

**UK-BRC Meeting
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Biofortifying *Brassica* with calcium and magnesium



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Nottingham



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RESEARCH



Shoot Calcium and Magnesium Concentrations Differ between Subtaxa, Are Highly Heritable, and Associate with Potentially Pleiotropic Loci in *Brassica oleracea*^{1[W][OA]}

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Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons

Low Ca intake: osteoporosis, rickets (Vit. D metabolism) etc.

Low Mg intake: hypertension, heart dysfunction, diabetes, preeclampsia

>30% globally deficient in dietary Ca or Mg

Probably more: soft-tissue biomarkers of Ca/Mg status are unreliable

**Dietary Ca/Mg deficiencies cannot be met sustainably through meat / dairy
or supplements in many groups**

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Table 1. Essential mineral elements required by humans^a

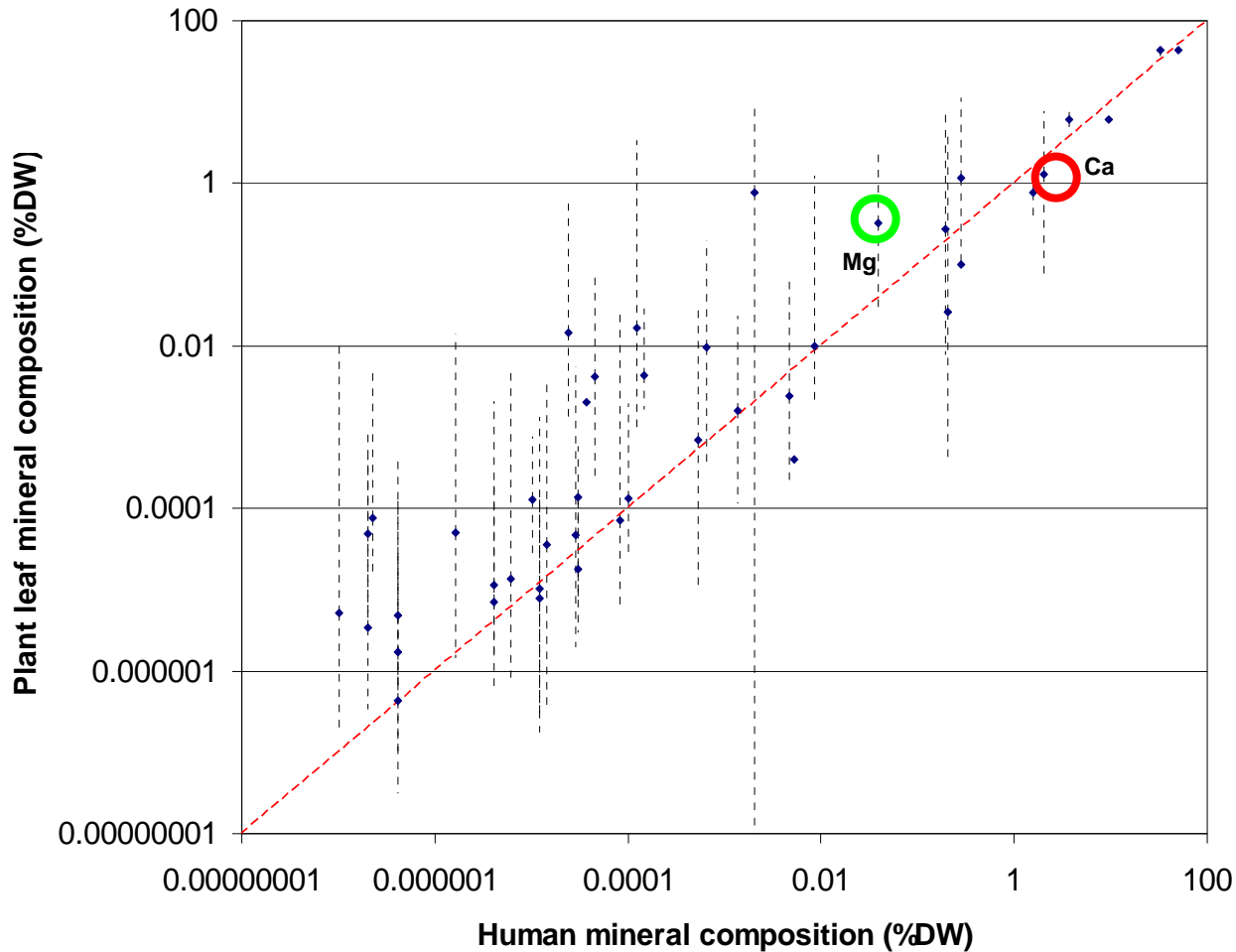
Element	RDA	RNI	UL	SUL	Antinutrients	Promoters
N	NS	NS	NS	NS		
S	NS	NS	NS	NS		
K (mg)	1600–3500	3500	NS	3700 ^b		
Cl (mg)	750–3400	2500	NS	NS		
Ca (mg)	1000–1200	700	2500	1500 ^b	Oxalate, phytate, tannins, fiber	Inuline
P (mg)	700	550	4000	250 ^b		
Na (mg)	500–2400	1600	<2400	NS		
Mg (mg)	310–420	300	350 ^b	400 ^b	Phytate	
Fe (mg)	8.0–18.0	11.4	45.0	17.0 ^b	Phytate, tannins, oxalate, fiber, hemagglutinins	Phytoferritin, riboflavin, ascorbate, β-carotene, cysteine, histidine, lysine, fumarate, malate, citrate
Zn (mg)	8.0–11.0	9.5	40.0	25.0 ^b	Phytate, tannins, fiber, hemagglutinins	Palmitic acid, riboflavin, ascorbate, cysteine, histidine, lysine, methionine, fumarate, malate, citrate
Mn (mg)	1.8–2.3	> 1.4	11.0	4.0 ^b		
Cu (mg)	0.9	1.2	10.0	10.0		
I (μg)	150	140	1100	500 ^b	Goitrogens	Selenium
Se (μg)	55	75	400	450		
Mo (μg)	45	50–400	2000	NS		
Cr (μg)	25–35	> 25	NS	NS		
F (mg)	3–4	NS	10	NS		
B (mg)	NS	NS	20.0	9.6		
Ni (μg)	NS	NS	1000	260		
V (mg)	NS	NS	1.8	NS		
Si (mg)	NS	NS	NS	1500		
As	NS	NS	NS	NS		

Abbreviations: NS, none specified.

^aThe US recommended daily allowances (RDA, or adequate intakes), the UK guidance daily reference nutrient intakes (RNI), the US tolerable upper intake levels (UL), and the UK guidance safe upper levels (SUL) for adults (<http://www.food.gov.uk/multimedia/pdfs/vitamin2003.pdf>, [96]). The required amounts of N and S can be obtained if the recommended daily protein intake is achieved.

^bNon-food.

Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons



Sources:

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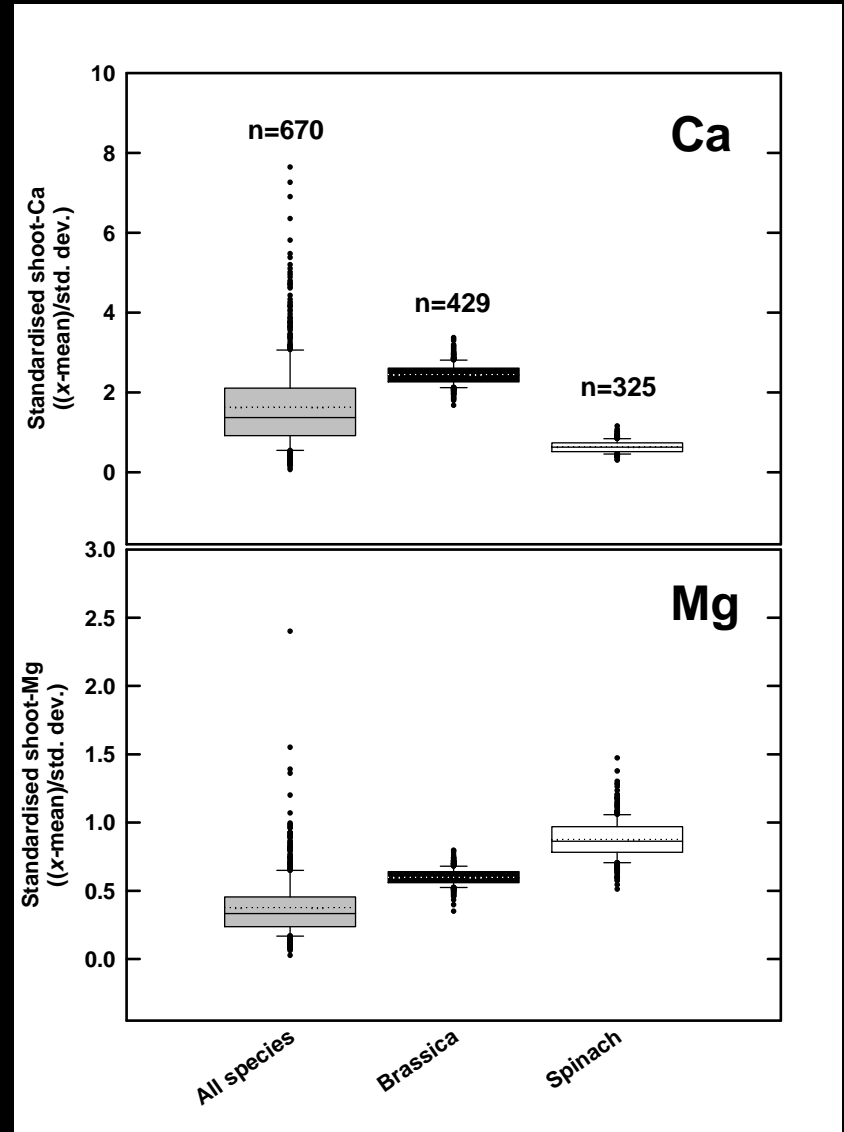
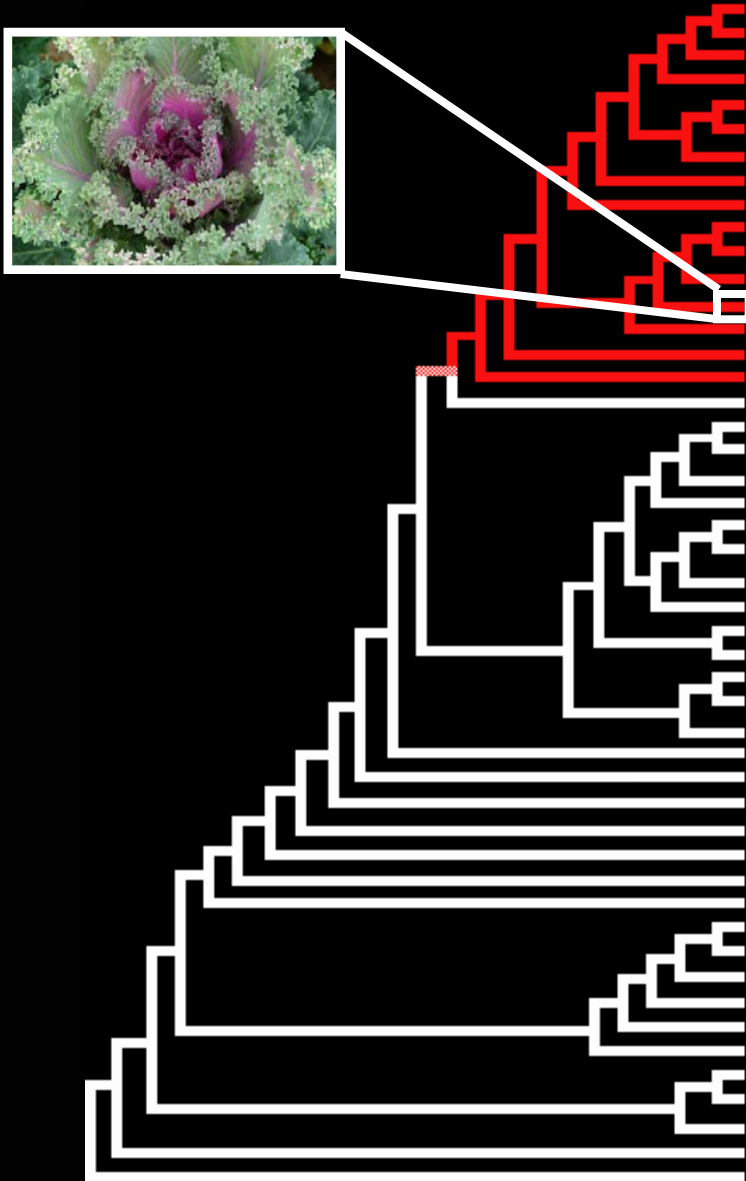
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Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons



Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons

Brassica high Ca/Mg in shoot

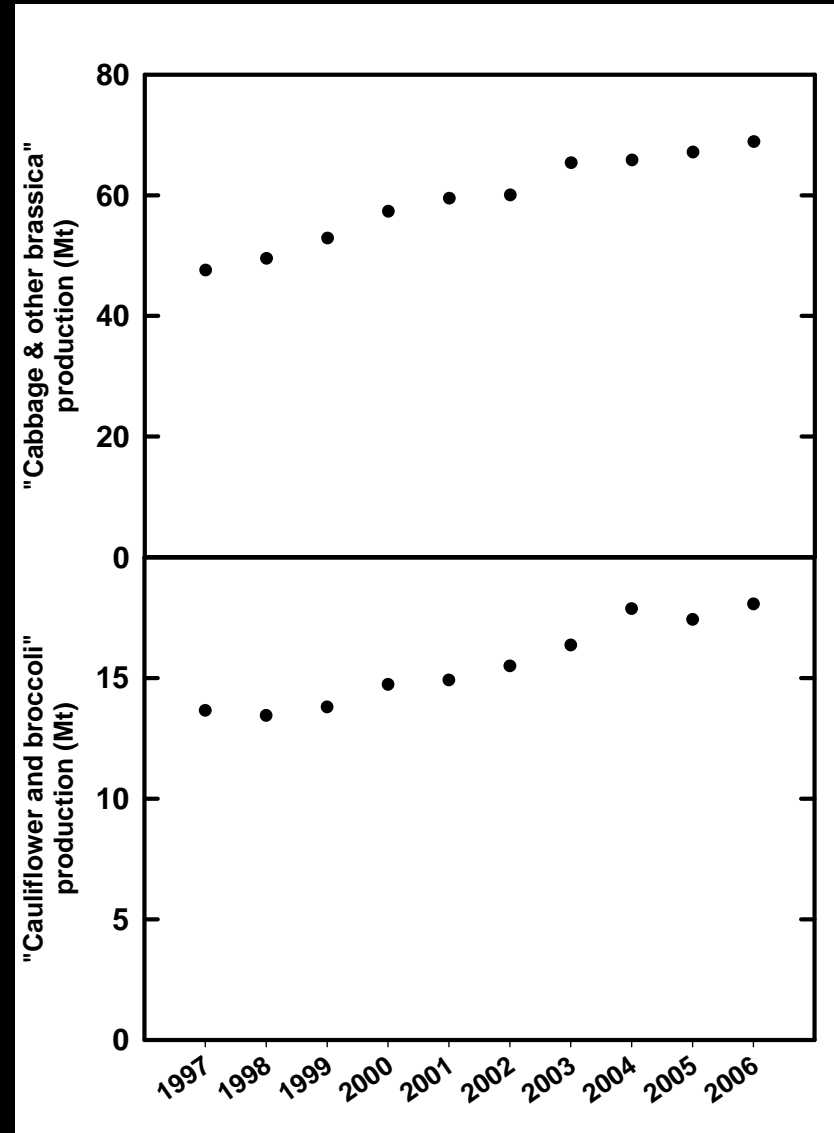
Brassica low oxalate/phytate in shoot

Brassica most widely eaten “leaf” ?

2006 production:

68.9 Mt yr⁻¹ “cabbages and other brassica”

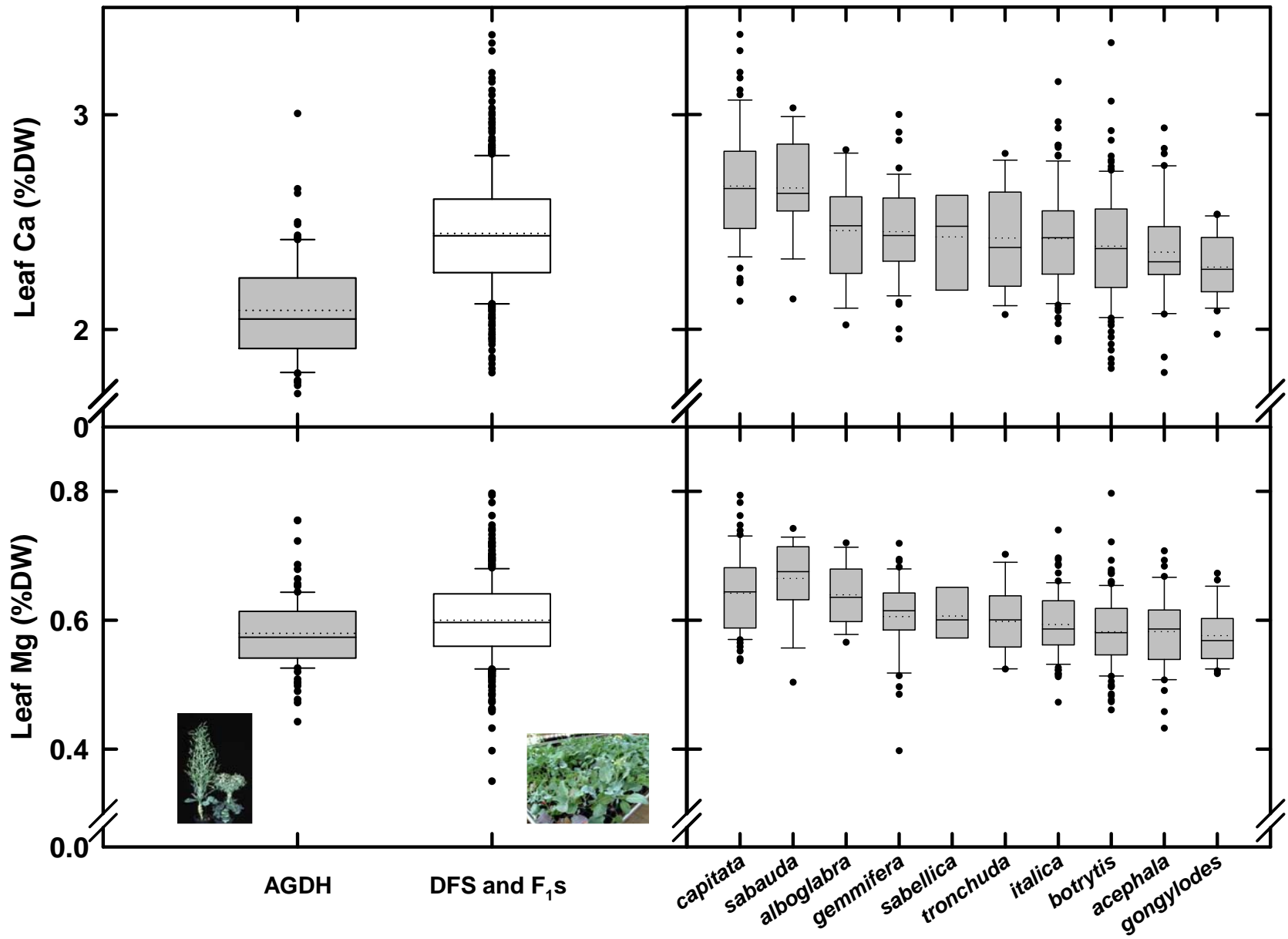
18.1 Mt yr⁻¹ “cauliflowers and broccoli”



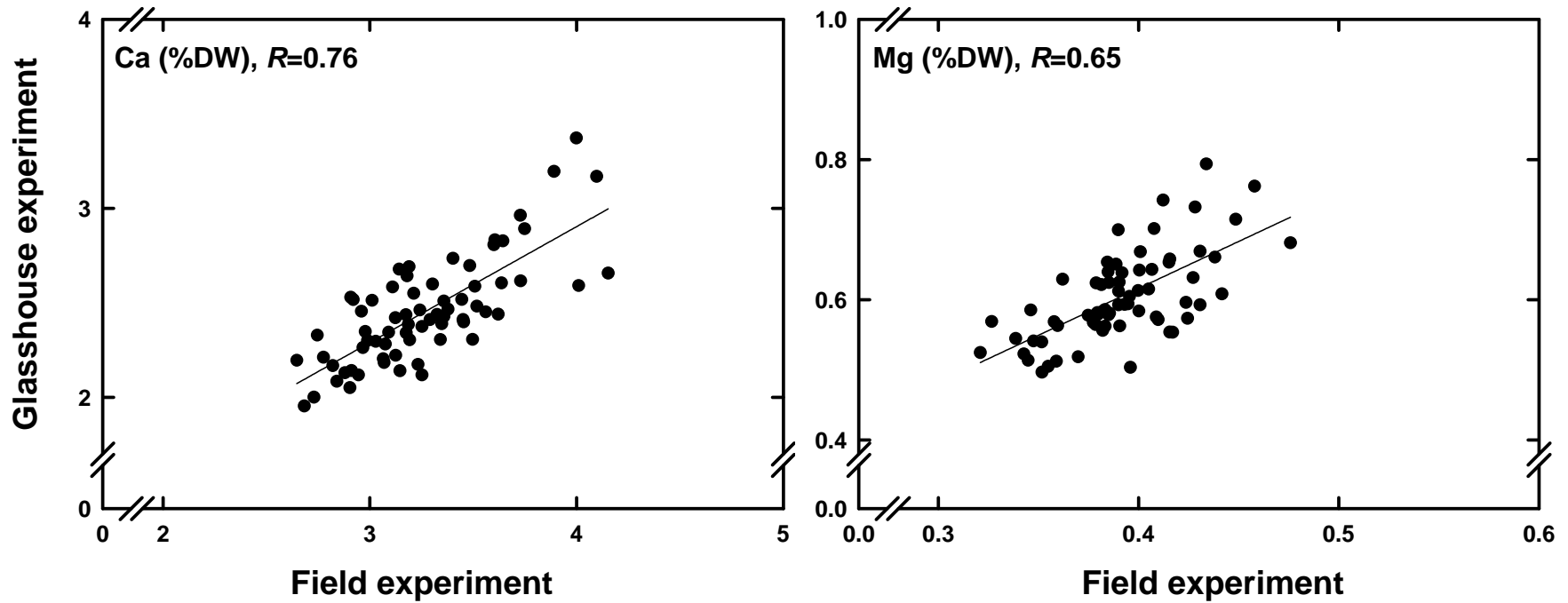
Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons



***Brassica* crops are ideal calcium biofortification targets: human health, agronomic and genetic reasons**



Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons



F_1 hybrids in field vs glasshouse ($P<0.0001$)

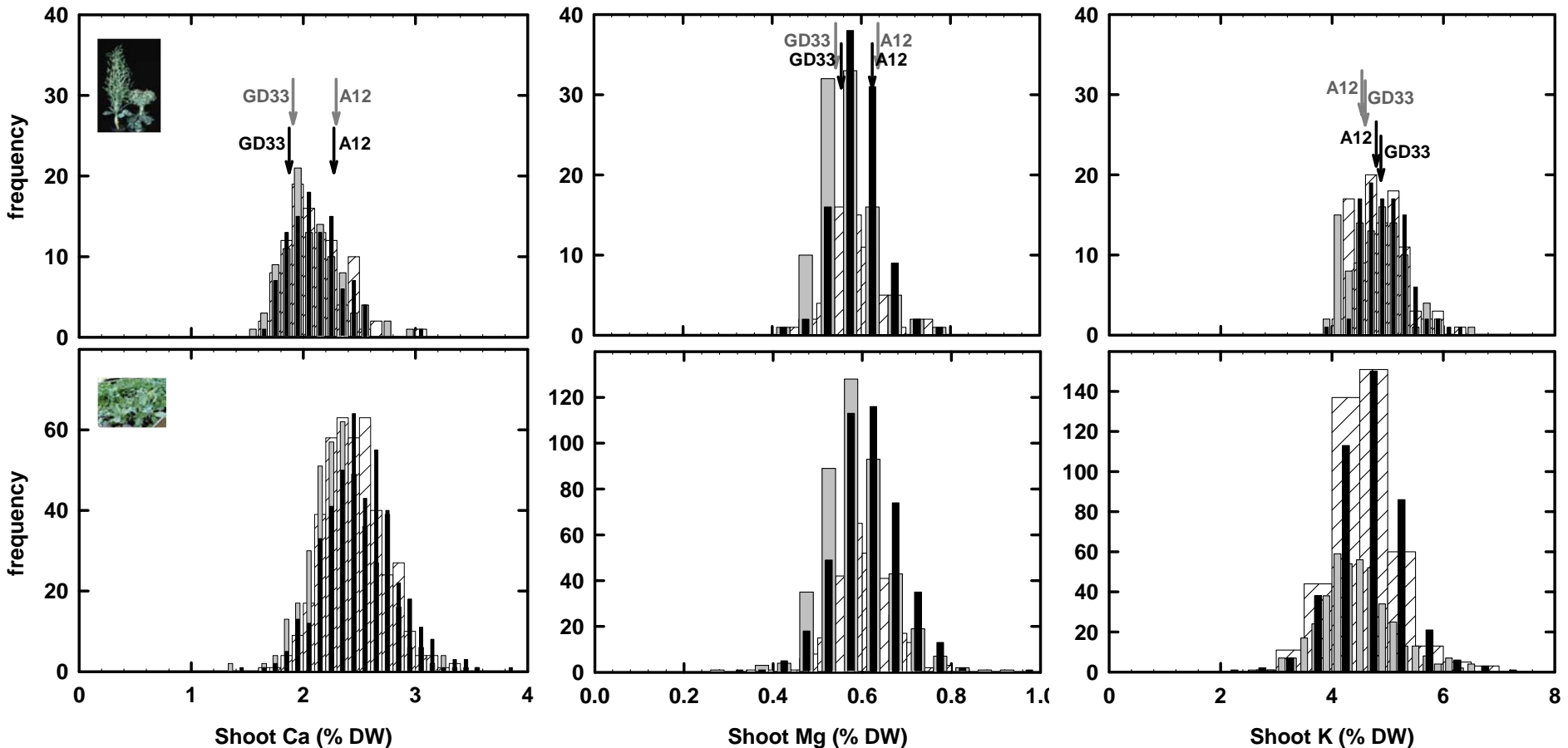
Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons

Variance component	Ca	Mg	K	P	Zn	Fe
Genotype (V_A)	36.0	37.7	22.2	7.4	18.5	7.1
$[P]_{\text{ext}}$	0.2	4.0	2.2	43.1	7.2	3.5
$[P]_{\text{ext}} /$ genotype	1.4	1.1	1.4	0.5	2.5	0.0
'other'	62.4	57.2	74.2	49.0	71.8	89.4



High heritability in AG population

Vegetable *Brassica* are Ca/Mg biofortification targets: dietary, evolutionary and genetic reasons

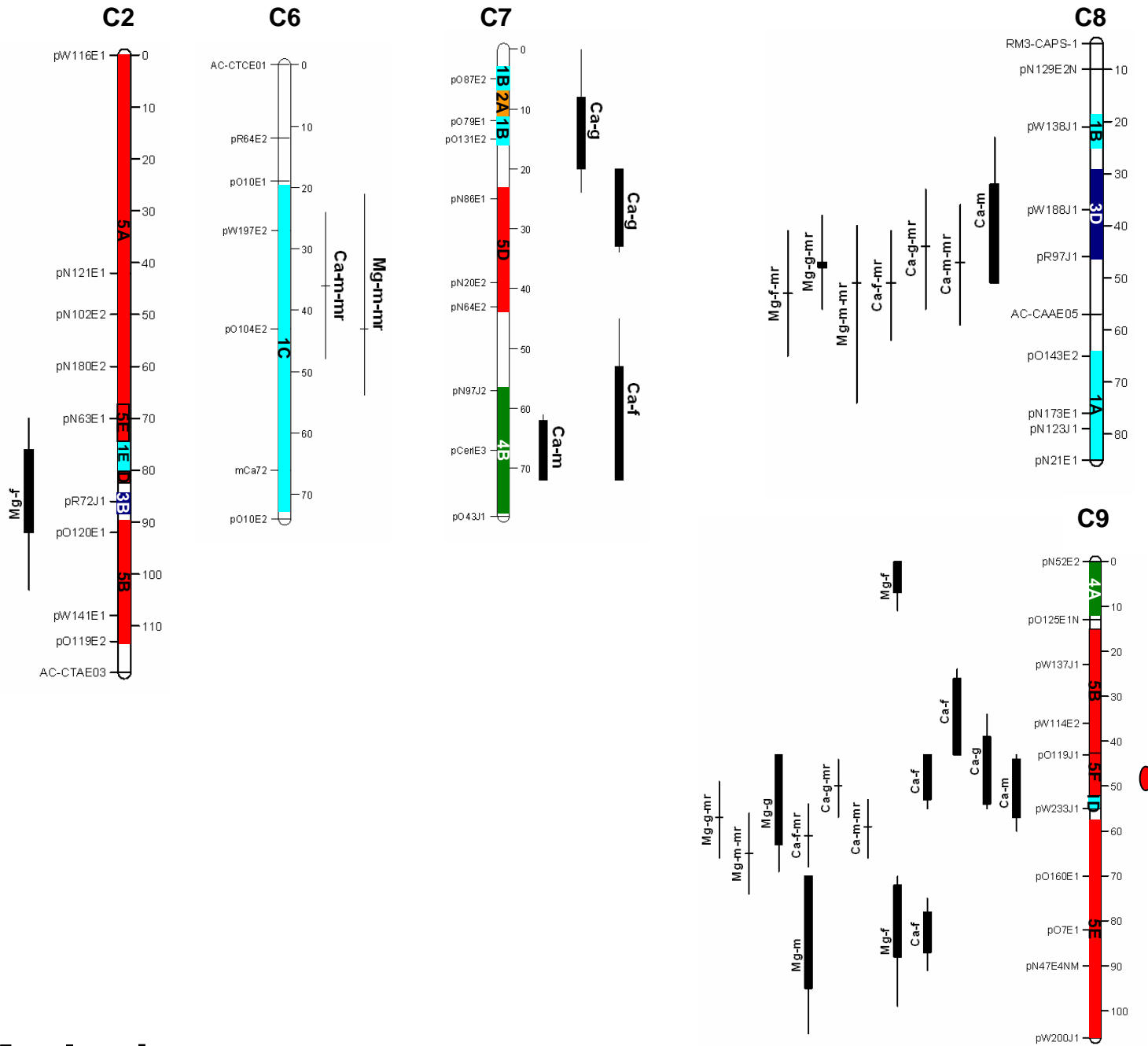


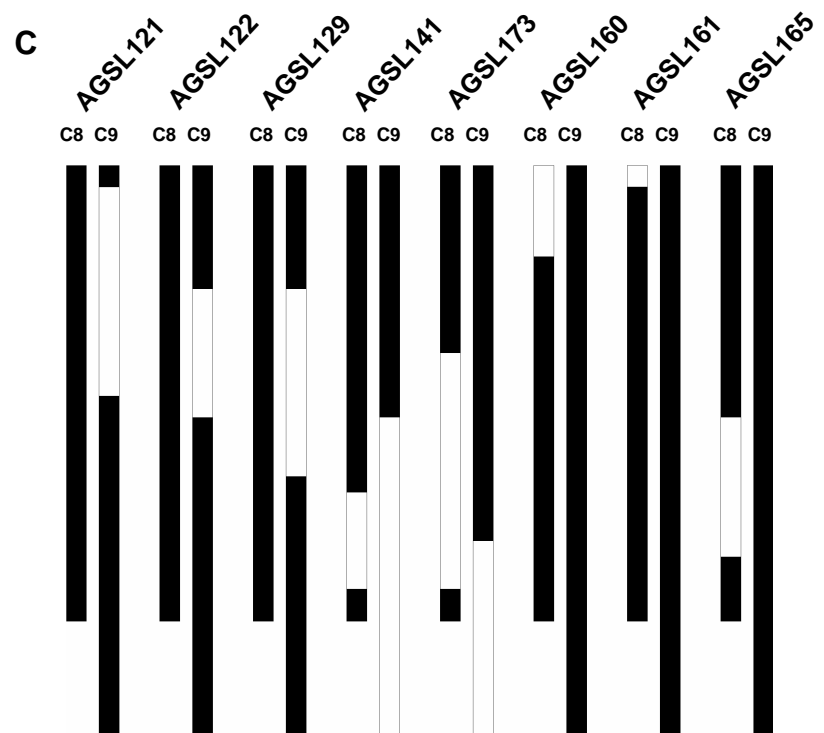
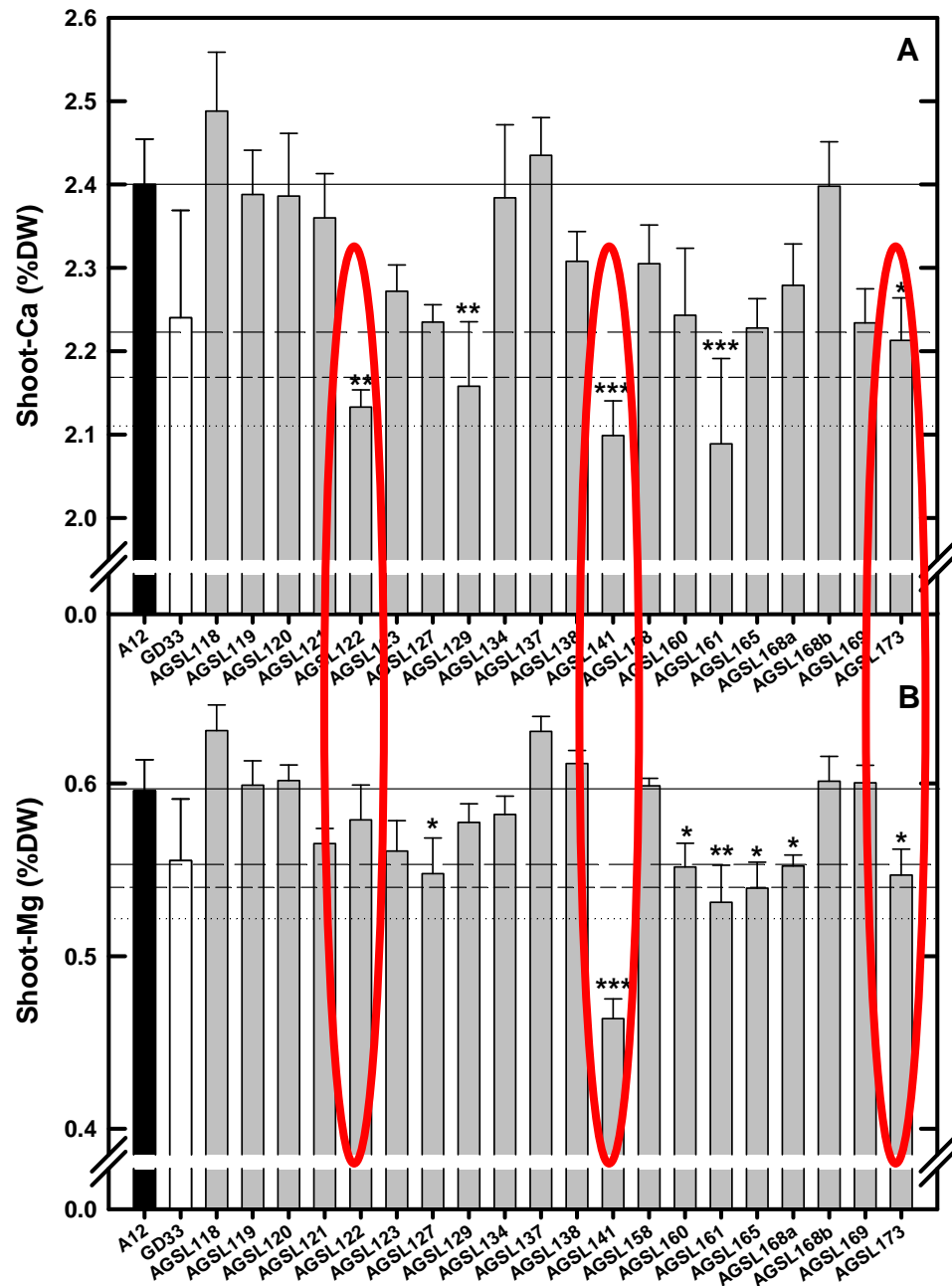
 All soils

 Low nutrient soil

 High nutrient soil

Ca/Mg-loci





Ongoing work

B₁F₂ of AGSLs 122, 141, 173 in prep. (for fine-mapping C9, C8, C6 loci)

Integrate eQTL, CaQTL and MgQTL (C- + A-genome ... AG / BraIRRI S₈s)

Characterise candidates in new A-genome TILLING population

Ongoing characterisation of divalent cation transporters: BBSRC Crop Science Priority Studentship (Seosamh Ó Lochlainn)

