

**UK-BRC Meeting
Rothamsted Research 23 May 2007**

**Species-wide genetic variation in leaf mineral composition
of *Brassica oleracea*.**

**¹Broadley MR, ²Hammond JP, ³King GJ, ²Astley D, ²Bowen HC, ¹Meacham MC, ²Mead A,
²Pink DAC, ²Teakle GR, ²Hayden RM, ²Spracklen WP, ⁴White PJ**

¹Plant Sciences Division, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, UK

²Warwick HRI, University of Warwick, Wellesbourne, Warwick CV35 9EF, UK

³Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, UK

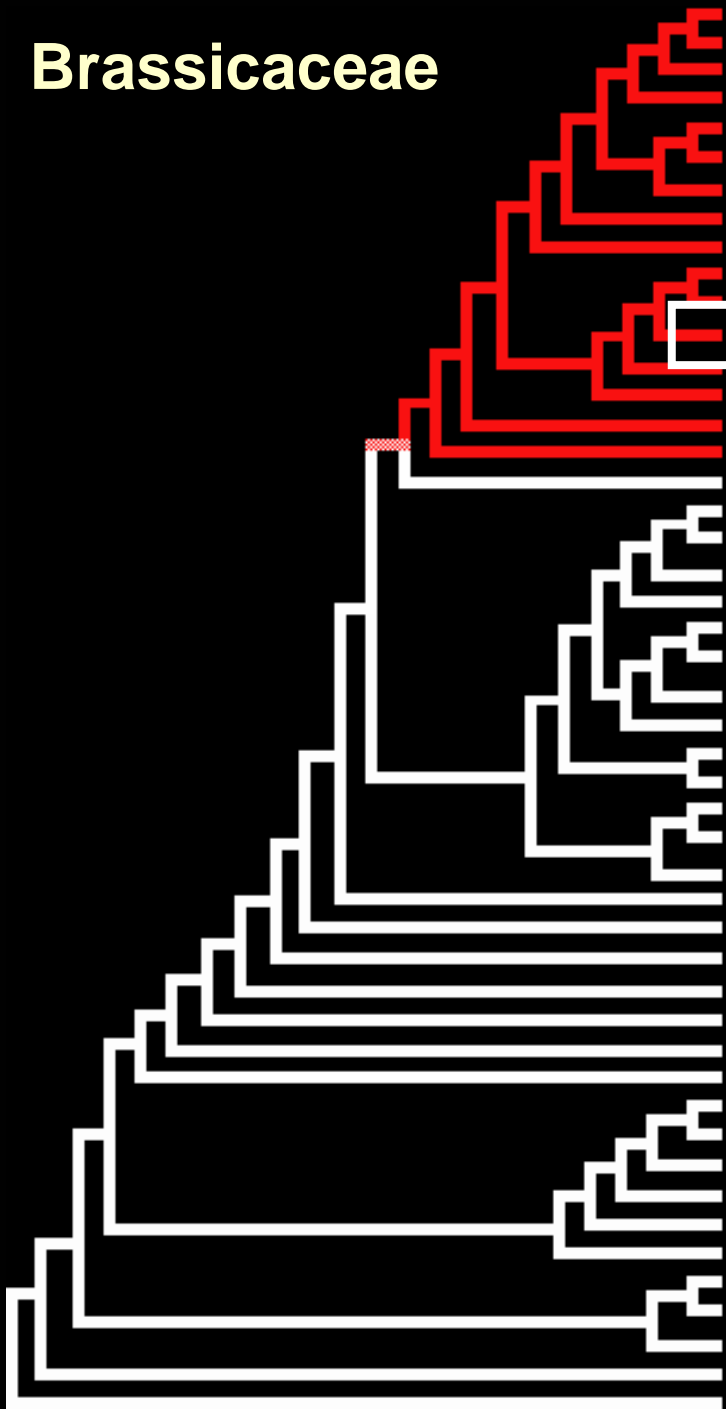
⁴The Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK



The University of
Nottingham



Brassicaceae



300,000 species of angiosperm
4,000 Brassicales
3,500 Brassicaceae

***Brassica* are good models for studying mineral composition**

***Brassica* are a widely eaten “leaf” ?**

Production stats for 2005: <http://faostat.fao.org/>

68.1 Mt yr⁻¹ “cabbages and other brassica”

17.6 Mt yr⁻¹ “cauliflowers and broccoli”

64.4 Mt yr⁻¹ “onions and shallots”

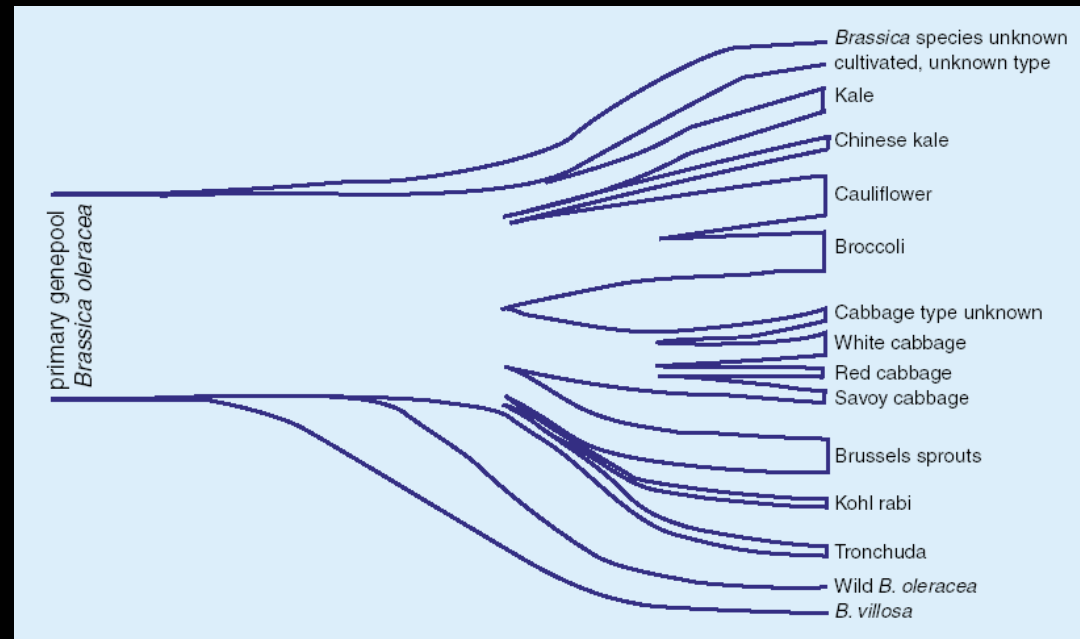


Species-wide variation in leaf mineral composition in *Brassica oleracea*

Diversity Foundation Set Experiment

acephala (n=34)
alboglabra (12)
botrytis (99)
capitata (48)
gemmifera (38)
gongylodes (14)
italica (78)
sabauda (6)
tronchuda (17)
24 unassigned accessions

+*B. hilarionis* (1)
B. villosa (1)
B. rapa (3)



Nine further accessions (six *italica*, and one each of *acephala*, *botrytis* and *tronchuda*) were used to replace non-germinating selections

Species-wide variation in leaf mineral composition in *Brassica oleracea*

Diversity Foundation Set Experiment

Glasshouse experimental design:

2 [P]_{ext}, 6-7 weeks growth

6 occasions

0.5 replicates DFS line per occasion (376 accessions)

1.5 replicates F₁ per occasion (74 accessions)

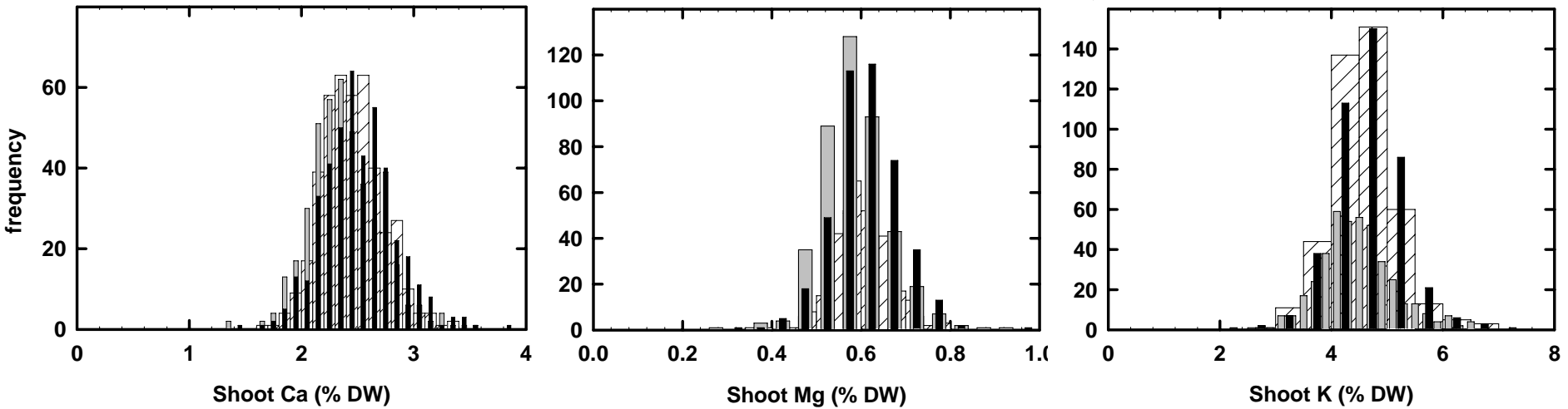
Internal blocking

Field experimental design:

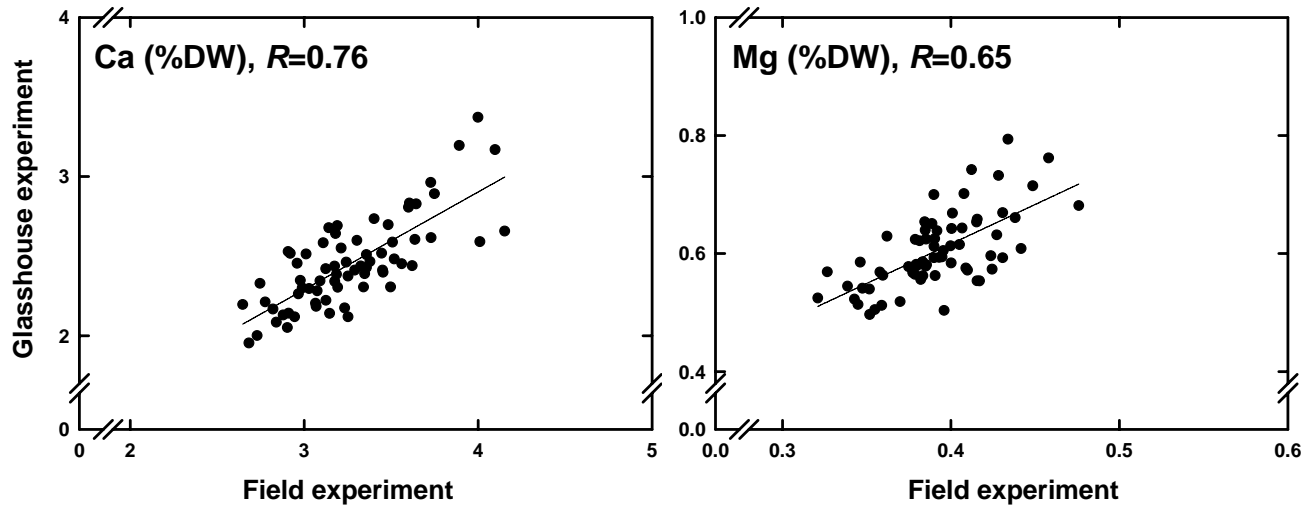


F₁ hybrid accessions, four [P]_{ext}, 3 occasions, ca. 2 months from transplanting

Species-wide variation in leaf mineral composition in *Brassica oleracea*

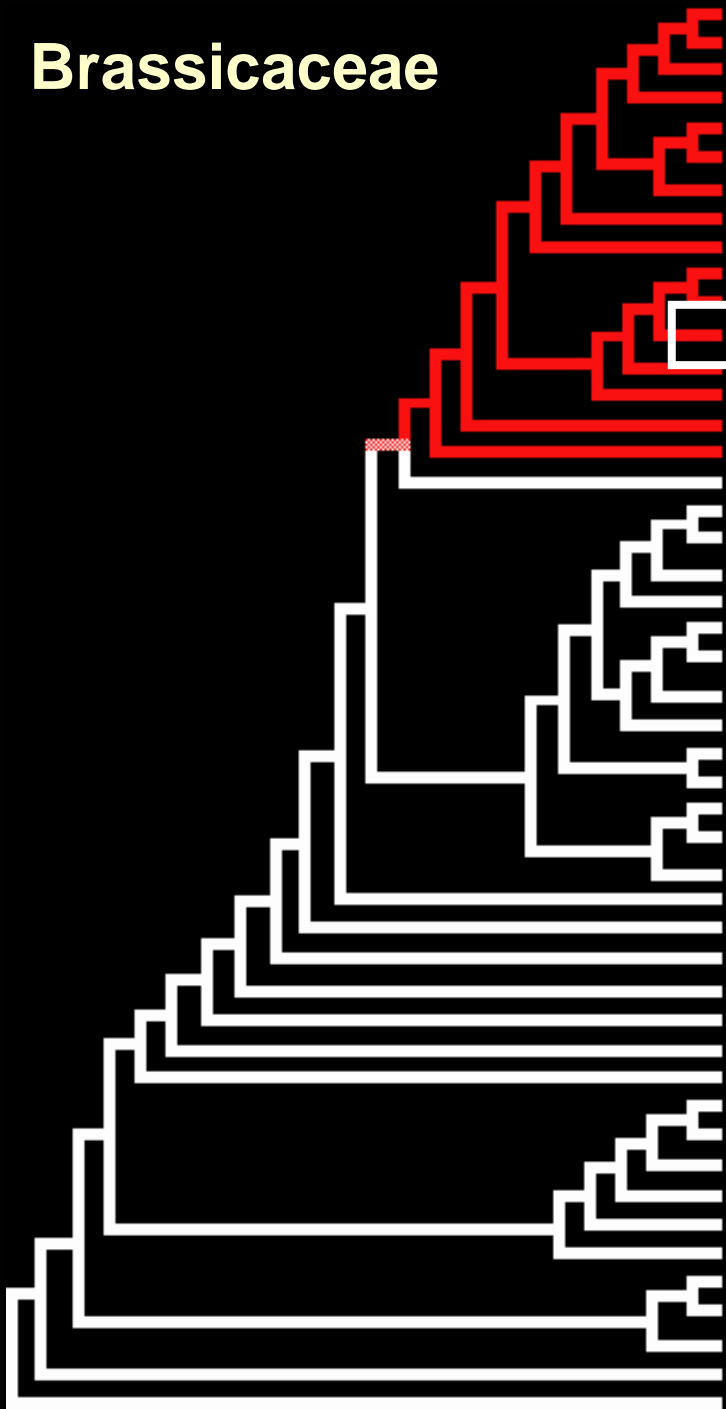


Species-wide variation in leaf mineral composition



Consistent across 69 F_1 hybrids in field and glasshouse conditions ($P < 0.0001$)

Brassicaceae



300,000 species of angiosperm
4,000 Brassicales
3,500 Brassicaceae

Variance components analysis of mineral composition in angiosperms

Proportion of variation

	Ca	Mg	K	N	P	Se
order and above (%)	64	65	50	9	7	5
within order (%)	36	35	50	91	93	95

MR Broadley *et al.* (2003). *Journal of Experimental Botany*, 54, 1431-1446.

PJ White & MR Broadley (2003). *Annals of Botany*, 92, 487-511.

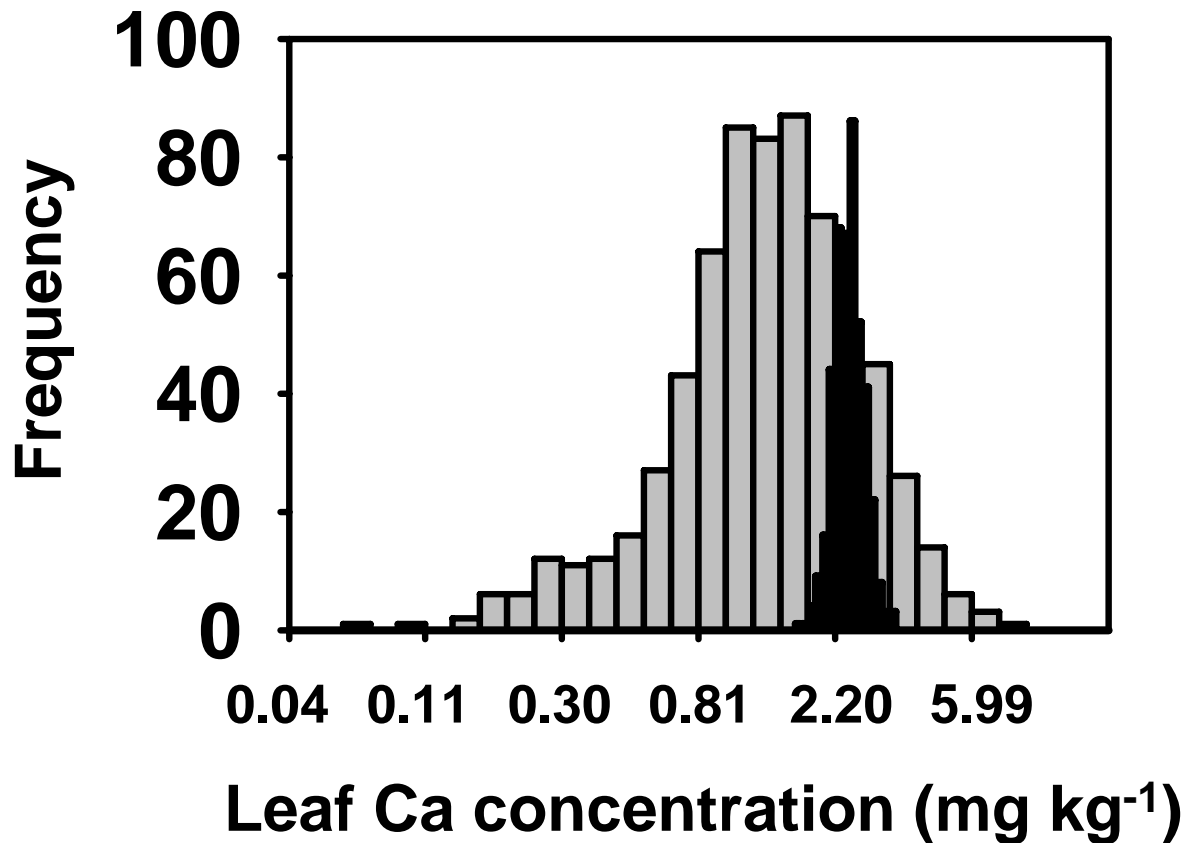
MR Broadley *et al.* (2004). *Journal of Experimental Botany*, 55, 321-336.

PJ White *et al.* (2004). *Journal of Experimental Botany*, 55, 1927-1937.

MJ Hodson *et al.* (2005). *Annals of Botany*, 96, 1027-1046.

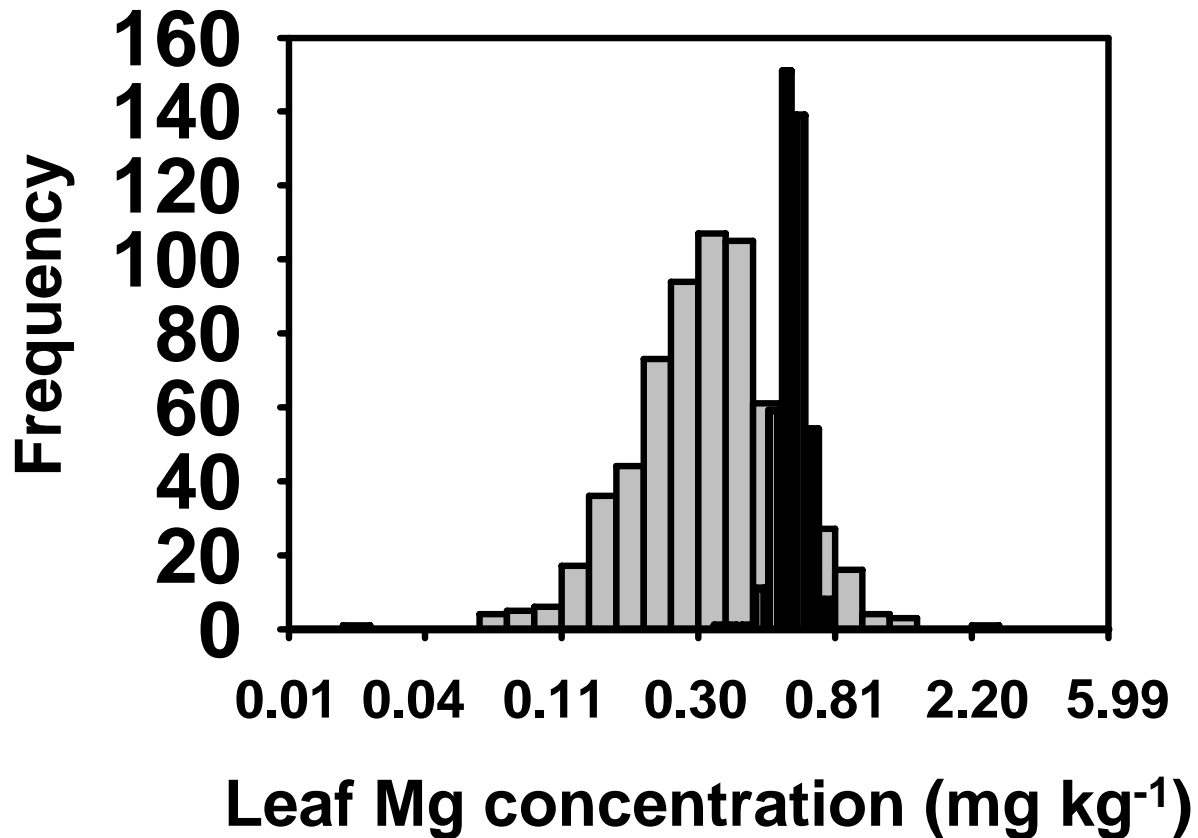
Wider phylogenetic variation in leaf-Ca

Angiosperms	0.06 – 7.33 %DW
<i>Brassica oleracea</i>	1.68 – 3.37 %DW

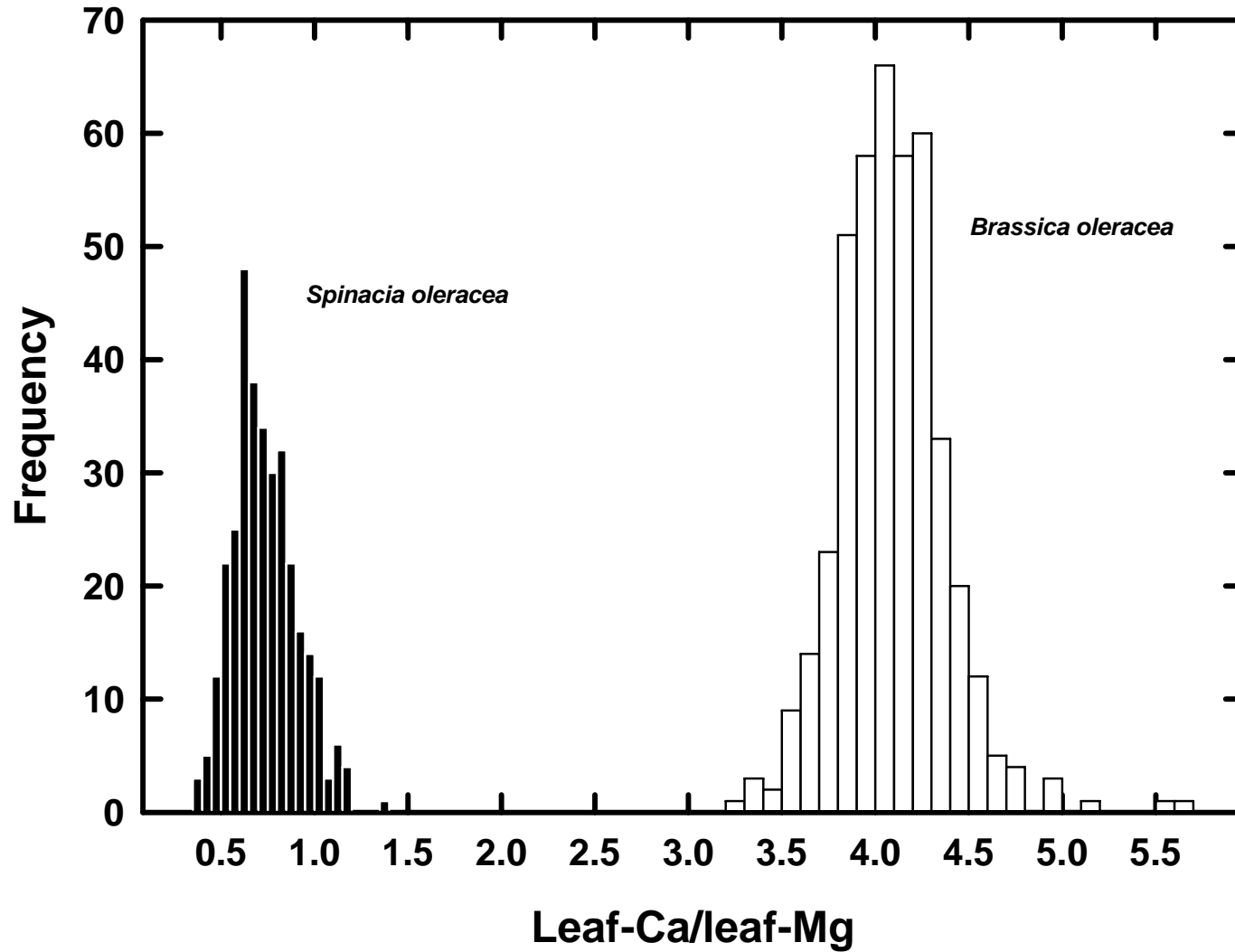


Wider phylogenetic variation in leaf-Mg

Angiosperms	0.02 – 2.47 %DW
<i>Brassica oleracea</i>	0.35 – 0.80 %DW



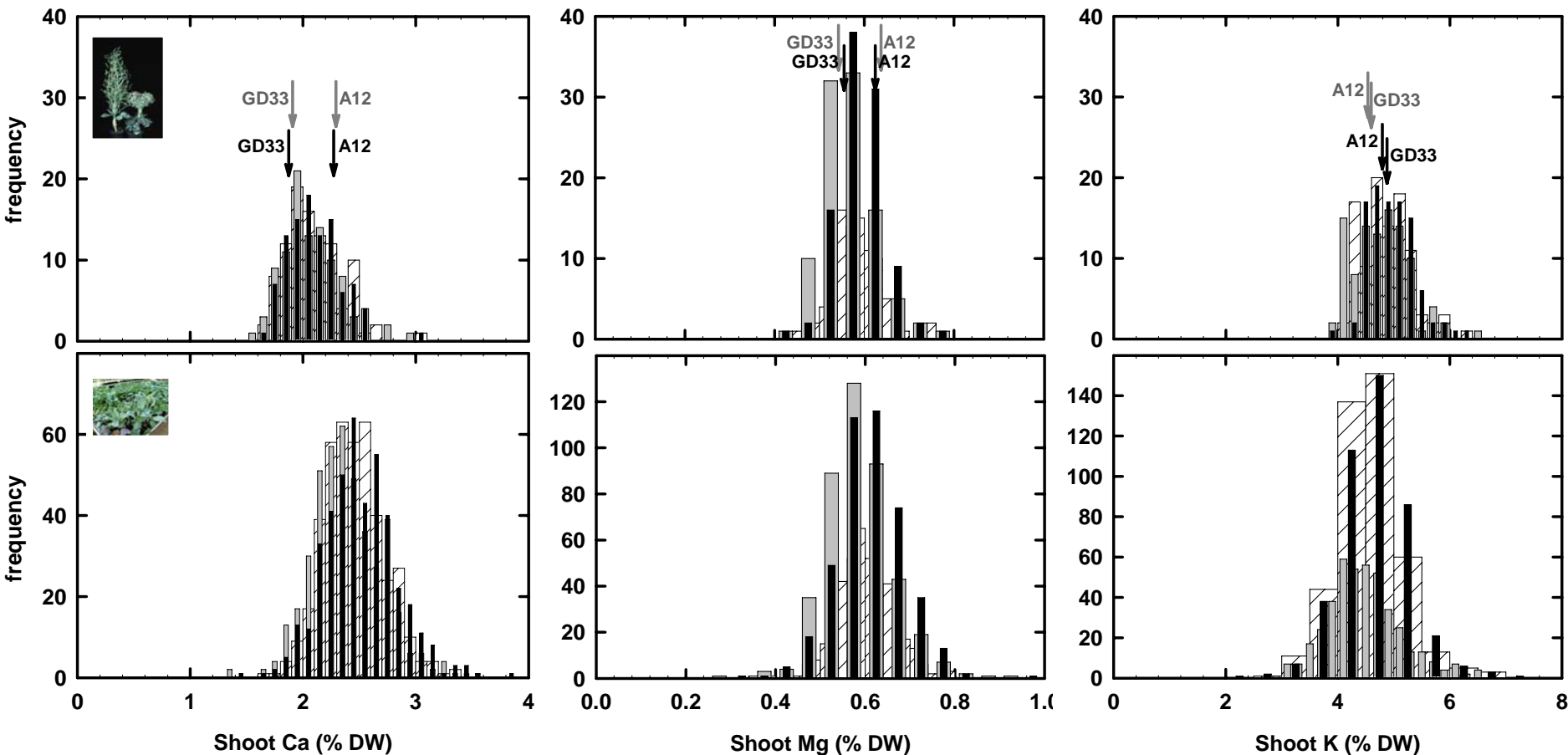
Phylogenetic variation in leaf-Ca/Mg



**Mapping leaf mineral composition:
90 informative doubled haploid accessions
(var. *alboglabra* A12DHd x var. *italica* GDDH33)**



Mapping leaf mineral composition



 Both $[P]_{ext}$

 Low $[P]_{ext}$

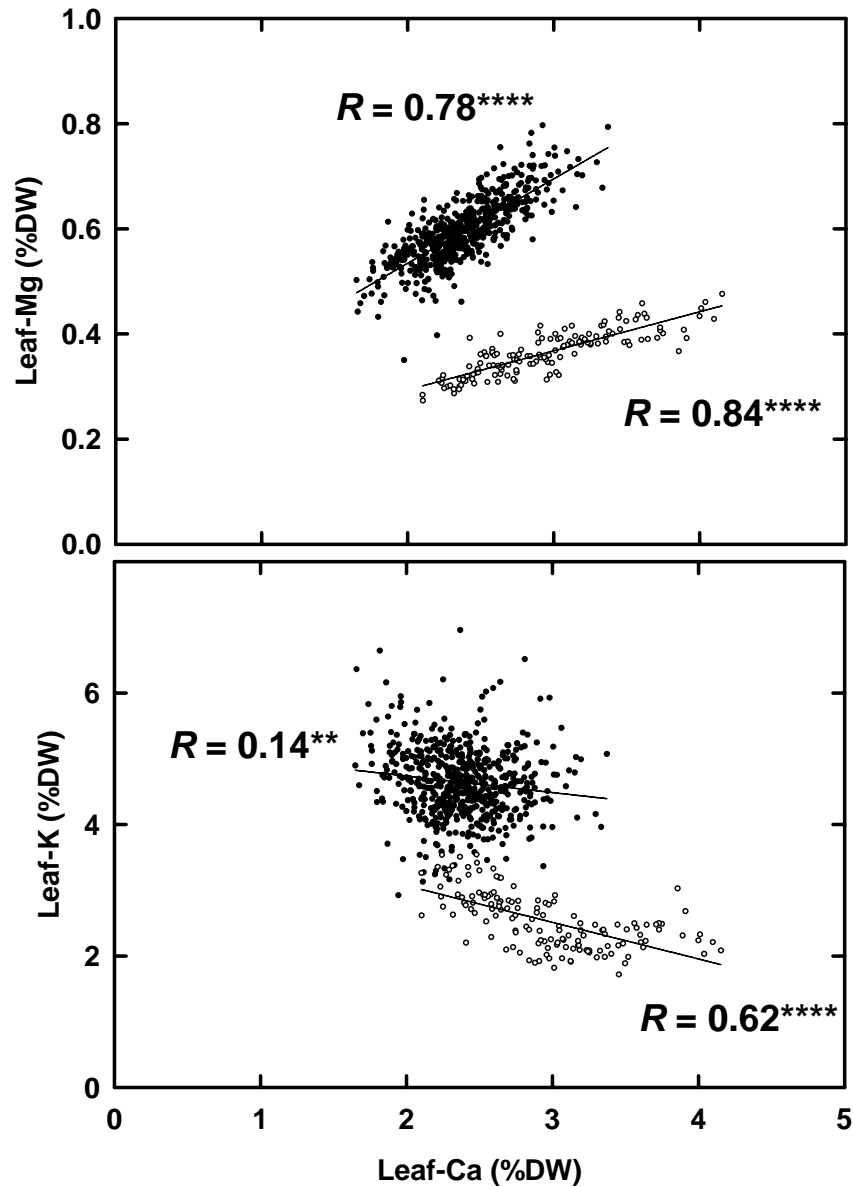
 High $[P]_{ext}$

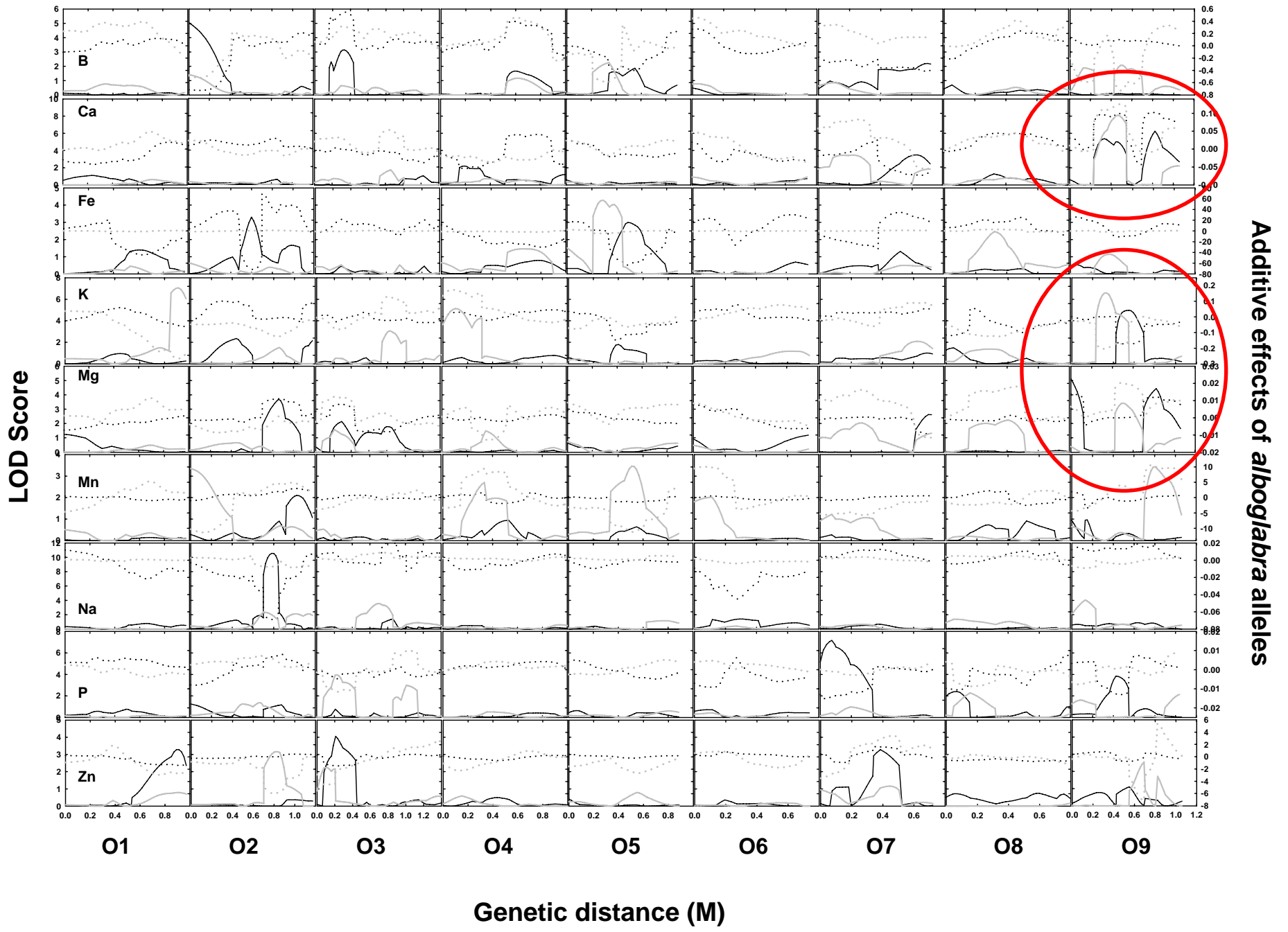
Heritability of leaf Ca and Mg concentration is highly significant

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



Mapping leaf mineral composition





**UK-BRC Meeting
Rothamsted Research 23 May 2007**

**Species-wide genetic variation in leaf mineral composition
of *Brassica oleracea*.**

**¹Broadley MR, ²Hammond JP, ³King GJ, ²Astley D, ²Bowen HC, ¹Meacham MC, ²Mead A,
²Pink DAC, ²Teakle GR, ²Hayden RM, ²Spracklen WP, ⁴White PJ**

¹Plant Sciences Division, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, UK

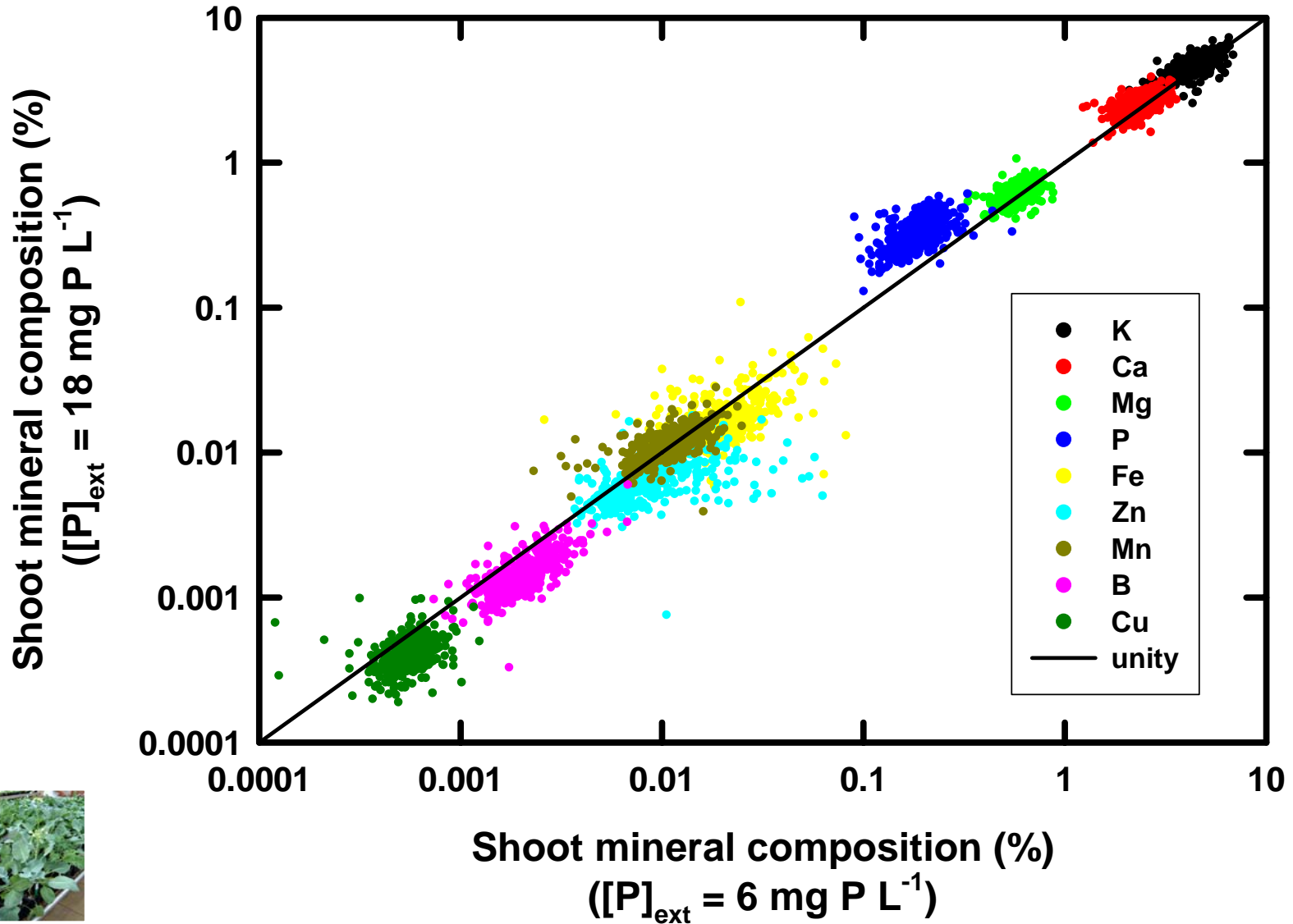
²Warwick HRI, University of Warwick, Wellesbourne, Warwick CV35 9EF, UK

³Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, UK

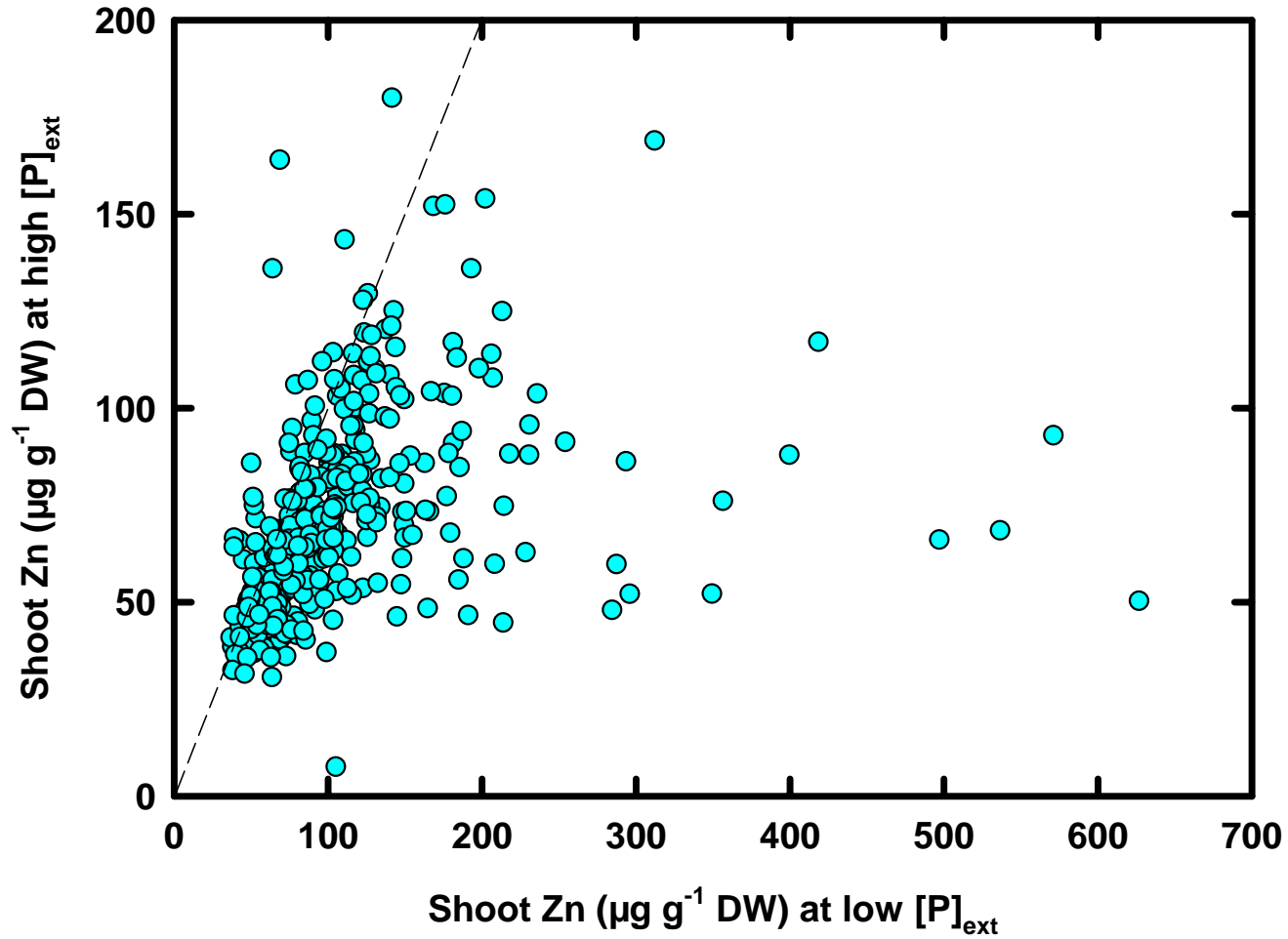
⁴The Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK



Species-wide variation in leaf mineral composition



Species-wide variation in leaf mineral composition



Brassicaceae are good models for studying mineral composition



Arabidopsis thaliana



Thlaspi caerulescens