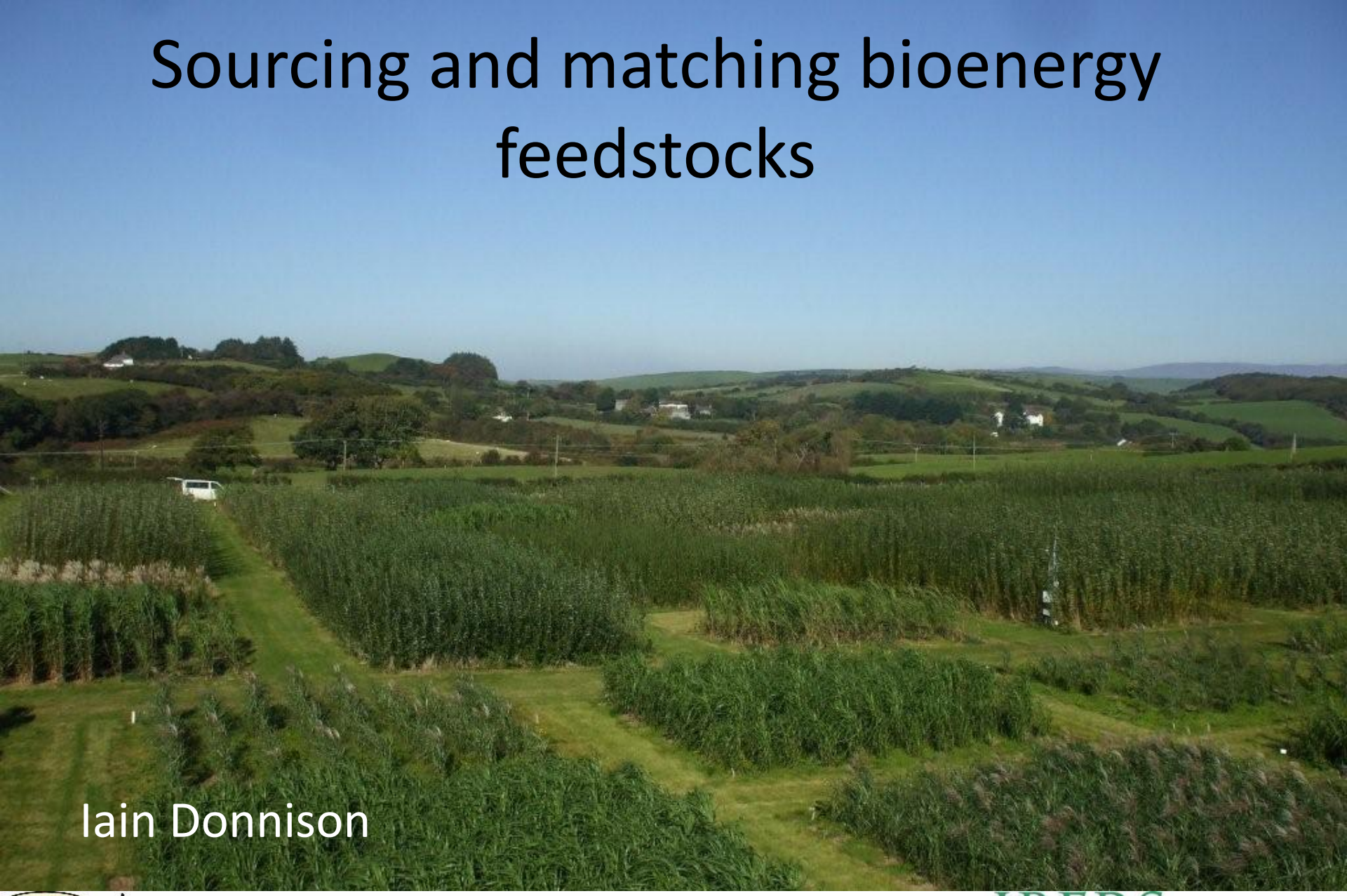
Sourcing and matching bioenergy feedstocks



Iain Donnison

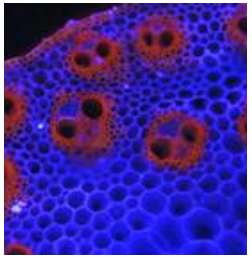
ABERYSTWYTH UNIVERSITY

IBERS
Athrofa y Gwyddorau Biolegol, Amgylcheddol a Gwledig
Institute of Biological, Environmental and Rural Sciences

Biomass can provide a renewable source of:

- GHG Removal, enhanced through BECCS
- Non-interruptible electricity
- Heat
- Liquid transport fuels
- Chemicals, plastics and materials

Feedstock issues



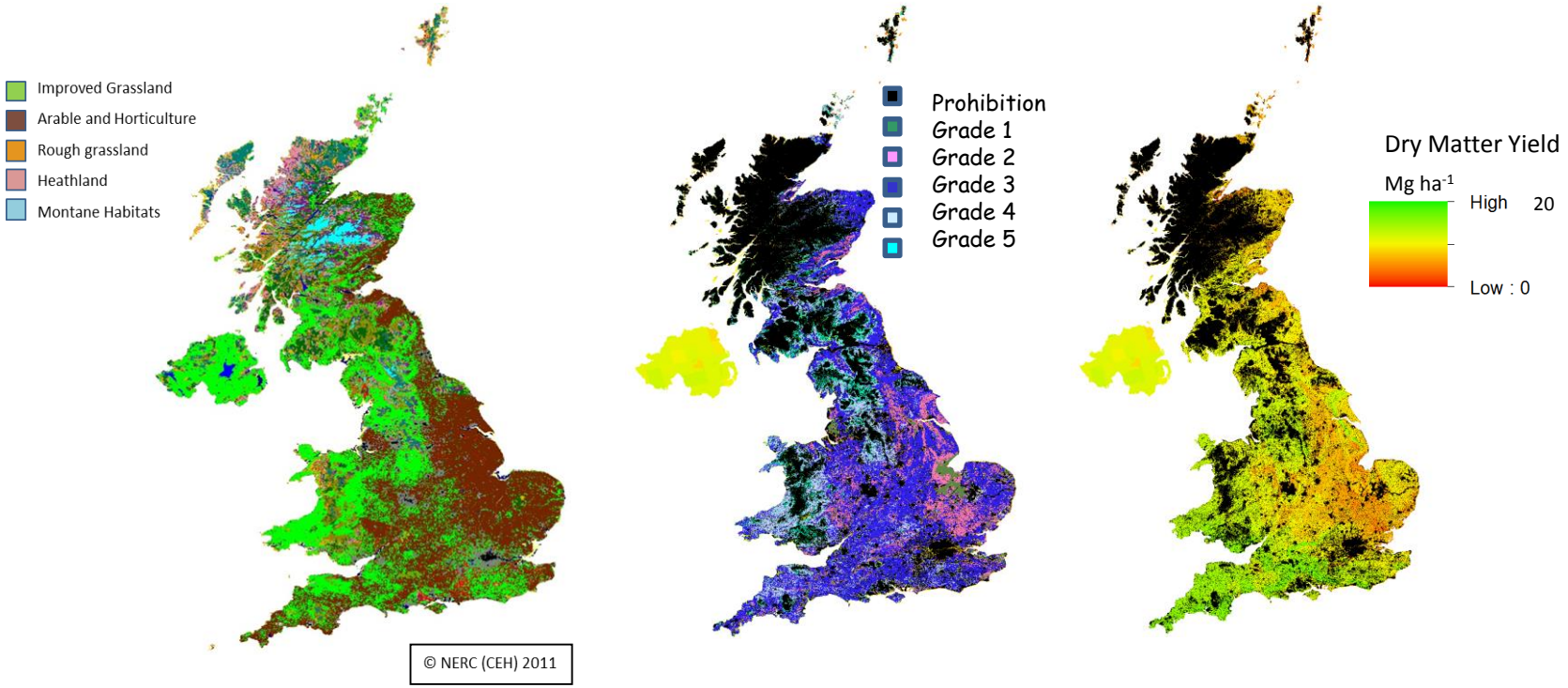
- Biomass Sources
- Biomass Yield
- Biomass Supply (Resilience)
- Biomass Quality
- Biomass Sustainability (De-risking)

Diversity - Comparison of energy ratios for different crops

Crop	Energy In (MJ/ha)	Energy Out (MJ/ha)	Ratio
Miscanthus	9,224	300,000	32.5
Willow (SRC)	6,003	180,000	30.0
Hemp (straw)	13,298	112,500	8.5
Wheat (grain)	21,465	189,338	8.8
Canola	19,390	72,000	3.8

Harvey, J., 2007. A versatile solution? Growing Miscanthus for bioenergy. Renewable Energy World.

Location - Land use, soil and yield potential



Energy grass options

High Biodiversity, Low Input Grasslands

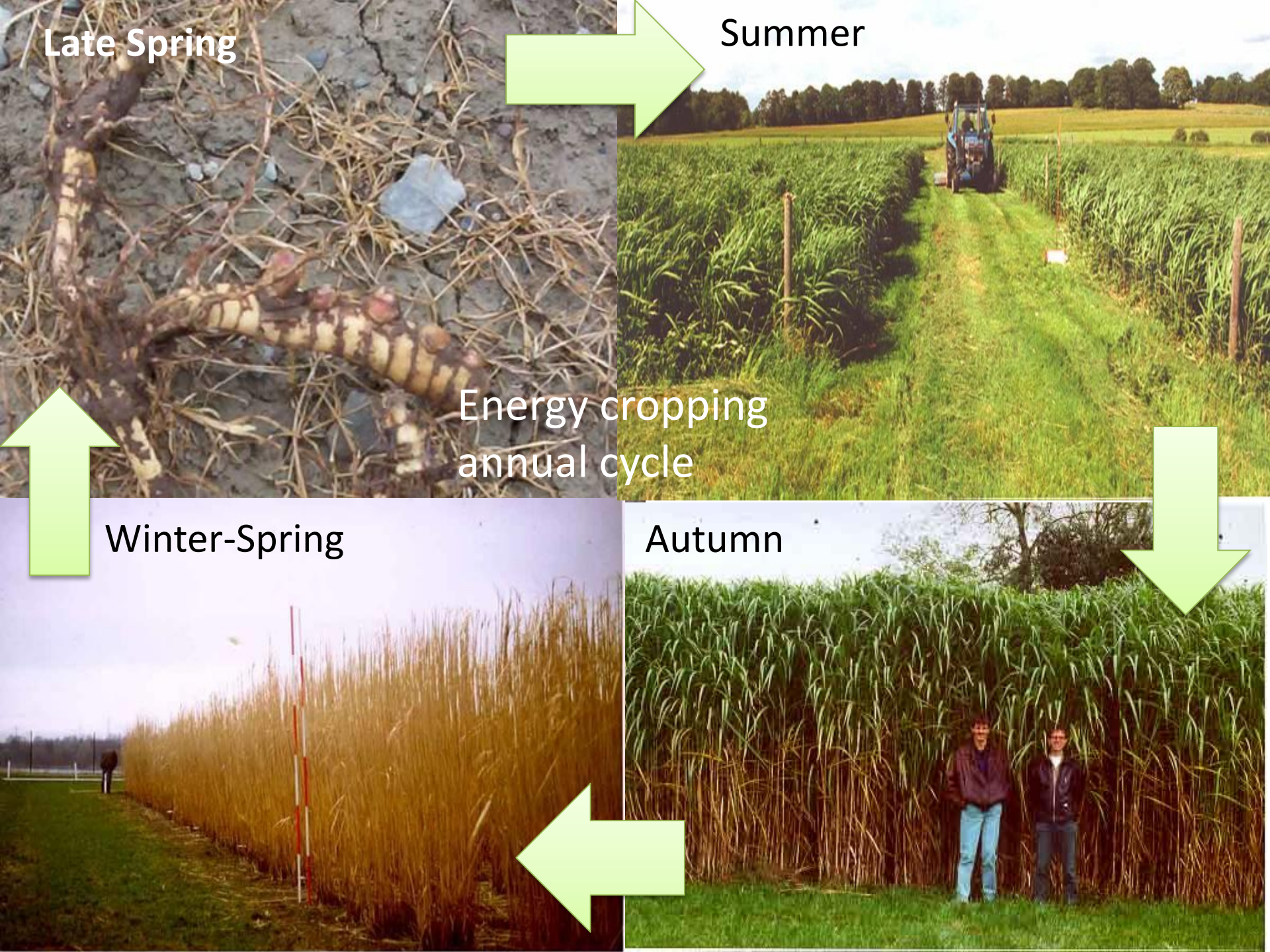
Delivers: Environmental Management & Energy

(High Sugar) Forage Grasses

Delivers: Animal Feed, Energy & Products

Dedicated Energy Crops

Delivers: Energy & Products: High Biomass and Defined End Quality


Late Spring
Summer
Energy cropping
annual cycle
Winter-Spring
Autumn

Energy crop genetic resources and plant breeding

- Create diverse collections of genetic resources from gene banks and from natural populations

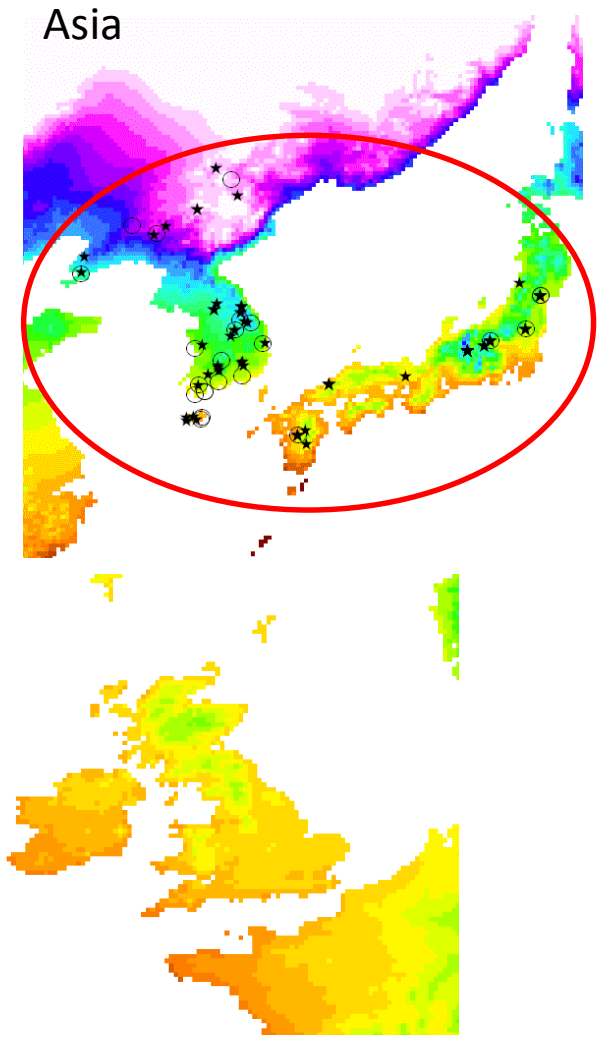
- Understand collections and learn how germplasm can be combined including in wide crosses to release hybrid vigour, and assess quality.

- Implement UN protocols on the Convention on Biological Diversity with donor countries from new collections.

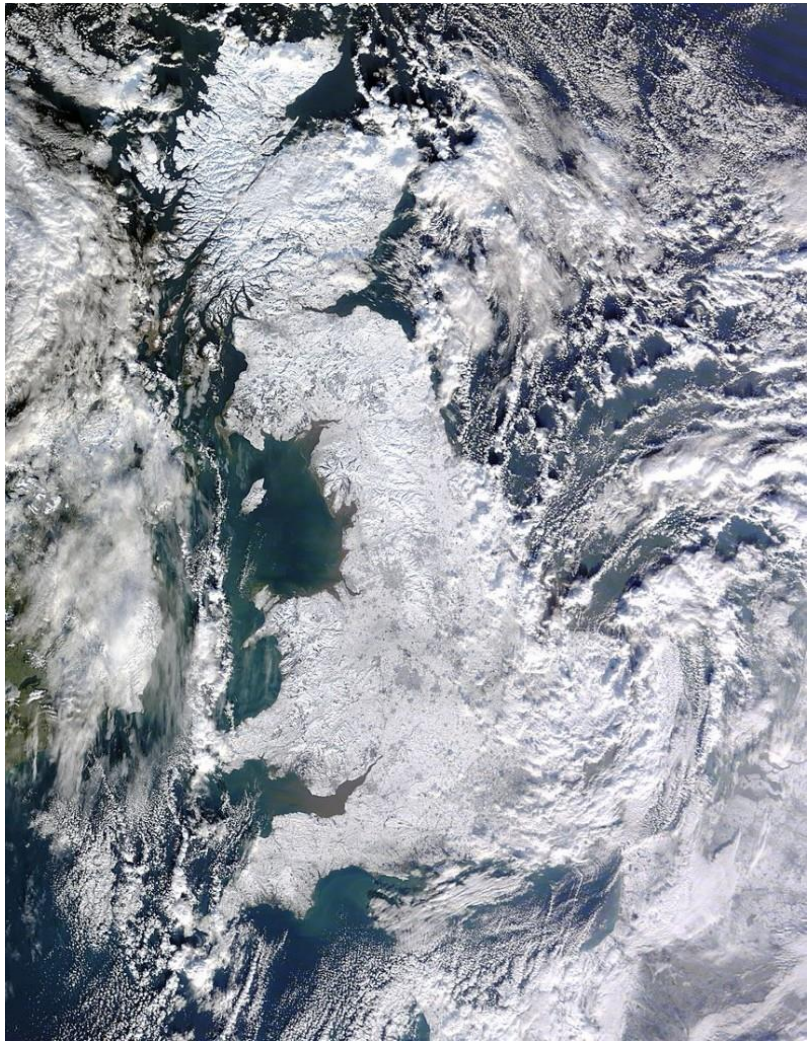
- Develop plant varieties and appropriate agronomy. Establish multi-location trials and assess quality.

Miscanthus Genetic Resources

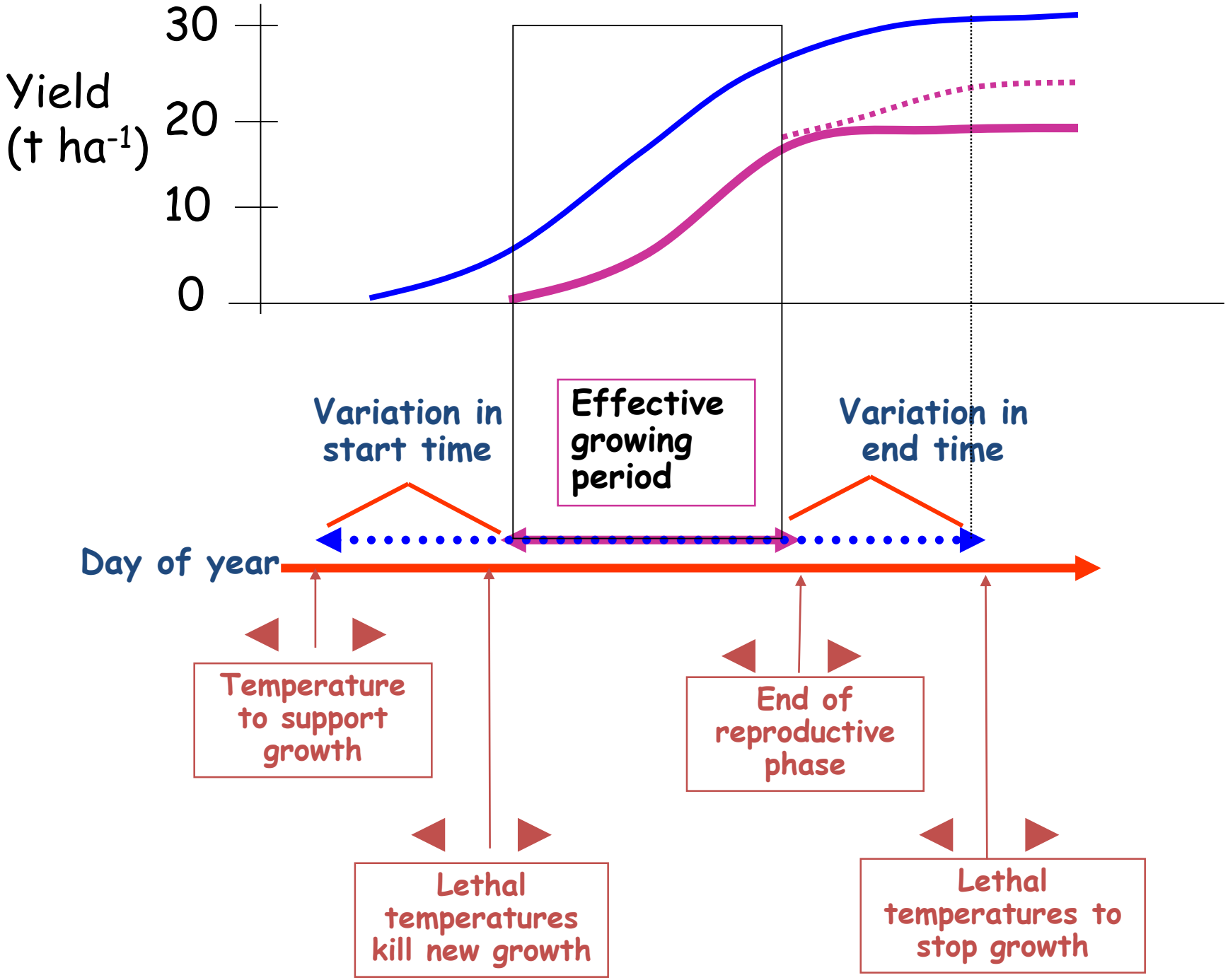
Matching accessions to target geographies



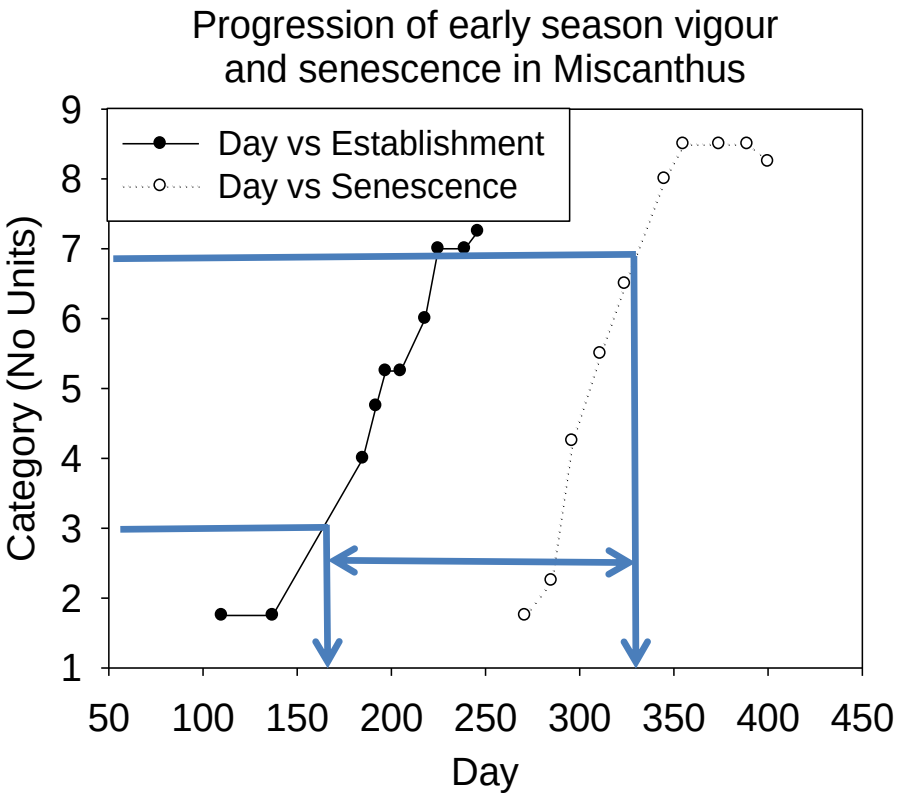
NW Europe

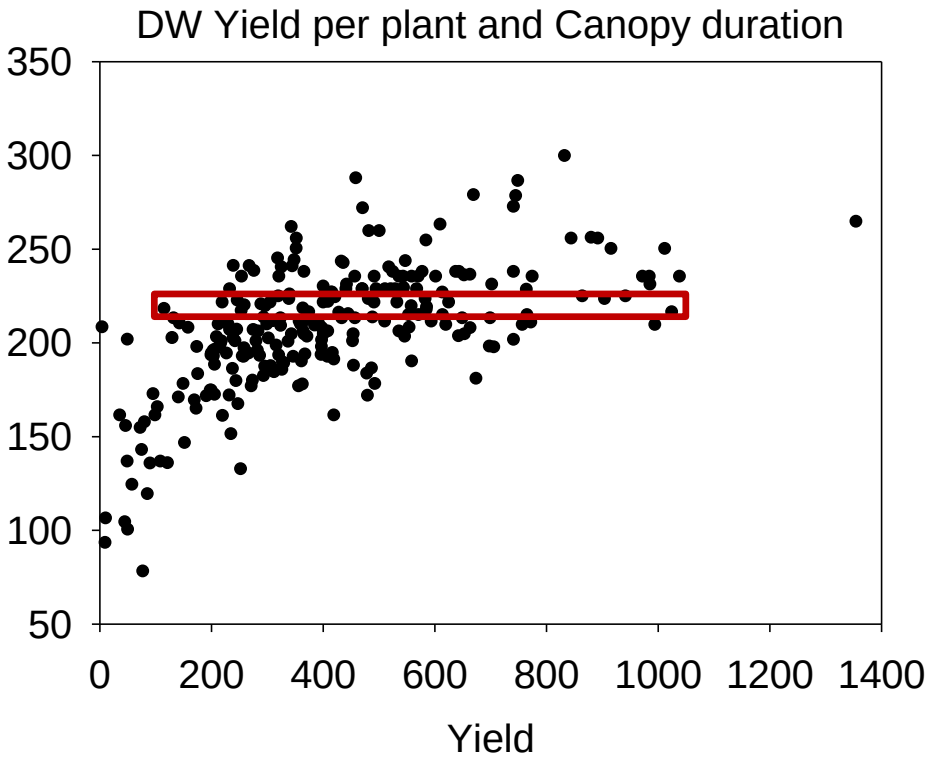


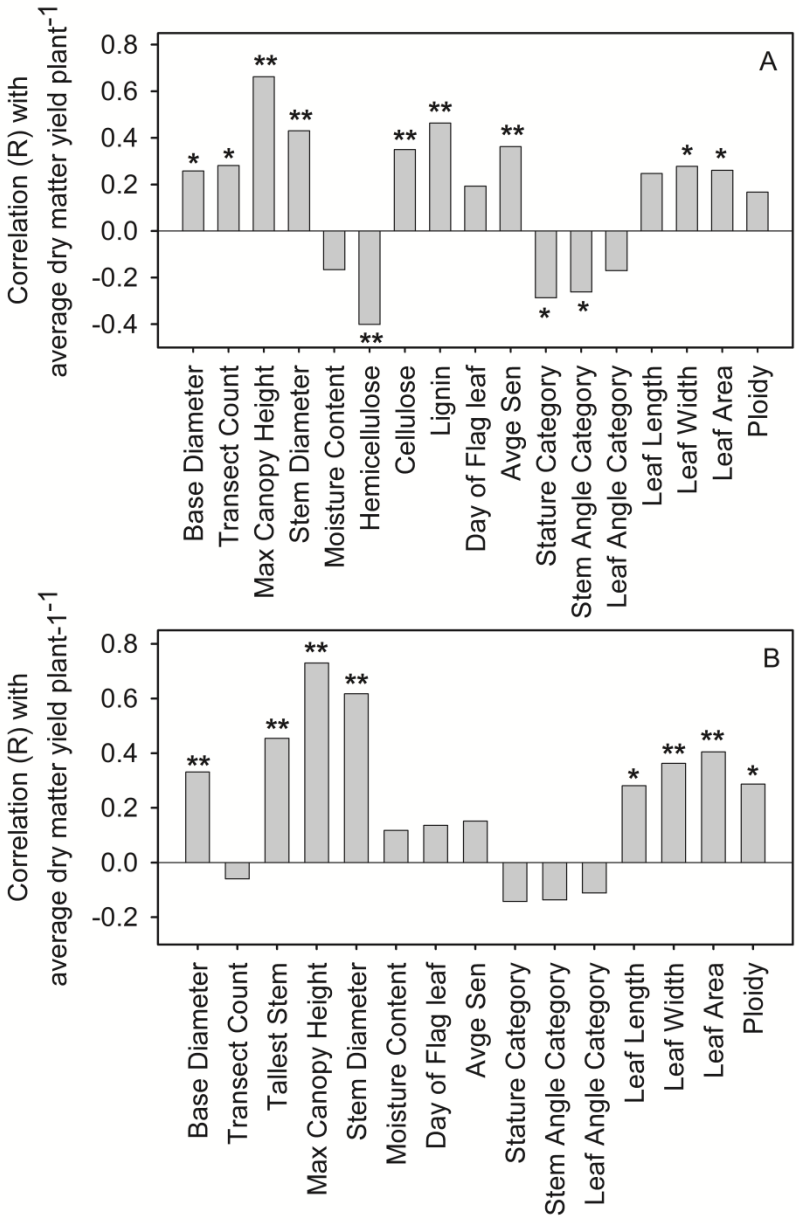
UK 2010


Yield
(t ha-1)
30
20
10
0
Variation in start time
Effective growing period
Variation in end time
Day of year
Temperature to support growth
Lethal temperatures kill new growth
End of reproductive phase
Lethal temperatures to stop growth

Canopy duration as a determinant of yield



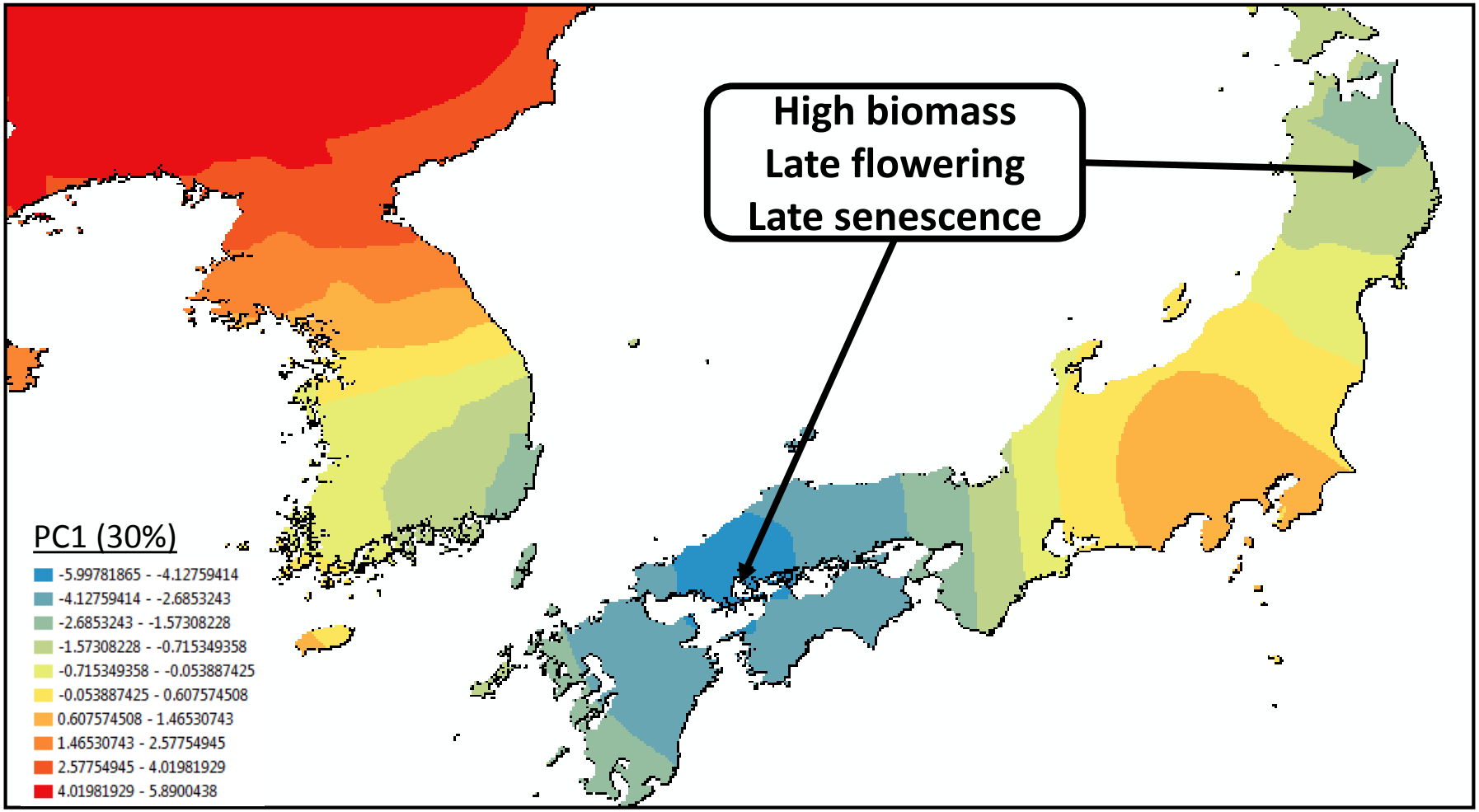




Individual trait correlations for all available traits from two sub-populations with large yield variances across canopy durations 200-210 (Fig. 5 A (2007)) and 170 to 180 (Fig. 5B (2009)) indicating variation in traits that are associated with yield variance at high canopy durations. One star indicates P >10%, two stars indicates P > 5%.

Robson et al., 2013; J. Ex. Bot. 64: 2373-2383.

Population genetic structure for 17 phenotypic traits



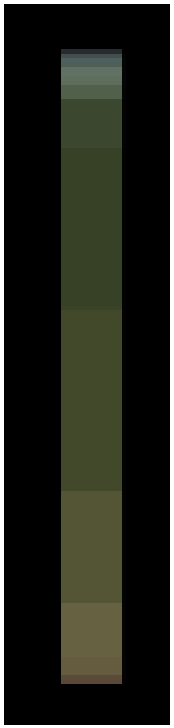
Slavov et al. GCB Bioenergy 5: 562-571. 2013.
Slavov et al. New Phytol 201: 1227-39. 2014.

High throughput drought study of approx. 100 genotypes

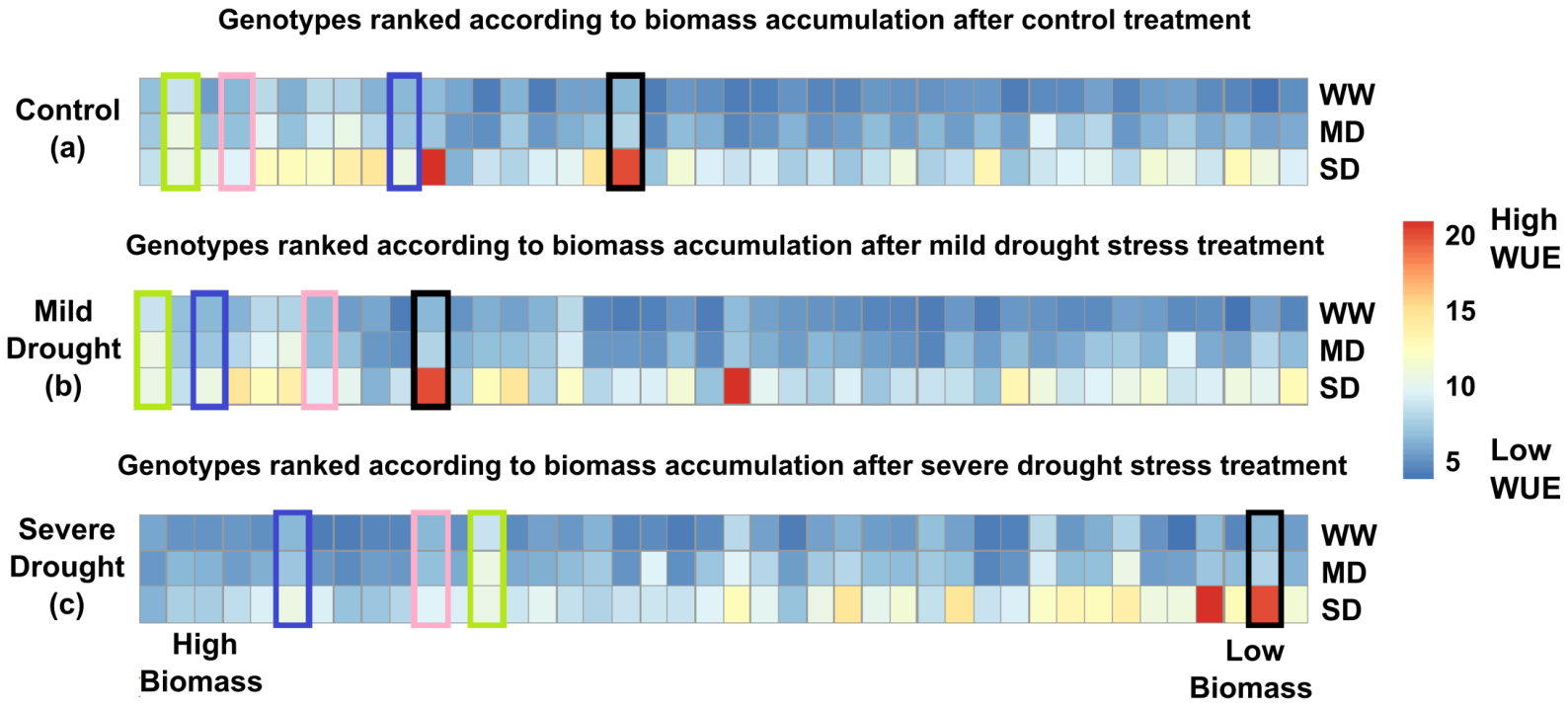

Watering Station


Plant separated from the background


Convex hull


Plant colours

A small number of Miscanthus accessions were identified that combine both high biomass and high WUE.



Malinowska et al. Phenomics analysis of drought responses in Miscanthus collected from different geographical locations. GCB Bioenergy 9: 78–91. 2017.

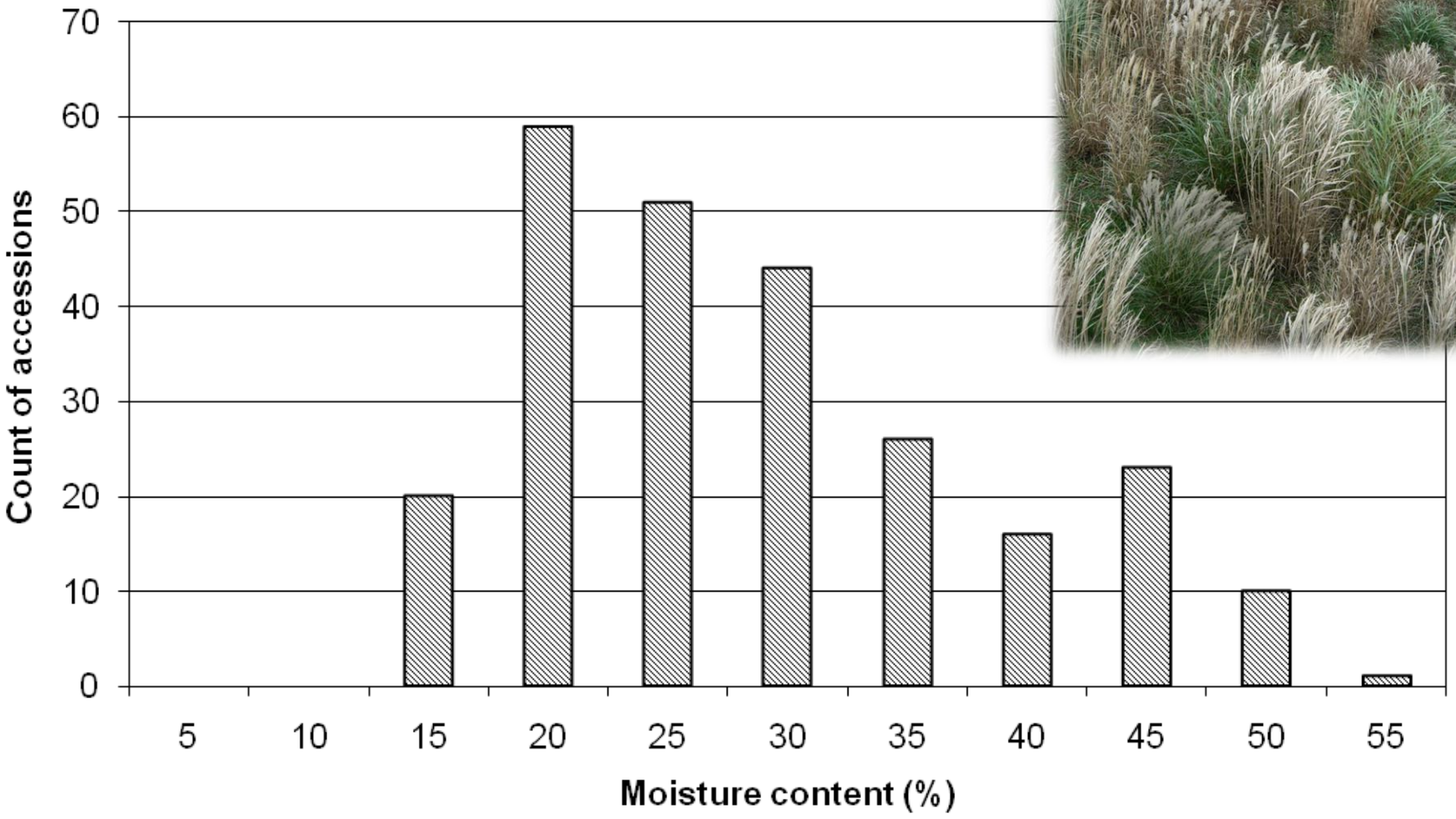
Biomass composition

Fuel specification & matching:

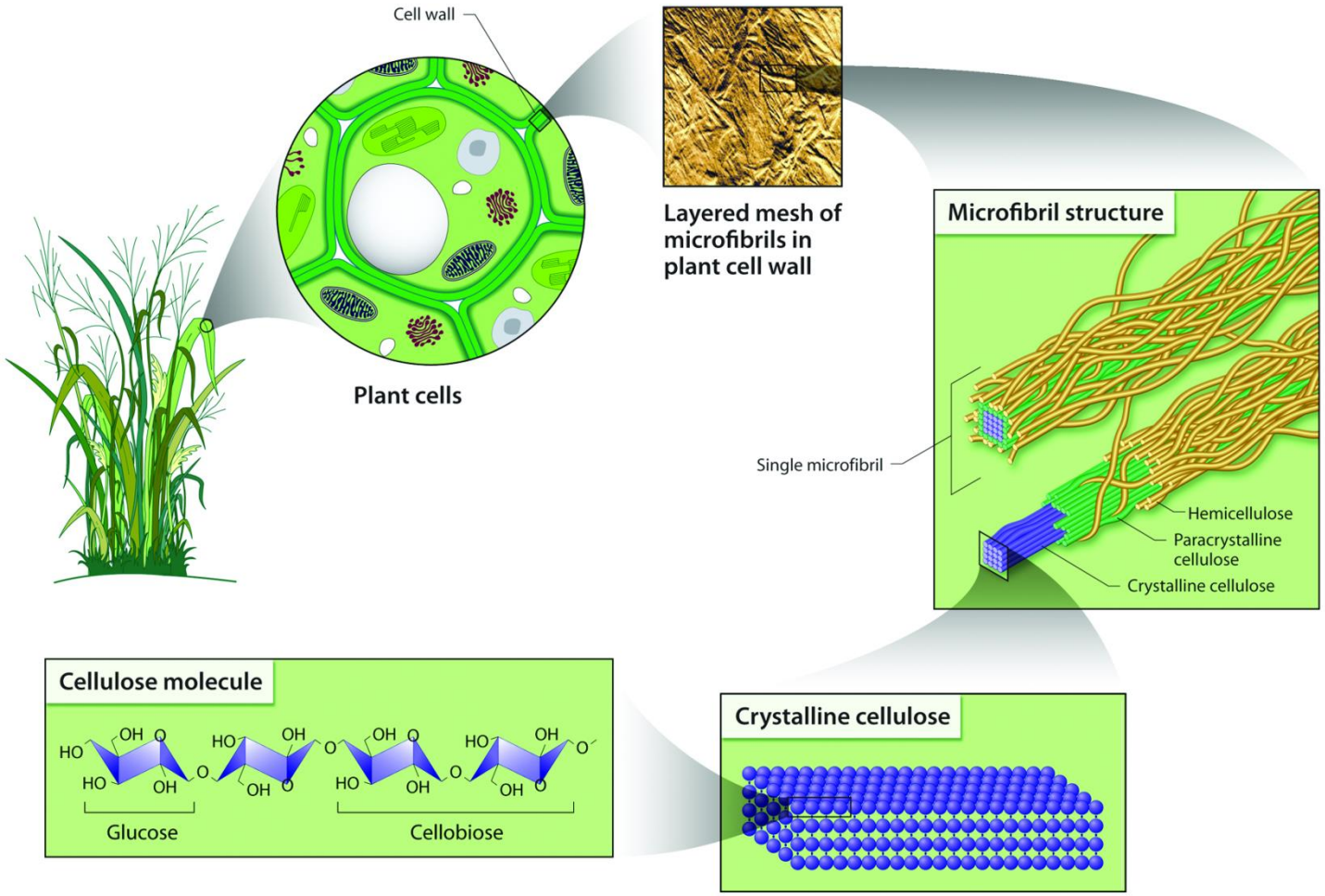
- Develop high throughput screening methods

- Establish relationship between biomass quality, conversion efficiency and end product quality characteristics

Variation in Moisture content

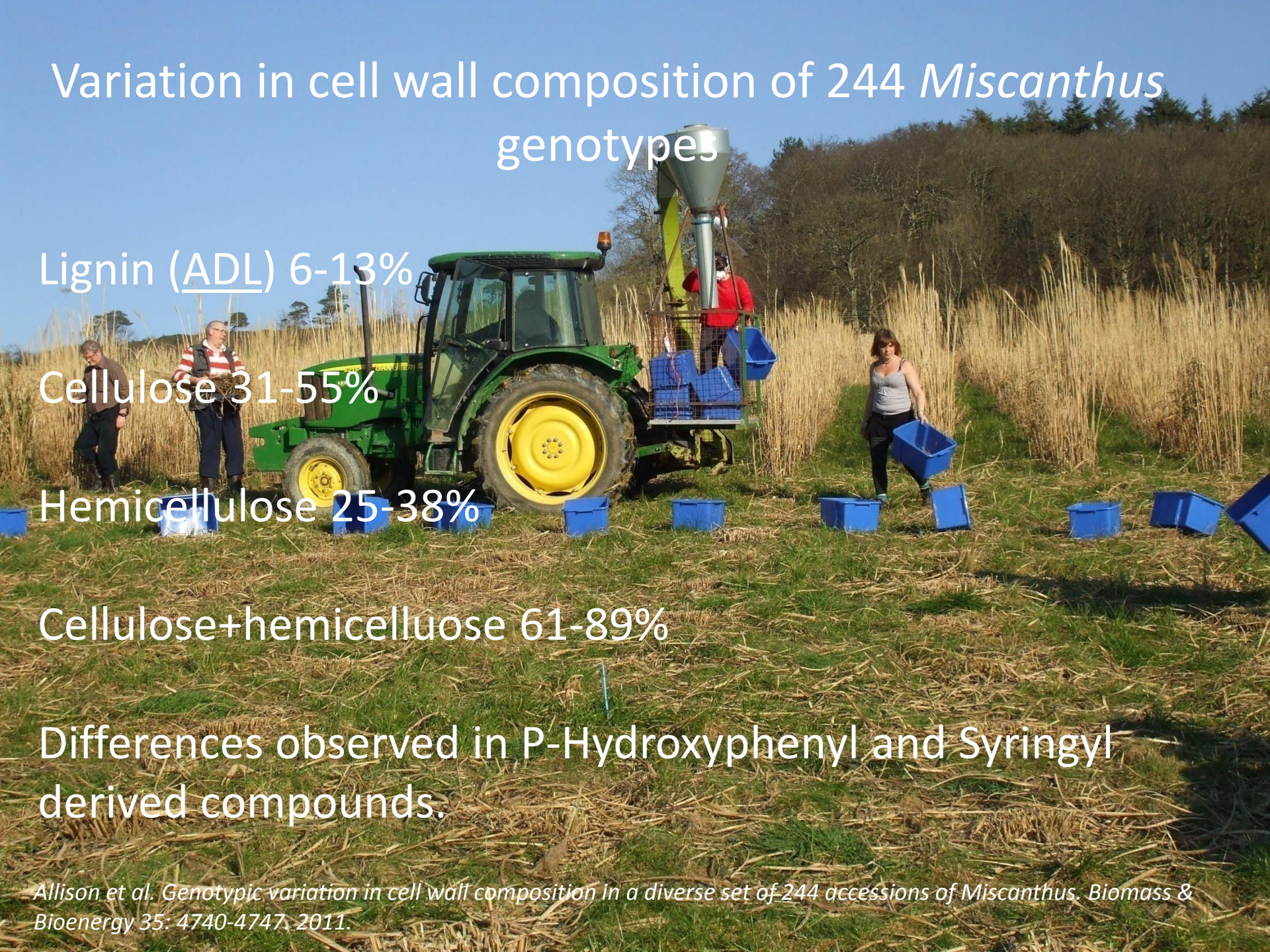


>70% of plant biomass is Cell Wall



Office of Biological and Environmental Research of the U.S. Department of Energy Office of Science. science.energy.gov/ber/

Variation in cell wall composition of 244 *Miscanthus* genotypes



Lignin (ADL) 6-13%

Cellulose 31-55%

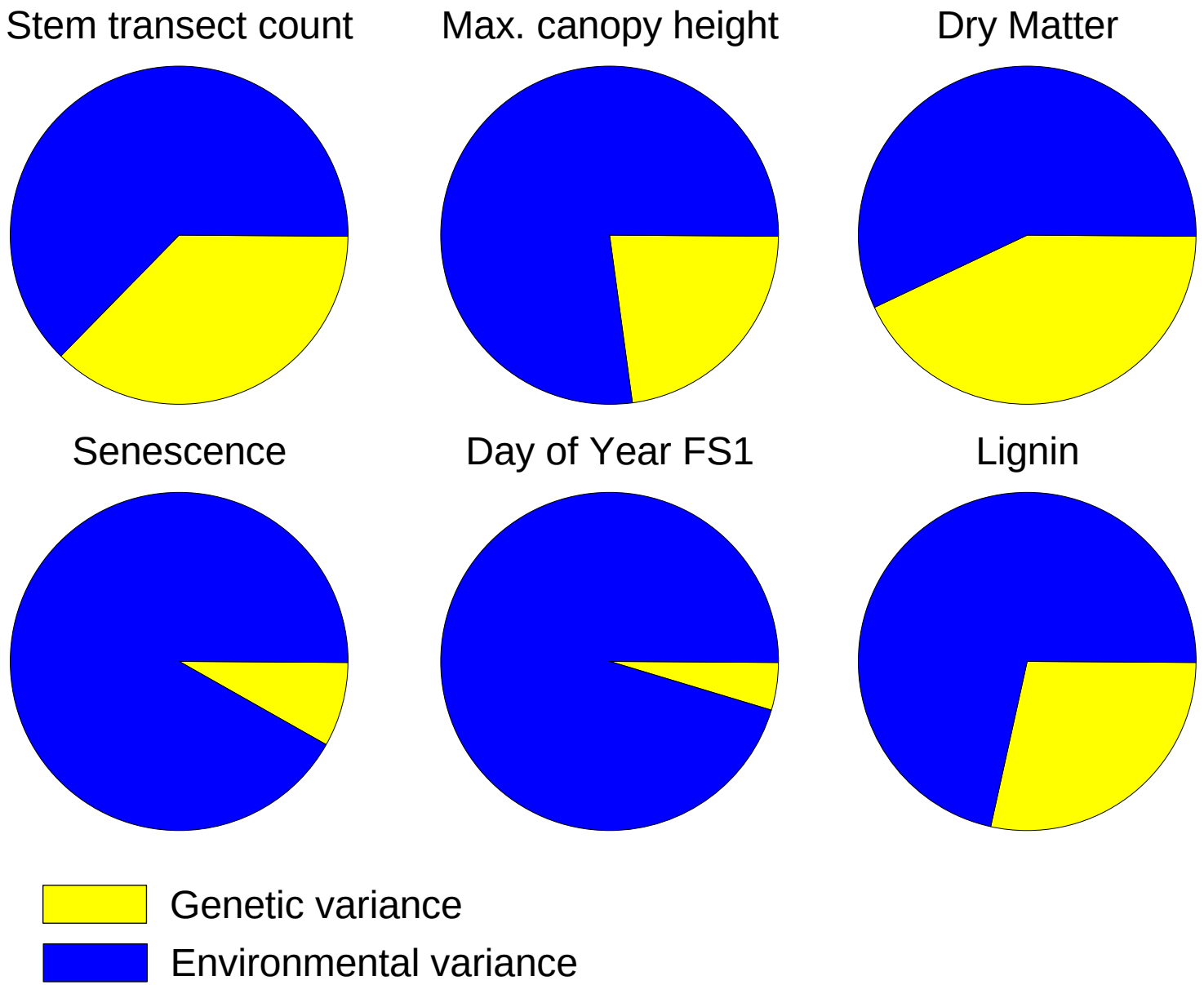
Hemicellulose 25-38%

Cellulose+hemicelluose 61-89%

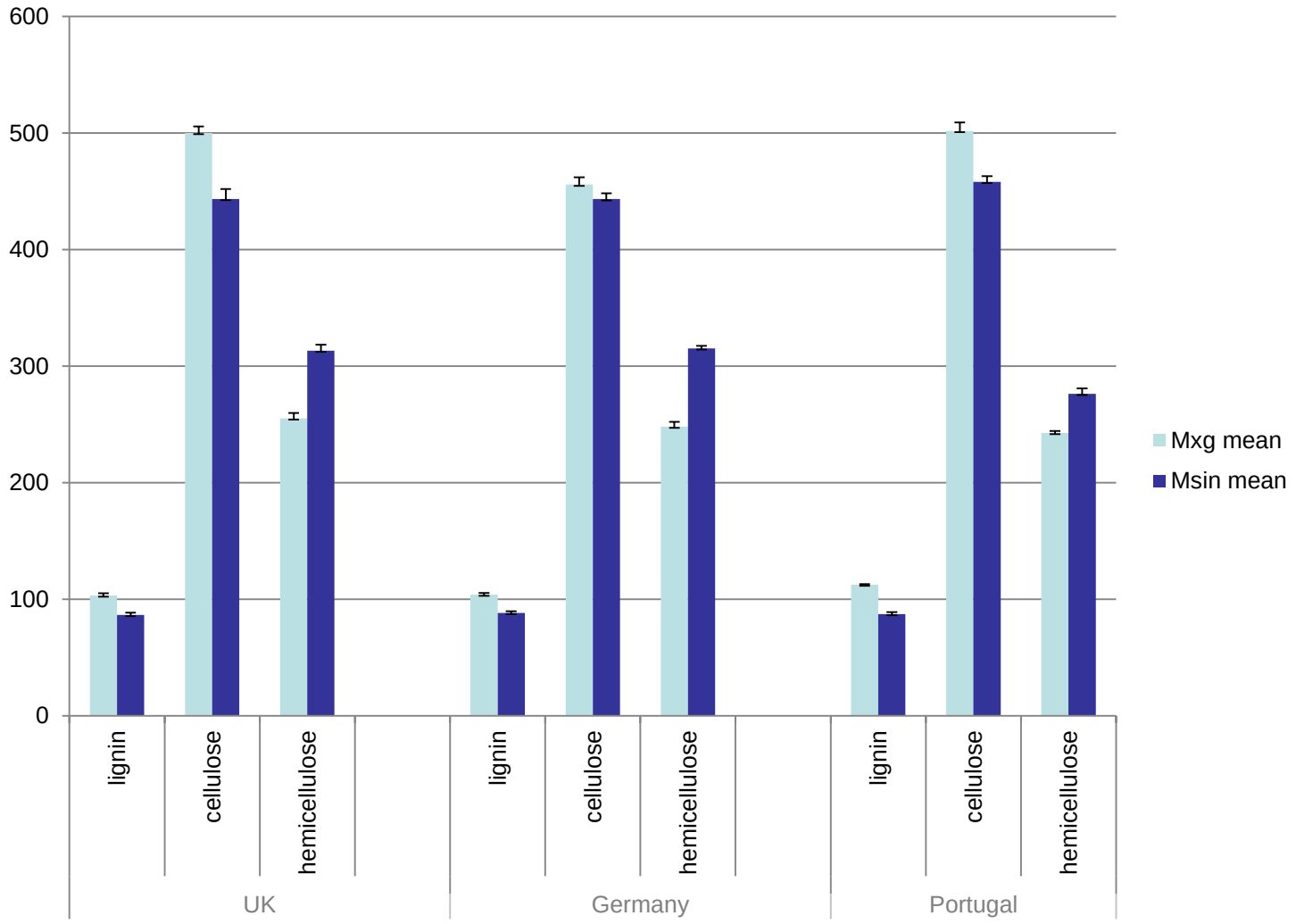
Differences observed in P-Hydroxyphenyl and Syringyl derived compounds.

Allison et al. Genotypic variation in cell wall composition in a diverse set of 244 accessions of Miscanthus. Biomass & Bioenergy 35: 4740-4747. 2011.

Variance in heritability due to genetic and environmental factors

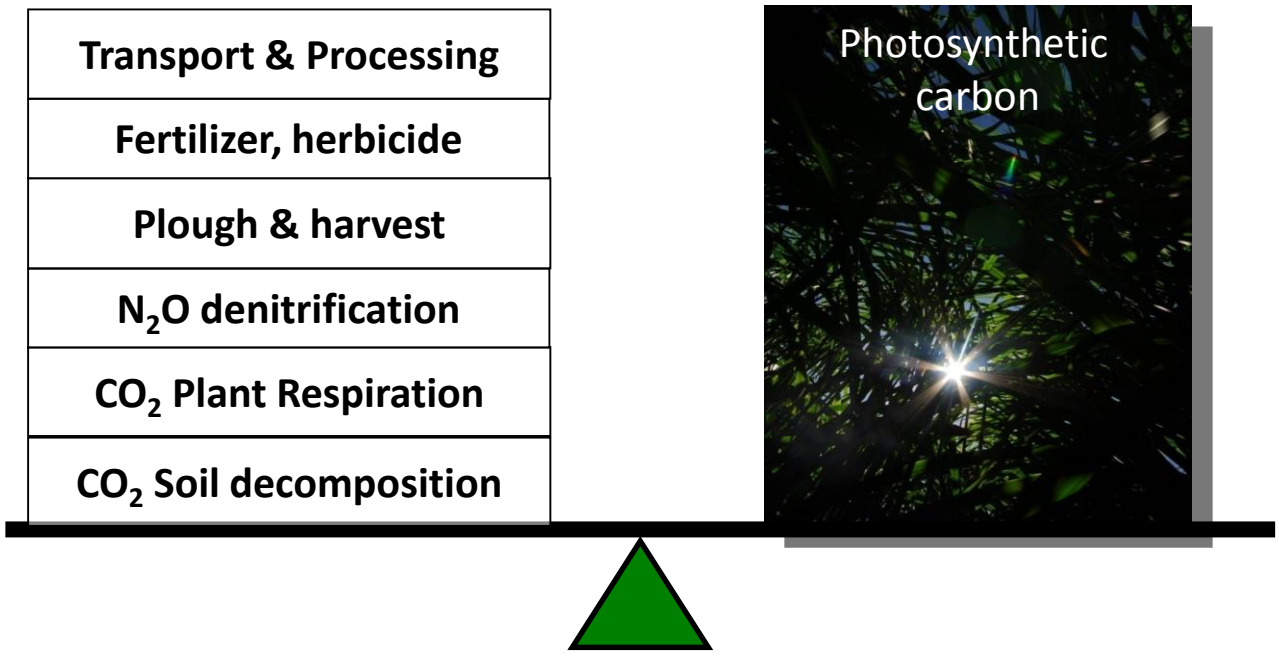


Variation in cell wall components of *M. x giganteus* and *M. sinensis* (g/ Kg)



Hodgson et al. Genotypic and environmentally derived variation in the cell wall composition of Miscanthus in relation to its use as a biomass feedstock. Biomass & Bioenergy 34: 652-660. 2010.

Sustainability
Greenhouse gas and energy balance



Total site 7 ha of semi-permanent grassland, re-sown 6 years previously

energy technologies institute

EPSRC
Engineering and Physical Sciences Research Council

NATURAL ENVIRONMENT RESEARCH COUNCIL

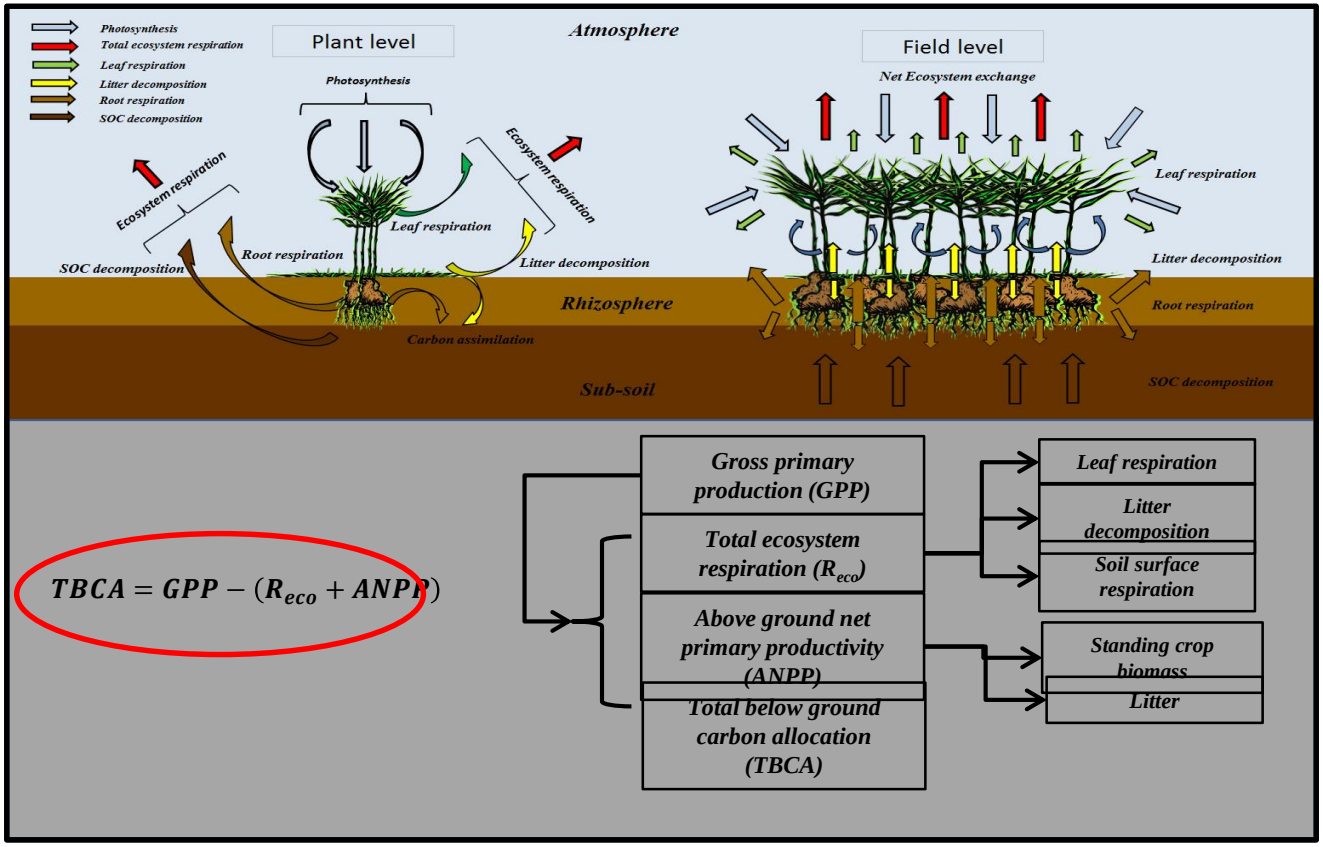
Supergen Bioenergy

elum
BIOENERGY DIRECT LAND-USE CHANGE

Carbo-BioCrop
Understanding processes determining soil carbon balance under perennial bioenergy crops.

MAGLUE

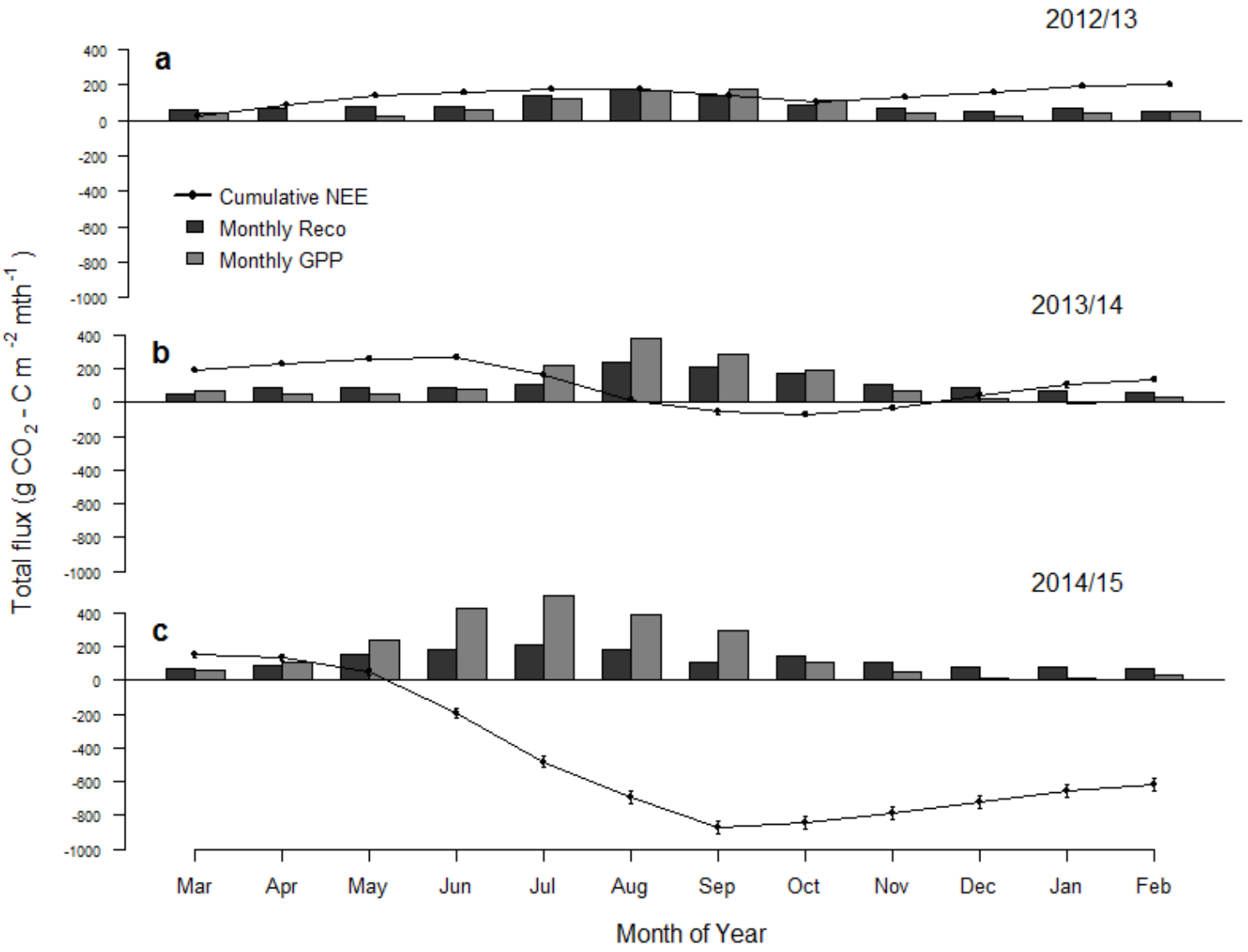
Harris et al *Biofuels* 5: 111-116. 2014.



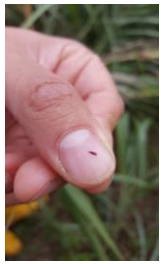
McCalmont et al. 2017. An inter-year comparison of CO2 flux and carbon budget at a commercial scale land-use transition from semi-improved grassland to Miscanthus x giganteus. GCB Bioenergy 9: 229-245.

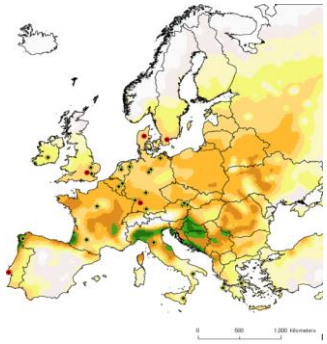
McCalmont et al. 2017. Partitioning of ecosystem respiration of CO2 released during land-use transition from temperate agricultural grassland to Miscanthus x giganteus. GCB Bioenergy 9: 710-724.

Paying back the carbon debt



Scalability and establishment cost: replacing rhizome with seed, and trialling





PLANTS AND ARCHITECTURE

GRACE

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

Cyngor Cyllido Addysg Uwch Cymru
Higher Education Funding Council for Wales
hefcw

- Green infrastructure - use of plants to improve building performance and reduce urban heat island affect
- Vertical farming – for low carbon urban production
- Biobased construction materials – insulation and embedded carbon
- Architecture learning from plants – nature inspired design (biomimicry)

ABERYSTWYTH UNIVERSITY

PRIFYSGOL BANGOR UNIVERSITY

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Acknowledgments

Miscanthus Science: Kerrie Farrar, Paul Robson, Elaine Jensen, Marta Malinowska, Gordon Alison, Edward Hodgson, Maurice Bosch
Miscanthus Breeding & Genetic resources: John Clifton-Brown, Lin Huang, Gancho Slavov, Chris Davey, Astley Hastings (Aberdeen);
Phenomics and image analysis: John Doonan
Environmental biology: John McCalmont, Gail Taylor (Southampton), Neil McNamara (CEH), Rebececca Rowe (CEH), Jeanette Whitaker (CEH)
Plants & Architecture: Peter Wotton-Beard, Phil Jones (Cardiff), Graham Ormondroyd (Bangor), Simon Curling (Bangor), Morwenna Spear (Bangor)