



United Kingdom research and development to support DUS examination

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DUS testing in the United Kingdom

- Defra provide the secretariat for Plant Varieties and Seeds Committee
 - Representatives from Defra, DAERA in Northern Ireland, Scottish Government, and Welsh Government
- Animal and Plant Health Agency provide secretariat for National List Seeds Committee
 - Government representatives from England, DAERA in Northern Ireland, Scottish Government, and Welsh Government
- Three UK DUS testing centres:
 - Agri-Food and BioSciences Institute
 - Niab
 - SASA
- The UK purchases or commissions DUS examinations from UPOV members for species not tested in the UK

Areas of research

Image Analysis

- Studio Imaging
- Unmanned Aerial Vehicles

Molecular Techniques

- Markers as a method of examining DUS characteristics
- Genomic prediction



Image Analysis – Studio



- Samples prepared and displayed according to type
- Depending on requirements samples are backlit or top lit
- Barcoding system for datafile management
- Multiple plant samples and measurements are captured in one image
- Live object analysis feedback allows for presentation correction pre-analysis
- Data stored in a datafile for each image

Analysis types

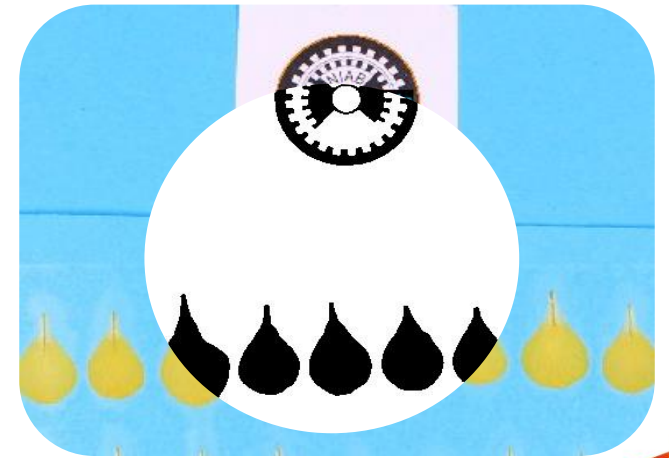
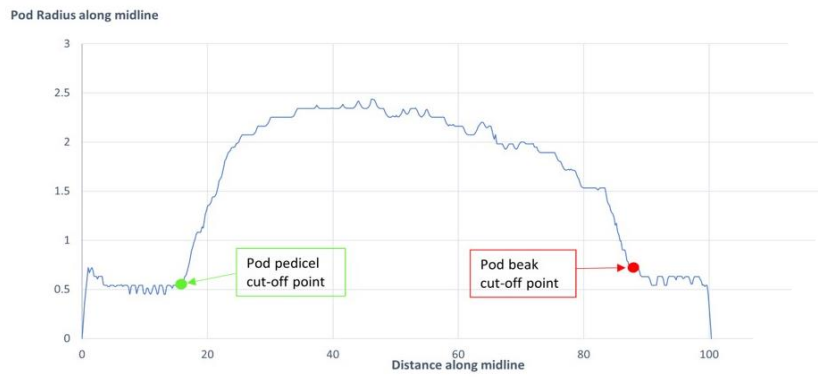


Image Analysis – UAV/drone

- Full trial image capture
- 3D image construction for canopy height measurements
- RGB and Multispectral image analysis for calculation of vegetative indices
- Efficient data capture for large trials but has limitations

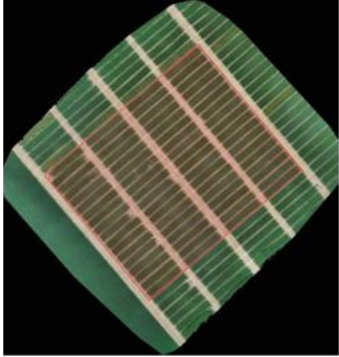
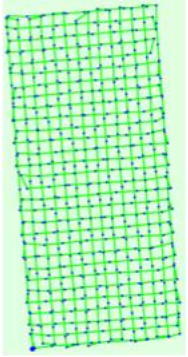


UAV with RGB camera



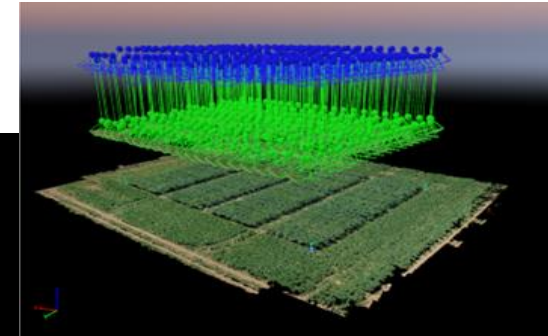
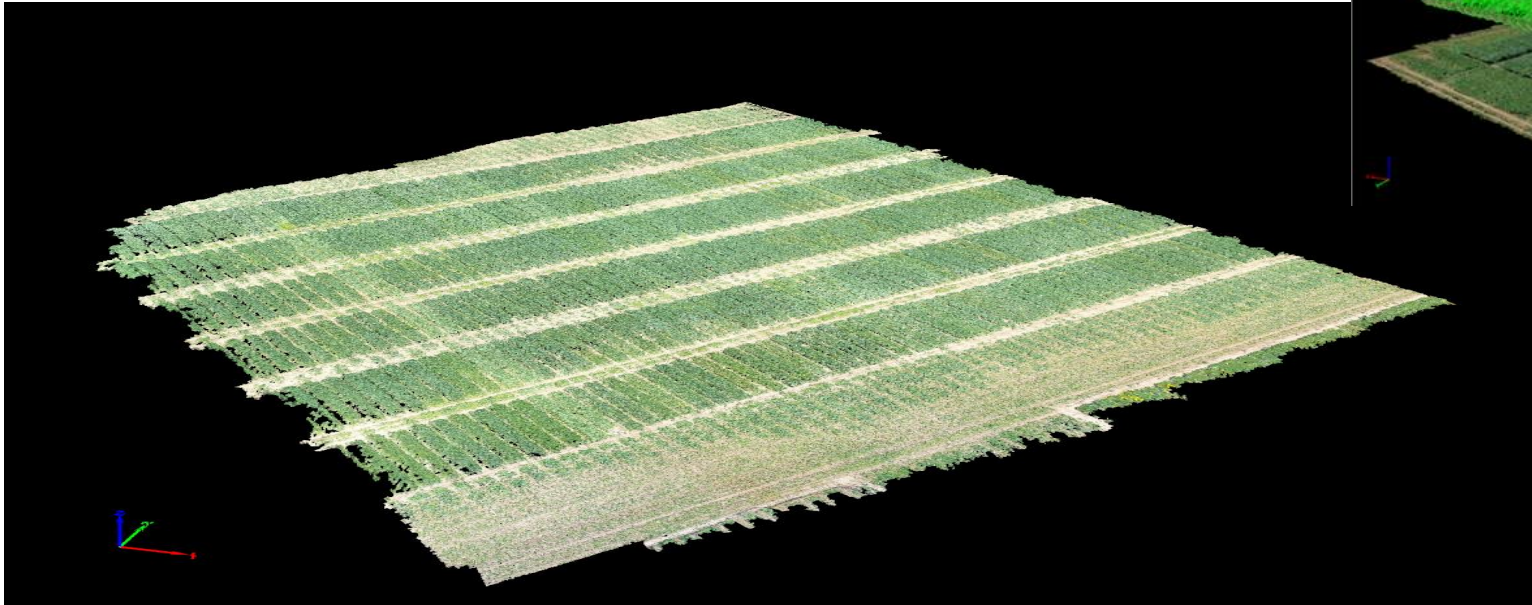
UAV with multispectral camera

UAV image capture and preparation



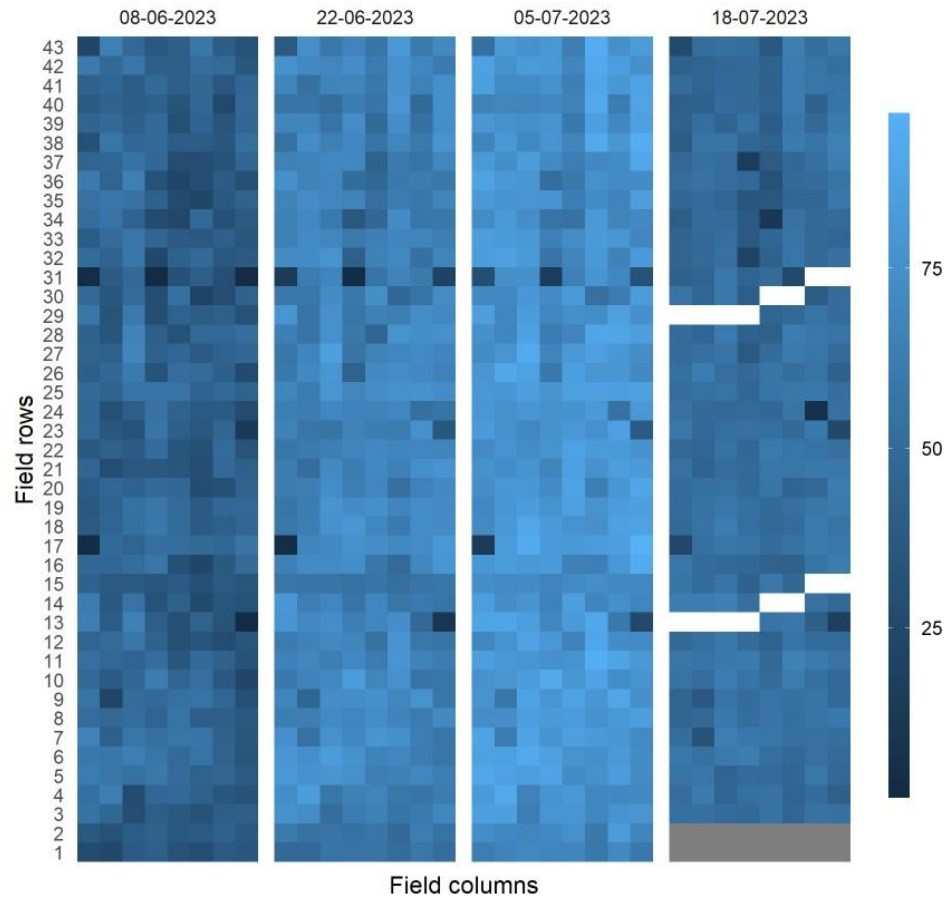
L-R:

1. Flight plan
2. 2D orthomosaic reconstruction
3. Detail image with ground control point (GCP)

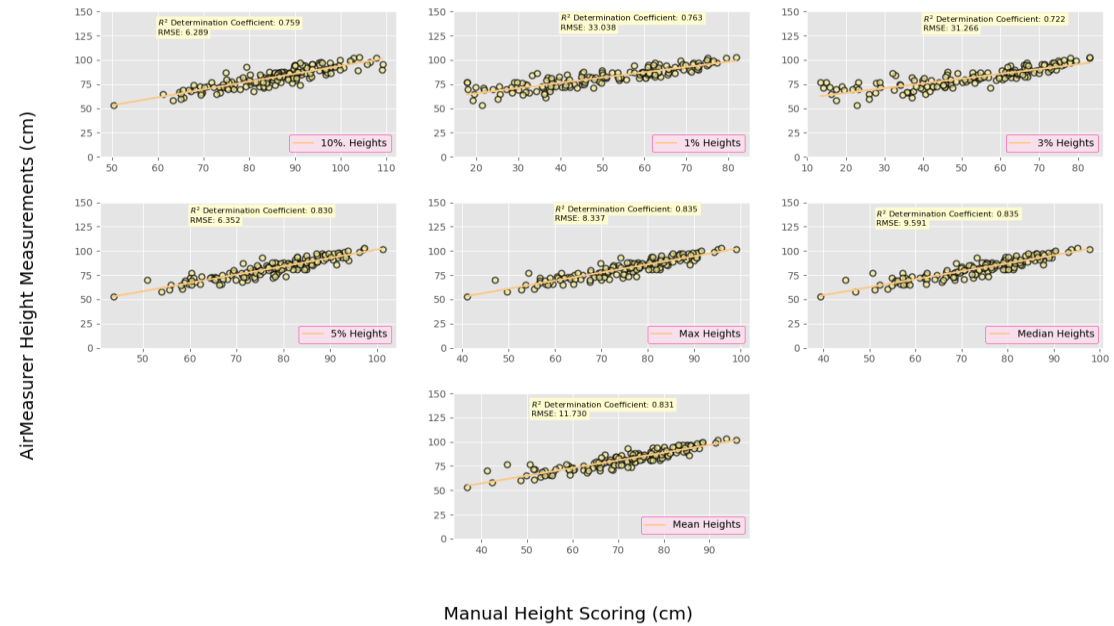


3D field-level representation

Plant height vs plant length



Manual Scoring vs. AirMeasurer Height Values Field Beans 2022

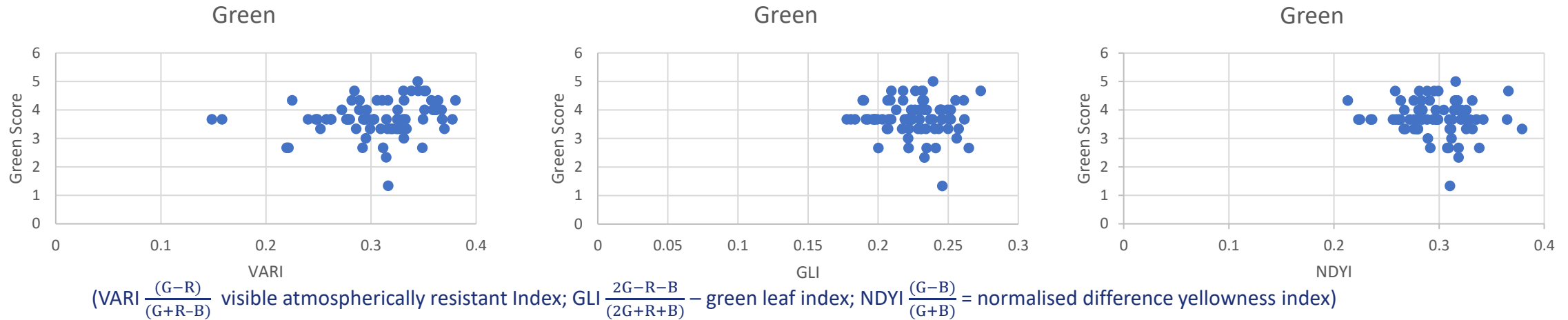


2022 $R^2 = 0.83$

2023 $R^2 = 0.8$

Future potential

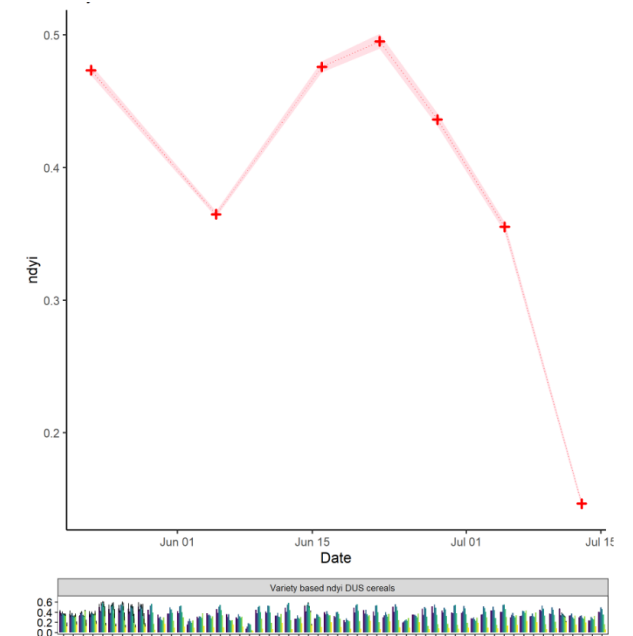
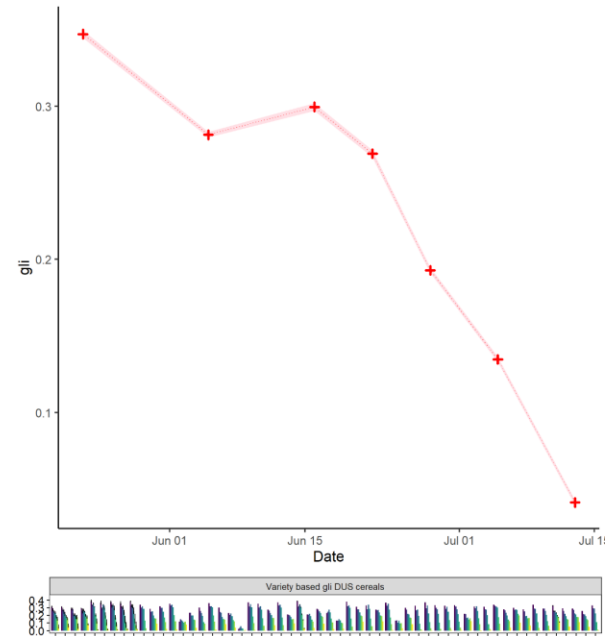
- RGB images used to investigate correlation between vegetative indices and green colour scores



- Multispectral imaging using red edge (RE) and near infrared (NIR) could provide additional information to investigate evaluation of green intensity further.

Future potential

Vegetative indices in combination with canopy measurements could be used to establish growth profiles and assess timing of maturity.



Conclusions so far

- Good accuracy in detecting and estimating plant heights and correlation with manual plant length measurements good in example cases.
- Data capture considerations – flight timing/frequency and obstacles
- Potential for additional assessments using multispectral images
- Data storage costs involved can be high.
- Method of data capture may not be appropriate for all species or trial size

Markers as a method of examining DUS characteristics

- No current implementation of markers as a method of examining DUS characteristics
- Identified useful markers
 - e.g. for seasonal type in Barley (BMT/13/5)
- Implementation must offer an increase in efficacy or efficiency... preferably both!
- Continue to explore this option
 - TWM/3/22 - Can better understanding of the genetic architecture of wheat DUS characteristics help streamline the DUS processes?



INVITE – EU Horizon 2020 funded project

29 partners – 13 countries

Improving assessment of crop varieties

BioSS role

Use of genetic markers for:

- Performance assessment
- Intellectual Property registration – Distinctness, Uniformity, Stability (DUS)

DUS Innovations

- Genomic prediction for planning DUS trials (wheat, perennial ryegrass)
- Enhancing distinctness assessment for cross-pollinated crops, by using genetic markers to improve estimates of DUS characteristics (COYDG)
- Assessing genetic uniformity in cross-pollinated crops using on a single pooled sample

Genomic Prediction for DUS

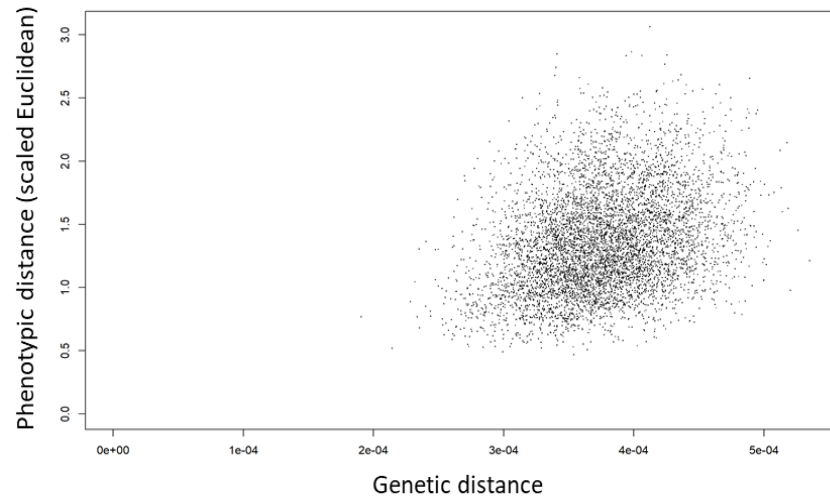


1. Plan trial by predicting traits using genetic markers in advance of trials
 - Not permitted to use markers on their own
 - Predict pairs of varieties that are distinct or identify similar varieties
2. Enhance distinctness assessment by including markers with field data

Use genomic prediction to maximise the link between genetic markers and phenotypic characteristic

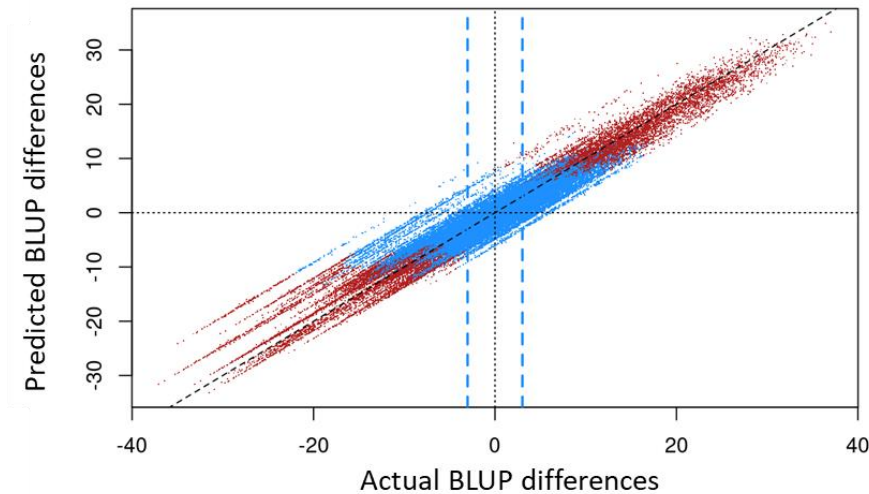
Current method

Comparison between phenotypic and genetic distances between pairs of varieties



Genomic prediction

Cross-validated (gBLUP) predictions for difference between pairs of varieties – single trait



Scatterplots showing a) relationship between phenotypic and genetic difference for all characteristics for perennial ryegrass varieties and b) relationship between predicted and actual best linear unbiased predictor (BLUP) differences for one phenotypic characteristic (time of inflorescence) where red = significant difference and blue = no difference. Blue lines show sig diff according to ANOVA

Genomic prediction in DUS

- Artificial Intelligence and molecular markers in soft fruit: a proof of concept - TWM/3/4
- Modelling using Random Forests
- Built with 500 trees
- Made predictions for three characteristics
 - Anthocyanin presence/absence
 - Spine presence/absence
 - Fruiting habit – floricanes/primocanes

Conclusion: Machine Learning models showed promise despite limited data set



Genomic prediction in Barley DUS – the story so far...

1. Established a **genomic database** for ~70% of the barley Variety Collection.
2. The machine learning **genomic prediction performed well** in predicting DUS phenotypes.
3. Optimisation can make some **modest improvements to accuracy**. However, accuracy **varied on a trait-by-trait basis**. This is due to inherent nature of some of the DUS phenotypes, rather than the method used.
4. Using the similar variety testing algorithm, the prediction approach tends to **select 50% more varieties** for field comparison with candidates than using observed data. However, there is **good overlap in which varieties are selected**.
5. Our model-based predictions would allow Variety Collection subsets to be sown alongside candidate varieties in the first year of DUS assessments. Meaning there is **potential for reducing a year of testing**.
6. Identification and validation of 22 KASP assays that can **fully discriminate between 1,171 genotypes**.

Next steps towards implementation:

1. **Genotyping remaining variety collection** varieties (~30% of the barley collection) and future candidates.
2. **Side-by-side testing** of the genomic informed approach with 'live' barley DUS testing activities across three consecutive submission years, combined with a **cost-benefit analysis** based on the experience gained in such real-world working scenarios.
3. **Optimisation of DUS characteristic information** integrated into our Random Forest-based model predictions.
4. For simply inherited traits controlled by major genes, **explore haplotypes** at specific genetic loci to further **improve model weighting parameters** and **find improved genetic markers**.
5. Explore **practical considerations** for genotyping approach.



fundamental

Secondary aims:

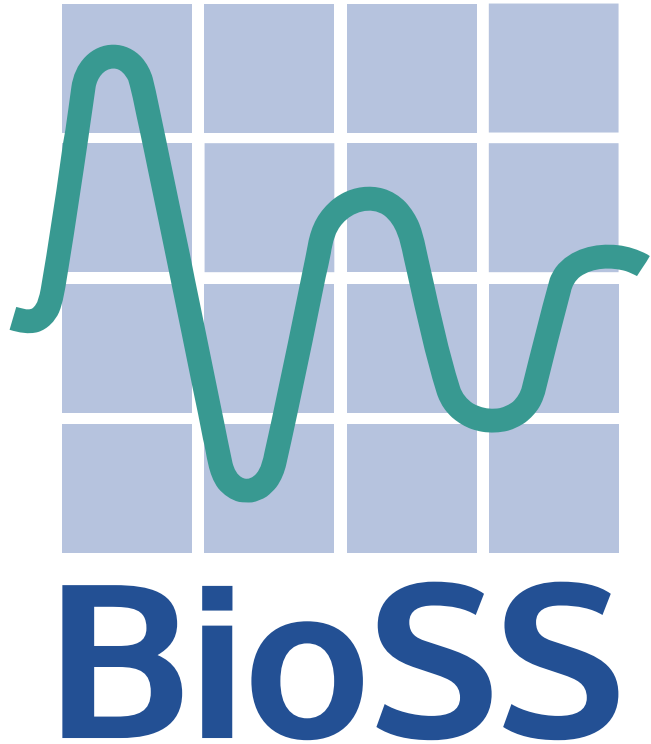
1. Repeat **minimum marker selection with complete Variety Collection** (starting off with existing 22 markers) and make parallel comparison to current seed stock authentications.
2. Use of molecular marker data to **highlight and correct potential DUS phenotyping errors**.

Information and upcoming events

- **Technical Working Party on Testing Methods and Techniques**
Cambridge, United Kingdom, 1 to 4 June 2026
 - **Landmark** <https://www.niab.com/news-views/publications-resources/landmark-magazine>
 - **Introduction to artificial intelligence (AI) in agriculture**
 - one day course for farmers, agronomists, students, and others in agriculture looking to understand how artificial intelligence (AI) can begin support on-farm decision-making (www.niab.com)
 - What artificial intelligence is and how it applies to agriculture
 - Basic principles behind AI tools like machine learning and computer vision
 - How to interpret AI-generated insights for use in agriculture
 - Ethical and practical considerations when using AI on the farm
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Funding and collaborators



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Food & Rural Affairs



Animal & Plant Health Agency



Biotechnology and
Biological Sciences
Research Council



The James
Hutton
Institute

IMPROMALT
Consortium



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