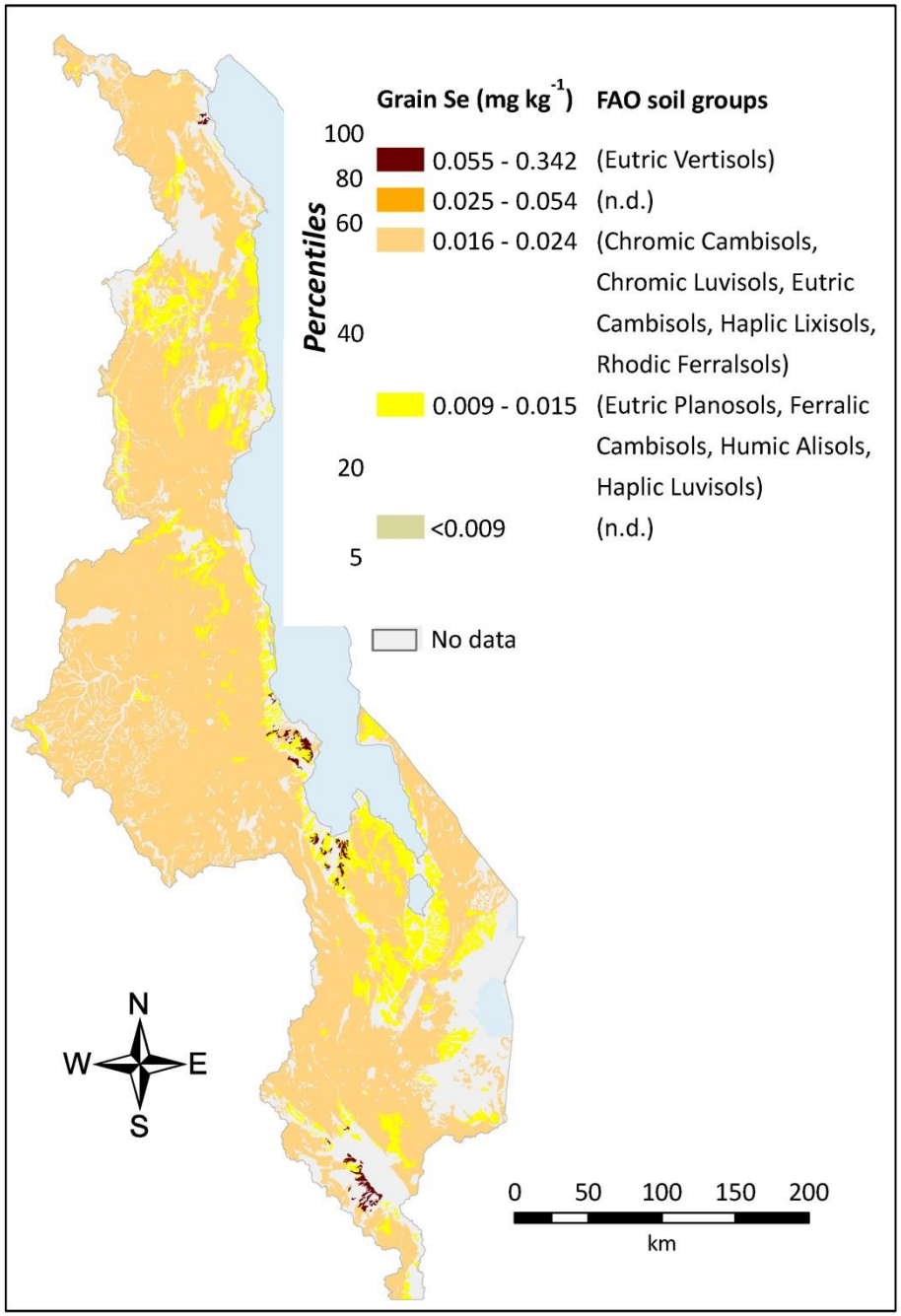


Shire valley (Eutric Vertisols)

Selenium supply in Malawi: maize-grain survey (2008-10)



Chilimba ADC, Young SD, Black CR, Rogerson KB, Ander EL, Watts M, Lammel J, Broadley MR (2011). Maize grain and soil surveys reveal suboptimal dietary selenium intake is widespread in Malawi. *Scientific Reports*, 1, 72.



SCIENTIFIC REPORTS

OPEN

Maize grain and soil surveys reveal suboptimal dietary selenium intake is widespread in Malawi

SUBJECT AREAS:
ENVIRONMENTAL SCIENCES
PLANT SCIENCES
BIOGEOCHEMISTRY
HUMAN

Received
23 May 2011
Accepted
1 August 2011

Allan D. C. Chilimba[1,2], Scott D. Young[1], Colin R. Black[1], Katie B. Rogerson[1], E. Louise Ander[3], Michael J. Watts[3], Joachim Lammel[4] & Martin R. Broadley[1]

[1]School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, UK, [2]Ministry of Agriculture and Food Security, Department of Agricultural Research Services, Lunyangwa Research Station, P.O. Box 59, Mzuzu, Malawi, [3]British Geological Survey, Keyworth, NG12 5GG, UK, [4]Yara International, Research Centre, Hanninghof 48249, Duelmen, Germany.

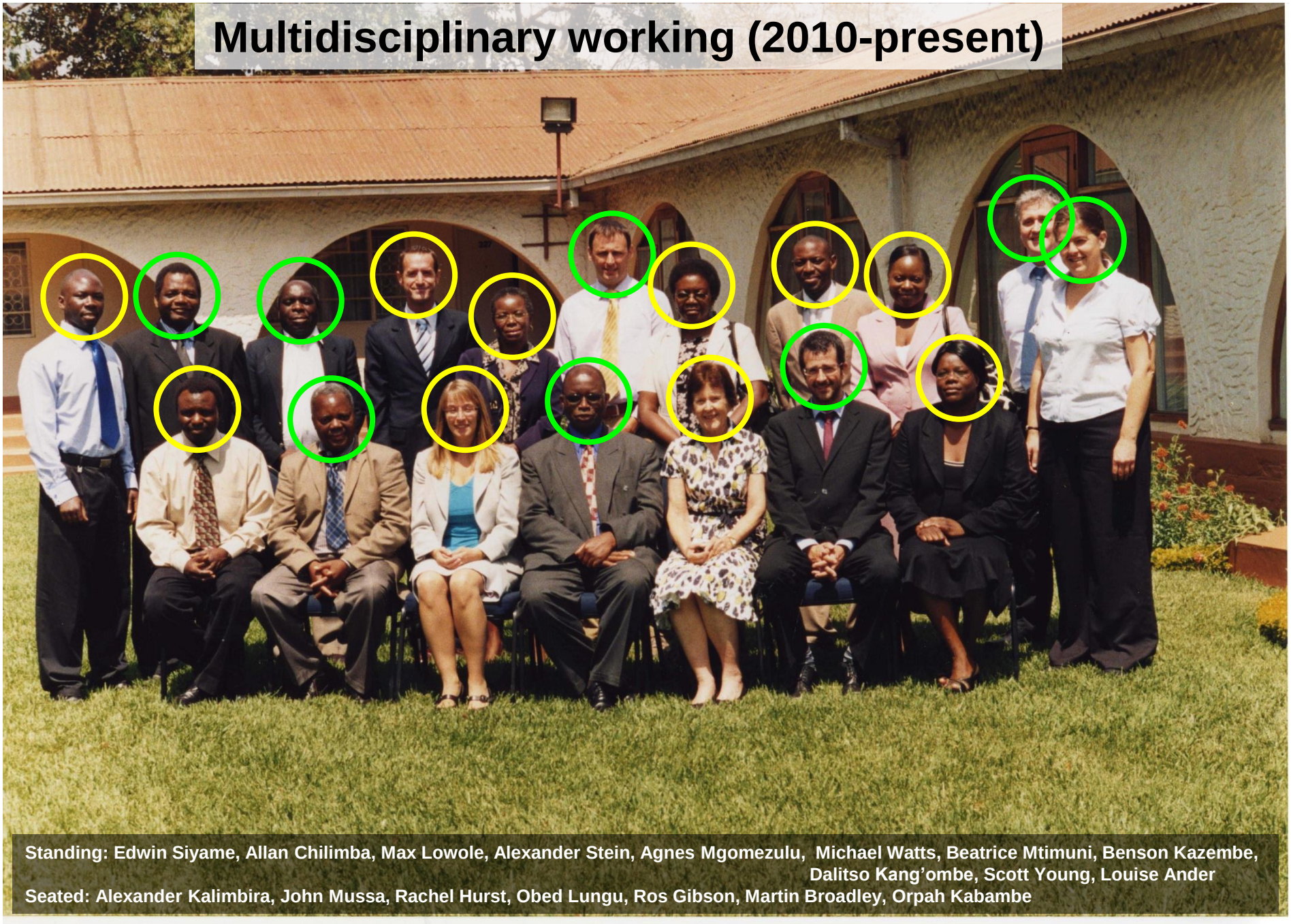
Selenium is an essential element in human diets but the risk of suboptimal intake increases where food

Se supply from maize:

90% of popultation <7.5 µg d^{-1}

UK Recommended Intake = 75 µg d^{-1}

Multidisciplinary working (2010-present)

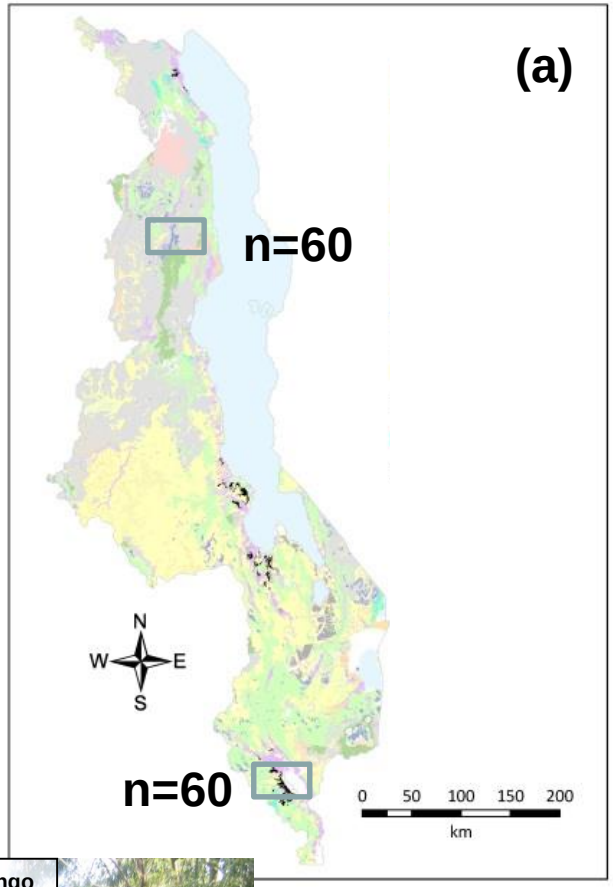


Standing: Edwin Siyame, Allan Chilimba, Max Lowole, Alexander Stein, Agnes Mgomezulu, Michael Watts, Beatrice Mtimuni, Benson Kazembe, Dalitso Kang'ombe, Scott Young, Louise Ander

Seated: Alexander Kalimbira, John Mussa, Rachel Hurst, Obed Lungu, Ros Gibson, Martin Broadley, Orpah Kabambe

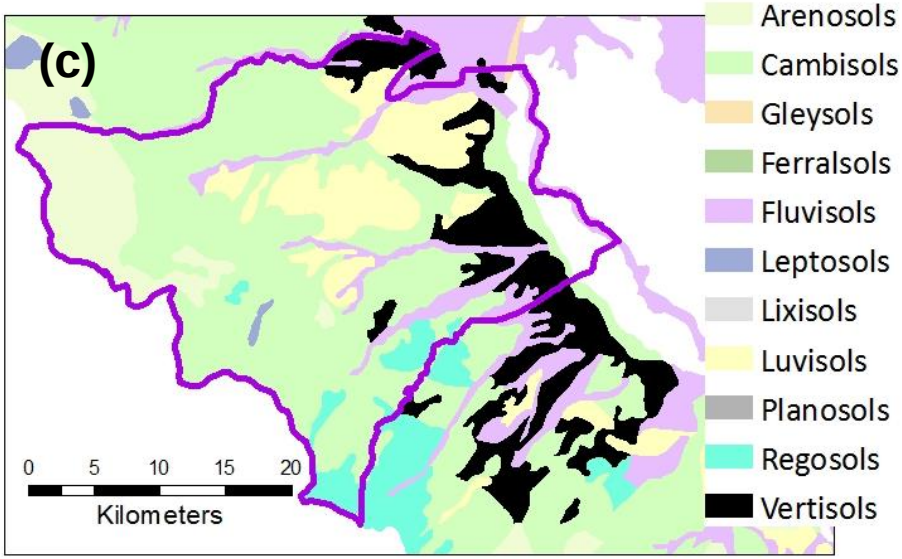
Lilongwe, Malawi, September 2010

Selenium intakes and status in Malawi

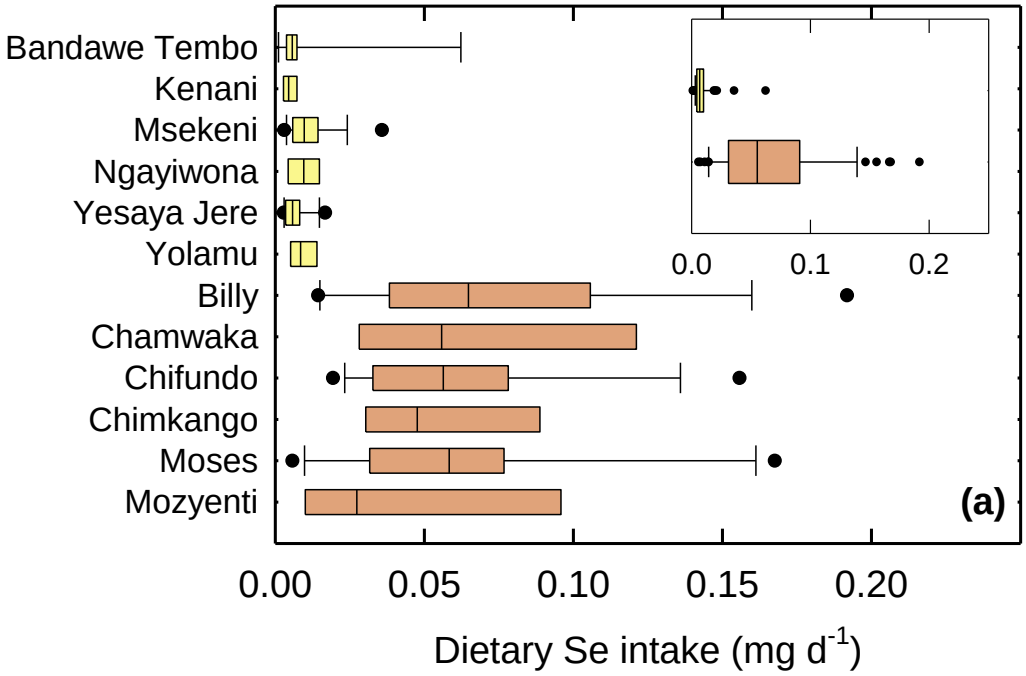



Bily villages, Mikalango


Mrs Miriam Nkhoma (Zombwe)



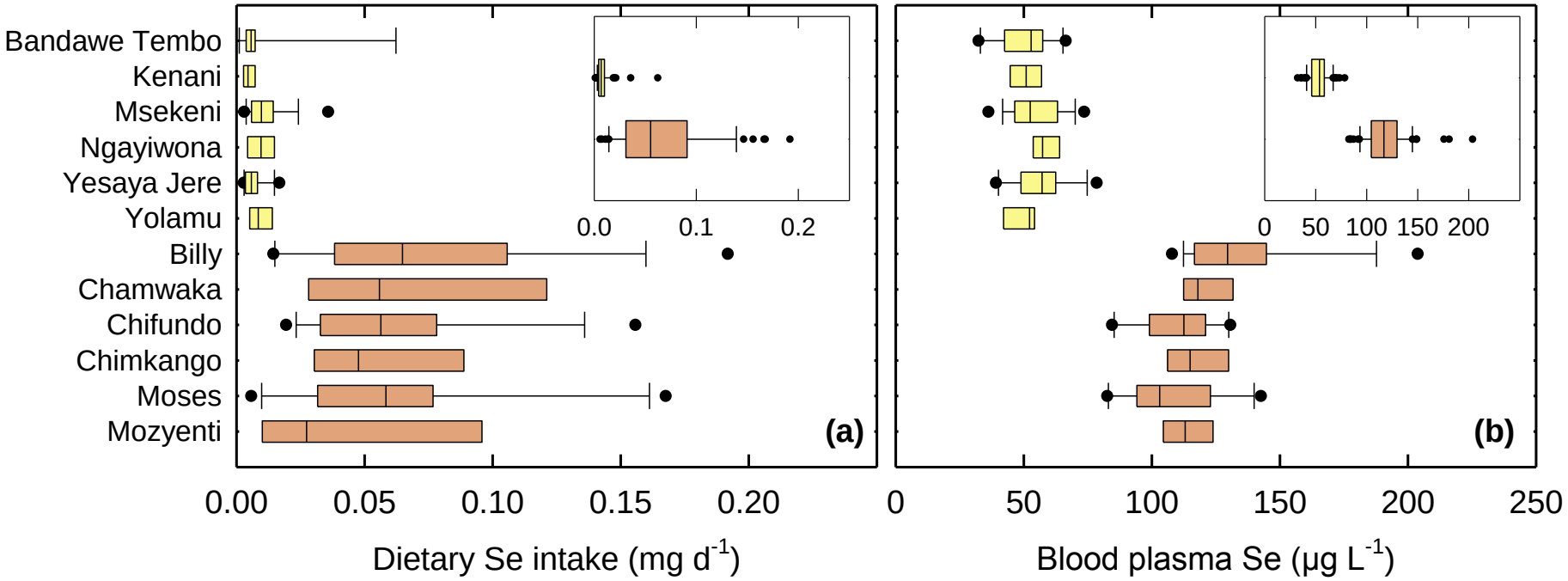
Soil geochemistry linked to selenium intake…



Hurst R, Siyame E, Young SD et al. (2013)

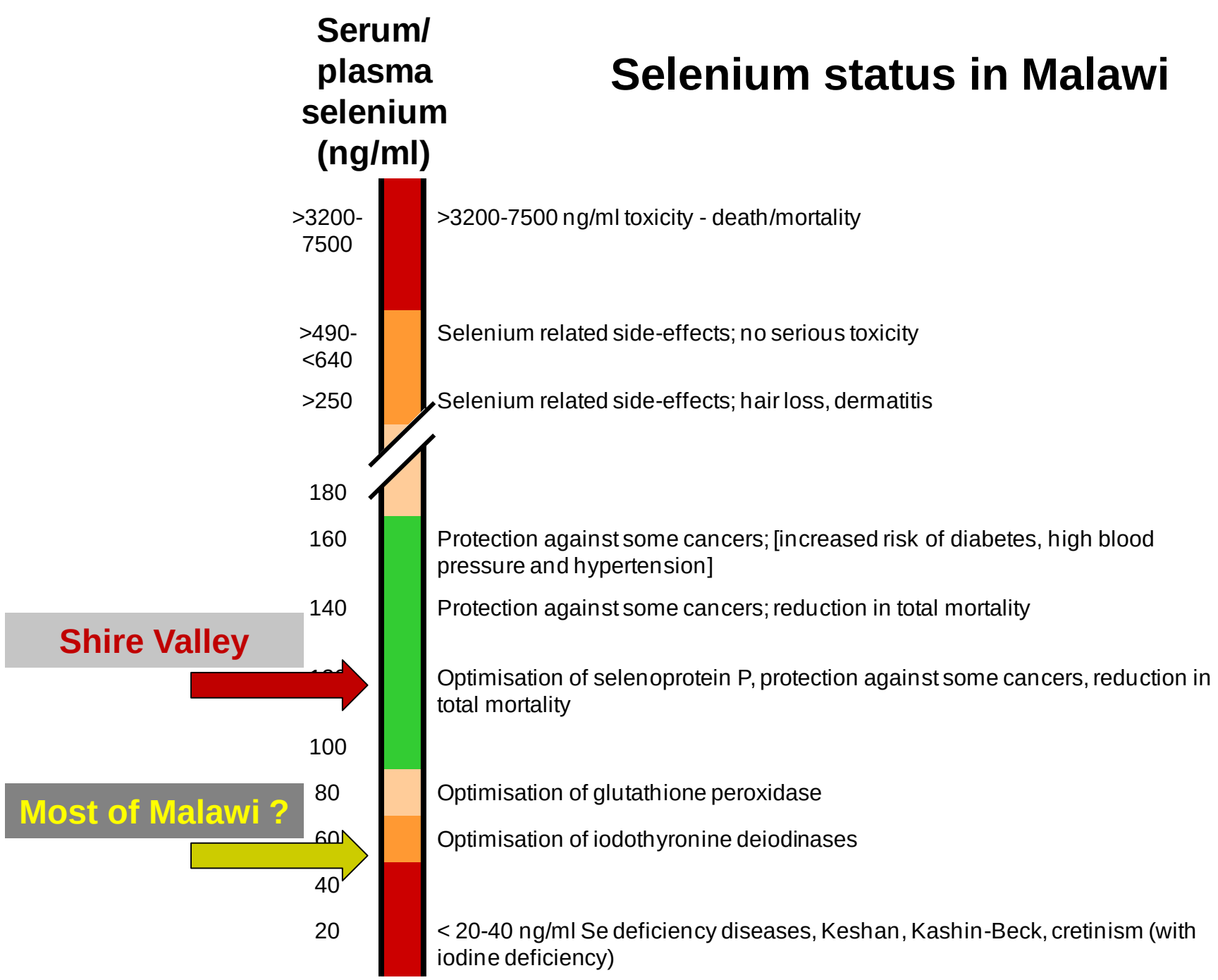
Soil geochemistry linked to selenium intake…

…and status



Hurst R, Siyame E, Young SD et al. (2013)

Selenium status in Malawi



Fairweather-Tait SJ et al. (2011). Selenium in human health and disease. Antioxidant & Redox Signaling, 14: 1337-83.

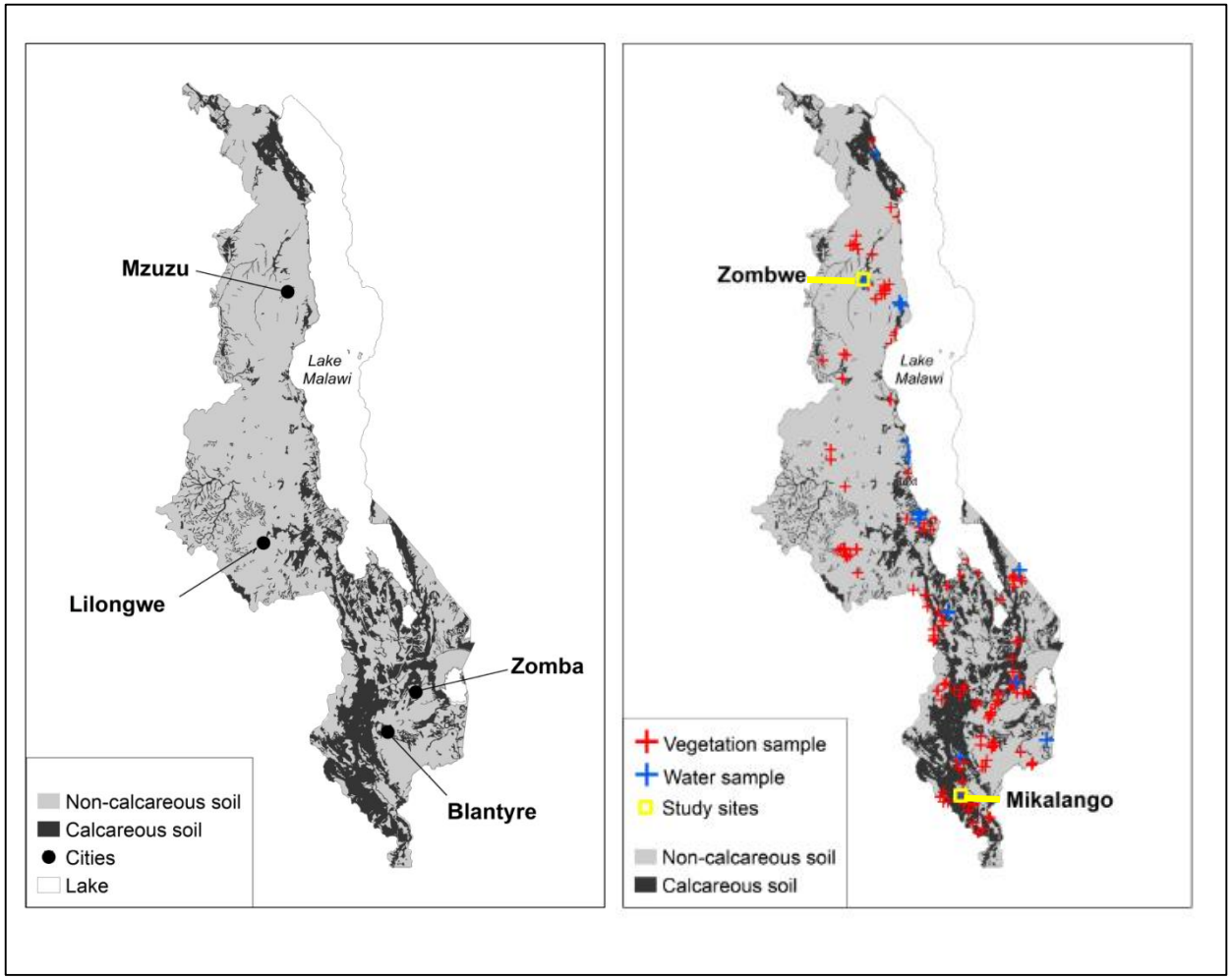
Improving dietary mineral supplies

1. **Diet diversification**
2. **Fortification**
3. **Agronomy**
4. **Crop breeding**

Diet Diversification


2011-2015
GERMINATION ROOM
DARS
Department of Agricultural Research Services
Crop Storage Research
NOVEMBER 2011
DECEMBER 2011
Edward Joy
Lazarus Singano
Dr Allan Chilimba

GeoNutrition: geographical variation in selenium supply



700 samples (+)

100 edible foods

Joy EJM, Broadley MR, Young SD, Black CR, Chilimba ADC, Ander EL, Barlow TS, Watts MJ (2015). Soil type influences crop mineral composition in Malawi. *Science of the Total Environment*, 505, 587-595.

Mineral nutrient supply from surveys (Malawi)

Data from Malawi Third Integrated Household Survey (IHS3)

>12,500 households interviewed in 2010-11

Food consumption module: households asked to recall foods consumed in past 7 d from 112 items (e.g. ‘Maize *ufa* refined (fine flour)’ , ‘Dried fish’)

Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

Mineral nutrient supply from surveys (Malawi)

MODULE G: FOOD CONSUMPTION OVER PAST ONE WEEK

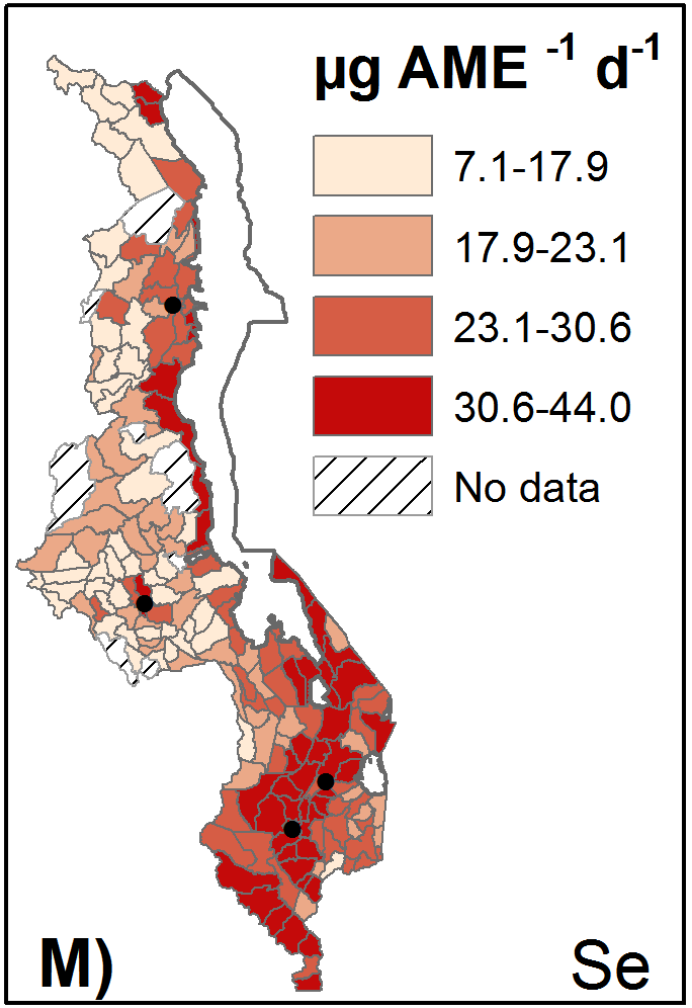
DATA ENTRY LINE NUMBER	Over the past one week (7 days), did you or others in your household consume any [. . .]? INCLUDE FOOD BOTH EATEN COMMUNALLY IN THE HOUSEHOLD AND THAT EATEN SEPARATELY BY INDIVIDUAL HOUSEHOLD MEMBERS.	G01 YES..1 NO...2>> NEXT ITEM	G02 ITEM CODE	G03 How much in total did your household consume in the past week? QUANTITY	G03 UNIT	G04 How much came from purchases? QUANTITY	G04 UNIT	G05 How much did you spend? MK	G06 How much came from own-production? QUANTITY	G06 UNIT	G07 How much came from gifts and other sources? QUANTITY	G07 UNIT
1	**Cereals, Grains and Cereal Products**											
2	Maize *ufa mgaiwa* (normal flour)		101									
3	Maize *ufa* refined (fine flour)		102									
4	Maize *ufa madeya* (bran flour)		103									
5	Maize grain (not as *ufa*)		104									
6	Green maize		105									
7	Rice		106									
8	Finger millet (*mawere*)		107									
9	Sorghum (*mapira*)		108									
10	Pearl millet (*mchewere*)		109									
11	Wheat flour		110									
12	Bread		111									
13	Buns, scones		112									
14	Biscuits		113									
15	Spaghetti, macaroni, pasta		114									
16	Breakfast cereal		115									
17	Infant feeding cereals		116									
18	Other (specify)		117									
19	**Roots, Tubers, and Plantains**											
20	Cassava tubers		201									
21	Cassava flour		202									
22	White sweet potato		203									
23	Orange sweet potato		204									
24	Irish potato		205									
25	Potato crisps		206									
26	Plantain, cooking banana		207									
27	Cocoyam (*masimbi*)		208									
28	Other (specify)		209									

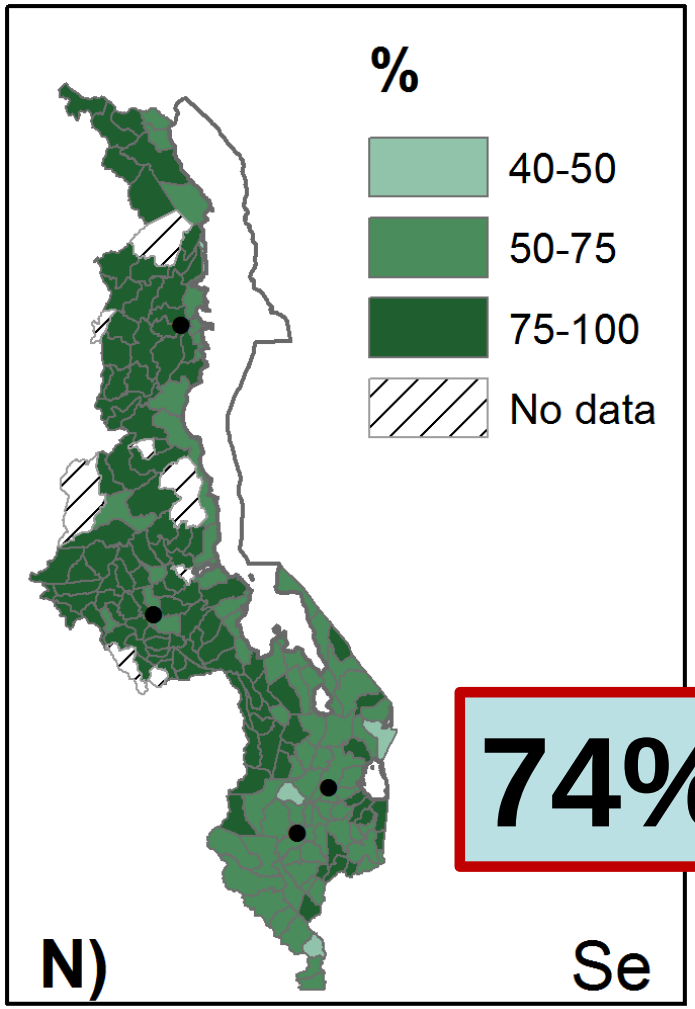
CODES FOR UNIT:

KILOGRAMME 1
50 KG. BAG 2
90 KG. BAG 3
PAIL (SMALL) . . .4
PAIL (LARGE) . . .5
No. 10 PLATE . . .6
No. 12 PLATE . . .7
BUNCH. 8
PIECE. 9
HEAP 10
BALE 11
BASKET (*DENGU*) (SHELLED). . . 12
BASKET (*DENGU*) (UNSHELLED) . . 13
OX-CART (UNSHELLED) . . 14
LITRE. 15
CUP. 16
TIN. 17
GRAM 18
MILLILITRE . . . 19
TEASPOON. 20
BASIN. 21
SATCHET/TUBE. . .22
OTHER (SPECIFY). 23

Selenium supply and deficiency risks in Malawi

AME = adult male equivalent





74%

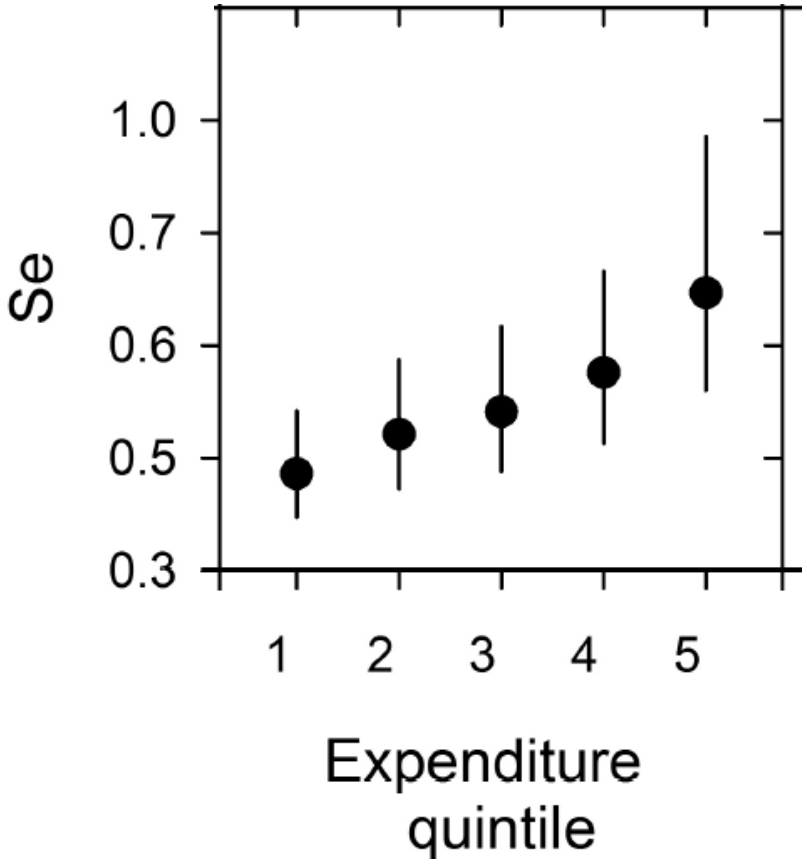
Median Se supply = 21.4 µg *capita*$^{-1}$ d^{-1}

Estimated Average Requirement = 36.0 µg *capita* d^{-1}

Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

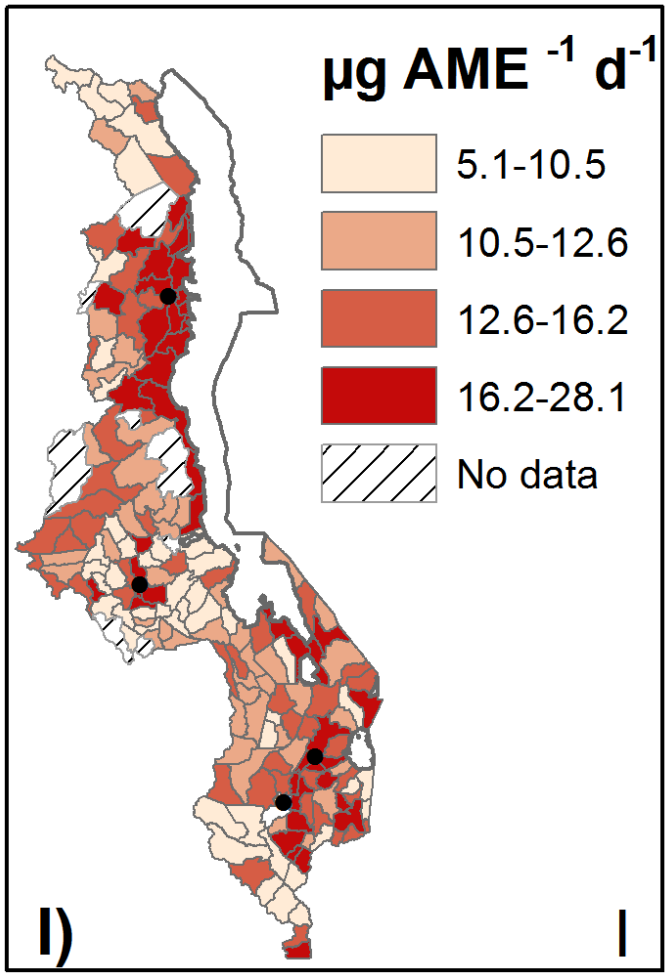
Se supply *vs* socioeconomic factors in Malawi

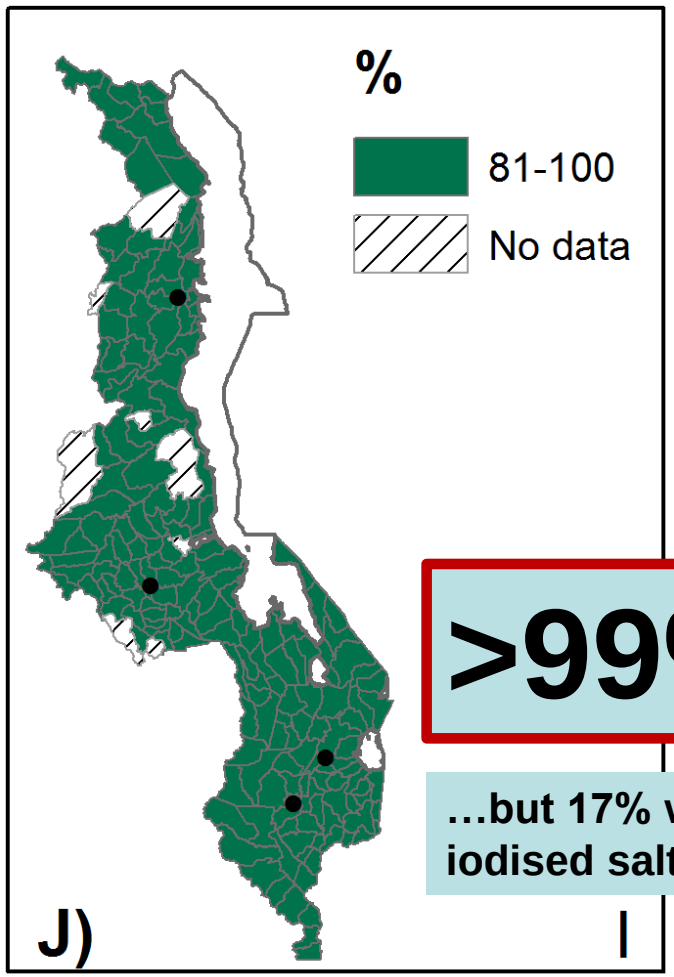
Se supply as proportion of household requirements (adequacy = 1)



Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

Iodine supply and deficiency risks in Malawi





>99%

…but 17% with iodised salt

Median I supply = 12.6 µg *capita*$^{-1}$ d^{-1}
Estimated Average Requirement = 107.0 µg *capita* d^{-1}

Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

Agronomy

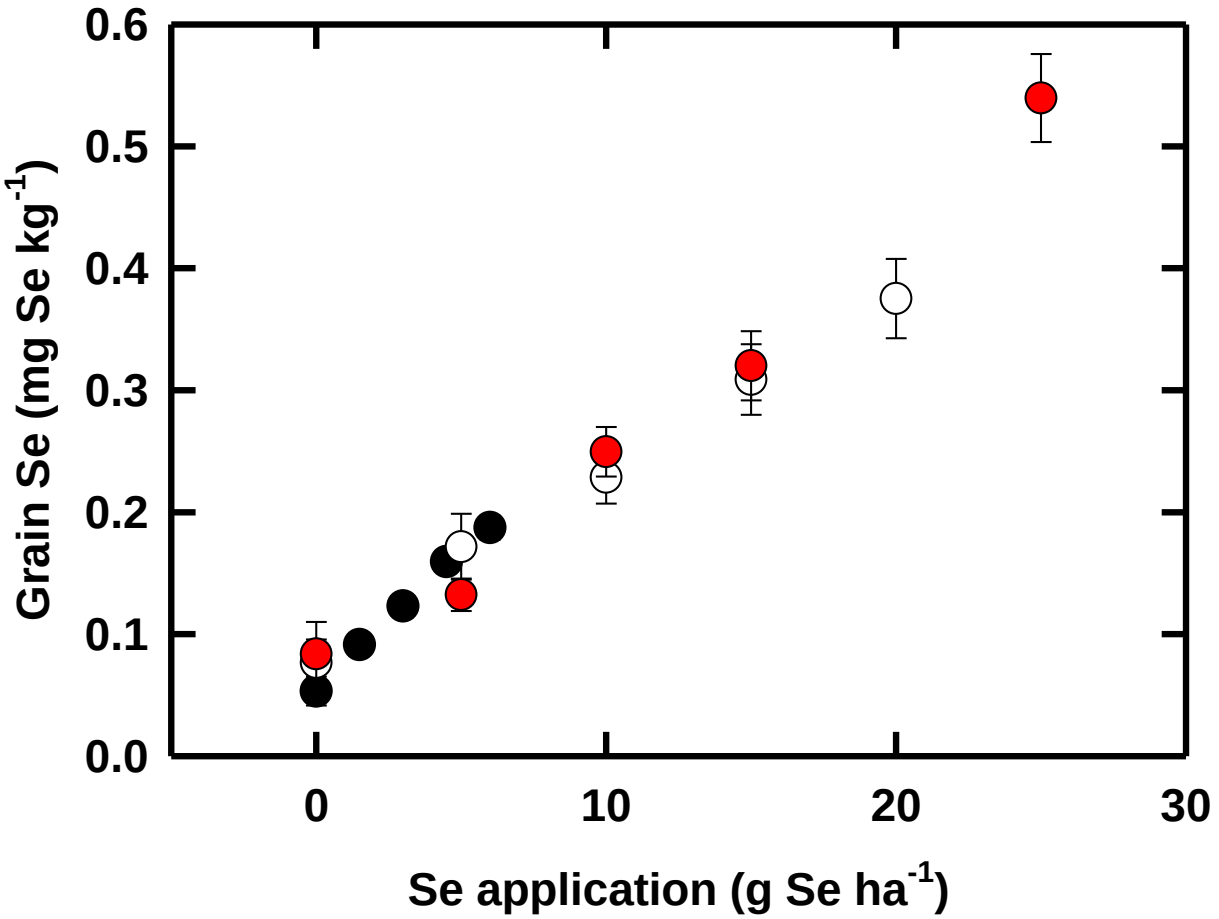
Se-fertilizer experiments in Malawi (2009 & 2010, plots=979)

Se-fertilizer experiments in Malawi (2009 & 2010)

January 2009

Se-fertilizer experiments in Malawi (2009 & 2010)

Se-fertilizer experiments Malawi: results summary



Liquid drench $y = 0.019x + 0.061$

CAN+Se (granular) $y = 0.015x + 0.085$

NPK+Se (granular) $y = 0.022x + 0.056$

15-22 µg Se kg^{-1} grain . g^{-1} Se ha^{-1}

Chilimba ADC et al. (2012). *Field Crops Research* 125: 118-128

Ultra-trace amounts of selenium are required

Flickr, Eamon Curry (CC BY 2.0)

Options to alleviate selenium deficiency in Malawi

1. **Do nothing?**

2. **Change fertilizer policy**
   [as done in Finland]

Precedent for using selenium fertilisers in Finland

Selenium added to solid multi-nutrient fertilizers (mg kg^{-1} arable / grass sectors)

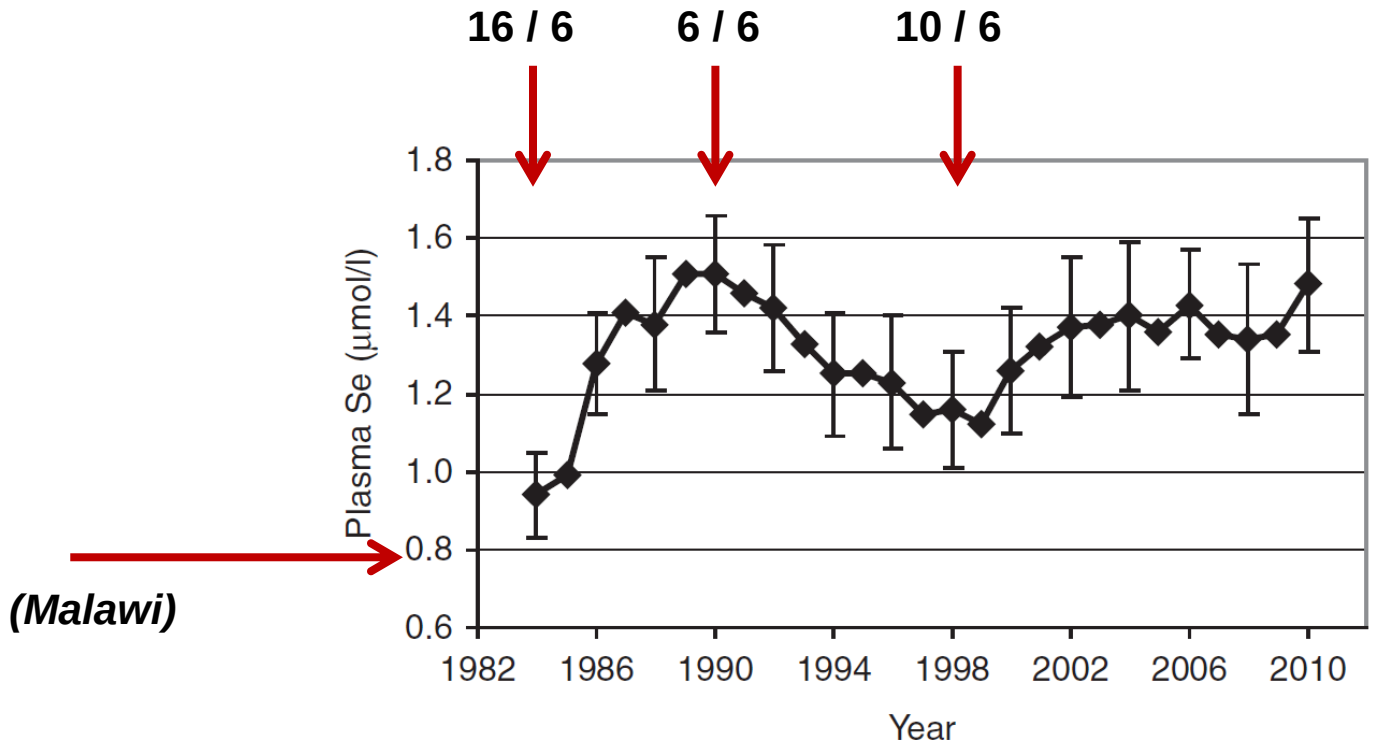


Fig. 17.7. Mean annual plasma selenium concentration in healthy Finns before and during the selenium fertilization.

Alfthan G. et al. (2012). Nationwide supplementation of sodium selenate to commercial fertilizers: history and 25-year results from the Finnish Selenium Monitoring Programme. In: Thompson B, Amoroso L (eds), Combating micronutrient deficiencies: food-based approaches. CAB International and Food and Agriculture Organization of the United Nations (FAO), Rome, pp 312-337.

Options to alleviate selenium deficiency in Malawi

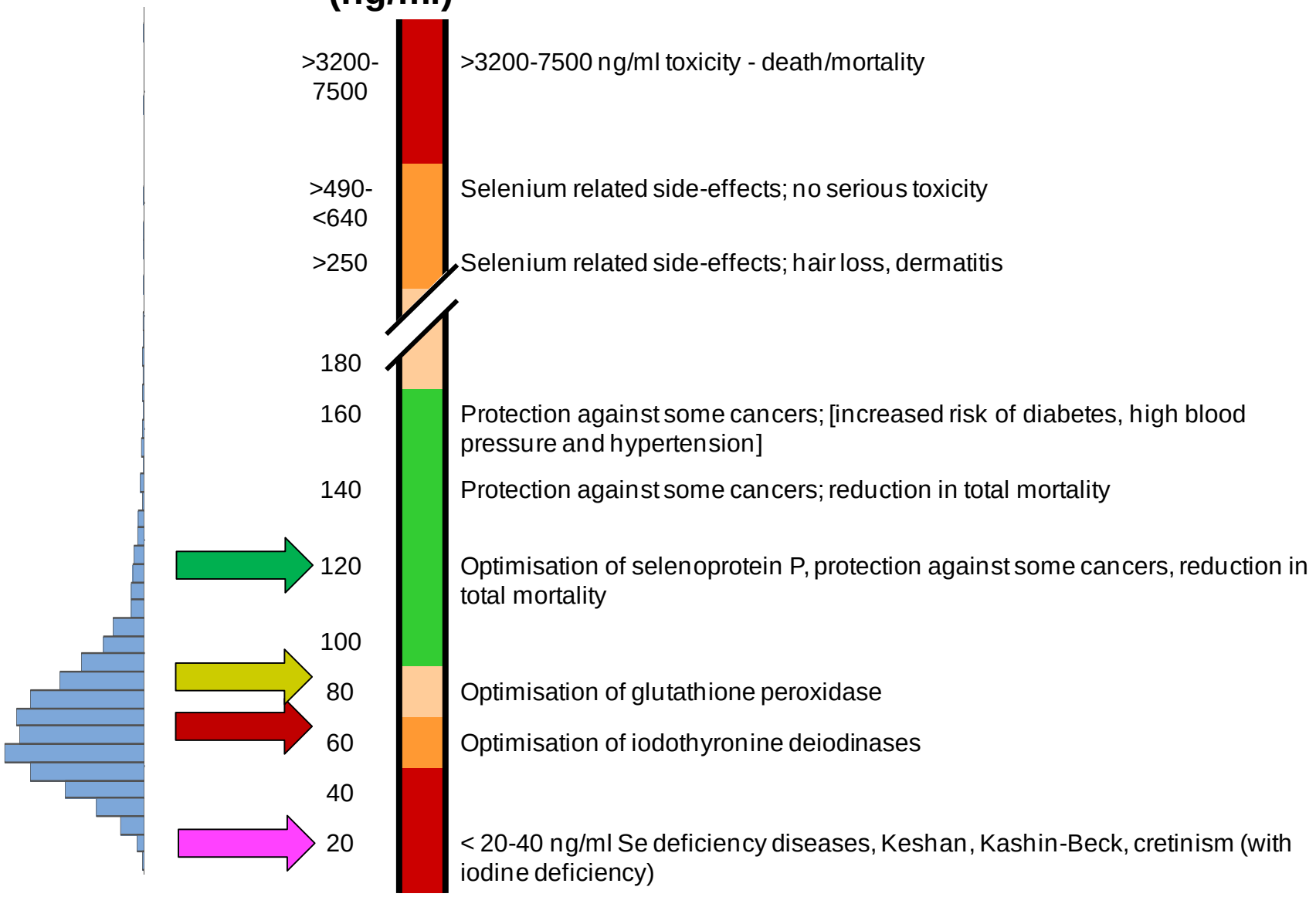
1. Do nothing?

2. Change fertilizer policy
   [as done in Finland]

3. **Extend the evidence base**

Extend the evidence base

Selenium status in Malawi



Options to alleviate Se deficiency in Malawi

1. Do nothing?

2. Change fertilizer policy
   [as done in Finland]

3. Extend the evidence base

4. **R&D**
   [intervention studies, single/multiple inputs, long-term health outcomes, cost-benefit, socio-economic analysis, social sciences, ethics]

FERTBIO 2016

"RUMO AOS NOVOS DESAFIOS"

16 a 20 de Outubro

Centro de Convenções de Goiânia - GO

Zinc (Zn) fertiliser use and its impact on human health

Martin R. Broadley

Munir Zia, Waqar Ahmad, Diriba Kumssa, Edward Joy, Louise Ander, Michael Watts, Alexander Stein, Scott Young

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

FFC

FAUJI FERTILIZER COMPANY LIMITED

FAO FIAT PANIS

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

BGS 1835

British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Int. J. Vitam. Nutr. Res., 83 (3), 2013, 176–187

Original Communication

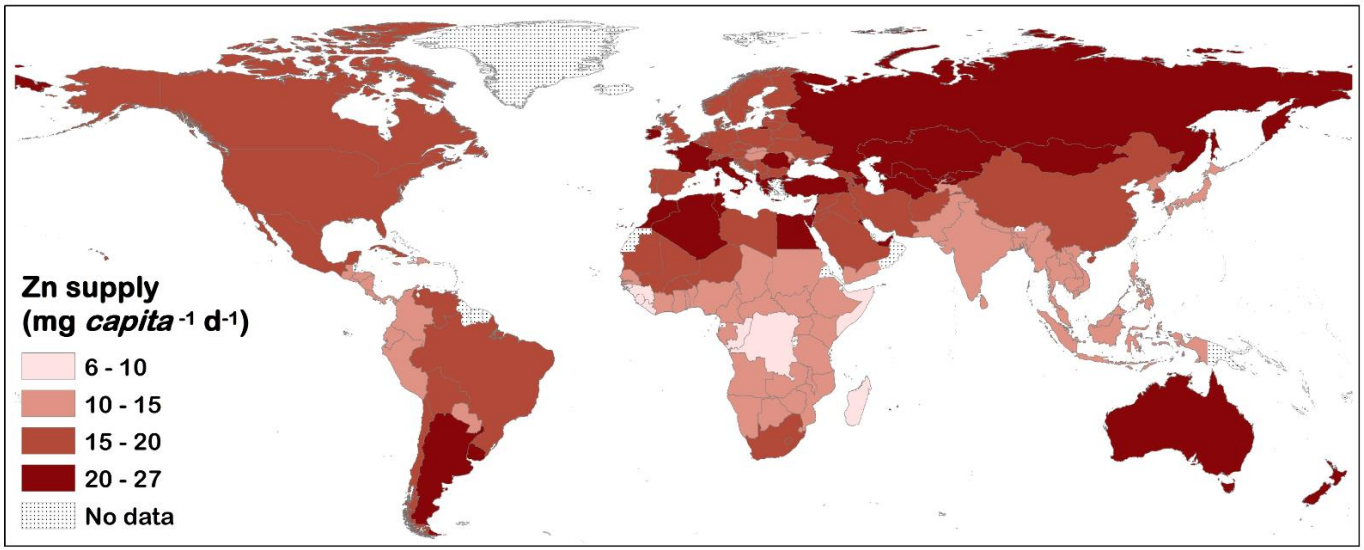
A High Prevalence of Zinc- but not Iron-Deficiency among Women in Rural Malawi: a Cross-Sectional Study

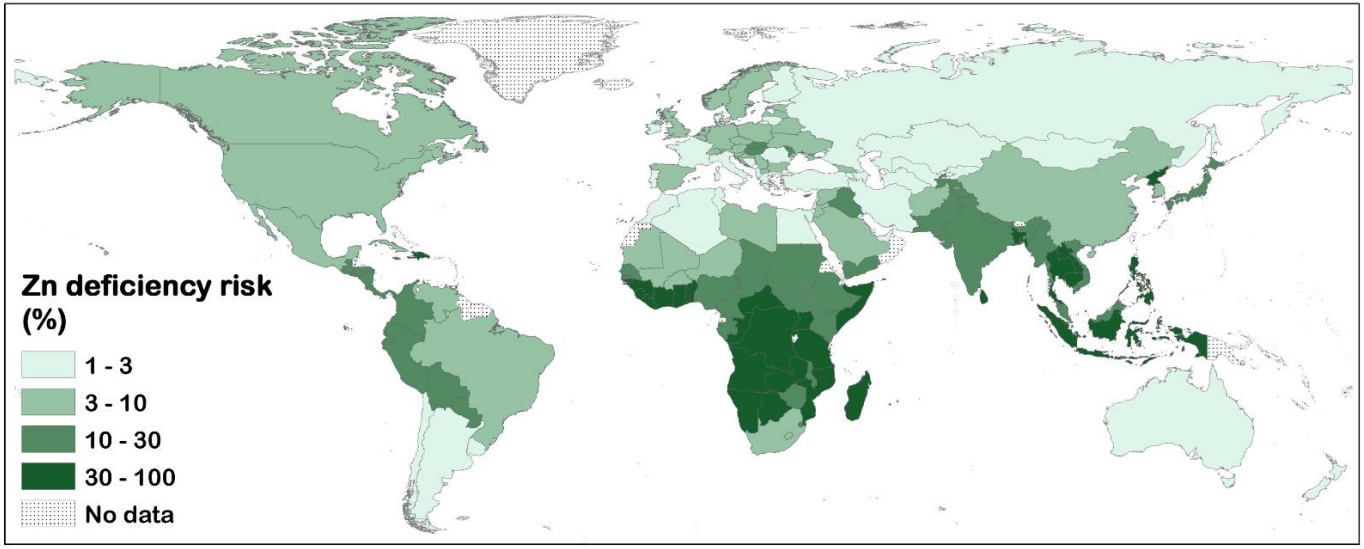
Edwin W. P. Siyame[1], Rachel Hurst[2], Anna A. Wawer[2], Scott D. Young[3], Martin R. Broadley[3], Allan D. C. Chilimba[4], Louise E. Ander[5], Michael J. Watts[5], Benson Chilima[6], Jellita Gondwe[6], Dalitso Kang'ombe[7], Alexander Kalimbira[1], Susan J. Fairweather-Tait[2], Karl B. Bailey[8], and Rosalind S. Gibson[8]

[1]Department of Home Economics and Human Nutrition, Lilongwe University of Agriculture and Natural Resources, Bunda College Campus, Lilongwe, Malawi
[2]Department of Nutrition, Norwich Medical School, University of East Anglia, Norwich, UK
[3]School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, UK
[4]Ministry of Agriculture, Irrigation and Water Development, Department of Agricultural Research Services, Lunyangwa Research Station, Mzuzu, Malawi
[5]British Geological Survey, Keyworth, Nottingham, UK
[6]Community Health Sciences Unit, Ministry of Health, Lilongwe, Malawi
[7]Nutrition Unit of Ministry of Health, Lilongwe, Malawi
[8]Department of Human Nutrition, University of Otago, Dunedin, New Zealand

Received: May 21, 2013; Accepted: August 9, 2013

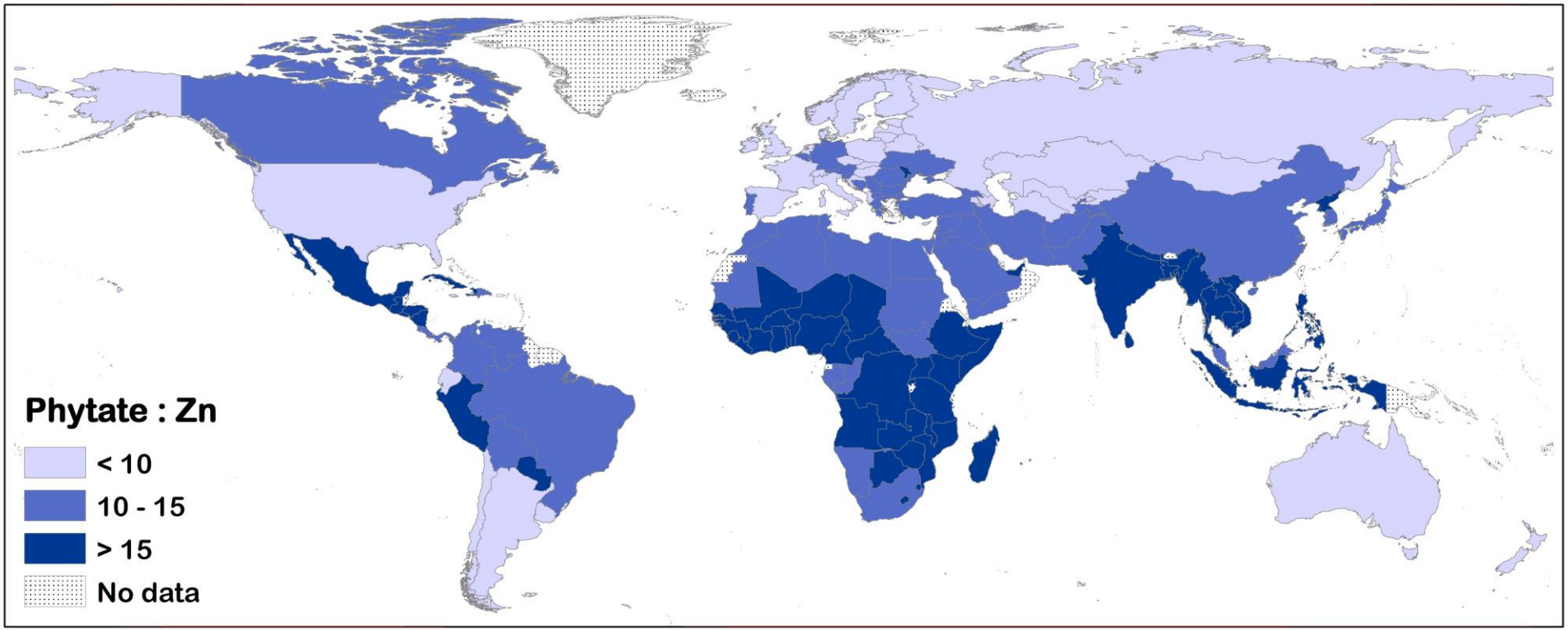
Dietary Zn supply: ~20% are deficient





Kumssa DB, Joy EJM, Ander EL, Watts MJ, Young SD, Walker S, Broadley MR (2015). Dietary calcium and zinc deficiency risks are decreasing but remain prevalent. *Scientific Reports*, **5**, 10974.

Zn deficiency risks increased due to phytate-P in cereal grains and legume seeds



Kumssa DB, Joy EJM, Ander EL, Watts MJ, Young SD, Walker S, Broadley MR (2015). Dietary calcium and zinc deficiency risks are decreasing but remain prevalent. *Scientific Reports*, **5**, 10974.

Health Economic Analyses
(based on Disability Adjusted Life Years, DALYs)

Intervention	Cost per DALY saved (US $)	Notes	Source
Granular fertiliser	773-6457	sub-Saharan Africa	Joy et al., 2015
Foliar fertiliser	81-575	sub-Saharan Africa	Joy et al., 2015
Soil + foliar fertiliser	256-549	Pakistan (Punjab, Sindh)	Joy et al., 2016
Foliar (w/ pesticide)	41-594	China	Wang et al. 2016
Crop breeding	0.7-7.3	India (1.1 billion)	Stein et al., 2006
Supplements	65-2758	Prophylactic, 1-4 yrs	Fink & Heitner, 2014
Flour fortification	401	Zambia, VA, Fe, Zn	Fielder et al., 2013

Joy EJM, Stein AJ, Young SD, EL Ander, MJ Watts, Broadley MR (2015). Zinc-enriched fertilisers as a potential public health intervention in Africa. *Plant and Soil*, 389, 1-24.

Joy EJM, Ahmad W, Zia MH, Kumssa DB, Young SD, Watts MJ, Stein AJ, Broadley MR (2016). Valuing increased zinc (Zn) fertiliser-use in Pakistan. *Plant and Soil*, doi: 10.1007/s11104-016-2961-7.

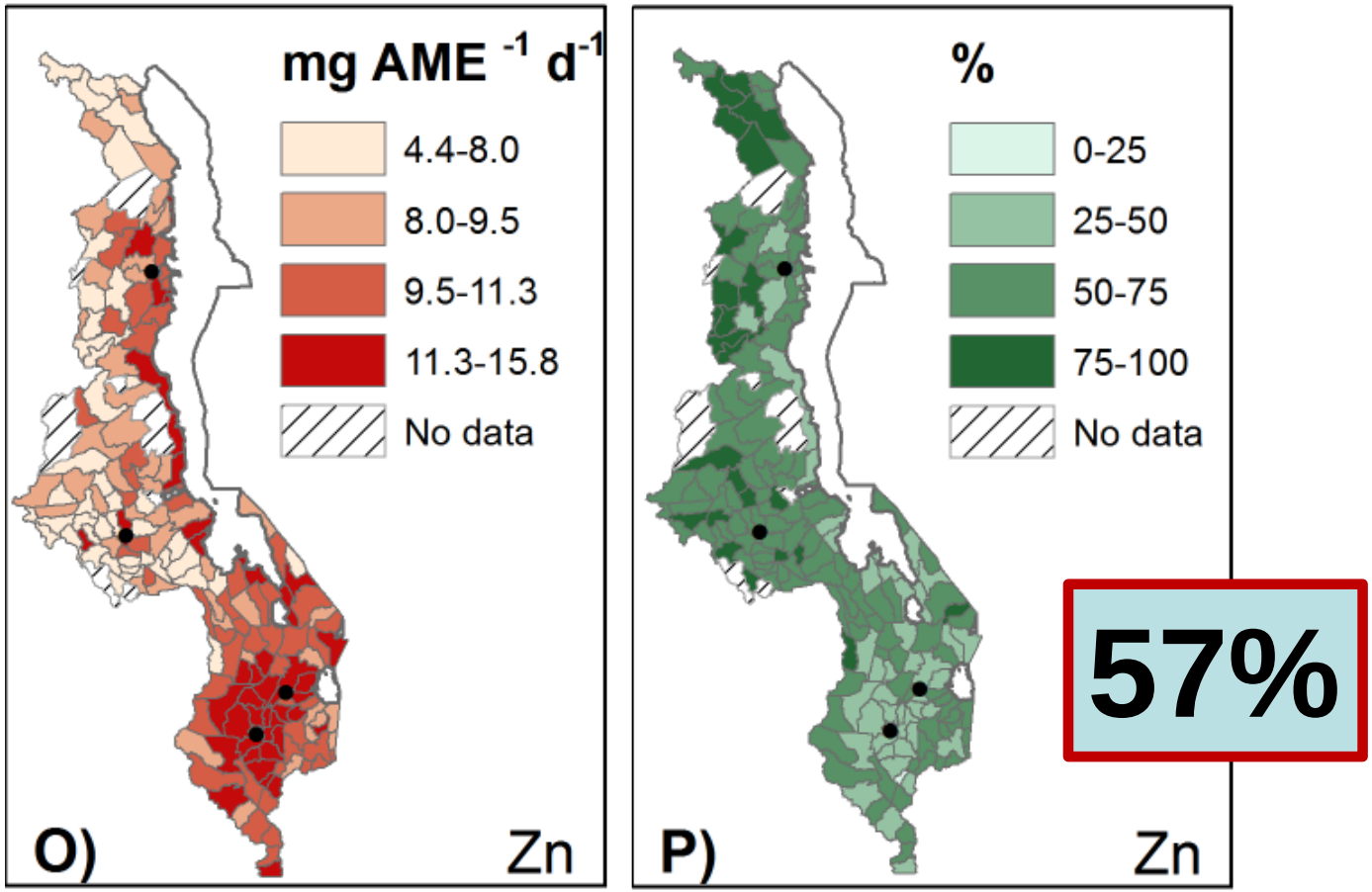
Improving dietary mineral supplies

1. **Diet diversification**
2. **Food fortification**
3. **Agronomy**
4. **Crop breeding**

Diet Diversification

Zn supply in Malawi

AME = adult male equivalent

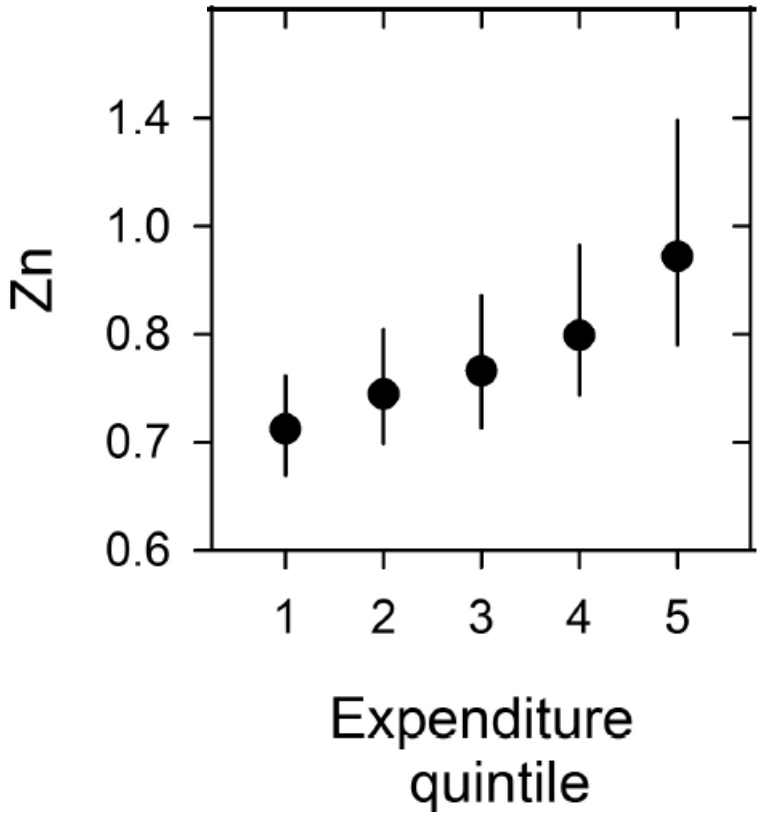


Median Zn supply (per AME) = 10 mg *capita*$^{-1}$ d^{-1}
Estimated Average Requirement = ~12 mg *capita*$^{-1}$ d^{-1}

Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

Zn supply *vs* socioeconomic factors in Malawi

Zn supply as proportion of household requirements



Joy EJM, Kumssa DB, Broadley MR, Watts MJ, Young SD, Chilimba ADC, Ander EL (2015). Dietary mineral supplies in Malawi: spatial and socioeconomic assessment. *BMC Nutrition*, **1**, 42.

Agronomy

Health Economic Analyses

Plant Soil (2015) 389:1–24
DOI 10.1007/s11104-015-2430-8

MARSCHNER REVIEW

Zinc-enriched fertilisers as a potential public health intervention in Africa

Edward J. M. Joy · Alexander J. Stein · Scott D. Young · E. Louise Ander · Michael J. Watts · Martin R. Broadley

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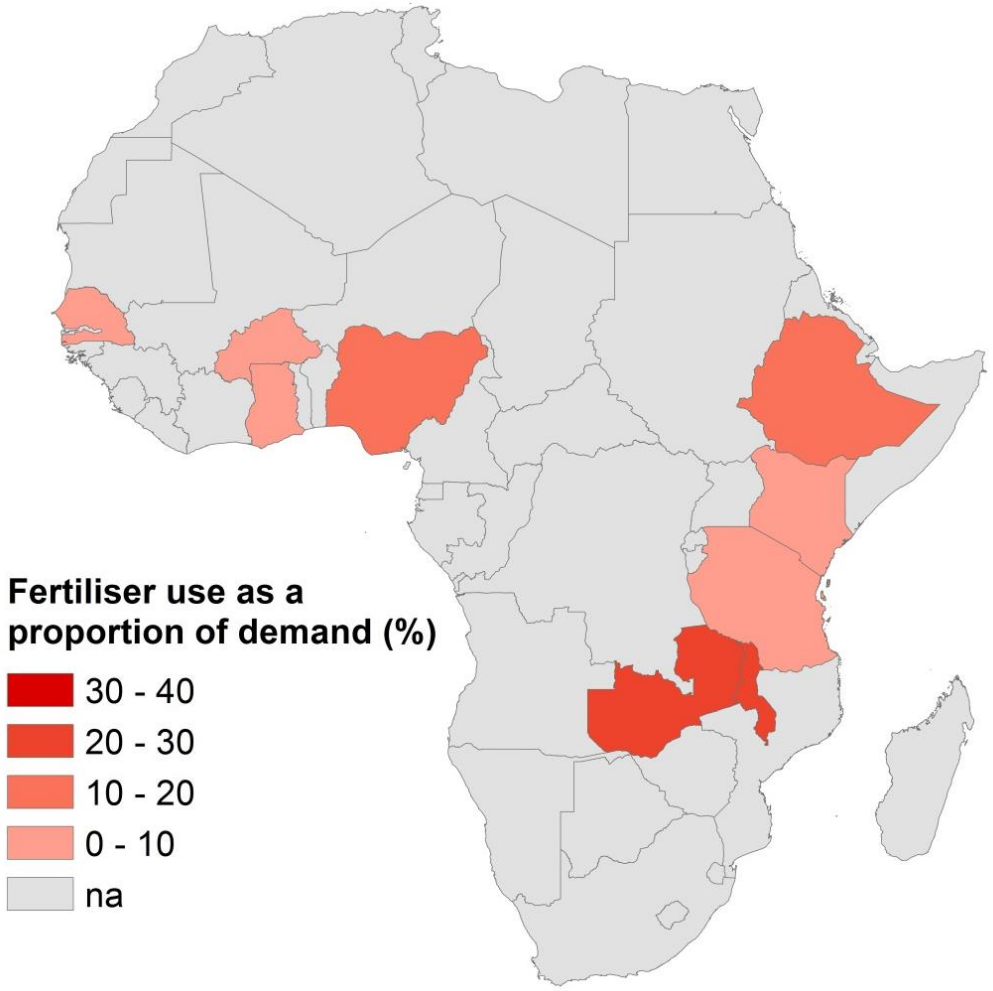
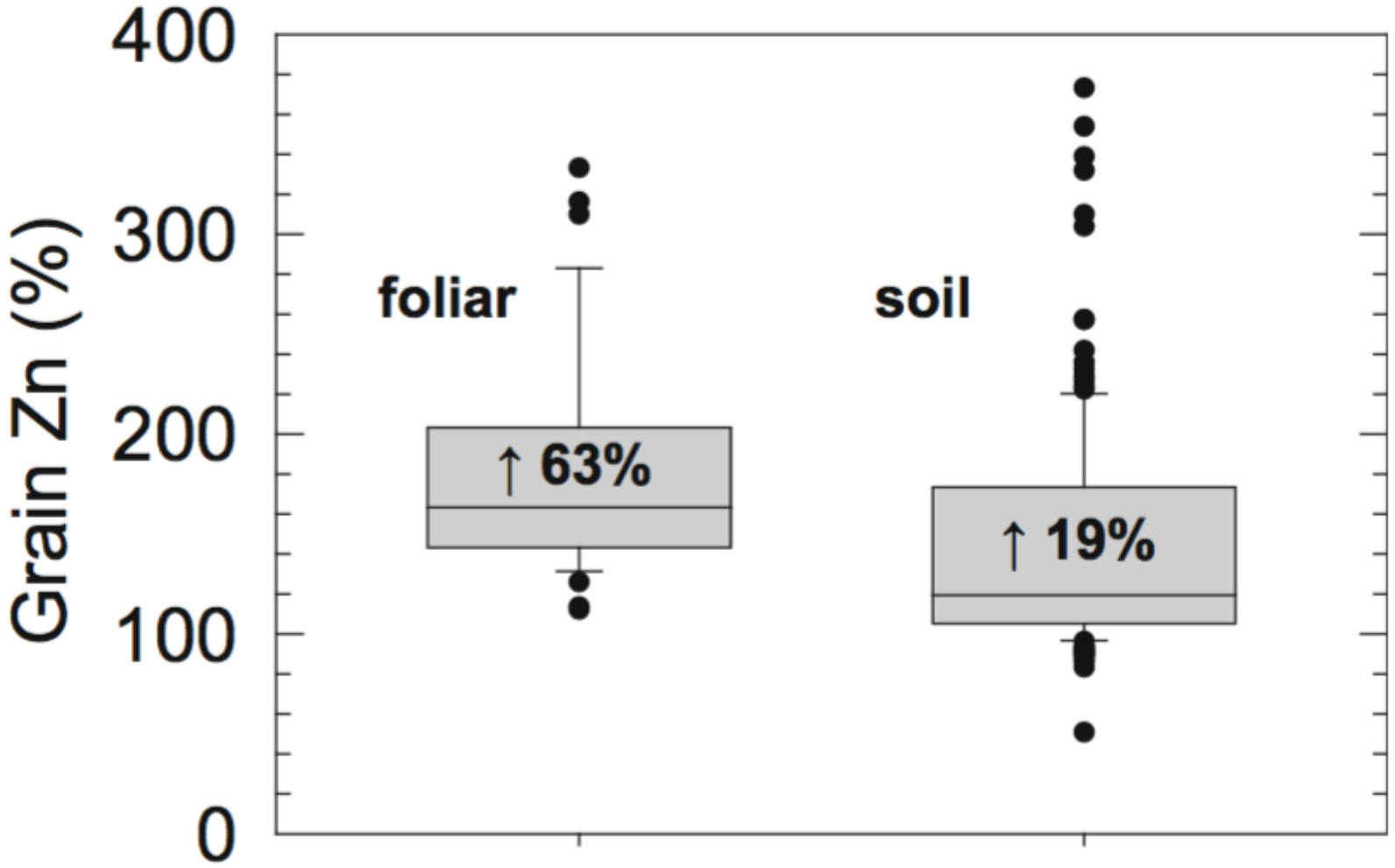
Fertiliser-use in sub-Saharan African countries with subsidies



Data from NEPAD/IFDC (2013) Practices and policy options for the improved design and implementation of fertilizer subsidy programs in sub-Saharan Africa. https://ifdcorg.files.wordpress.com/2015/01/sp-41_rev.pdf [October 2015]

Increases in grain Zn concentration as a result of Zn fertilisation (literature-survey; Joy et al., 2015)



Joy EJM, Stein AJ, Young SD, Ander EL, Watts MJ, Broadley MR (2015). Zinc-enriched fertilisers as a potential public health intervention in Africa. *Plant and Soil*, 389, 1-24.

Foliar Zn fertiliser application to maize on a smallholder farm, Zimbabwe, 2009 (photo, Prof. Florence Mtambanengwe, University of Zimbabwe)

Health Economic Analyses
(based on Disability Adjusted Life Years, DALYs)

Intervention	Cost per DALY saved (US $)	Notes	Source
Granular fertiliser	773-6457	sub-Saharan Africa	Joy et al., 2015
Foliar fertiliser	81-575	sub-Saharan Africa	Joy et al., 2015
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Joy EJM, Ahmad W, Zia MH, Kumssa DB, Young SD, Watts MJ, Stein AJ, Broadley MR (2016). Valuing increased zinc (Zn) fertiliser-use in Pakistan. *Plant and Soil*, doi: 10.1007/s11104-016-2961-7.

Health AND Yield Economic Analyses

Plant Soil
DOI 10.1007/s11104-016-2961-7

REGULAR ARTICLE

Valuing increased zinc (Zn) fertiliser-use in Pakistan

Edward J. M. Joy · Waqar Ahmad · Munir H. Zia · Diriba B. Kumssa · Scott D. Young · E. Louise Ander · Michael J. Watts · Alexander J. Stein · Martin R. Broadley

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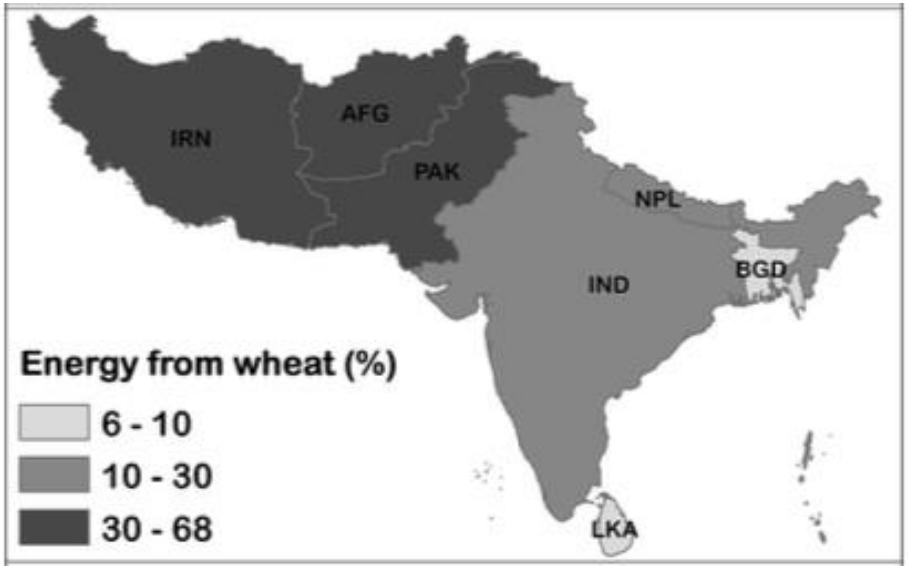
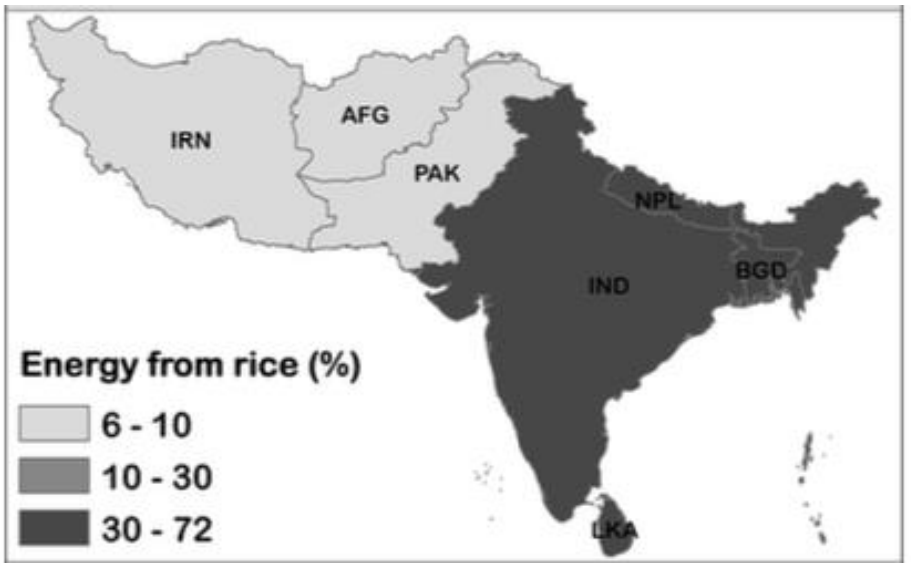
Valuing Zn fertiliser use in Pakistan





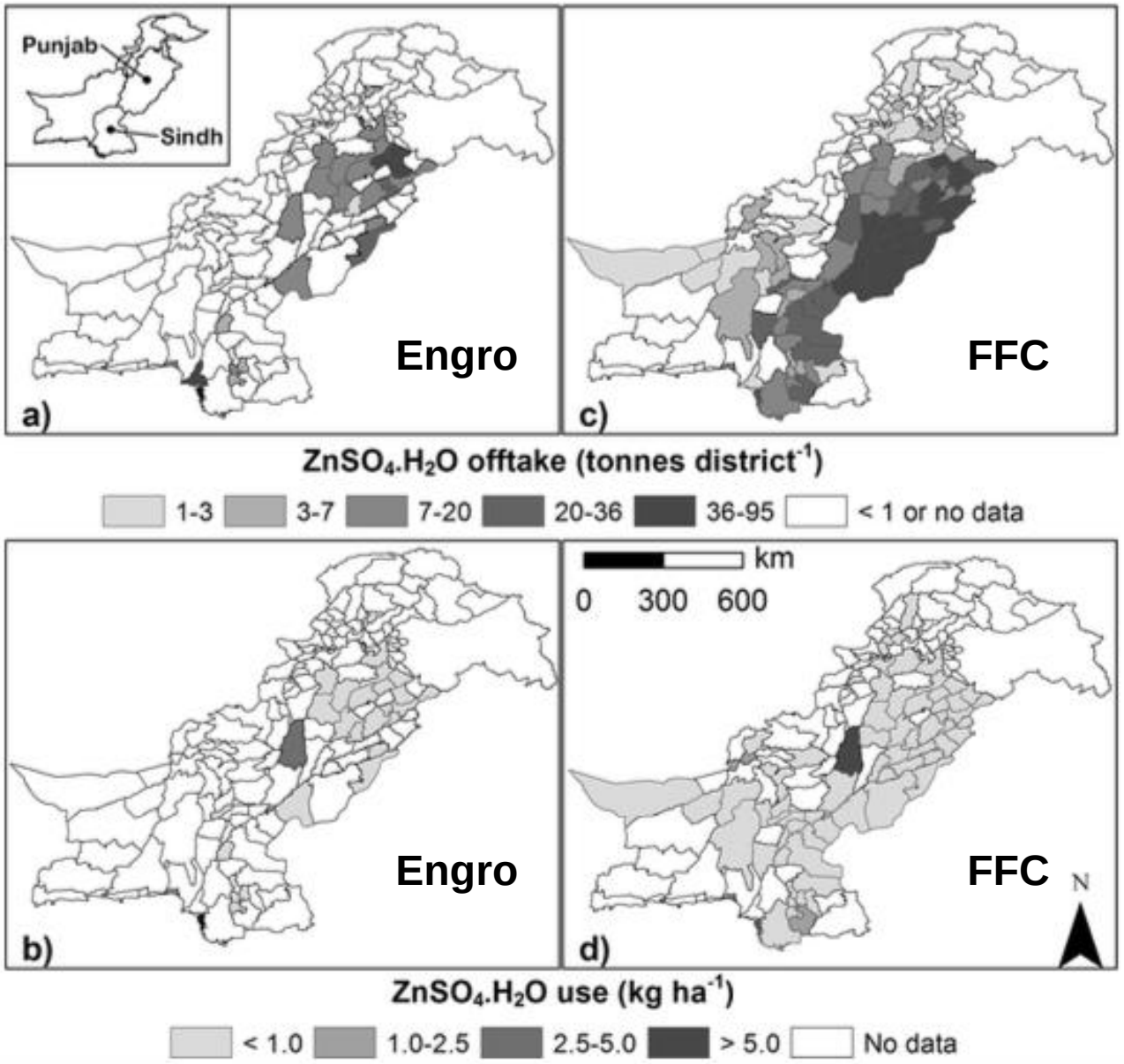
Joy EJM, Ahmad W, Zia MH, Kumssa DB, Young SD, Watts MJ, Stein AJ, Broadley MR (2016). Valuing increased zinc (Zn) fertiliser-use in Pakistan. *Plant and Soil*, doi: 10.1007/s11104-016-2961-7.

Wheat is the major crop of Punjab and Sindh Provinces

Area	Cropped area, wheat (Mha)	Wheat production (Mt)	Wheat yield (t ha^{-1})
Punjab	7.5	18.4	2.5
Sindh	1.9	3.5	1.9
Pakistan	~10	~25	~2.7

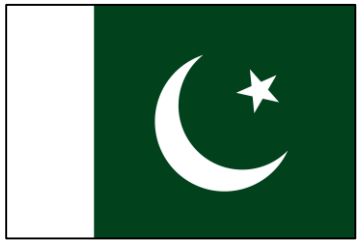
Source. PBS Agriculture Census 2010 (p. 36); N.B. 90/97% of wheat is irrigated in Punjab/Sindh (p.39)

Industry estimates of Zn-use in Pakistan



NFDC

FFC
FAUJI FERTILIZER COMPANY LIMITED



Agricultural Zn-use baselines in Pakistan

Based on rapid farmer surveys

Farmers surveyed in Punjab (n=1193), and Sindh (n=1338) Provinces

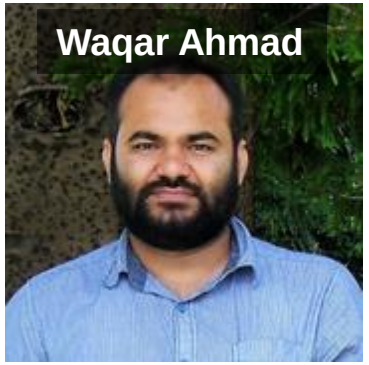
Farmers asked about their crop-specific fertiliser-usage and yields
wheat, rice, cotton, sugarcane, maize, 'other'

Only data for wheat are used in this study

NFDC

FFC
FAUJI FERTILIZER COMPANY LIMITED

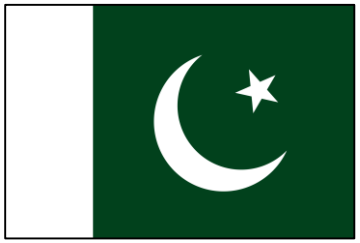
FAO
FIAT PANIS



Rapid farmer survey in Punjab and Sindh

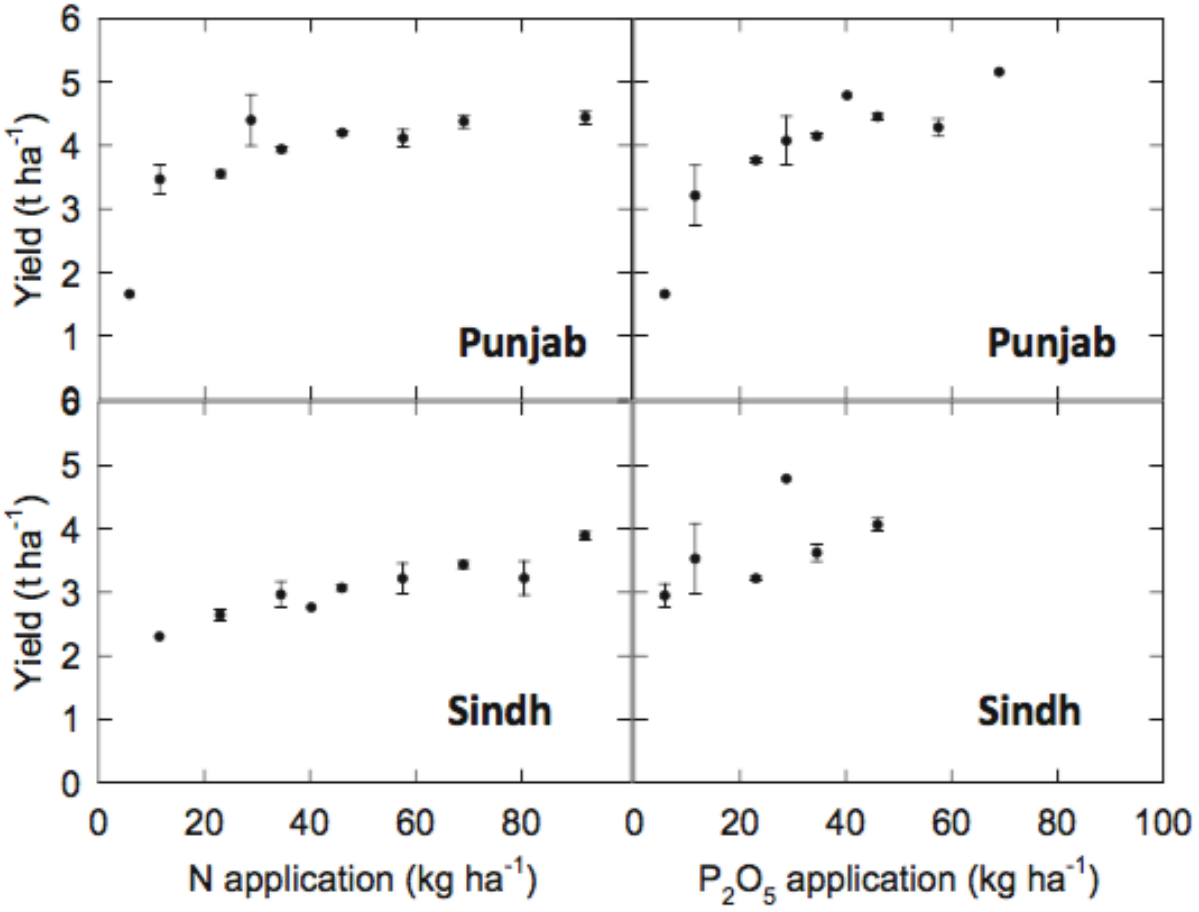
Area	Farmers surveyed		
Punjab	1,193		
Sindh	1,338		
Combined	2,531		

Source. W. Ahmad et al. (2015), unpublished survey data.



Rapid farmer survey in Punjab and Sindh

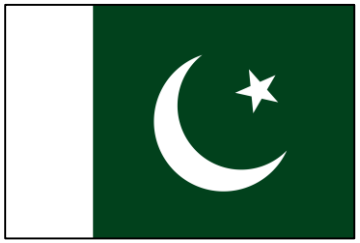
Yield-response of wheat to N (urea) and P_2O_5 (di-ammonium phosphate, DAP)



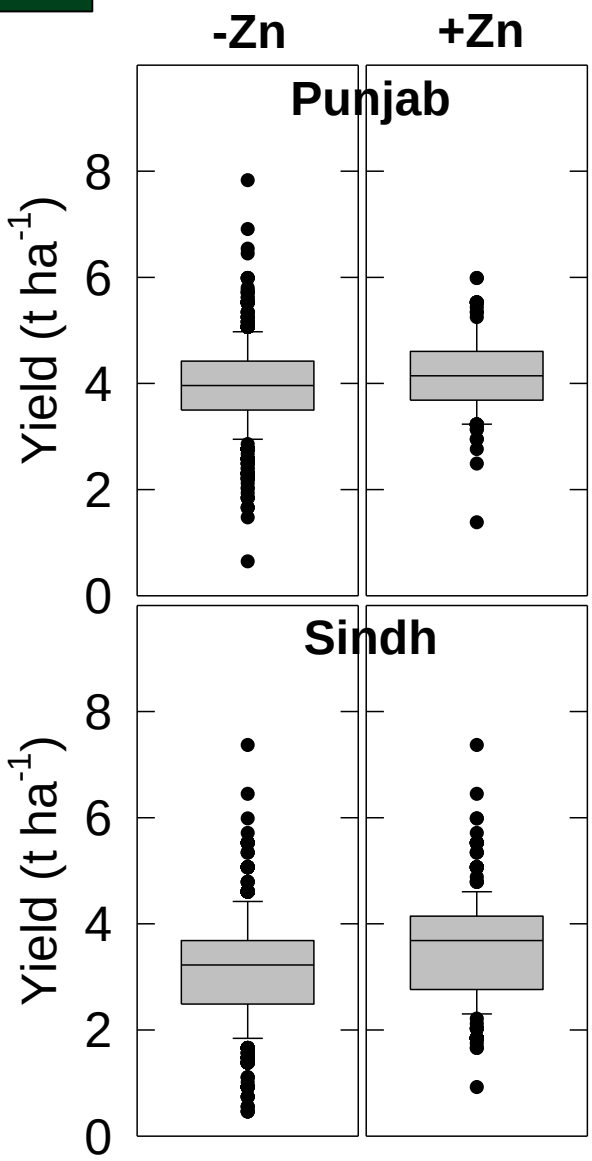
Joy EJM, Ahmad W, Zia MH, Kumssa DB, Young SD, Watts MJ, Stein AJ, Broadley MR (2016). Valuing increased zinc (Zn) fertiliser-use in Pakistan. *Plant and Soil*, doi: 10.1007/s11104-016-2961-7.

Zn fertilisers are currently used by a proportion of (progressive) farmers

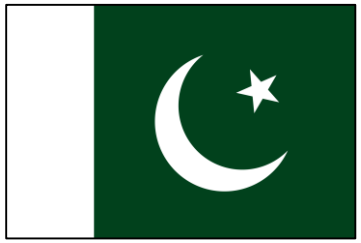
Area	Farmers surveyed	Using Zn fertilisers	Using Zn fertilisers? (%)
Punjab	1,193	172	14
Sindh	1,338	310	23
Combined	2,531	482	19



Yield response to Zn fertiliser



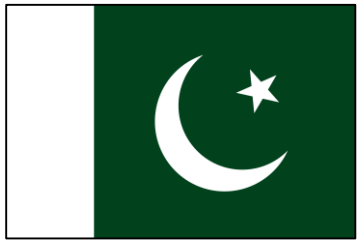
Area	-Zn mean yield (t ha^{-1})	+Zn mean yield (t ha^{-1})	%	*P*
Punjab	4.0	4.3	108	<0.001
Sindh	3.1	3.6	114	<0.001



Value of increased Zn fertiliser-use in Pakistan

Assumptions used to value Zn fertiliser-use:

1. **Baseline Zn-use 7.3 kt y^{-1} at 4.8 kg ha^{-1} ($ZnSO_4.H_2O$ eq. @ 33% Zn)**
2. **Constant granular:foliar ratio of 0.7:0.3**
3. **Wheat support price: $312 USD t^{-1}**
4. **Cost of $ZnSO_4.H_2O$: $1600 USD t^{-1}**
5. **Scenario: ↑ Zn fertilisers are distributed to 100% wheat in Punjab, Sindh**
6. **Benefit:Cost Ratios (BCRs) estimated for ↑ yield**
7. **Health economic impact of ↓ in DALYs lost, due to an ↑ in grain Zn concentration from national baseline surveys of wheat**



Value of increased Zn fertiliser-use in Pakistan

Assumptions used to value Zn fertiliser-use:

8. **4.8 kg ha^{-1} soil-Zn, ↑ grain Zn by 19% to 29.6 mg kg^{-1}**

9. **4.8 kg ha^{-1} foliar-Zn, ↑ grain Zn by 63%, to 40.6 mg kg^{-1}**

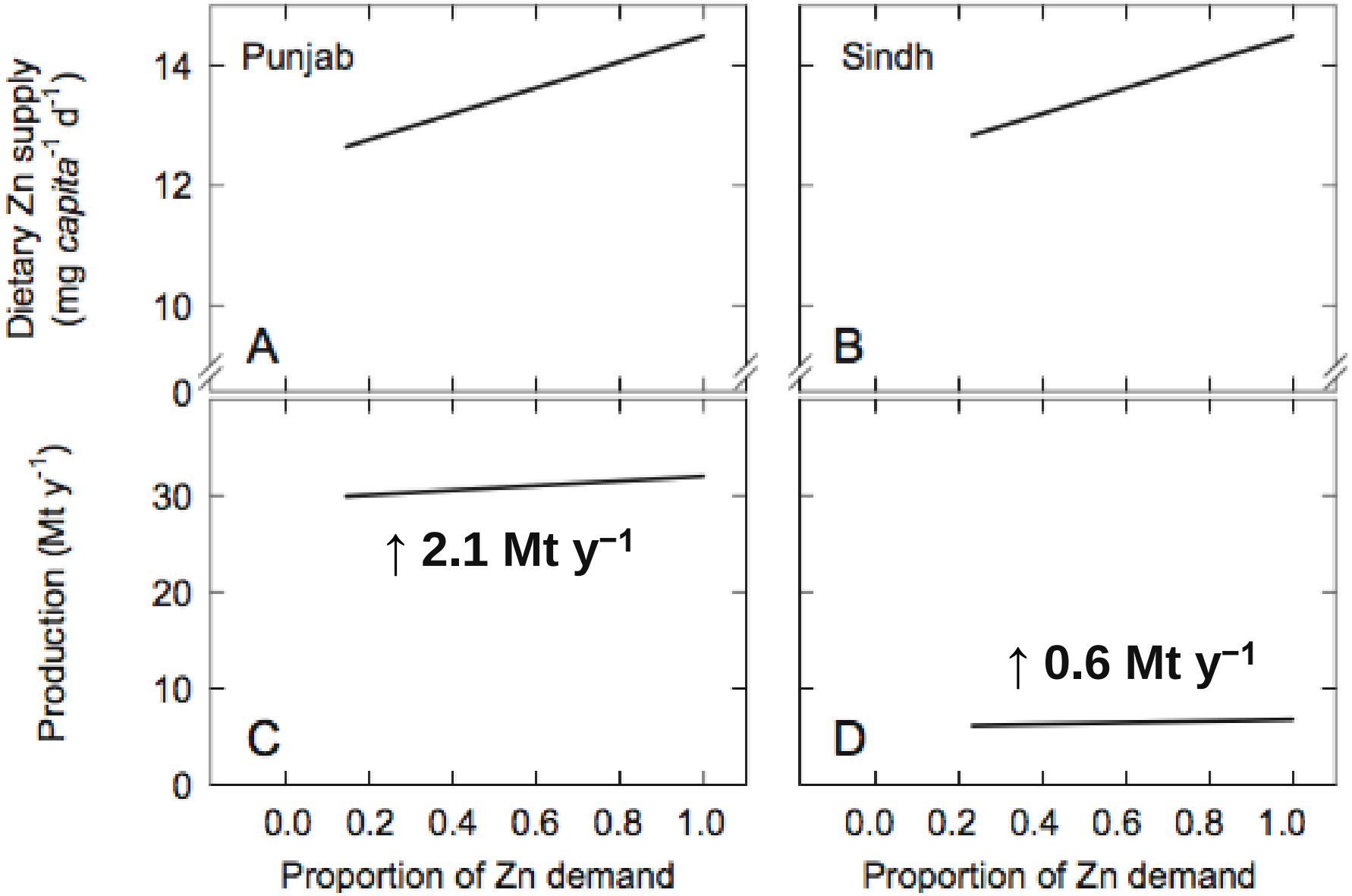
10. **Value of 1 DALY = *x* * Gross National Income-PPP, i.e. *x* * I$ 5,110**
    PPP=parity purchasing power: I$ based on 2011 International Comparison Program*

11. **BCRs for ↑ yield and ↓ in DALYs lost are additive**

12. **No discounting**

*http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD

Valuing Zn fertiliser use in Pakistan (Zn supply, yield)



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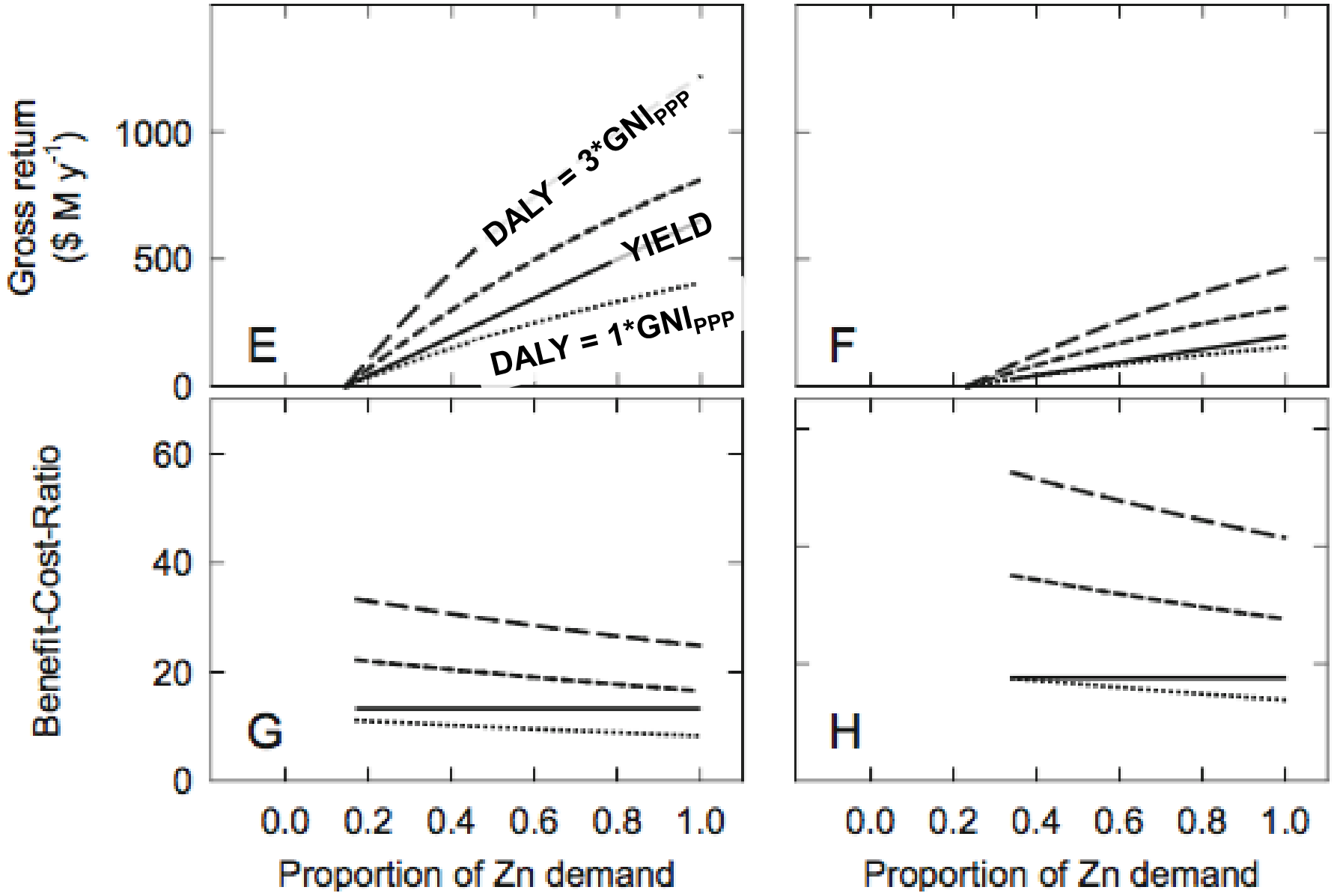

Valuing Zn fertiliser use in Pakistan (yield + DALYs)

Cost per DALY saved:

Punjab = $392-549 USD

Sindh = $256-349 USD

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(based on Disability Adjusted Life Years, DALYs)

Intervention	Cost per DALY saved (US $)	Notes	Source
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Valuing Zn fertiliser use in Pakistan (yield + DALYs)

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Conservative BCRs

Used 24% Zn deficiency prevalence, likely to be >40%

Zn fertiliser effects can persist for 3-4 subsequent crops

Strong drivers for private and public investment in Zn fertilisers

Blending Zn and granular fertiliser in Punjab, Pakistan (photo, Dr Munir Zia, Fauji Fertiliser Company)

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Other soil improvements will increase yield further

P, K, and B fertilisers are under-utilised in Pakistan

Many saline/sodic soils

Breeding for increased grain Zn concentration adds further 'value'

Acknowledgements

Colleagues at:

Malawi (DARS, DNHA, CHSU, LUANAR)

Zambia (UNZA, ZARI, CBU)

Zimbabwe (UZ)

University of Nottingham

British Geological Survey

Other institutes (e.g. Rothamsted, LSHTM, CDC, UEA, Otago)

Funders…

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