A breeding journey with *Miscanthus*

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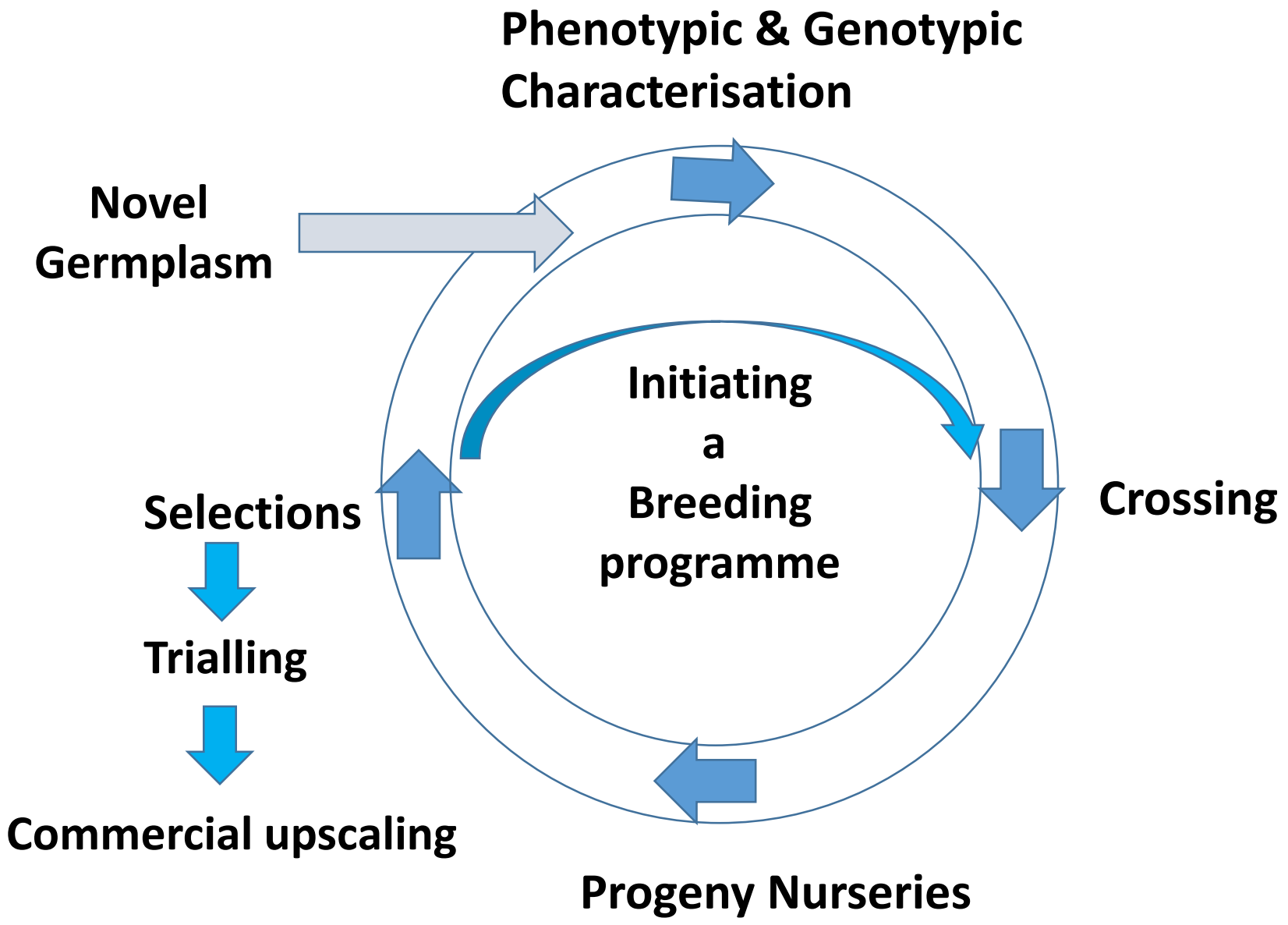
Breeding Objectives

- **Increase net energy yield per hectare**
  - **Increased yield**
  - **Reduced moisture content at harvest**
- **Tailor physical and chemical composition to different end-use applications**
  - **Increased lignin content and decreased corrosive elements for thermal conversion**
  - **Reduced lignin content for next generation biofuels from lignocellulose**
- **Reduce genetic vulnerability**
  - **Abiotic and biotic stress tolerance**
- **Reduce propagation costs**


Phenotypic & Genotypic Characterisation
Novel Germplasm
Initiating a Breeding programme
Crossing
Selections
Trialling
Commercial upscaling
Progeny Nurseries


68
26/10/2006
Image © 2008 TerraMetrics
Google
28°51'22.31" N 112°25'48.56" E
Eye alt 26.49 km

Development of germplasm

In-situ phenotypic characterisation & collection of wild germplasm → *Ex-situ* phenotypic characterisation in nurseries within production areas → Crossing / Hybridisation → Phenotypic selection in nurseries

TRACK 1

TRACK 2

TRACK 3

TRACK 4

Plot Scale --> Field Scale --> Commercial Scale


TRACK 1 & 2

Crossing

TRACK 3

TRACK 4

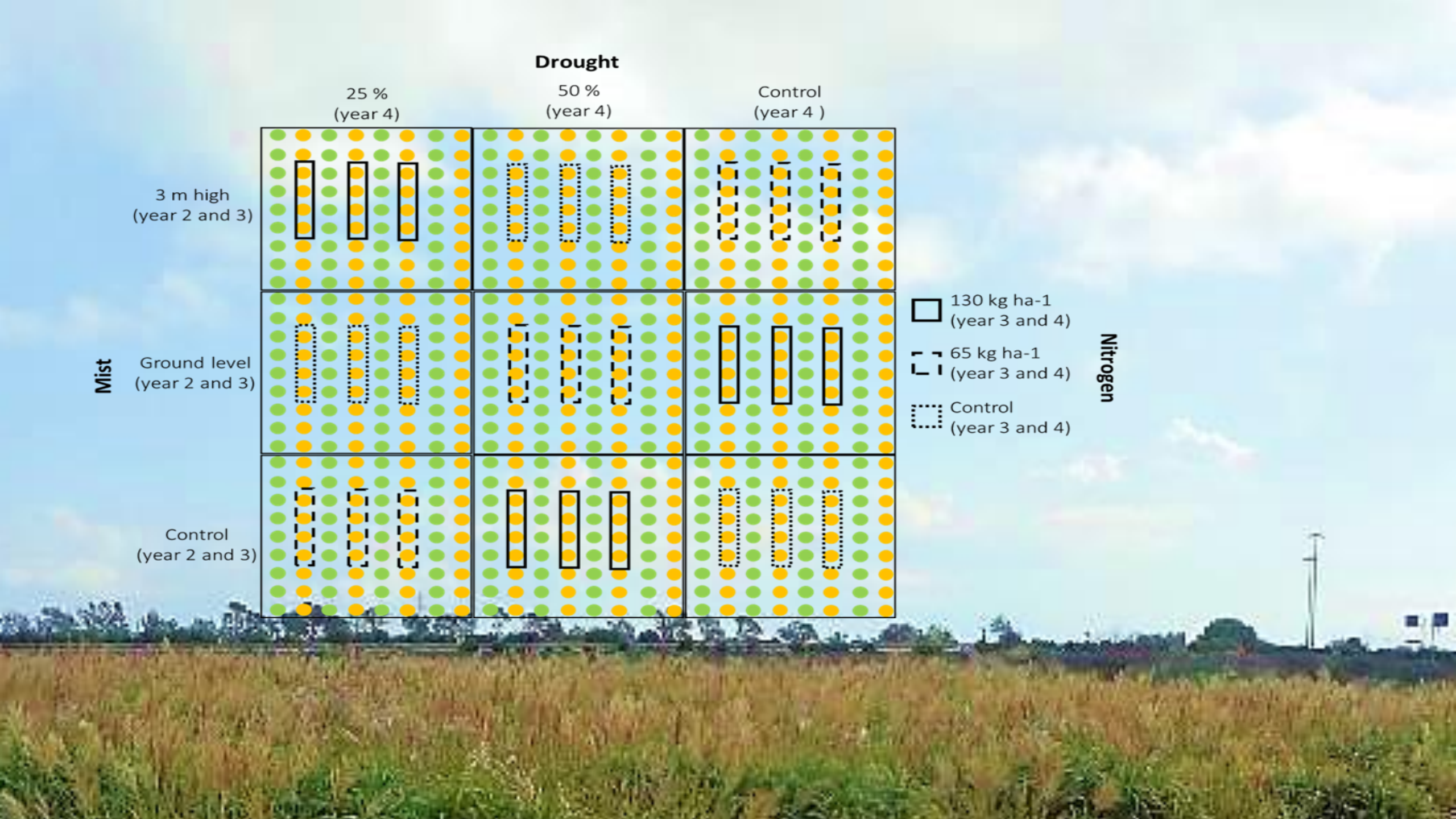
TRACK 4

Sicily

Uni of Catania

Canaries

Energene® Seeds Ltd


Drought
25 %
(year 4)
50 %
(year 4)
Control
(year 4)
3 m high
(year 2 and 3)
Ground level
(year 2 and 3)
Control
(year 2 and 3)
Mist
130 kg ha-1
(year 3 and 4)
65 kg ha-1
(year 3 and 4)
Control
(year 3 and 4)
Nitrogen

UNIVERSITY OF HOHENHEIM

GRACE

John Clifton-Brown[1*], Danny Awty-Carroll[1], Chris Ashman[1], Luisa Trindade[2], Mohamed Al Hassan[2], Kasper van der Cruijse[2], Oene Dolstra[2], Andrea Ferrarini[3], Enrico Martani[3], Henri Blandinieres[3], Stefano Amaducci[3], Vanja Jurisic[4], Mislav Kontek[4], Gert-Jan Petrie[8], Chris Davey[1], Jason Kam[9], Michael Squance[9], Emmanuel de Maupeou[6], Philip van der Pluijm[6], Boris Slijepčević[7], Uwe Kuehn[10], Carmen Retzela[10], Astley Hastings & Anita Shepherd [11], Elena Magenau[5], Andreas Kiesel[5].

[1] University of Aberystwyth, [2] Wageningen University, [3] Universita Cattolica del Sacro Cuore, [4] Zagreb University, [5] University of Hohenheim, [6] Novabiom, [7] INA-Industrija Nafte d.d., [8] Miscanthus Group, [9] Terravesta, [10] Gießereitechnik Uwe Kühn, [11]University of Aberdeen. *new address, JLU, Gießen, Germany.

BBI project GRACE

Upscaling *Miscanthus* biomass production with novel hybrids

Providing Growledge.

Bio-based Industries Consortium

BBI

Horizon 2020 European Union Funding for Research & Innovation

The GRACE project has received funding from the Bio-Based Industries Joint Undertaking (BBI JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 745012.

Economically marginal land

- **Shallow soil**
- **Poor drainage**
- **Texture extremes (Sand, Clay)**
- **High stone content**
- **Slope (>15 %)**
- **pH (extremes)**
- **De-graded lands (erosion, black grass….)**
- **Compaction**
- **Chemical contamination e.g. Salinity**
- **Awkward areas (unsuitable for sustainable intensification)**

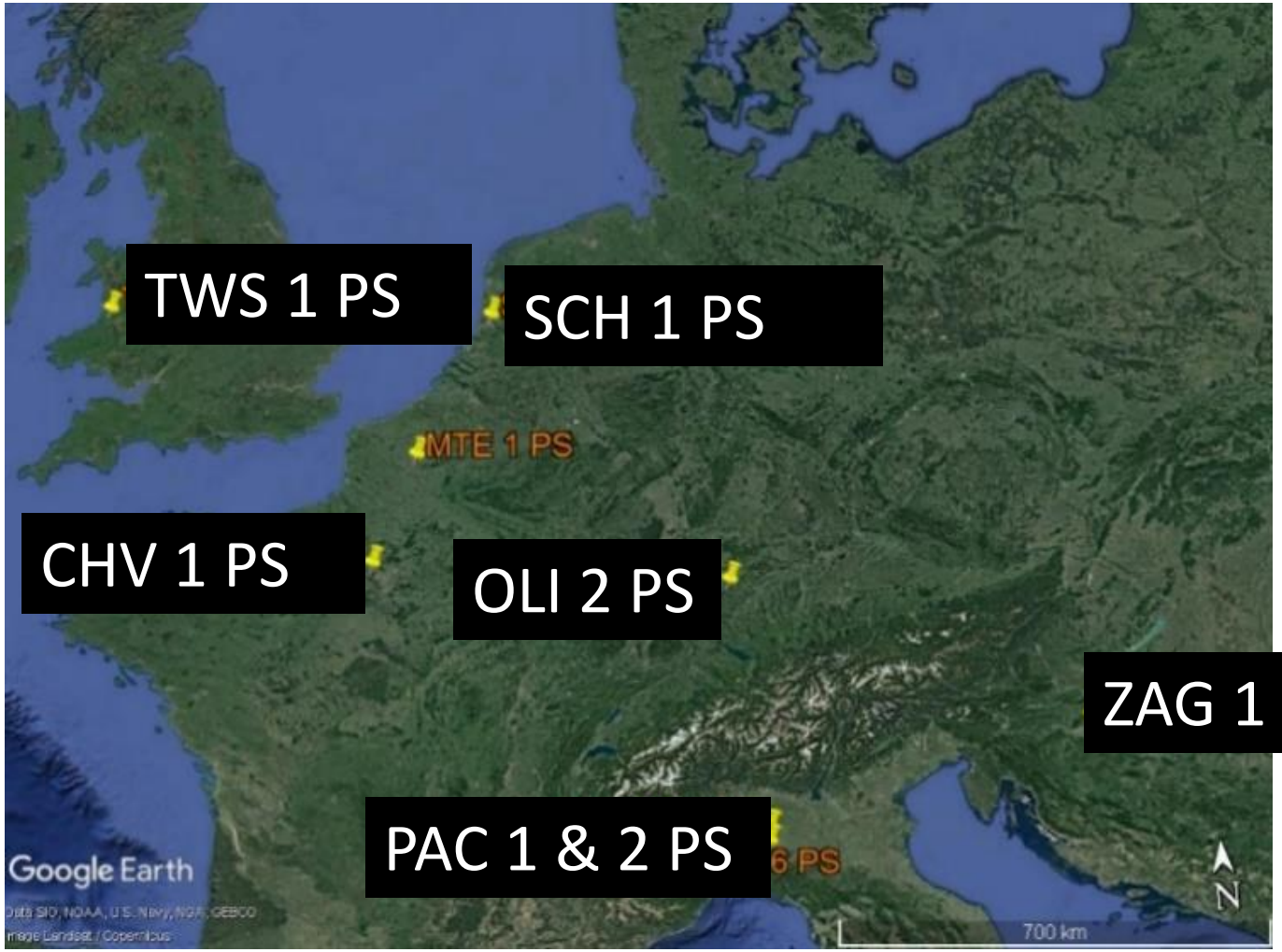
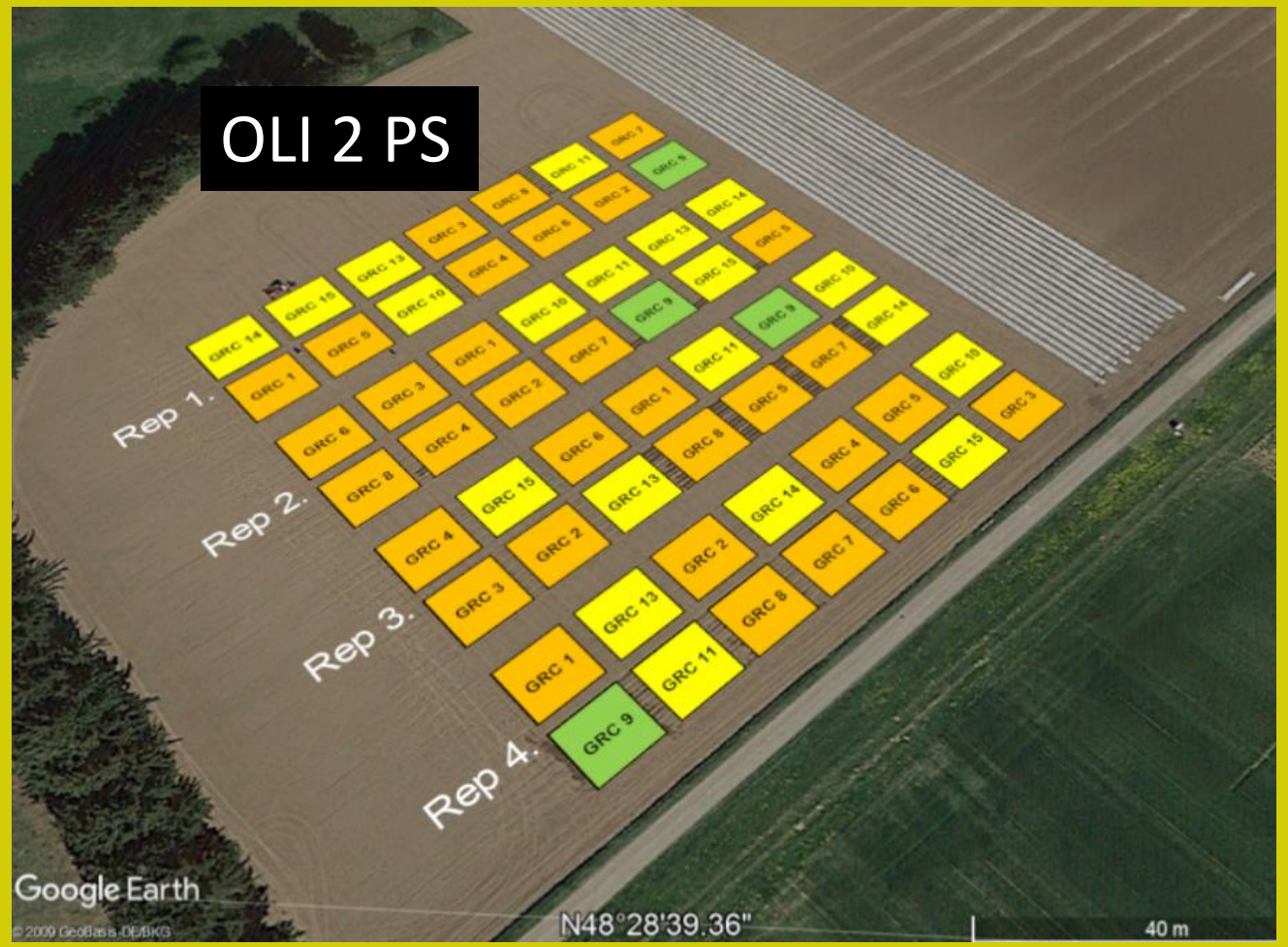


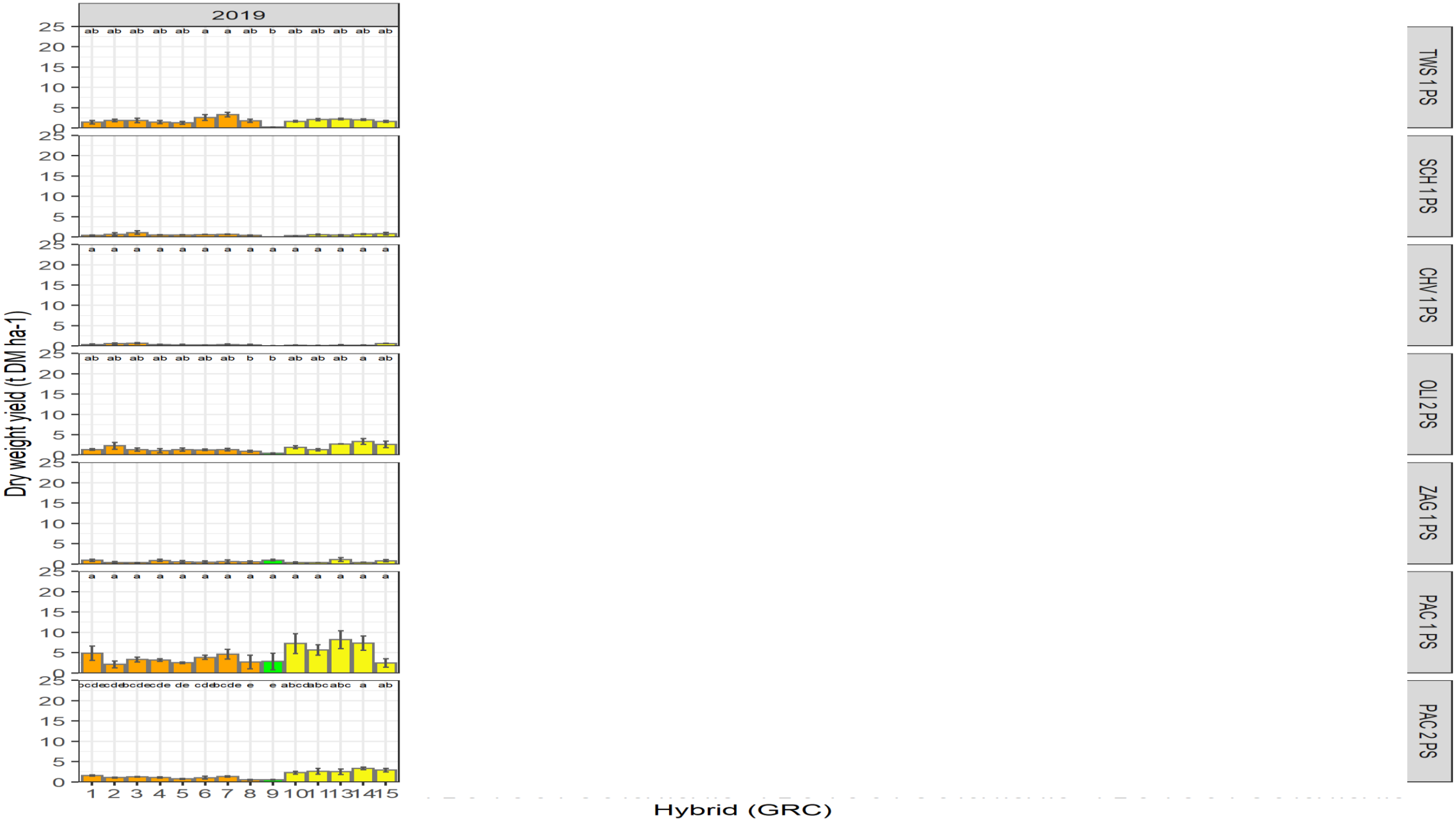
Table 1 - Target numbers of plantlets for establishing nine plot scale (PS) tri
one commercial scale (CS) trial in 2018.

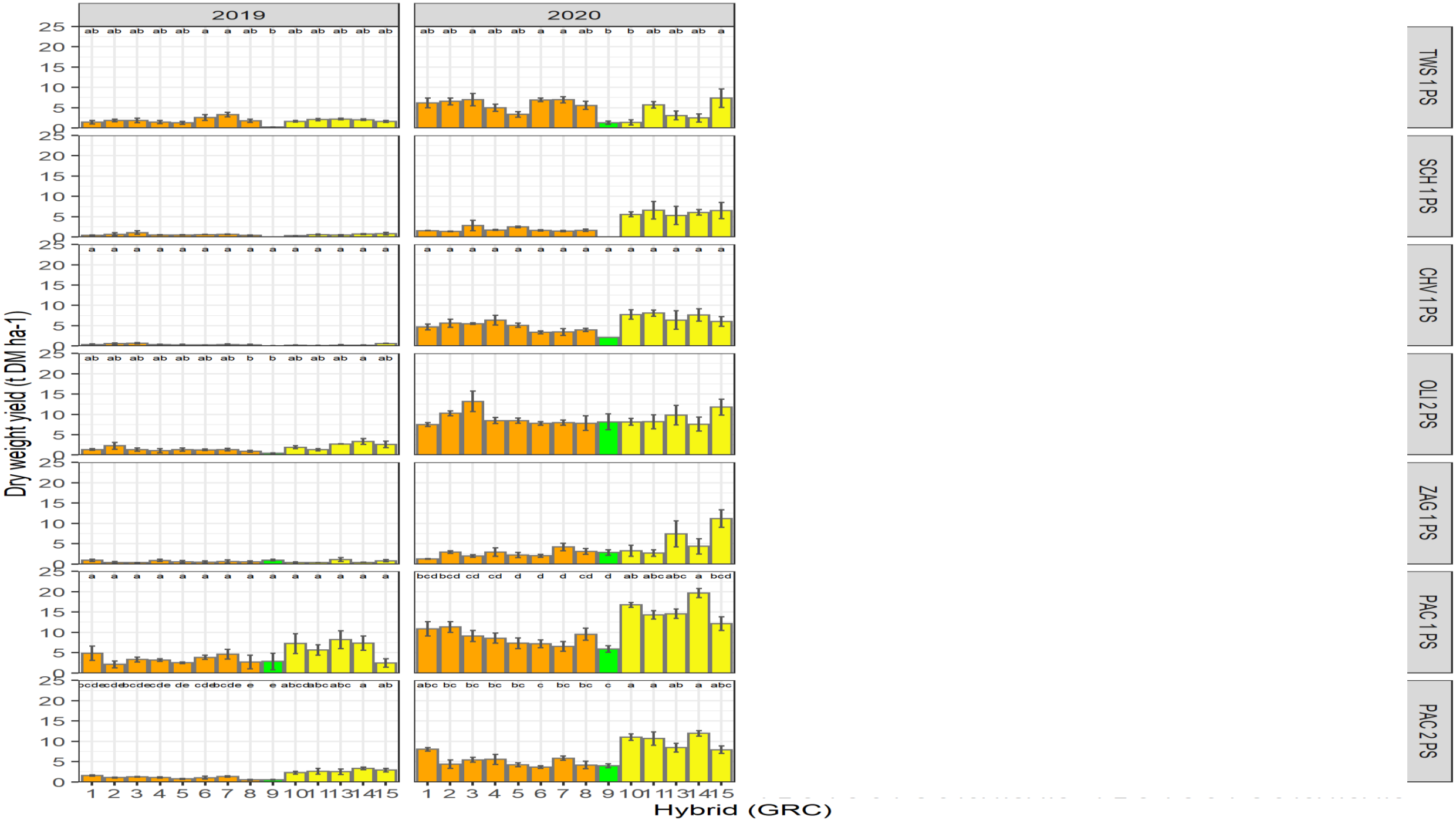
GRACE code	Species	Hybrid type	PS
GRC-1	*M. sinensis x M. sinensis*	Seed	10800
GRC-2	*M. sinensis x M. sinensis*	Seed	10800
GRC-3	*M. sinensis x M. sinensis*	Seed	10800
GRC-4	*M. sinensis x M. sinensis*	Seed	10800
GRC-5	*M. sinensis x M. sinensis*	Seed	10800
GRC-6	*M. sinensis x M. sinensis*	Seed	10800
GRC-7	*M. sinensis x M. sinensis*	Seed	10800
GRC-8	*M. sinensis x M. sinensis*	Seed	10800
GRC-9	*M. x giganteus* (commercial)	Rhizome	5400
GRC-10	*M. sacchariflorus x M. sinensis*	Seed	5400
GRC-11	*M. sacchariflorus x M. sinensis*	Seed	5400
GRC-12	*M. sacchariflorus x M. sinensis*	Seed	
GRC-13	*M. sacchariflorus x M. sinensis*	Seed	5400
GRC-14	*M. sacchariflorus x M. sinensis*	Seed	5400
GRC-15	*M. sacchariflorus x M. sinensis*	Rhizome	5400

3 plants m^{-2}

1.5 plants m^{-2}

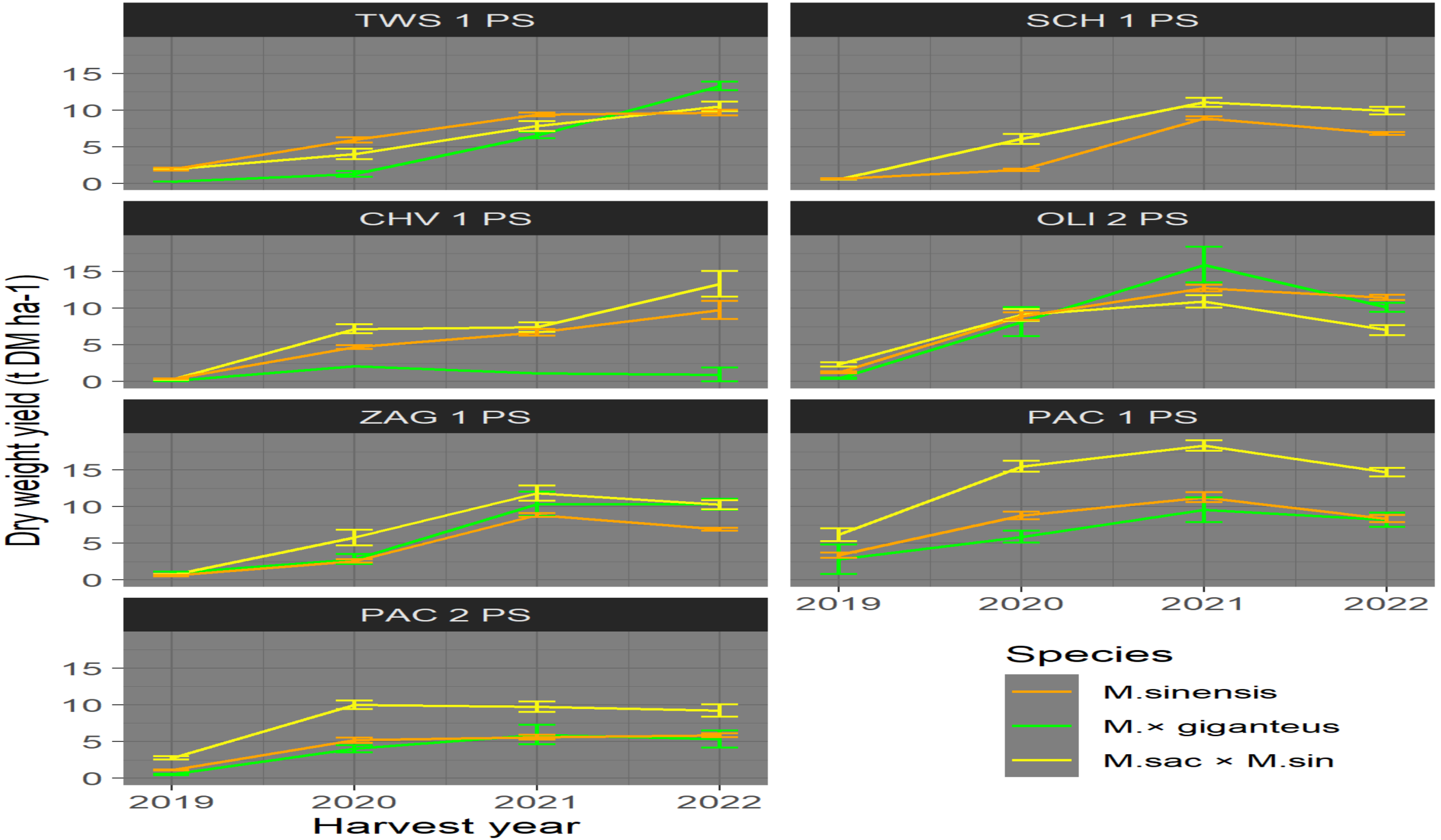



2019
Dry weight yield (t DM ha-1)
Hybrid (GRC)
TWS 1 PS
SCH 1 PS
CHV 1 PS
OLI 2 PS
ZAG 1 PS
PAC 1 PS
PAC 2 PS


2019
2020
Dry weight yield (t DM ha-1)
Hybrid (GRC)
TWS 1 PS
SCH 1 PS
CHV 1 PS
OLI 2 PS
ZAG 1 PS
PAC 1 PS
PAC 2 PS


2019
2020
2021
TWS 1 PS
SCH 1 PS
CHV 1 PS
OLI 2 PS
ZAG 1 PS
PAC 1 PS
PAC 2 PS
Dry weight yield (t DM ha-1)
Hybrid (GRC)


2019
2020
2021
2022
TWS 1 PS
SCH 1 PS
CHV 1 PS
OLI 2 PS
ZAG 1 PS
PAC 1 PS
PAC 2 PS
Dry weight yield (t DM ha-1)
Hybrid (GRC)


TWS 1 PS
SCH 1 PS
CHV 1 PS
OLI 2 PS
ZAG 1 PS
PAC 1 PS
PAC 2 PS
Dry weight yield (t DM ha-1)
0
5
10
15
2019
2020
2021
2022
Harvest year
Species
M.sinensis
M.× giganteus
M.sac × M.sin

From Nurseries

Seed production

Early Plant Develp. Survival Growth	Over – Wintering Freezing	Yield Year 1,2,3 Rank	Quality MC% Ash%	Floods / Drought	HMC Metals Nutrient depleted
Temperate zones					
✓	✓	✓	✓	✓	✓
Continental zones					
✓	✗				

Nurseries and
Small plot trials


Plugs GNT 43

GOE 21st July 2021

PERENNIAL BIOMASS CROPS

PBC4GGR

GREENHOUSE GAS REMOVAL

9 hectares for assessment of Greenhouse Gas fluxes (using Eddy Covariance) compared to a conventional Arable Rotation to provide quantifications of the costs and benefits…

Photo: Dr. Chris Ashman at Bishop Burton College (Yorkshire, UK)

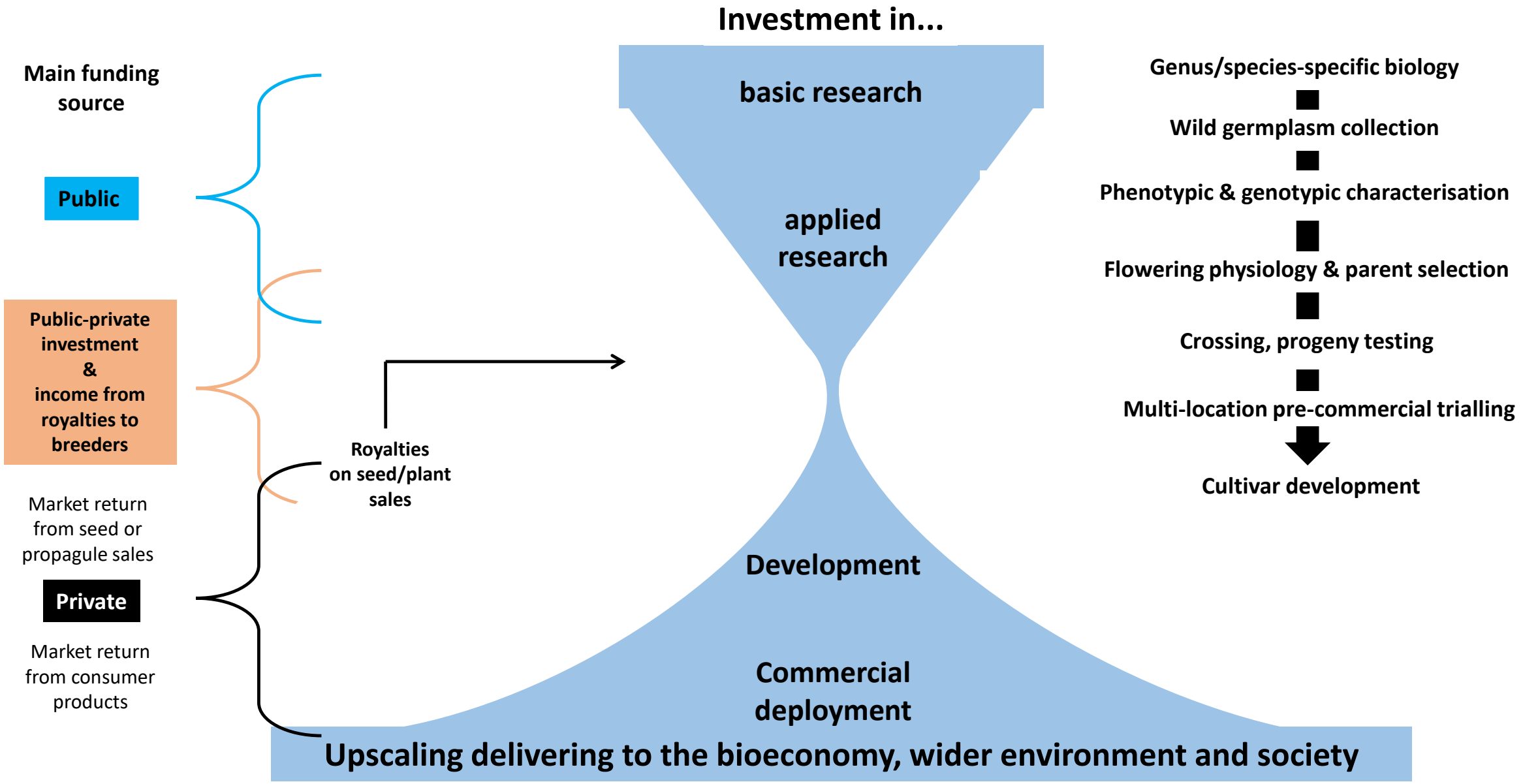
1872 Prifysgol Aberystwyth University

UK Centre for Ecology & Hydrology

1495 University of Aberdeen

Rothamsted Research

CCRI Countryside and Community Research Institute


Investment in...
Main funding source
Public
Public-private investment & income from royalties to breeders
Market return from seed or propagule sales
Private
Market return from consumer products
Royalties on seed/plant sales
basic research
applied research
Development
Commercial deployment
Upscaling delivering to the bioeconomy, wider environment and society
Genus/species-specific biology
Wild germplasm collection
Phenotypic & genotypic characterisation
Flowering physiology & parent selection
Crossing, progeny testing
Multi-location pre-commercial trialling
Cultivar development