UPOV
International Union for the Protection of New Varieties of Plants

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**Technical Working Party on Testing Methods and Techniques** **TWM/1/20**

**First Session**
**Virtual meeting, September 19 to 23, 2022**

**Original:** English
**Date:** August 31, 2022

# UAV POTENTIAL IN DUS TESTING

*Document prepared by an expert from the United Kingdom*

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The annex to this document contains a copy of a presentation on “UAV potential in DUS testing”, prepared by an expert from the United Kingdom, to be made at the first session of the TWM.

[Annex follows]

# UAV potential in DUS testing

TWM/1 – September 2022

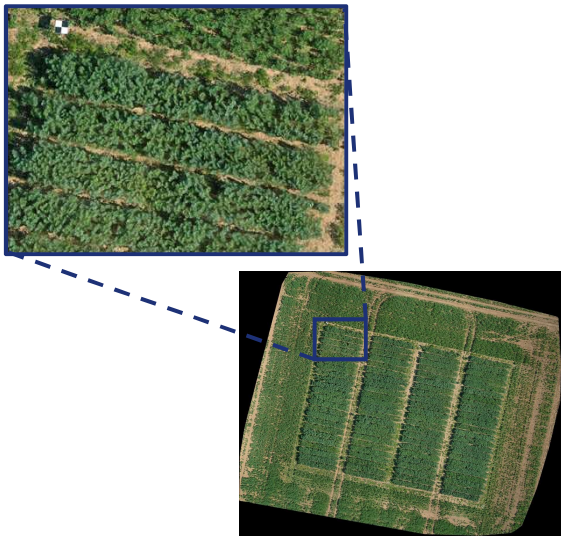
## Introduction

- NIAB have good experience using image analysis in DUS Testing
  - Taking field samples (time consuming), laboratory photography (very specific conditions and set up)
  - Quick analysis, with manual review and quality check

- In 2021 we focussed on field beans
  - Relatively small trial size
  - Shorter flight time
  - Easier to analyse

- In 2020 we started to look at the potential for using UAV (unmanned aerial vehicles) in DUS testing.
  - Some practice flights over OSR and cereals field
    - Large trial areas
    - Multiple flights
    - Battery power
    - Staffing

## In-field set up and aerial imaging



- Ground control point (GCPs) in the four corners of the test field
- Geo-coordinates of the GCPs were recorded using GPS (Global Positioning System). Real-time kinematic positioning (RTK) can be used to increase accuracy
- Height reference to help rectify crop measurements in the automated trait analysis
- Black-grey-white panels were also included for colour and contrast calibration when required.

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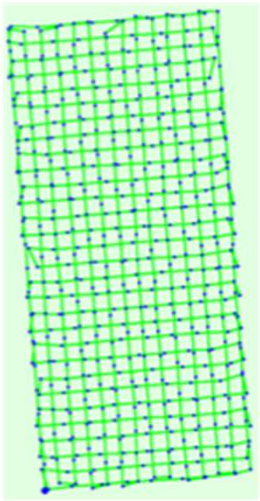
## In-field set up and aerial imaging





- Tailored flying protocol developed using cost-effective drones
  - DJI Mavi 2Pro (Red-Blue Green)
  - DJI Phantom P4 Multispectral
- Flight control software used to fly at 15m altitude
- Pre-programmed flight plan
- Ground sampling distance (GSD) of 0.25 to 0.5 cm per pixel

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## Preparation of images

- Stitching the images gave an overview of the field – Pix4Dmapper software
- To remove slopes and terrain features in the field, tailored methods have been applied to geo-reference field trials:
  - including manual 3D coordinates calibration, RTK-based 3D calibration to inform the 2D/3D trait analysis developed by the Data Sciences Department

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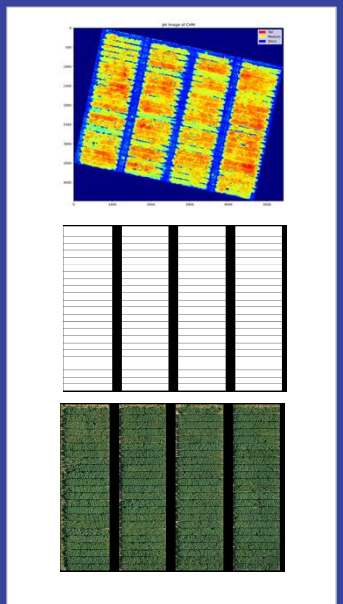

## Dividing plots and removing edge effects

- Using Statistical Outlier Remover algorithms, 3D point cloud outliers were removed (denoising)
- Ground level filtering classified the ground level and above ground 3D points
  - Potential terrain distortion removed

Winter field bean images top to bottom:

3D canopy height model

Labelled masks

Sampling plots

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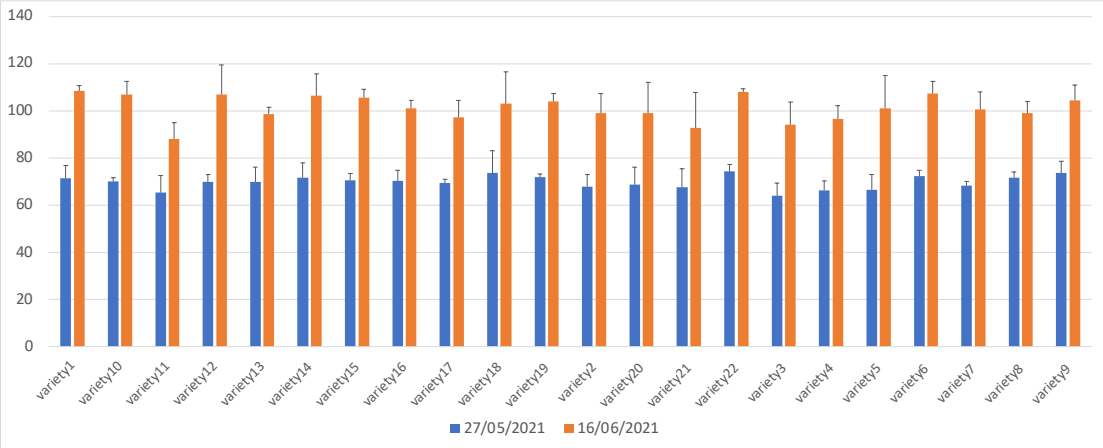
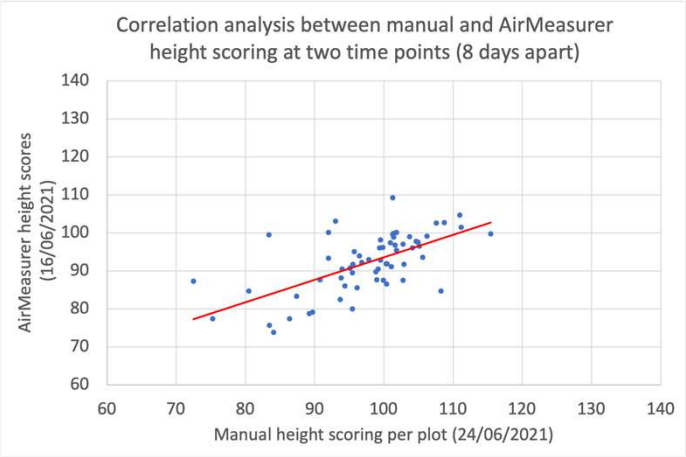
## Winter varieties – Height measurements from images

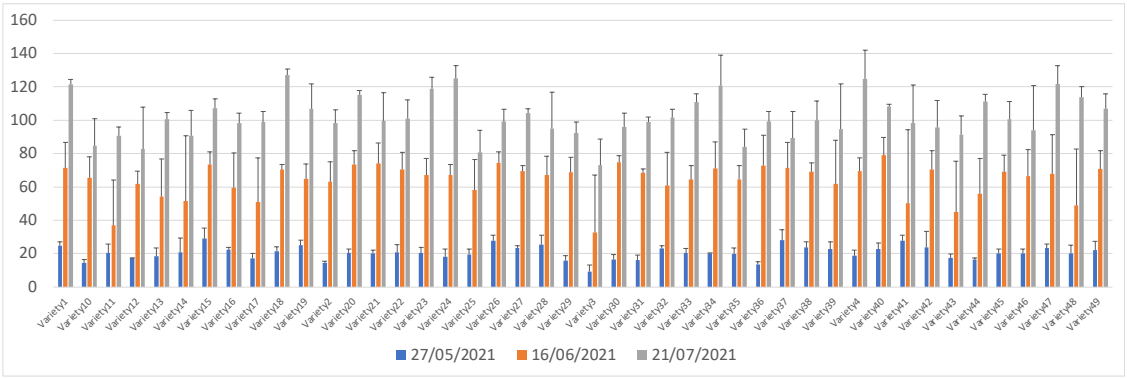



## Plot-based correlation analysis for winter field beans

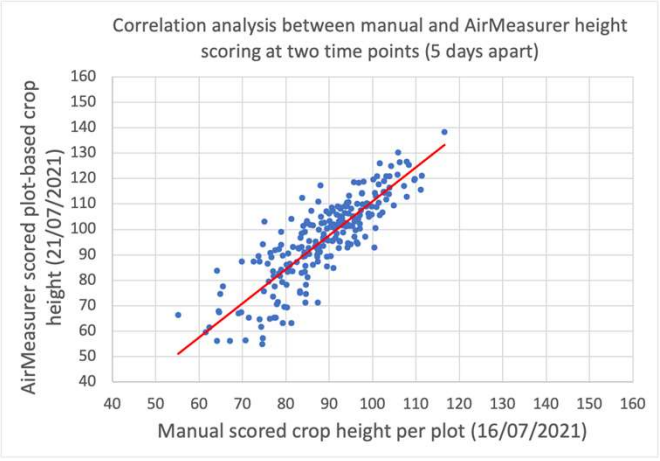



Adjusted R = 0.6977
$R^2$ = 0.6285
RMSE = 8.764 cm
*p*-value < 0.001

## Spring Varieties – height measurements from images (49 of 80 varieties)

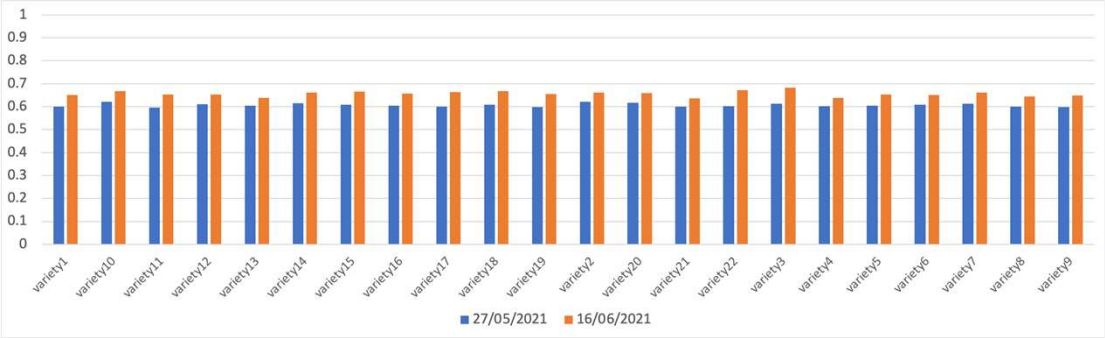



## Plot-based correlation analysis for spring beans




Adjusted R = 0.8553
$R^2$ = 0.7838
RMSE = 12.172 cm
*p*-value < 0.0001

## Winter bean Variety – “greenness” measurement

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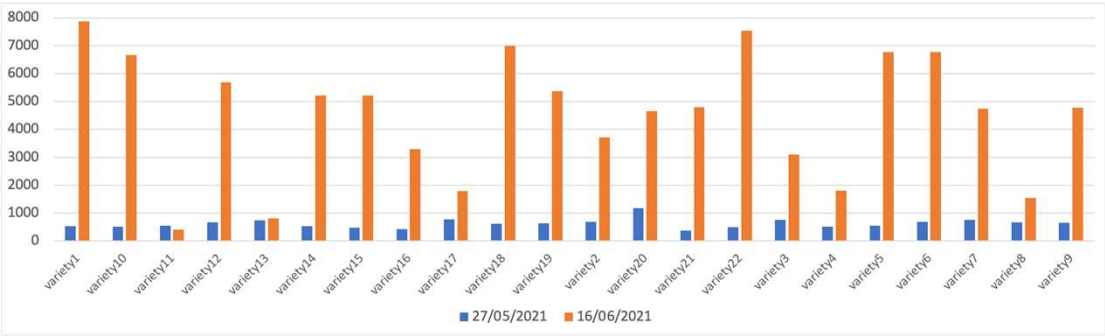
## Winter field beans – vegetative intensity

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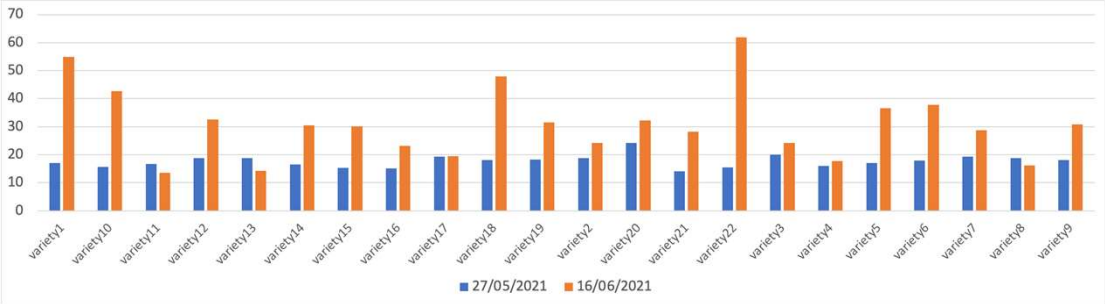
## Winter varieties – canopy texture

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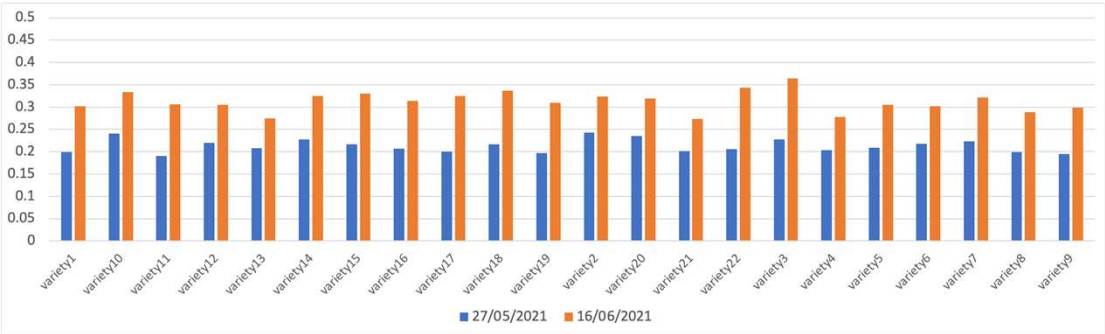
## Winter varieties – yield potential

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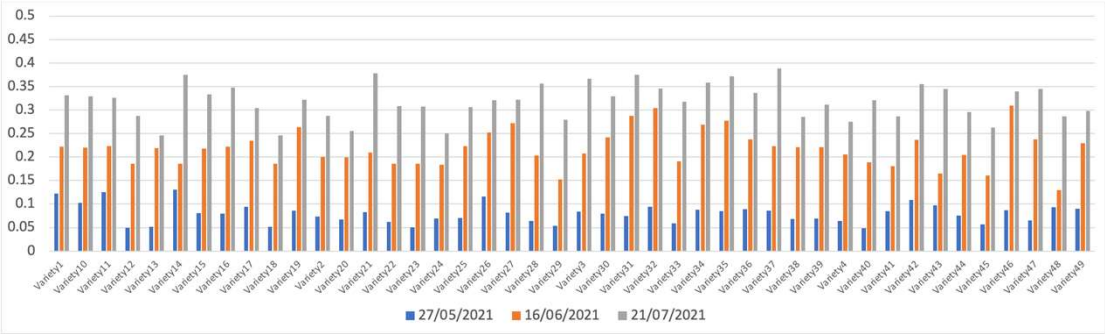
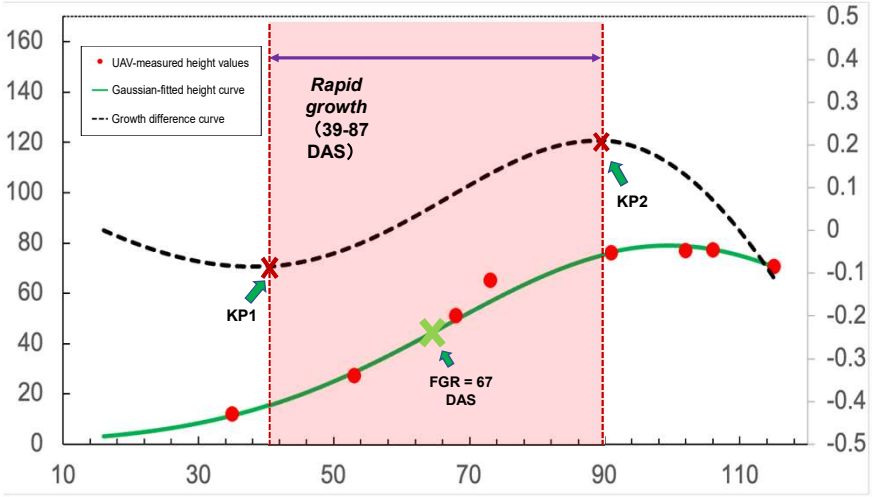
# Spring varieties – yield potential






# Future potential - dynamic trait analysis

Sun G, Lu H, Zhao Y, Zhou J, Jackson R, Wang Y, Xu LX, Wang A, Colmer J, Ober E, Zhao Q. AirMeasurer: open-source software to quantify static and dynamic traits derived from multiseason aerial phenotyping to empower genetic mapping studies in rice. New Phytologist. 2022 May 31. https://nph.onlinelibrary.wiley.com/doi/full/10.1111/nph.18314




- Can be used when flights are limited to understand growth profiles.
- Data from multiple seasons could be used to predict performance.

## What is next?

- Maximise the analysis
- Explore dynamic trait analysis to better understand the relationship between air and ground measurements
- Investigate other characteristics in more crops
- Analyse images from 2022
- Plan a schedule for imaging in 2023

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## Acknowledgements


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|---|---|
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[End of Annex and of document]