

WGIN and nitrogen

Dissecting NUE

M J Hawkesford

WGIN Stakeholder Meeting

22nd November 2011



Talk overview

- Why N, why NUE?
- Dissecting NUE
- Examining genetic diversity (WGIN project, since 2003)
<http://www.wgin.org.uk/>
- Even more diversity!
- Exploiting diversity and environment to dissect pathways and identify novel genes



Why do we care about nutrient (nitrogen) efficiency in wheat?

Financial costs

Conventional farmers
Fertilizer producers
Organic growers
Millers
Bakers



Sustainability

Non renewable (P?)
Energy costs for production
Carbon footprint

efficiency



Food security

Increase yields
Challenging environments
Challenging climate
World agriculture



Environmental costs

Government/legislation
Public concerns
Carbon footprint

Many ways to dissect NUE

- Crop
- Plant
- Metabolic pathways
- Genes



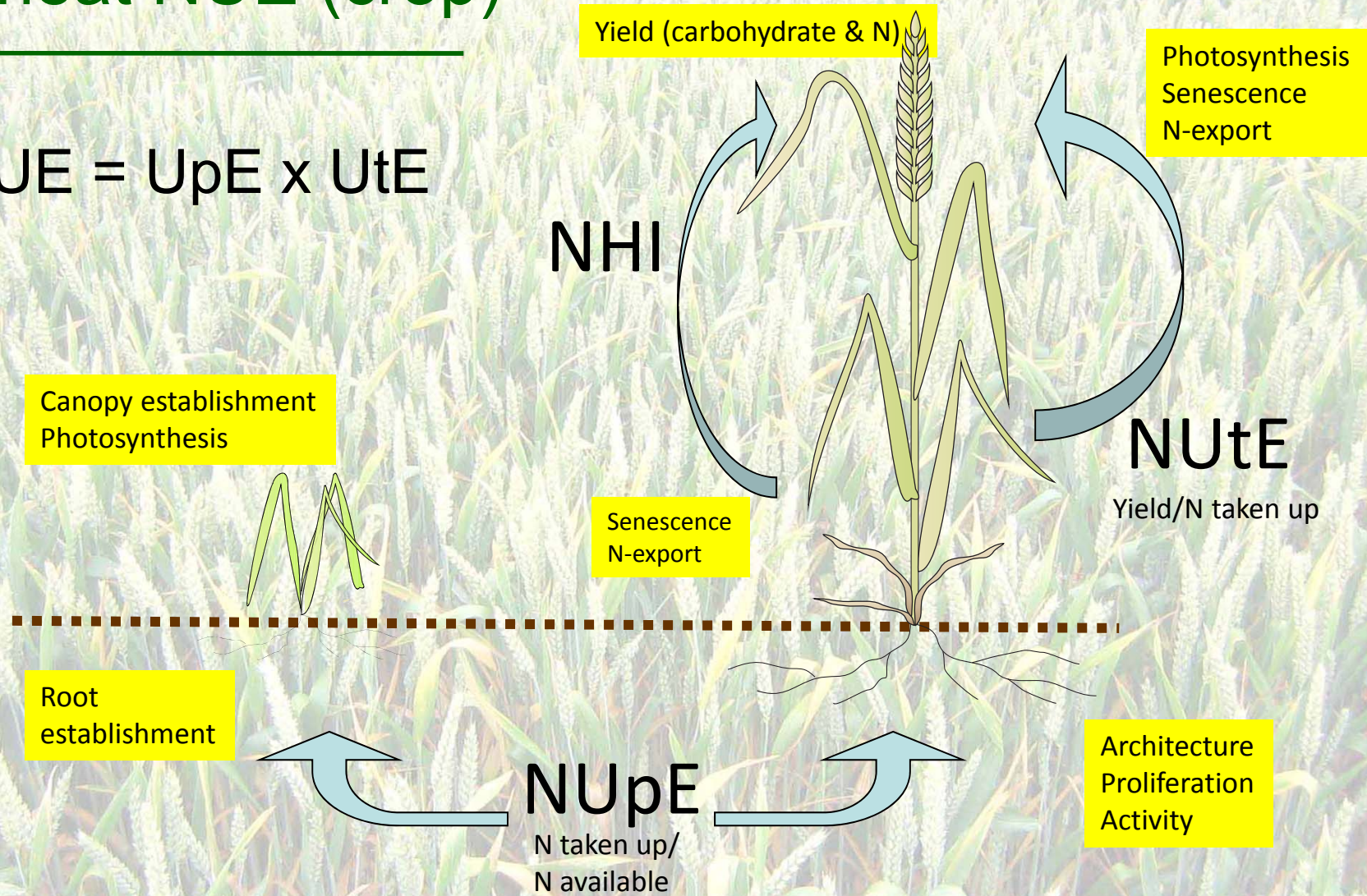
Field → lab → field

Avalon x Cadenza, Rothamsted 2010

Stakeholders 2011

Wheat NUE (crop)

$$\text{NUE} = \text{UpE} \times \text{UtE}$$



Resolving traits (physiology/biochemistry)

acquisition



canopy



yield

Root architecture
Activity
Sink strength
Translocation

Establishment
Extent
Activity
Longevity
Senescence

Leaf N
N export
Stature
HI
NHI

Carbohydrate
N content (1.1-2.8%)

For all component traits:

Multiple pathways, enzymes, genes and control sites/forms of regulation involved

The WGIN Diversity trials

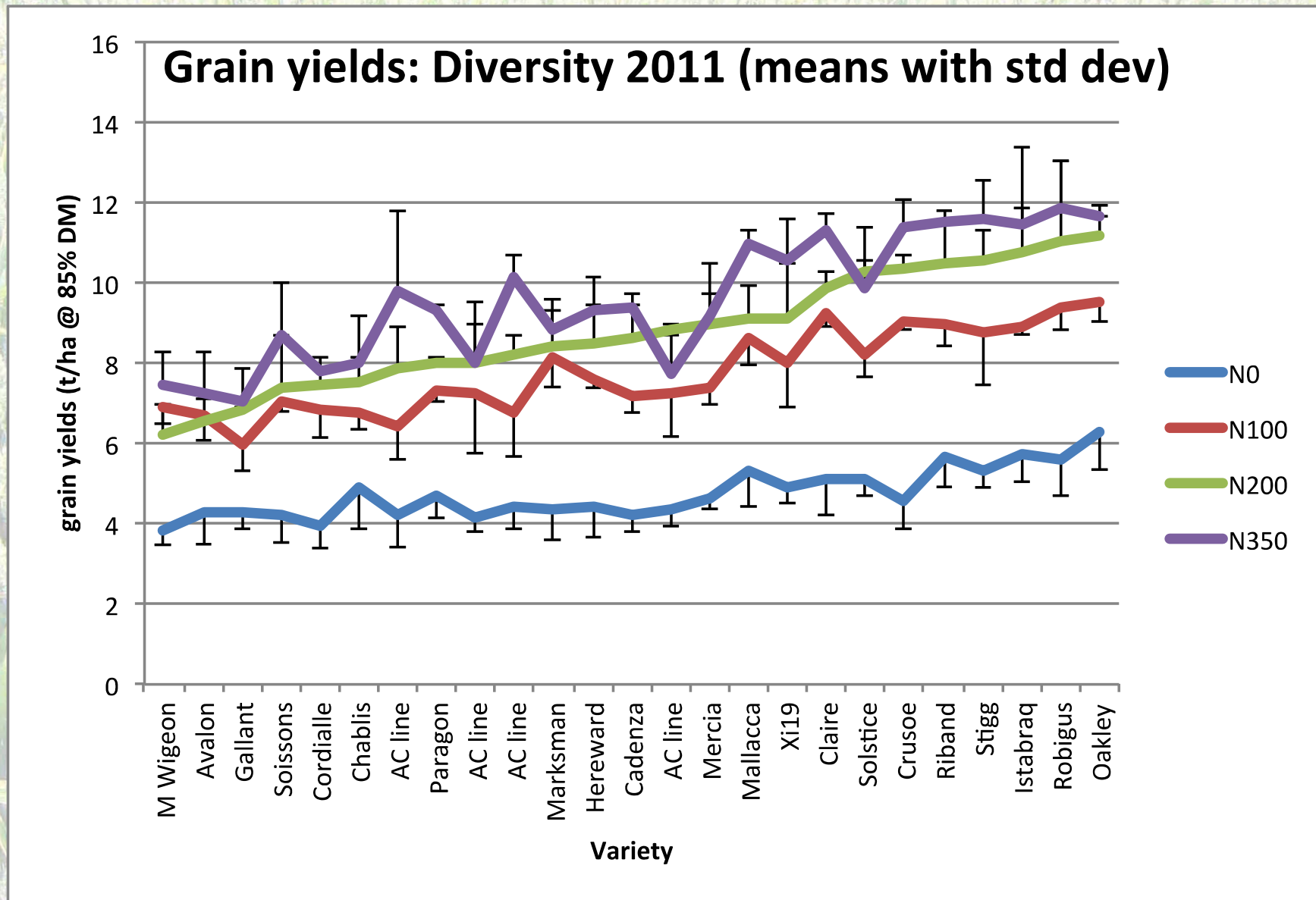


Stakeholders 2011

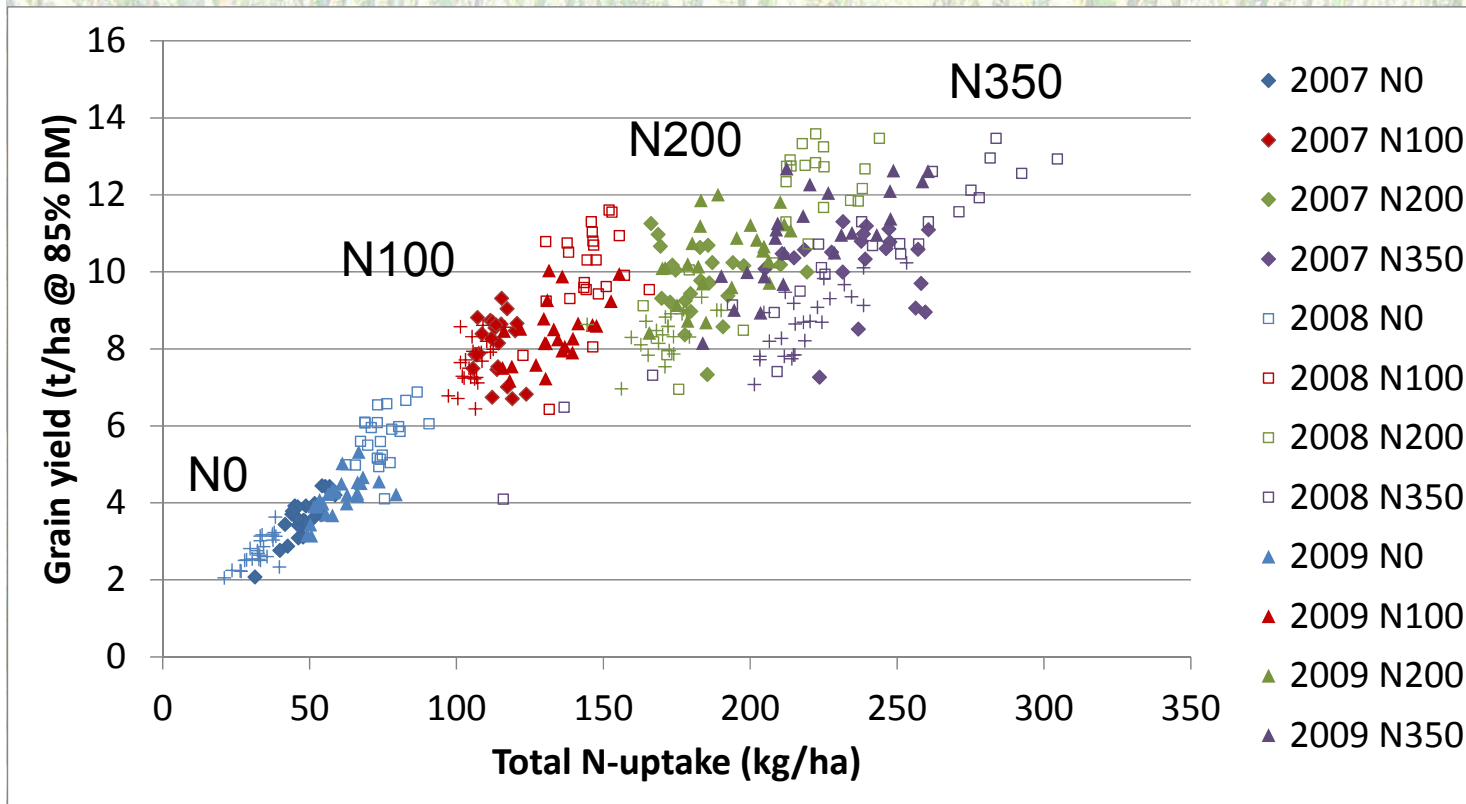
WGIN Diversity trial history

Trial	Year	Varieties (core of 9)	N-levels	kg N/ha
1	2004	32	4	0,50,200,350
2	2005	20	2	0,200
3	2006	24	3	0,100,200
4	2007	24	4	0,100,200,350
5	2008	24	4	0,100,200,350
6	2009	24 (include 6 x A x Cs)	4	0,100,200,350
7	2010	25 (include 6 x A x Cs)	4	0,100,200,350
8	2011	25 (include 4 x A x Cs)	4	0,100,200,350
9	2012	25 (include WUE/take-all lines)	4	0,100,200,350
10	2013	25 (include WUE/take-all lines)	4	0,100,200,350

N-responses



Grain yield and N uptake



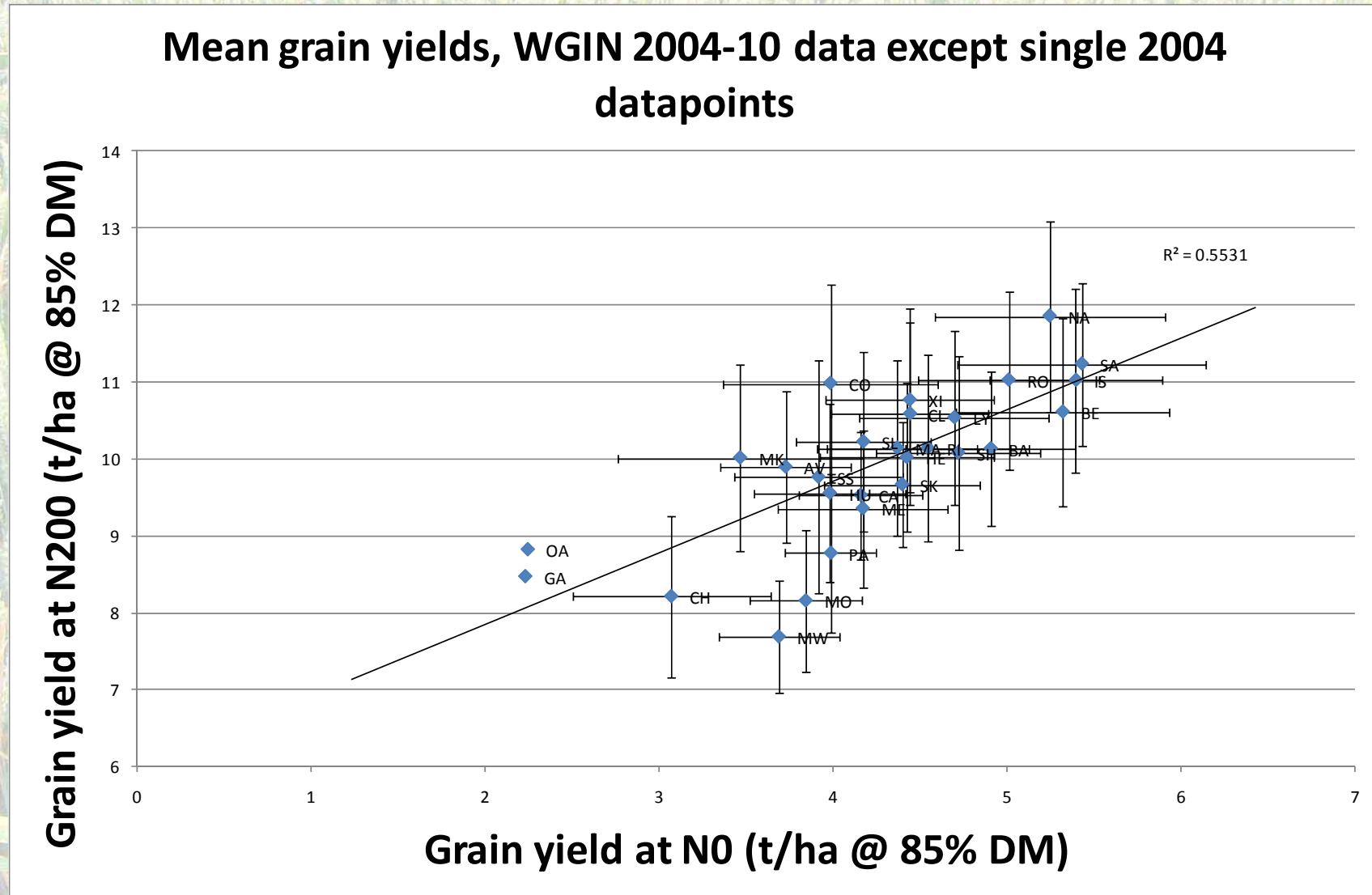
- Plateau of yield although uptake increases with increasing N-supply

- Factors other than uptake limiting yield

- Grain yield less strongly related to N-uptake

- Clustering (weak relationship between yield and N-uptake) at any one N-supply and year

Performance at high compared to low N



Variety Performance at 200 kg-N/ha (2004-08)

Variety	Code	Nabim	Years	Yield	%N	Uptake	Utilisation
Avalon	AV	1	5				
Flanders	FL	1	1				
Hereward	HE	1	5				
Hurley	HU	1	5				
Malacca	MA	1	5				
Mercia	ME	1	4				
Maris Widgeon	MW	1	5				
Shamrock	SH	1	4				
Solstice	SL	1	5				
Spark	SP	1	1				
Xi 19	XI	1	5				
Cadenza	CA	2	5				
Cordiale	CO	2	3				
Einstein	EI	2	1				
Lynx	LY	2	5				
Rialto	RL	2	1				
Scorpion	SC	2	1				
Soissons	SS	2	5				
Beaver	BE	3	4				
Claire	CL	3	4				
Riband	RI	3	5				
Robigus	RO	3	4				
Istabraq	IS	4	4				
Napier	NA	4	3				
Savannah	SA	4	4				
Paragon (spring)	PA	1	5				
Chablis (spring)	CH	2	1				
Arche	AR	F	1				
Batis	BA	G	5				
Caphorn	CP	F	1				
Cappelle Desprez	CD	F	1				
Enorm	EN	G	1				
Isengrain	IG	F	1				
Monopol	MO	G	5				
Opus	OP	G	1				
PBis	PB	G	1				
Petrus	PE	G	1				
Sokrates	SK	G	5				
Zyta	ZY	P	1				

Upper-Q
Inter-Q
Inter-Q
Lower-Q

Individual varieties show specific attributes

Summary of variety performance (quartile rankings) based on 2004-07 WGIN datasets

Europ. J. Agronomy 33 (2010) 1-11 **EJA (2010) 33, 1-11**



Contents lists available at ScienceDirect

European Journal of Agronomy

journal homepage: www.elsevier.com/locate/eja



Nitrogen efficiency of wheat: Genotypic and environmental variation and prospects for improvement

Peter B. Barraclough^{a,*}, Jonathan R. Howarth^a, Janina Jones^a, Rafael Lopez-Bellido^b, Saroj Parmar^a, Caroline E. Shepherd^a, Malcolm J. Hawkesford^a

Stakeholders 2011

Even more diversity?



Stakeholders 2011

2011/RWW/1104
LOLA Germplasm Phenotyping Year 1
Great Harpenden 1

100 G161 W07	181 300 301 420 421 540	541 660 661	780 781 900	901 1020 1021 1140 1141 1260	1261 1380 1381
G136 W07	W83 W82 W53 W84 W85 W10	G134 NAB11 NAB2	W26 W24 W98	W26 W24 W98	W46 W46 NAB30 NAB30
W09 W10	W82 299 302 419 422 539	542 609 662	779 782 899	902 1019 1022 1139 1142 1259	1262 1379 1382
G136 G136	W119 G146 W119 W16	W119 W16	W46 W46 NAB30	W46 W46 NAB30	G137 W10 W10
57 64 177	185 298 303 418 423 538	543 608 663	778 783 898	903 1018 1023 1138 1143 1258	1263 1378 1383
W24 W02 W08	G158 6166 G109 G139 G13 G108	G167 NAB20 NAB10	G170 W10 W89	W36 219 1040 W104 W12 615	W77 NAB31 NAB30
59 65 176	186 299 304 419 424 539	544 609 664	779 784 899	904 1019 1024 1139 1144 1259	1264 1379 1384
G127 Ribato W102	W116 G137 Oakley Jarlman W06 W17	W25 NAB20 NAB21	G171 W10 W89	W36 219 1040 W104 W12 615	W77 NAB31 NAB30
58 66 178	187 300 305 420 425 540	545 610 665	780 785 900	905 1020 1025 1140 1145 1260	1265 1380 1385
W49 G131 W1	W19 299 304 419 424 539	W19 NAB20 NAB17	G174 G179 W106	W36 219 1040 W104 W12 615	W77 NAB31 NAB30
54 67 174	187 300 305 420 425 540	547 604 667	774 787 894	907 1014 1027 1134 1147 1254	1267 1374 1387
W119 W12 G182	W111 W111 G189 W116 W14 W05	G175 G183 W08	G175 G183 W08	G175 G183 W08	W77 NAB31 NAB30
53 68 173	188 293 308 413 428 533	546 603 666	773 786 893	908 1013 1028 1133 1148 1253	1268 1373 1388
W2 W78 G179	W12 W42 G132 G125 W81 W51	W88 NAB31 NAB1	W88 NAB31 NAB1	W42 W42 W116 W118	W72 NAB31 NAB30
52 69 172	189 292 307 412 427 532	547 604 667	774 789 896	909 1014 1029 1134 1149 1254	1269 1374 1389
G128 G143 G170	G150 W03 W08 G176 W118 G108	W82 NAB18 NAB14	W82 W82 W05 G165	W82 W82 W05 G165	W82 W82 W05 G165
61 70 181	189 293 308 413 428 533	547 604 667	774 789 896	909 1014 1029 1134 1149 1254	1269 1374 1389
G158 W41 Sacrament	W67 W68 G142 W44 G121 W72	W71 NAB1 NAB1	W85 405 W112	G173 G130 G172 W32 W04 W70	W13 W13 NAB37 NAB3
60 71 180	190 294 309 414 429 534	548 605 668	775 790 897	910 1015 1030 1135 1150 1255	1270 1375 1390
Y06 G161 G173	G144 W45 W04 G162 W69 W09	W72 NAB2 NAB13	W72 NAB2 NAB13	G143 G143 G161 W02 W19 W02	W72 NAB2 NAB13
62 72 182	191 295 310 415 430 535	549 606 669	776 791 898	911 1016 1031 1136 1151 1256	1271 1376 1391
W22 W106 W23	G129 W11 6181 G160 G122 G181	W83 NAB2 NAB20	G171 G127 G141	W83 W83 W109 W28 W02 W79	G188 NAB17 NAB20
63 73 183	192 296 311 416 431 536	550 607 670	777 792 899	912 1017 1032 1137 1152 1257	1272 1377 1392
G178 W41 W183	G153 W48 G165 G183 G171 W72	W18 NAB20 NAB30	W17 W17 G187 G187	W18 W18 W115 W78 W20 W71	W17 NAB20 NAB30
64 74 184	193 297 312 417 432 537	551 608 671	778 793 900	913 1018 1033 1138 1153 1258	1273 1378 1393
Glasgow W09	G120 G151 W104 W103 W53 W30	W58 NAB5 NAB6	G153 W1 G154	G173 Oakley G144 Cordoba G181 W81	W52 NAB5 NAB21
65 75 185	194 298 313 418 433 538	552 609 672	779 794 901	914 1019 1034 1139 1154 1259	1274 1379 1394
G148 W08 W09	W68 G175 W07 G154 6186 W03	W68 NAB5 NAB24	W68 NAB5 NAB24	G148 G148 G152 G152 G152 G152	W68 NAB5 NAB24
66 76 186	195 299 314 419 434 539	553 610 673	780 795 902	915 1020 1035 1140 1155 1260	1275 1380 1395
G172 G174 W115	W68 W29 W110 G141 W46 W47	W54 NAB4 NAB10	G139 W5 G180	W68 W68 G150 G150 G150 G150	W68 NAB4 NAB10
67 77 187	196 300 315 420 435 540	554 611 674	781 796 903	916 1021 1036 1141 1156 1261	1276 1381 1396
W21 G123 G146	W87 Steroid G168 W109 W70 W20	G124 NAB20 NAB12	W53 W54 W119	G164 G126 G149 G161 G177 W114	W88 NAB1 NAB10
68 78 188	197 301 316 421 436 541	555 612 675	782 797 904	917 1022 1037 1142 1157 1262	1277 1382 1397
69 79 189	198 302 317 422 437 542	556 613 676	783 798 905	918 1023 1038 1143 1158 1263	1278 1383 1398
70 80 190	199 303 318 423 438 543	557 614 677	784 799 906	919 1024 1039 1144 1159 1264	1279 1384 1399
41 80 161	200 304 319 424 439 544	558 615 678	785 800 907	920 1025 1040 1145 1160 1265	1280 1385 1400
W34 W43 G147	W102 W100 W39 W89 W25 W65	W102 NAB27 NAB5	W102 NAB27 NAB5	G123 W33 G151 W96 W08 W48	G121 NAB27 NAB5

Wheat pre-breeding Lola :

Rothamsted and Nottingham Biomass/NUE trials

2011 and 2012

'Donor material' comprising Watkins and Gediflux collections, SHWs (NIAB) and more mapping populations

Stakeholders 2011

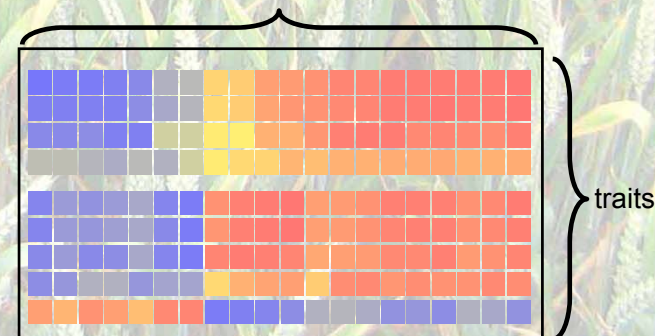


Summary

- NUE is a complex trait
- Many ways to dissect NUE
- There is substantial genetic diversity in modern elite wheat but potentially a lot more in more exotic germplasm
- Germplasm screening combined with transcriptomics is a powerful tool for novel gene identification
- Key target traits? Roots, canopy longevity and grain N



Candidate genes

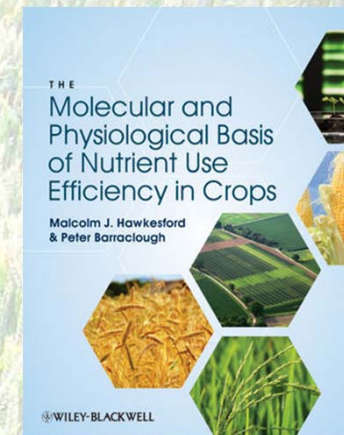




ROTHAMSTED
RESEARCH

Thanks

- Group and field team: Peter Barraclough, Peter Buchner, Andrew Riche, Saroj Parmar, Yongfan Wan, Jonathan Howarth, Adinda Derkx, Caihong Bai, Astrid Grün + many summer students
- WGIN and LOLA Pre-breeding teams
- RRes Farm staff



Stakeholders 2011

