# Optimising the use of UAV-remote sensing to phenotype varietal tolerance to Virus Yellows

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The Virus Yellows (VY) complex represents the most significant biotic threat to sugar beet production in North-West Europe. The climate of this region favours host plants of these viruses as well as their aphid vectors, of which the most important species is *Myzus persicae*, the peach-potato aphid.

BBRO's VY trials in 2023 demonstrating clear differences in canopy symptoms in response to the virus species being tested.

Restrictions on neo-nicotinoid seed treatments came into force across Europe in 2019. This resulted in the sugar beet crop losing its effective control measure for the aphids. Now, alternative strategies are needed to manage VY. Varietal tolerance to VY is the target of multiple breeding programmes across Europe and is starting to deliver novel varieties for growers to deploy.

BBRO is supporting these efforts by independently testing varieties for their tolerance to three viruses [Beet Yellows Virus, Beet Mild Yellowing Virus & Beet Chlorosis Virus]. This is done through a dedicated trials programme where plots are inoculated with virus and grown until harvest in Autumn. As they develop, plots are assessed to support claims of virus tolerance/resistance. Assessments include ELISA to determine virus levels in leaf tissue and regular imaging via UAV (Unmanned Aerial Vehicle) to phenotype VY symptom development

## UAV Data Acquisition:

### 1. Trial Inoculation

All plants in plots are inoculated with virus-carrying aphids reared in culture by BBRO in late May or early June. This ensures even infection and symptom expression when phenotyped.

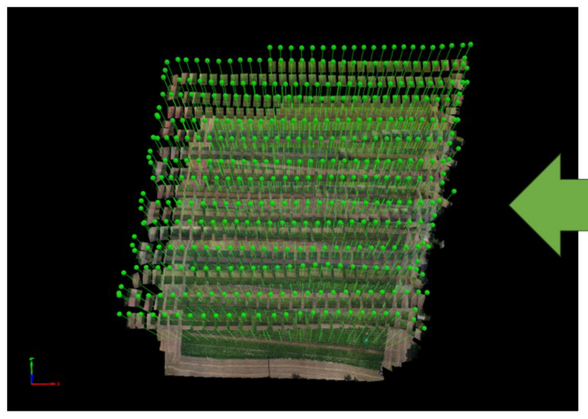
### 2. VY Symptom Expression

After around -six weeks symptoms begin to appear, with yellowing peaking in most years by mid-August.

### 3. Multi-spectral & full colour imagery capture by UAV

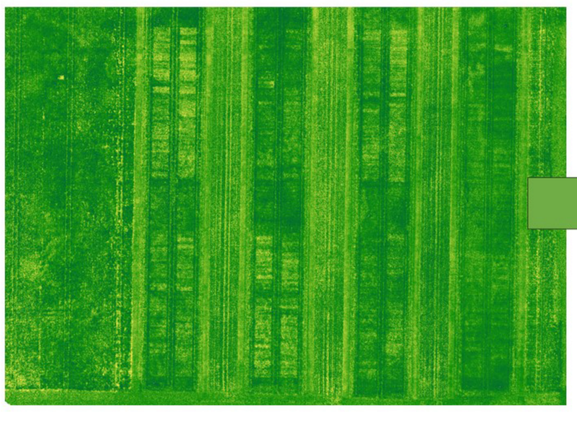
Once VY symptoms appear then the trial is regularly flown over by UAV. On-board it carries a range of cameras which capture full colour (RGB), thermal and multispectral imagery.

### 4. Orthomosaic Generation



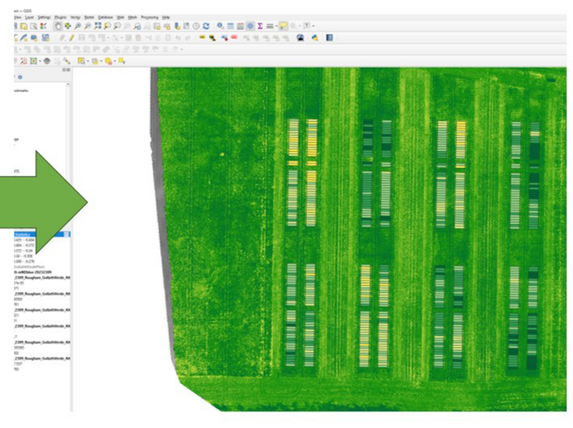
Computer software (Pix4D Mapper) creates a calibrated orthomosaic of each image set, which ensures the imagery depicts accurate reflectance values for each pixel.

### 5. Image rendering



The computer creates maps of each band in GIS software (QGIS v3.16.11) and can calculate reflectance values for vegetation indices for each pixel. A false-colour image of mNDblue[1] is shown.

### 6. Data extraction

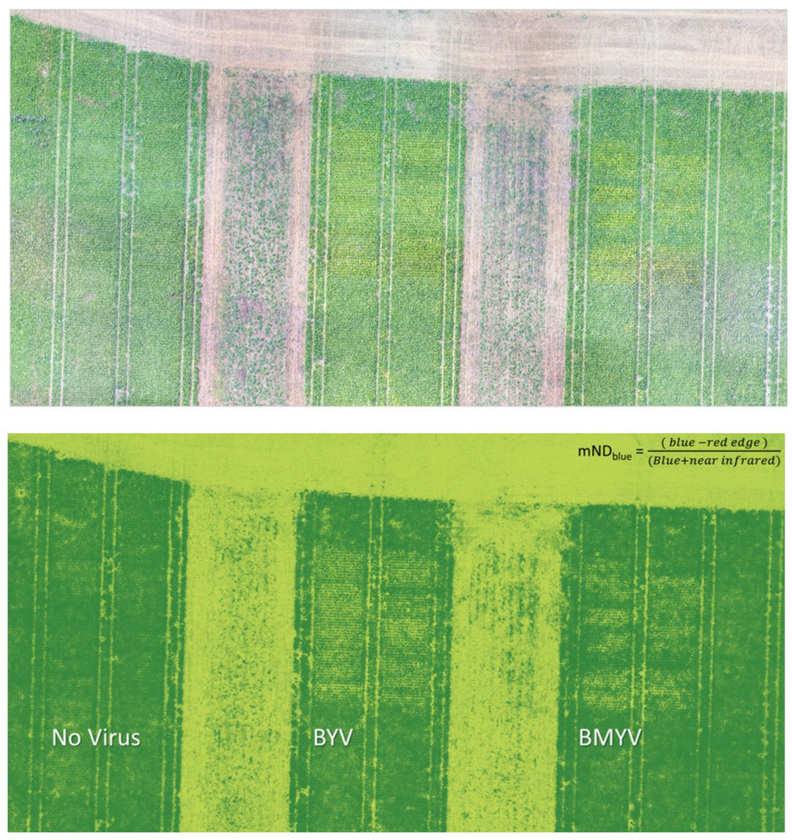


Shapefiles of each plot are overlaid on each layer of the map which allows the computer to extract average values for each plot for analysis.

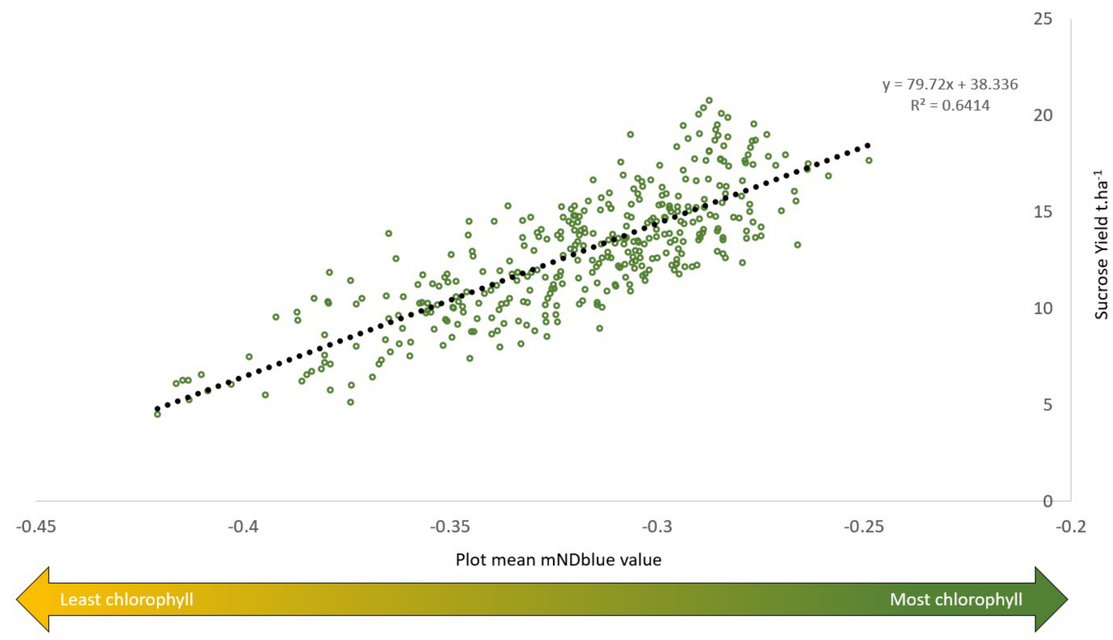
RESULTS:
The use of calibrated vegetation indices allows for accurate, rapid and reliable assessment of canopy condition

Data from five years of trials (2019-2023) shows a significant relationship between decreases in canopy chlorophyll level and yields achieved across a range of varieties tested.

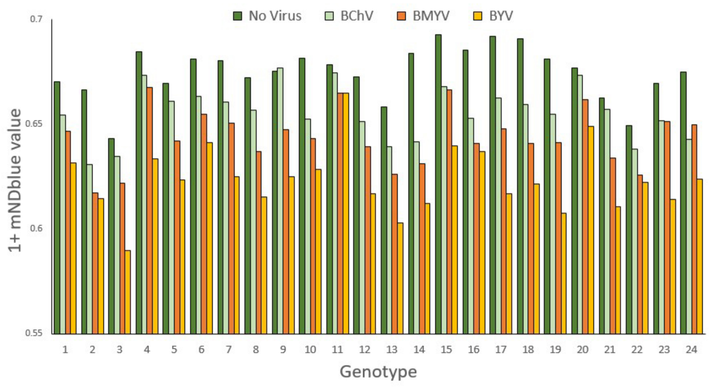
This consistent response is important to unlock the potential of remote sensing for VY tolerance assessments




Example data set showing RGB image (above) and calibrated mNDblue map (below) when uninoculated or infected with either BMYV or BYV.




Linear regression showing results of BBRO variety experiments (2019-2023). This significant relationship (P<0.001) shows plots with greater chlorophyll levels in summer achieve greatest yields at harvest.




mNDblue results of 2023 testing of varieties in the UK for VY tolerance from a flight conducted in late August 2023.

As predicted, varieties showing the least change in chlorophyll levels when infected with virus went on to achieve higher proportions of their yield potential

*N.B. values have been transformed by adding 1 to make data appear positive.*

## CONCLUSIONS:

- Remote sensing now forms an integral part of BBRO variety evaluations

- mNDblue values demonstrate an accurate and reliable measure of canopy yellowing whilst being agnostic to the type of virus and variety being assessed. It is also sensitive to genotypes from all major breeding houses in Europe.

- Using a UAV allows us to collect the data we need in a matter of minutes and can be completely processed in <24 hours and is less subjective than human-derived scores of canopy yellowing.

- This method could also prove beneficial to estimate the extent and severity of VY infections during epidemic seasons, although this needs further validation.

Acknowledgements:
Between 2019 and 2021 this research was partly funded by BBRO & HM Government via an UKRI Innovate UK Knowledge Transfer Partnership (No. 11116) in collaboration with the University of Nottingham. We also wish to thank the breeding houses for their co-operation with the experiments and supplying varieties for assessment.

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1 - Jay et al. (2017) Remote Sensing of Environment. **198** p173-186