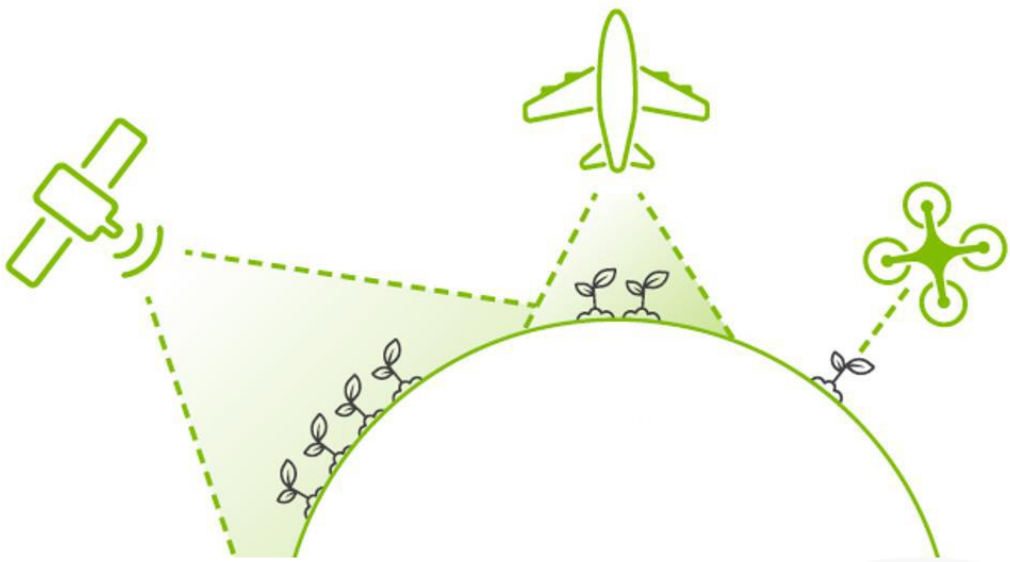
International Seed Federation
Seed is Life



Potential of remote sensing technology in vegetable seed production

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THIS GUIDE WAS PREPARED BY THE ISF EXPERT GROUP VEGETABLE SEED PRODUCTION

1. INTRODUCTION

Digital technologies – including the internet, mobile technologies and devices, data analytics, artificial intelligence, digitally-delivered services, and apps – are changing agriculture.

Examples widely used today are:

- data capture by a various range of in-situ sensors to steer irrigation management and nutrition,
- decision support modelling systems to predict the risk on certain pathogens impacting the crop grown
- precision farming allowing fine-tuning of inputs and reducing demand for manual labor.

The collection of large scale, accurate and reproducible in-season data is of great interest and value for seed producers and seed companies to monitor, steer evaluate and improve their seed production as well to increase transparency along the seed supply chain.

The production of vegetable seeds spreads all over the globe. Gathering information on critical control stages is largely dependent on actual field visits today. They are indispensable to understand the crop status and to obtain the information needed for (corrective) control actions.

ISF Vegetable Seed Production Working Group (VSPWG) has decided to embark on an investigation about the possibilities, feasibility and added value of remote sensing techniques in vegetable seed production. This work was triggered by the following factors:

- the digital technology revolution
- the interest in more accurate and reproducible field data
- the global nature of our vegetable seed production business
- limitations of visiting seed production fields due to Covid regulations and restrictions

2. REMOTE SENSING

Remote sensing technologies provide an important tool to aid site-specific management of crops. It has the potential to provide 'real-time' analysis of the attributes of a crop at various stages of growth, which can assist in making timely management decisions that affect the outcome of the production. Today's commercial remote sensing industry is primarily comprised of a variety of platforms i.e. satellites and drones. The development of remote sensing in agriculture has shown rapid progress by improved image resolution, mapping accuracy, speed and analytics.

There are many available solutions for monitoring crops by satellites and drones, but predominantly tailored for larger scale field crop applications (mostly satellite applications), or specific R&D purposes for which more detail is required and applied by drones with high resolution cameras.

At the time of this exploration, the specific remote sensing offered for (open field) vegetable seed production was quite limited.

Measuring the success of remote sensing techniques in vegetable seed production is possible by comparing the added value created by accurate, reproducible, 'real-life' and unique data with the cost & effort of capturing this data.

Key success factors in understanding the potential of remote sensing in vegetable seed production were:

- the close cooperation between vegetable seed production experts,
- accurately and precisely indicating their needs for added value data capture
- involvement of remote sensing digital experts explaining the possibilities of the technique and the translation into a practical and functioning solution.

The pilot project was conducted in close cooperation with the company VITO Remote Sensing.

3. REMOTE SENSING PILOT

In the exploratory study we've focused on four areas:

1. Understanding and describing the specific remote sensing data capture opportunities
2. Running an exploratory pilot in two vegetable seed crops (cabbage & onion)
3. Evaluating the added value captured versus the cost & effort made
4. Outlining next steps to create practical and added value remote sensing solutions for the global vegetable seed production industry

3.1. DATA CAPTURE OPPORTUNITIES

In exploring the data capture opportunities, we distinguished the general versus vegetable seed specific needs.

The general field data capturing opportunities are available from different remote sensing providers:

- Planted area, plant population, ground coverage, crop uniformity, plant loss identification, plant height, biomass index, crop type detection, detection of illegal propagated seed production fields.

Specific data capturing opportunities of interest in vegetable seed production:

- Isolation management, pest- and disease (stress) mapping, targeted use of fertilizer and pesticide to enable precision spraying, weed identification, flowering index & synchronization, crop maturity (harvest index), flower/pods/fruit counting (for yield estimation purposes, i.e. in combination with biomass), purity / off-types detection assessment.

3.2. EXPLORATORY PILOT

To test the possibilities and opportunities of remote sensing in vegetable seed production in practice we ran two image capturing drone flights in a flowering bunching onion- and hybrid cabbage field. The aimed data capture mission was to:

- Bunching onion: Flower count & size, spatial distribution over the field
- Hybrid cabbage: Flowering index, distinction between female and male rows, non-flowering plants, nicking index and spatial distribution over the field

General lessons learned

- The observed traits define the remote sensing setup. Data traits like planted area, ground coverage, biomass index can be measured by satellite images (max. resolution ~0.5x0.5m for purchased images, or 10x10m for free obtainable imagery). Satellite images are cheaper, frequently captured, but do not have the suitable resolution for all traits. The quality/availability of satellite images is influenced by clouds.
- More detailed observation requires imaging by drones + high specification cameras. The detail of the targeted observation defines the specification of the drone + camera setup. The smaller the detail to be captured, the higher resolution required to observe the object (i.e. detecting a watermelon fruit vs a Brassica seed pod). Current cameras can go up to 1 mm in resolution. It was noticed that the higher resolution targeted, the less acreage can be captured, resulting in a higher cost and less acreage/day output.
- Different types of cameras are suitable for different purposes. Optical camera can be used, for example, for counting flowers, whereas for stress or health detection other types are more suitable (NDVI, NDRE, Thermal, OSAVI, PSRI).
- The drone flights can be done by professional drone flight providers or by a self-operated drone setup. Flights operated by a service provider has the advantage of providing access to the latest camera setups and upgrades. Owning a drone provides flexibility and it is cost effective when the tool is frequently used. This certainly requires some upfront investments such as buying the equipment and building the necessary expertise and capacity within the company. The setup of the drone + camera is key to capture the right data for its purpose.

  Crop specific findings
- Bunching onion – drone imaging was capable of accurately measuring the following features:
  - Detection of early bolters
  - Detection of non-bolting plants
  - Flowering synchronization
  - Off type detection (with more AI training)
- Hybrid cabbage - drone imaging was capable of accurately measuring the following features:
  - Detection of non-bolting (male vs female) plants

    - Flower synchronization
    - Flowering timespan (start – full – end) (4-5 flights required)
    - Off type detection (with more AI training)
- Images are displayed to give a visual representation of the data from the built algorithms for the bunching onion and hybrid cabbage field used in the pilot. (Annex 1)

3.3. UNDERSTANDING THE OPERATING MODEL & COST

Three different cost elements of remote sensing data can be distinguished:

- Drone operating cost
    - Flying your own drone. Capacity at the resolution of;
            - <0.5mm: ~5-10ha/day
            - 0.5-1cm: ~50ha/day
            - 2-5cm: ~150-200ha/day
        - Drone + camera investment: ~€7.500-10.000 / unit
        - Drone licensing training: varies per country
        - Labor cost: per company
    - Using services of a drone company
        - Highly variable country to country (availability / quality / cost). Less flexible.
        - Some examples; Pilot: CL $650/day. NL/FR: €500-600/day.
        - In this case when covering 50ha/day (depending on the resolution and fields proximity): $10-15/ha.
- Image analytics & Artificial Intelligence platform usage cost
    - Company dependent, i.e. hectare based. Some companies offer a platform allowing users to train a new algorithm therefore they charge an annual license fee.
- Algorithm development cost
    - To capture new traits, i.e. specific crop off types, the algorithm needs training (machine learning) to be able to deliver accurate data.

The cost versus added value is very subjective. Eventually it's the seed production- or breeding company's responsibility to evaluate the value of the captured data vs cost.

3.4. OUTLINING THE NEXT STEPS

Currently, it is still a significant investment and effort to use drone and/or satellite remote sensing in the field. However based on the history of technological developments (personal computer, electric cars,…) presumably remote sensing technologies will be more accessible and advanced in the future. There are still many areas with huge development potentials such as better imaging technology, faster data processing, smarter AI platforms, autonomous operating- and recharging drones, higher resolution satellites and atmospheric drones.

We are at the forefront of a fast-evolving development of the digitization of our vegetable seed production operation.

The question today is not whether the technology is ready for it; it is rather whether (and how much) the seed sector is ready and willing to embark on this technological transformation.

4. ACKNOWLEDGEMENTS

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Christiaan Evenhuis (Syngenta)

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Jürgen Decloedt (VITO Remote Sensing)

ANNEX I – Pilot images

Figure 1: Bunching onion flower count

Figure 2: Bunching onion flower size (mm^2)

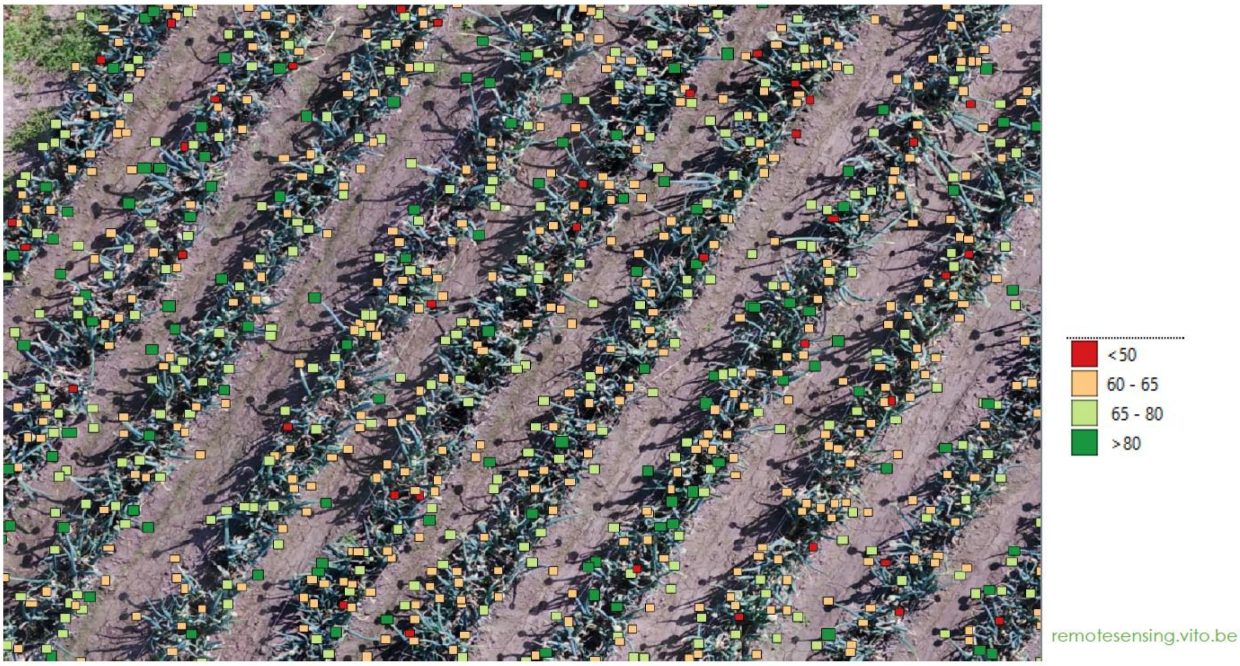


Figure 3: Bunching onion distribution map - flower size

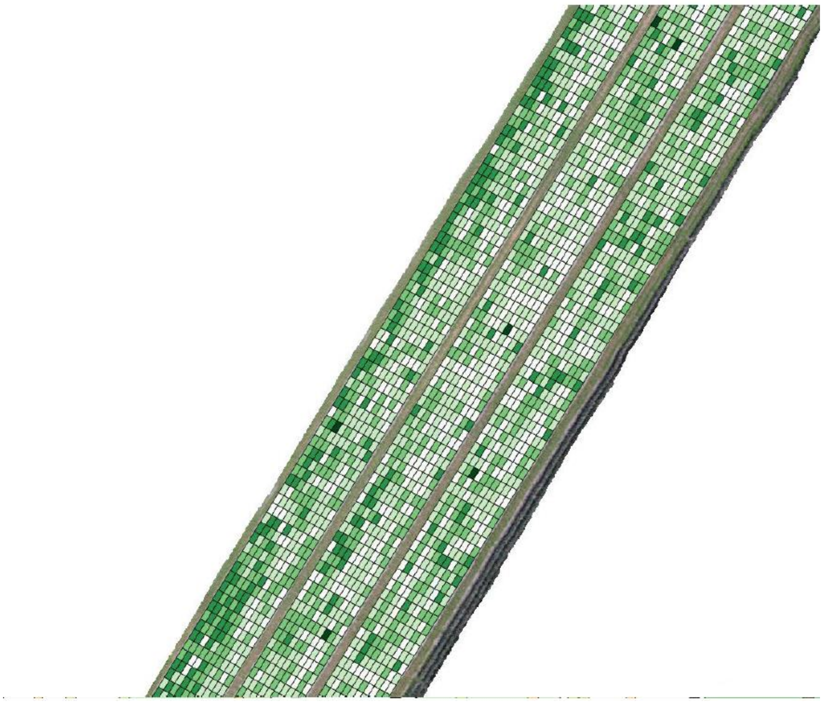


Figure 4: Bunching onion distribution map - flower count

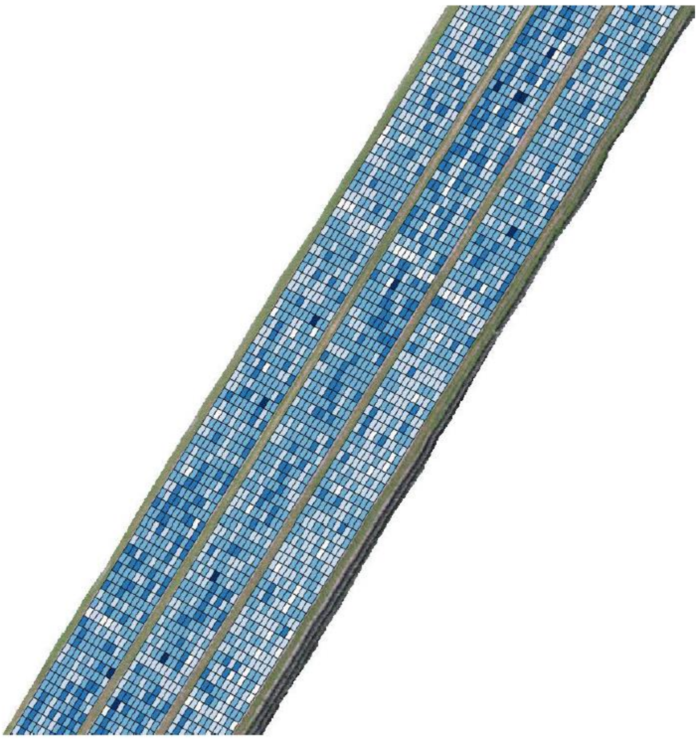


Figure 5: Hybrid cabbage – detection of non-bolting plants

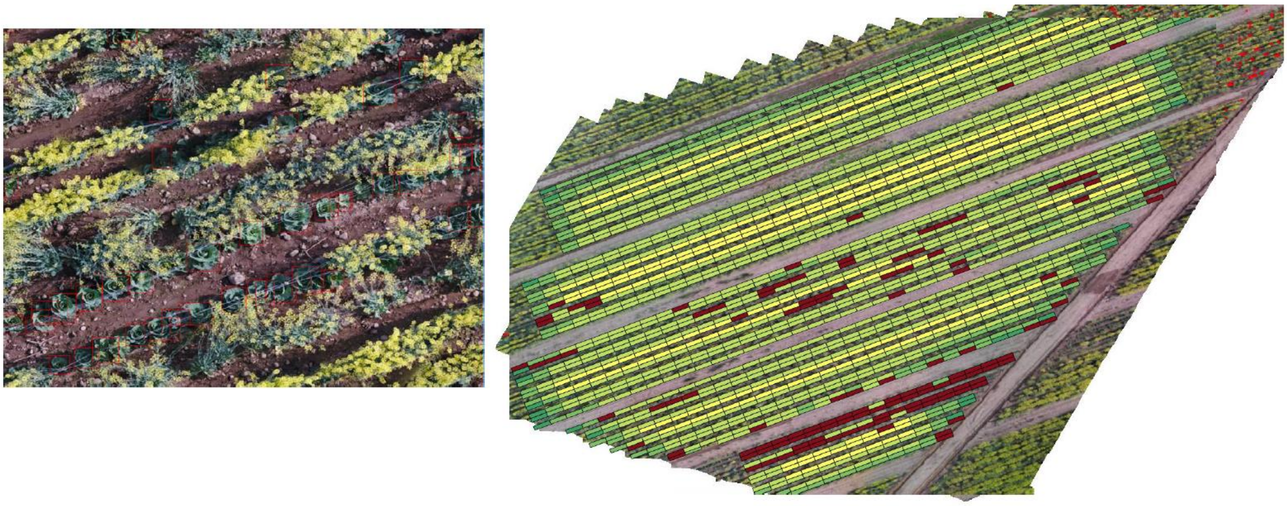


Figure 6: Hybrid cabbage – flower detection

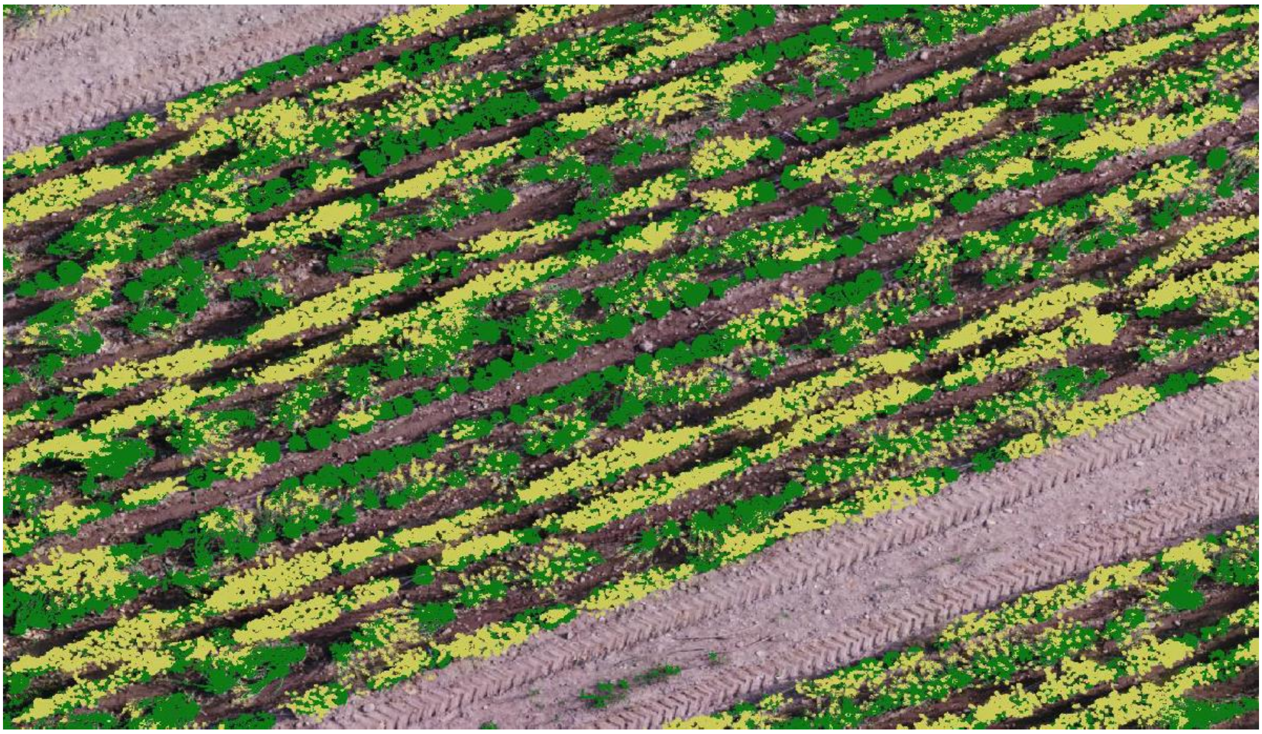


Figure 7: Hybrid cabbage – flowering count (cm^2)

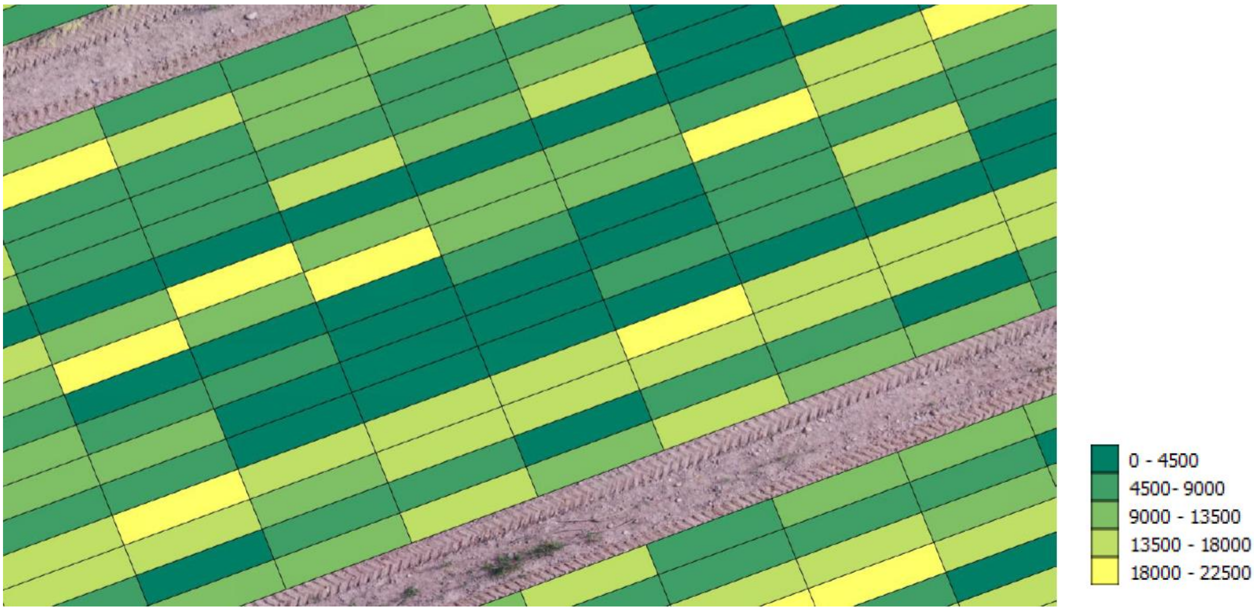
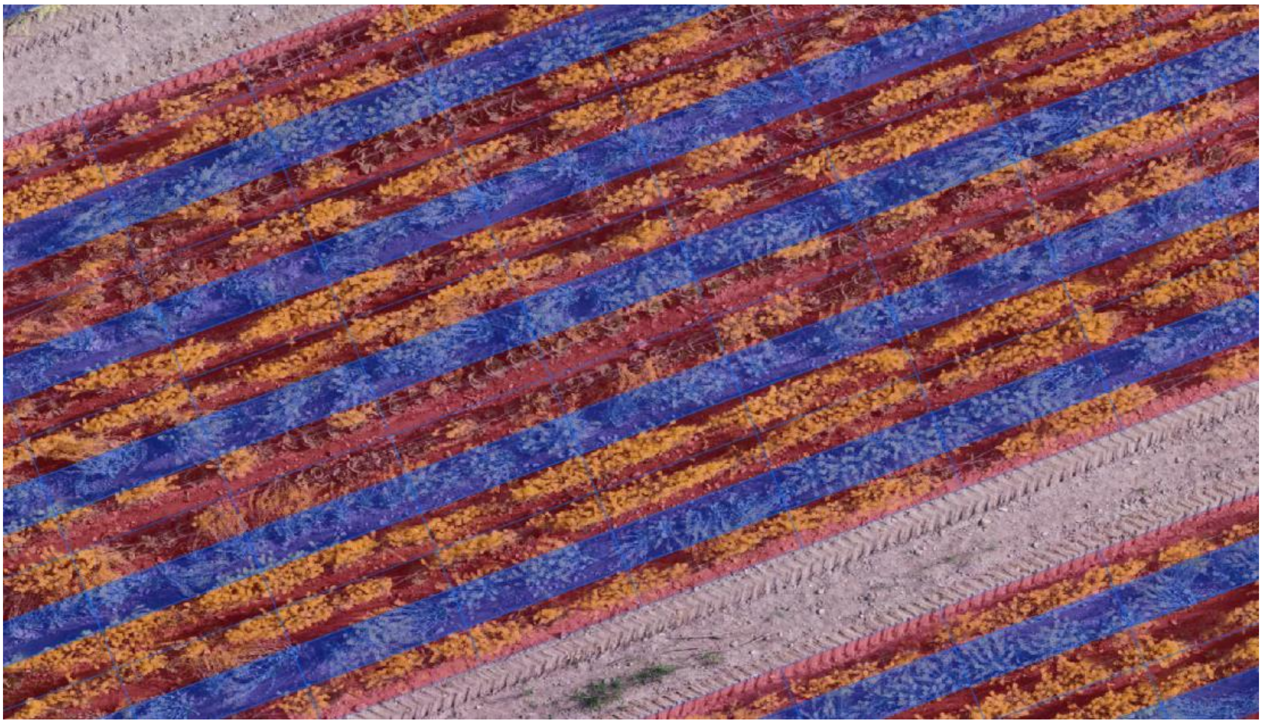


Figure 8: Hybrid cabbage – male – female differentiation



5. ANNEX II – Useful links

Remote sensing for agricultural applications: a meta-review. M. Weiss, F. Jacob, G. Duveiller – 2019.

file:///C:/Users/U271173/Downloads/Weissetal_2020_RSE_ReviewAgriculture_HAL.pdf