INNO-VEG Framework for farmer-led research

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For more information visit: https://www.inno-veg.org/

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Overview

Benefits of farmer-led research

- Simple field experiments using yield mapping or remote sensing data allow farmers to check their own decisions and ideas, at a commercial scale and with high precision.
- Networked farmers can use farm trials to bring 'fast learning' about new practices and products.
- Trials can help farmers build trusted understanding of best practices specifically relevant to their own farm conditions.

Costs of farmer-led research

- Care is needed to avoid false conclusions, particularly from underlying soil variation which often has larger effects on yield than test treatments.
- Considerable time and effort can be needed to conduct a good trial.
- Assistance from a research partner may be needed for detailed statistical analysis of the results .

The process

1. Check whether your question already has a good answer!
2. Find like-minded farmers willing to replicate your trial.
3. Choose the field and the trial layout carefully, to make the test fair.
4. Apply treatments, locate them accurately, and record everything.
5. Photograph and assess treatment effects in the field.
6. Collect spatial data to assess the result: yield mapping, drone imagery or satellite imagery.
7. Compare the treatment effect(s) with 'background effects' to gauge how likely it is that the differences are 'real'.
8. Share, learn and profit! … Now, what is the next question?

Posing useful questions

- What decision do you want to test? E.g. rotations, cultivations, varieties, fertiliser rates, crop protection products, application timings? Does the importance of this decision merit the effort invested in a trial?
- Most questions have been asked and many answered already. Check with an expert (or search the internet) to see what research has already been done.
- Share your plans: several farms doing the same trial and getting the same results will make the conclusions much more trustworthy and valuable.
- Define the control or 'standard' practice with which you want your new idea to be compared. Avoid testing too many treatments in one trial: the most informative trials usually compare just one test treatment against a 'farm standard' control.
- For any question posed, you need an answer that you can use in future. So ensure that the results will be relevant to your farm and unaffected by expected future changes on farm.

Practical considerations before starting

Fields

- Do you have fields with the right crop which are big enough, square enough and even enough? See section below on choosing a suitable trial field.
- Will the whole trial field be sown with the same variety? Be careful not to confound other treatments with varieties, or it will be unclear what caused any yield effects._In the same way, all cultivation practices that you don't aim to evaluate in the trial (fertiliser application, crop protection product, soil tillage...) must remain the same across the testing field.

Equipment

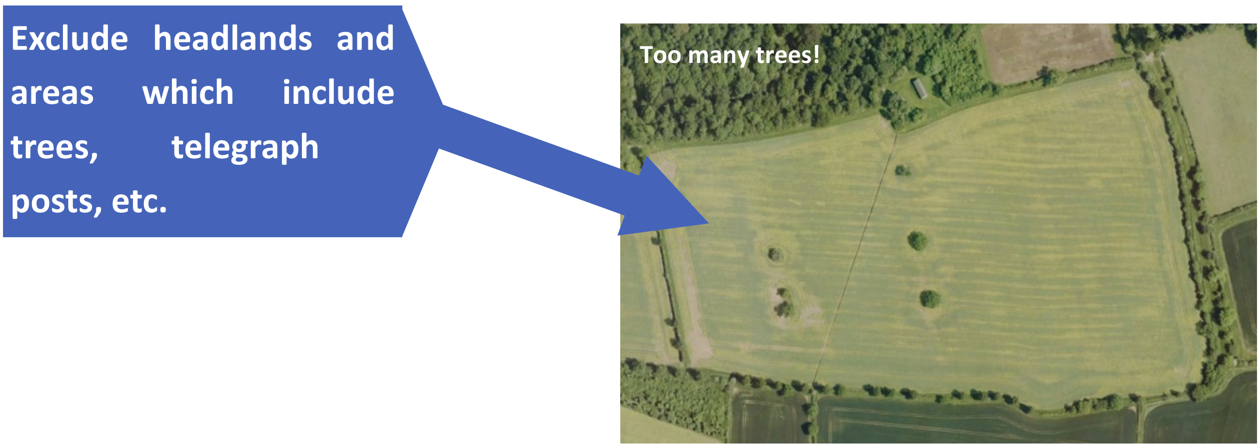
- How easily can you apply the different treatments that you want to test?
- How will yields be measured: using yield mapping, drone data or satellite data? The assessment method will affect trial design and management.
- For remote sensing data, is it known which vegetation indices, measured at which growth stages, correlate best with marketable yield?
- If using yield mapping, do you know how to retrieve and process the data?
- Can you geo-locate tramlines, treatments and yields accurately? Mobile phone precision is crude (>5m). RTK gives the best GPS accuracy (<1m).

Attitude

- Will you be willing to put up with extra hassle at treatment applications and harvest?
- If you use a contractor, are they fully on board?

Choosing a suitable trial field

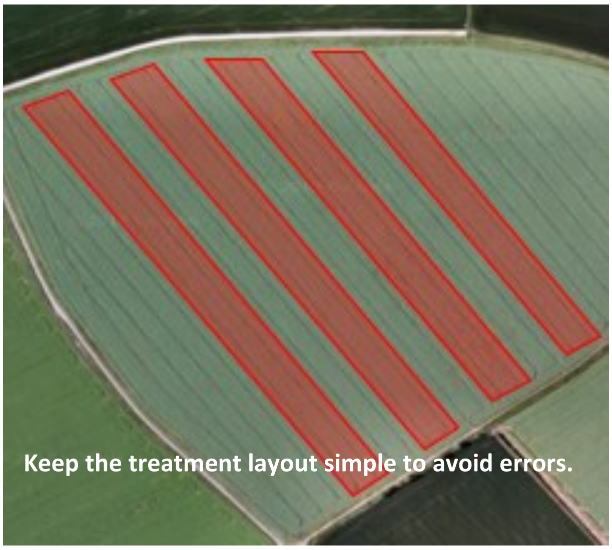
- The more even the field is, the more accurate the result will be.
- Assess underlying variation in possible trial fields using:
  - aerial images (e.g. from GoogleEarthPro),
  - satellite NDVI images (e.g. from www.datafarming.com.au),
  - soil maps,
  - previous yield maps,
  - local knowledge.
- If there is underlying variation, it is better for it to run across the direction of treatments, affecting all treatments equally, than for it to be in line with the treatments.
- Avoid fields and areas with recent differences in management e.g. fields previously split. Contrasting field histories can continue to affect yield for decades after fields have been joined.
- Avoid areas with known problems of drainage or weeds (unless central to your question).
- Exclude headlands and areas which include trees, telegraph posts, etc.
- The trial area should be wide enough to accommodate the trial; using a thin field will limit the number of comparisons that can be made.



Fair trial design

- Where possible, **replicate treatments** in the trial to give greater confidence in the results. At the very least, test any new treatment in a block with standard on either side, then gauge the variability between standard areas to judge your confidence in the treatment effect.
- Consider **treatment plot width**: if the trial is to be assessed using satellite imagery, plots will be need to be wider to allow for the low resolution of the data, e.g. when using free 10m resolution Sentinel 2 data, plots should be at least 40m wide. If the trial is to be assessed with yield mapping, plots should be at least two harvest widths wide. With higher resolution drone data, plots can be narrower. Plots also need to be wider where treatments are applied with a spinning disc fertilizer spreader: at least two spreader bouts wide.
- Note that 'natural' **within-field variation** in yield will almost always exceed the expected effects of your treatments, so you need to locate your plots very carefully to be as fair as possible. Consider underlying variation and arrange treatments such that any patterns of variation affect all treatment equally.
- In replicated trials, **treatment order** may be randomised, to avoid confounding treatment with any spatial trend across the trial, or systematically to reduce the risk of application errors. A simple and scientifically robust option is to test just two treatments in alternating plots.


Simple trial layout with a treatment plot running across previous NDVI variation.


Keep the treatment layout simple to avoid errors.

Treatment applications

- Make a proper record of treatment placement, ideally using mapping software/apps, or at least using a sketch on a field map. To record GPS positions, either stand in the centre of the tramline (e.g. for spray treatments) or at the corner of plots / beds, and use a proper GPS device with correction signal (e.g. RTK or EGNOS) as the accuracy of smart phone is typically poor (>5m)
- It is also worth marking the locations of the plots in the field using canes or flags.
- Tell all those that might be carrying out field operations about the trial and its requirements.

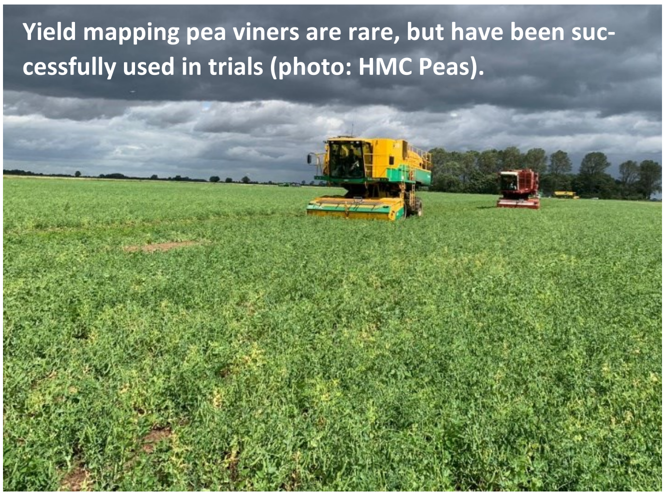
Crop monitoring

- Depending on your question, it will usually be worth making some explanatory measures (e.g. of disease or by sampling for nutrient analysis).
- The more measurements you take, the more confidence you are likely to have in the outcome of the comparison you are making.
- Point measurements should be in adjacent positions along the length of each plot, geo-referenced if possible.
- Effects 'to a line' coinciding with the boundary of a treatment can be particularly convincing . Take photos of any visual effects you can see.

Effective use of yield mapping

- Where yield mapping is available, this is an excellent way to assess the results of a trial, but careful data analysis is needed. Yield data may be handled in farm software packages or general mapping software (e.g. QGIS, available free from www.qgis.org).
- Clean the data by excluding
  - headlands;
  - harvest runs which straddle two treatments;
  - harvest runs with incomplete harvest width, even if the software has adjusted for width, as sometimes an over-correction is applied;
  - data where the harvest speed or direction was changing.
- Assign data to treatment plots and calculate the mean of the cleaned data for each plot.
- Look at the spatial variation in the field and judge whether this was likely to have affected the comparisons. Variation in yields of standard plots can indicate whether treatment differences are real. Any treatment effect needs to be bigger than the difference between standard plots.
- If your treatments were associated with different input costs, you can calculate a gross margin for each plot.
- More detailed statistical analysis of yield map data is available from the ADAS Agronomics service – see below for more details.

Yield mapping is available from several suppliers for root crops e.g. potatoes (photo: SoilEssentials).

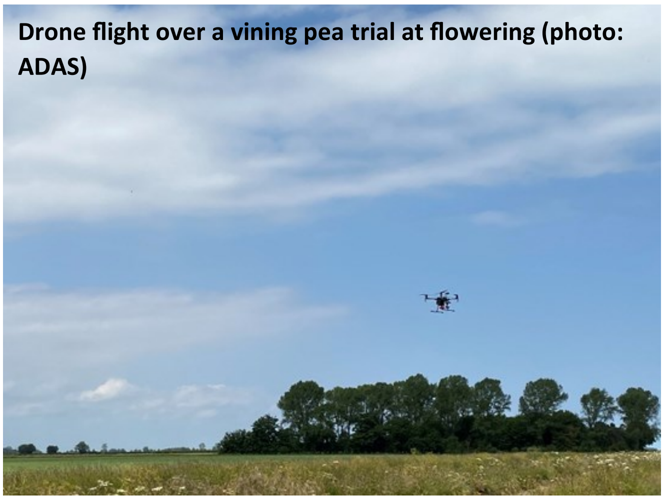


Yield mapping pea viners are rare, but have been successfully used in trials (photo: HMC Peas).

Using spectral reflectance data as an indicator of yield

- Remotely sensed vegetation indices such as NDVI have been shown to correlate well with marketable yield in some vegetable crops, and can be assessed more easily than yield itself.
- Vegetation indices (VIs) can be assessed using satellite data (cheap but low resolution), drones equipped with multispectral cameras (more expensive but more accurate) or hand-held sensors.
- The exact correlations between VIs and yield tend to differ with field and variety, so to interpret results in terms of marketable yield it is necessary to harvest small 'yield validation' plots from the trial. These may be used to establish the relationship between yield and VI for the trial crop, so that the VI map can be converted to a map of predicted yield.
- Without yield validation plots, the trial may still be assessed by VI, with the assumption that treatment effects on a suitable VI reflect effects on marketable yield

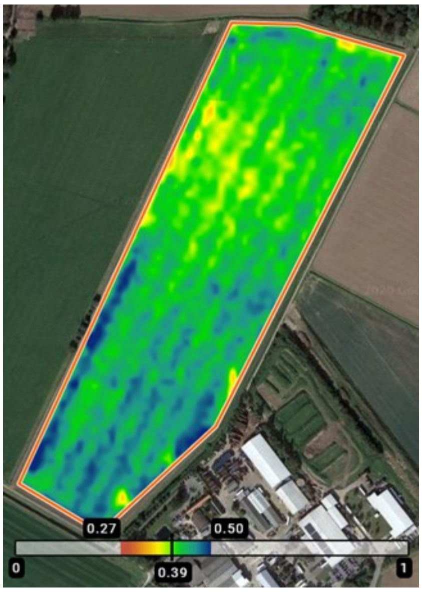
Drone with multispectral camera (photo: ADAS)



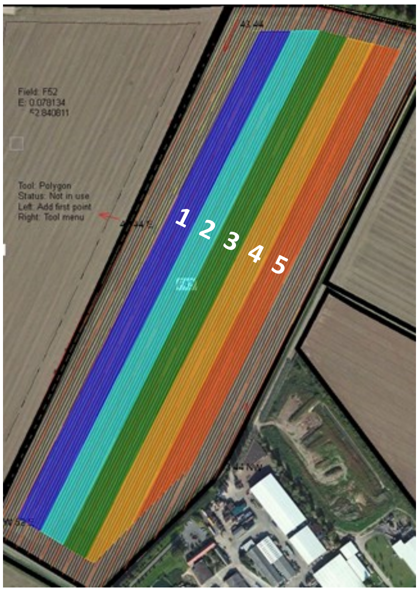
Drone flight over a vining pea trial at flowering (photo: ADAS)

Analysis of spectral reflectance data

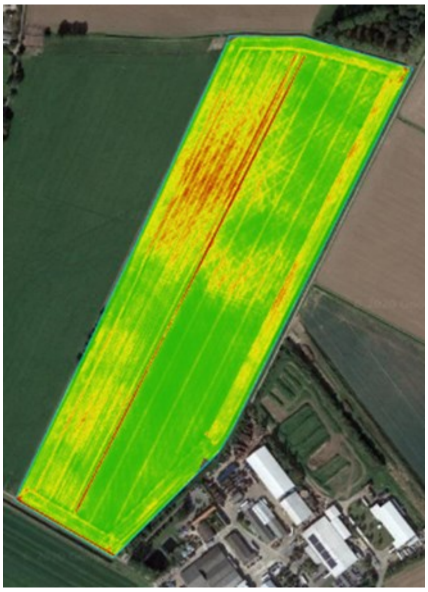
- Where treatments have large effects on yield, this may be obvious from visual examination of a drone or satellite image, as in the example below; look for step-changes in VIs along the boundary lines between treatments.
- Always compare images from the trial with images from before treatments were applied, to make sure the patterns observed are due to treatments rather than due to soil variation.
- For comparison between different farms, ensure that the same sensor is used. If not, keep in mind that some vegetation index can present a bias arising from using different spectral band definition. More information on this point can be found in the INNOVEG website.



Satellite NDVI image of previous crop, showing soil variation (www.datafarming.com.au).

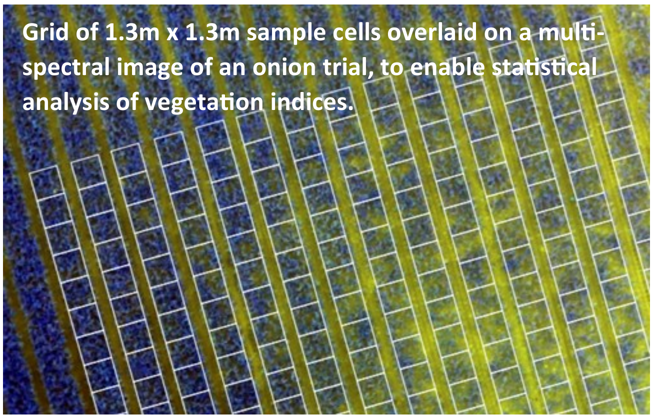


Trial plan for fertilizer treatments in vining peas.

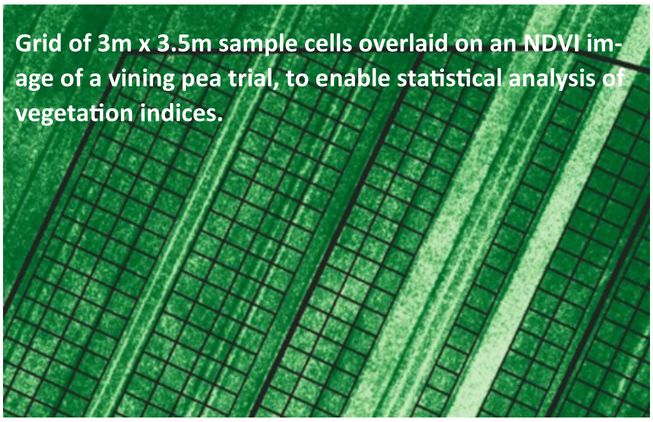


Drone NDVI image at flowering, showing treatments 3 to 5 out-performing treatments 1 and 2

- Where treatment effects are too subtle to be clearly visible in VI maps, the VI data should be analysed. Mapping software such as QGIS can be used to calculate the average of each multispectral band for a given area, such as a trial plot, then VIs can be calculated from these averaged bands.
- Full statistical analysis of the data can be done in the same way as for a yield map, by averaging the data for each cell in a sample grid placed over the trial. Sample cells should be placed to avoid bare soil in wheelings or between beds, as bare soil will give different and irrelevant VI data. This analysis is available as part of the ADAS Agronomics service , described below.



Grid of 1.3m x 1.3m sample cells overlaid on a multi-spectral image of an onion trial, to enable statistical analysis of vegetation indices.



Grid of 3m x 3.5m sample cells overlaid on an NDVI image of a vining pea trial, to enable statistical analysis of vegetation indices.

ADAS Agronomics

ADAS has developed a process, software and new statistical procedures so those conducting farm trials can reach the right conclusions quickly and easily. The Agronomics process includes;

- **Assignation** of data to tramlines, treatments and headland areas.
- Data cleaning and processing of **yield maps** to define harvest directions, combine runs and distances; to remove extreme outliers and anomalous runs; to filter data anomalies; and to correct for any offset between opposing harvest runs.
- Processing of **remote sensing data** (satellite or drone) to calculate vegetation indices, and where appropriate to establish correlations with marketable yield from yield validation plots.
- **Spatial analysis** to model spatial variation both related and unrelated to treatments, estimating the average treatment effect(s) and their uncertainties.
- **Reporting**, displaying yields and/or vegetation indices as labelled maps with a standardised colour key, and providing clear conclusions.
- **Meta-analysis** of trial series.

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