IIRB Seminar 2019

Sensors and digital technologies in sugar beet production

17th December 2019
Forschungszentrum Jülich,
Wilhelm-Johnen-Straße, 52428 Jülich (D)

INTERNATIONAL INSTITUTE
OF SUGAR BEET RESEARCH

Programme

8.00 am	Registration at FZ visitor's centre and seminar registration
8.30 am	Welcome and introduction to the seminar (Ronald Euben, IRBAB)

Session 1: Innovative technologies for breeding and cultivation

8.40 am	Non-invasive phenotyping: deep, high-throughput and field technologies and networks (Ulrich Schurr, FZ Jülich, D)
9.00 am	Methods of field-based crop phenotyping and their application in sugar beet (Achim Walter, ETH Zürich, CH)
9.20 am	Sugar beet crop state estimation from UAV observations (Frédéric Baret, Sylvain Jay, INRA, F)
9.40 am	High throughput phenotyping of sugar beet seeds, seedlings and adult plants in practice (Antje Wolff, Strube, D)

10.00-10.30 am Coffee break and exhibition

Session 2: Crop management and plant protection

10.30 am	The challenge of sensing plant diseases in variety trials and for decision making in crop management (Stefan Paulus, IfZ, D)
10.50 am	Perspectives for an implementation of robots in weed control—an overview (Bo J.M. Secher, Nordic Sugar A/S, DK)
11.10 am	Precision farming in practice (Jacob van den Borne, farmer, NL)
11.30 am	Visit of facilities at FZ Jülich
1.00 pm	Lunch and exhibition

Session 3: Precision harvesting and quality assessment

2.30 pm	SMART BEET – development of an electronic "SmartHarvestSystem" for a sugar beet harvester (Ulrike Wilczek, Univ. Kassel/Witzenhausen, D)
2.50 pm	The application of computer image analysis methods to assess the quality of sugar beet yield (Natalia Mioduszewska, Poznań University of Life Sciences, PL)
3.10 pm	Sample preparation and presentation is crucial for application of NIRS in quality analysis of sugar beet (Elke Hilscher, KWS SAAT SE & Co. KGaA, D)
3.30 pm	Discussion and outlook (Anne-Katrin Mahlein, IfZ)
4.00 pm	End of meeting

Abstracts of seminar talks

Ulrich Schurr

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Non-invasive phenotyping: deep, high-throughput and field technologies and networks

Plant phenotyping is a essential tool for many applications ranging from functional genomics, to (pre-)breeding, breeding and analysis of biodiversity. It develops rapidly into a bottleneck for progress in basic and applied research. Lack of adequate solutions for quantitative analysis of plant architecture and function as well as their interaction with the dynamic and heterogeneous environment hampers progress in basic sciences as well as in breeding-related research. In recent years significant interdisciplinary approaches have been started to overcome this “phenotyping bottleneck”. Techniques were developed to quantify the dynamics and the heterogeneity of plant structure and function as well as of environmental cues. In this presentation we will explain recent results from the phenotyping chain approach, by which we study the relevance of phenotyping technologies at various scales from the lab to the field in direct experimental approaches and from meta-analysis. The integration of different scales is also a central element of EMPHASIS: the new pan-European Research Infrastructure for Multi-Site Plant Phenotyping And Simulation for Food Security in a Changing Climate, which is developing on the basis of the portfolio of existing national plant phenotyping centers in Europe. Here we will discuss the recent developments since EMPHASIS has been established as a ESFRI project.

Achim Walter

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Methods of field-based crop phenotyping and their application in sugar beet

Image-based methods for the detection of growth and of plant stress reactions have been elaborated and applied in a wide range of field-based plant research projects recently. The determination of plant size, canopy cover and leaf area index from unmanned aerial vehicles and from on-site field camera stations is among the basic procedures applied by a lot of research groups worldwide. Often, investigations of such biomass-related parameters have been performed in the context of crop phenotyping with the aim to advance crop breeding pipelines. Moreover, analyses of evapotranspiration — via thermographical images — and of spectral reflectance have been frequently applied to investigate the performance of crops.

In this talk, I will also present some results from our recent field phenotyping studies on sugar beet. There, two microplot experiments were performed to elaborate the predictive power of visible light imaging, thermography and spectrometry to evaluate the effect of beet cyst nematodes on the growth of sugar beet plants. The methods were carried out on infested and non-infested plants of two cultivars – the nematode susceptible cultivar Aimanta and the nematode tolerant cultivar Blue Fox. Growth differences were obtained as early as 15 days after sowing. Spectrometry was suitable to identify the stress even when the canopy reached full coverage. Thermography could only detect stress on the susceptible cultivar. Overall, the study demonstrated the potential as well as drawbacks of crop phenotyping methods to assess sugar beet performance in the field.

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High-resolution imagery provides accurate estimates of several traits of sugar beet crops

The technological advancement in sensors, vectors and computing performance has made accessible new high-throughput techniques to characterise sugar beet crops under field conditions. These techniques were developed under the AKER project to help breeders to select improved cultivars.

In this presentation, we describe high-throughput phenotyping methods developed to estimate several relevant traits. The traits targeted are the plant population density, the green fraction, the green area index, the chlorophyll or nitrogen content at the leaf or canopy level and Cercospora Leaf Spot infestation. These traits are derived from sub-millimeter to meter spatial resolution imagery acquired with either UAVs or UGVs and either RGB or multispectral or hyperspectral cameras.

For each trait, the estimation performances obtained with high and coarse spatial resolution systems are compared, with due attention to the minimum spectral richness required. All the results confirm the superiority of high-spatial resolution systems capable of providing robust and accurate estimates of the targeted traits. Recommendations are proposed to optimally and operationally estimate these traits for field phenotyping experiments.

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High throughput phenotyping of sugar beet seeds, seedlings and adult plants in practice

High throughput phenotyping of crop plants is a key technology to objectively differentiate plants or varieties regarding their natural phenotype under different environmental conditions and to describe their reaction to biotic or abiotic stress. As such, this technology enables highly targeted and efficient breeding: Phenotypic plant responses to stress such as disease, heat or drought can be objectively measured and traced, and be linked to specific underlying genomic sequences of the plants, enabling the identification of biomarkers and an accelerated and targeted breeding of resistant and tolerant varieties.

This technology is as well a mighty tool to objectively measure seed quality in the lab and in the field to optimise seed production, processing, priming and pelleting.

As the plant´s life starts from the seed, followed by the germination, seedling development, young plant development and ends as an adult plant exposed or not exposed to stress, high throughput phenotyping technologies for all physiological stages of a plant are needed.

Three non-destructive, inhouse developed technologies are presented to measure the phenotype of sugar beets over the entire developmental process from the dry seed and germinating seedling in the lab up to the adult plant in the field on a single seed and single plant basis:

- The ‘seed inspector’ for dry seeds and fruits
- The ‘phenoTest’ for germinating seeds and developing seedlings
- The ‘phenoFieldBot’ for emerging seedlings and plants in the field

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The challenge of sensing plant diseases in variety trials and for decision making in crop management

Sensing plant disease is a key ability to establish adequate control strategies in the field. Hyper- and multispectral cameras measuring the visible and NIR spectrum can be used to fulfil this task with high objectivity and repeatable results.

Techniques from the field of remote sensing and computer science can be adapted for precise and highly automated interpretation of the recorded data. These techniques need an adapted workflow, starting from the merging of different images to a huge orthomosaic, calculation of adapted vegetation indices and the use of machine learning methods.

Within field trials neural net architectures, support vector machines or decision trees can be used to learn how infection begins. Manually analysed field plots are used to train a model. This model is able to classify new plots depending on whether they are infected or not.

Field trials depict the proof of concept for latest digital techniques for a broad application in crop management and plant phenotyping. This presentation will show the workflow for the detection of *Cercospora beticola* leaf spots in sugar beet together with the use of machine learning methods based on spectral sensing. The key steps for data processing are shown starting from the flight planning, merging the single images to a orthophoto, segmentation of the plants, and implementing the machine learning data analysis resulting in an automated analysis for the quantification of a *Cercospora beticola* infestation in an experimental field.

Bo JM Secher

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Perspectives for an implementation of robots in weed control – an overview

A number of autonomous vehicles are under development for the management of sugar beet fields and other crops. Some are concept studies, many are still under development, and only few are commercially available or have been taken in to operational use in practice. Two autonomous vehicles have been developed in Denmark, which can be used for weed control in sugar beets.

Farmdroid is a 6 row light unit which can seed the beets, and mechanically clean for weeds in and between the beet rows. The unit will record the position of each seeded plant, and it is using those records for later cleaning. The unit is electrically driven by solar panels and batteries, and due to its lightness and slow speed, it is approved for use without direct monitoring. It is commercially available, and has been used at 12 farms in 2019. The economy, functionality and perspectives of this unit will be discussed.

Agrointelli Robotti is a diesel engine driven tool carrier, which can be used for beet growing when implemented with the right tools. It has been tested in 2019 where the unit with success autonomously seeded, band sprayed and hoed a small beet field. The economy, functionality and perspectives of this unit will be discussed.

From the literature and the internet, other examples of robots will be presented. Their perspective will be discussed and the developments will be put into a practical and operational context in conventionally and organically grown sugar beets.

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SmartBeet – development of an electronical smart harvest system for a sugar beet harvester

The SmartBeet project aims to develop a sensor system able to detect beet damages occurring in the harvester cleaning system. Sensor information should allow to design driver assistance systems securing low-damage beet harvest and producing beets most suitable for long term storage.

Long-term storage trials in climate containers revealed that root tip breakage caused by turbine cleaning correlated sufficiently close with sugar losses, and thus can serve as an overall damage indicator.

In systematic drop tests, heavier beets (> 700 g), beets impacting the ground with the root tip ahead and dropping from 2,5 m caused largest tip breakage.

Field experiments were conducted with measuring bodies which were shaped like beets and equipped with accelerometers and surface pressure sensors. They showed that type and form of impacts affect damage severity in addition to impact intensity. Moreover, strainer wheels exerted less impact compared to lifter, sieve conveyor and auger conveyor. Results imply that the throughput with beets in the cleaning section significantly affects the occurrence of damages.

In addition, the structure-borne sound of the cleaning turbines was measured. Single beet damage events were identified from videos taken by high-speed cameras and synchronised with the associated frequency spectra. Time segments and synchronised Fast-Fourier-transformed frequency spectra will be used to derive specific trait variables in order to develop a Machine-Learning-Model.

Natalia Mioduszewska, Jacek Przybył, Radosław Kozłowski, Gniewko Niedbała, Maciej Zaborowicz

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The application of computer image analysis methods to assess the quality of sugar beet yield

The scientific problems of the agricultural sector, including sugar beets production, are highly complex. Modelling issues related to agriculture is a very difficult issue. Therefore, more and more often neural algorithms are used to solve non-linear problems occurring in broadly understood life sciences.

The aim of the study was to create a new, non-invasive method of assessing the quality of sugar beet using computer image analysis and artificial neural networks. A literature review was carried out to analyse the methods used so far for a topping assessment of roots, and the possibilities of using the newly proposed method were analysed.

The study used 50 images of topped sugar beet roots, which have been subjected to computer analysis in order to improve the image contrast and brightness. The image was converted from colour to images in grayscale and segmentation and morphological transformations were carried out. Binary image was used to determine the surface area and root circuit and topping circuit. This information was used as input to the neural network, which was expanded to two features, i.e. the ratio of the areas and circuits. On the output of the network was information about the topping in the form 0 and 1. Created neural network MLP 6:6-26-1:1 allowed for a sensitivity analysis, which returned information about two important independent features, i.e. the surface area of the root and root surface area to topping.

The analysis showed that it is possible to use methods of computer image analysis for non-invasive assessment of the quality topping sugar beets.

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Sample preparation and presentation is crucial for application of NIRS in quality analysis of sugar beet

Analysis of sugar beets via NIRS has two key challenges: the preparation of the sample and its presentation to the sensor. For the preparation of the beet sample it is essential to know that the sugar is very heterogeneously distributed within one beet and that there are significant differences in the average sugar content between beets in one field. The current method for measuring the quality of farmer-delivered samples in the sugar beet quality lab is based upon the need to create brei. The process for the most part, is based upon manual inputs which requires trained staff and specialised analytical equipment to operate correctly for reliable results, starting with equipment calibration through sample preparation and analysis. With the development of the BEETROMETER® these steps can be automated to remove the potential error of manual inputs, which can then increase the reliability of the system and provide process improvement.

KWS developed a patented system that chops a beet sample (40-100 g) into the optimal particle size and presents it in a constant and uniform stream of the right height to the sensor. Based on a continuously updated calibration, the spectrometer is able to accurately determine f.i. gross and net sugar content of the sample within 20 seconds. The BEETROMETER™ system employs therefore the automated method of sample preparation and sample presentation to analyse sugar beet quality parameters. This innovative system has the advantage that the whole sample is processed and presented to a Near-Infrared Sensor that is calibrated to provide accurate and rapid sample measurement and results.

Posters

Rosa Martínez-Arias *et al.*	NIR Determination of primary energy sources in sugar beet seed
Elke Hilscher *et al.*	Capturing the heterogeneity of sugar beets by combining a newly developed sample preparation with analysis through NIRS
Alain Tossens *et al.*	Embedded technologies on-field at SESVanderHave

Exhibitors

AgriCircle (Rapperswil, CH)	Digital modelling and data processing
VISTA (München, D)	Remote sensing and modelling for hydrology, agriculture and environment
Agvolution (Göttingen, D)	Radio sensor network and satellite data processing
xarvioTM (Münster, D)	Digital farming solutions
HAIP Solutions (Hannover, D)	Early detection of plant diseases in the field
Argus monitoring (Alsdorf, D)	Service for a modern agriculture
LemnaTec GmbH (Aachen, D)	Digital phenotyping, seed testing and lab equipment
Phenospex (Heerlen, NL)	Smart plant analysis
Octinion (Leuven, B)	Mechatronic product development applied to biological material
Zasso (Aachen, D)	Advanced electrophysics for weed control
Escarda technologies, Berlin, D)	Laser-based weeding
Phenorob (Bonn, D)	Robotics and phenotyping for sustainable crop production
Mascor (Aachen, D)	Mobile autonomous systems and cognitive robotics

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NIR Determination of primary energy sources in sugar beet seed

Oil, protein, and starch are the initial energy reservoirs for the sugar beet embryo. Before the germinating embryo starts photosynthesis, it relies solely on these stored reserves for energy and carbon. Polished monogerm seed available from 7 different production years were measured every 2 nm in the spectral range 850 to 1650 nm with a PSS 1720 NIR spectrometer (Polytec GmbH). One measurement encompassed a seed batch of 50 g representative of a given seed lot. 386 samples formed the calibration set and 78 samples were used as an independent validation set. A Partial Least Squares Regression was used to develop calibration models. The model with the best performance reached a Pearson correlation coefficient of R = 0.94 and a Standard Error of Prediction (SEP)= 6.72% for the prediction of oil content, R = 0.94 and SEP= 4.47% for the prediction of protein, and R = 0.90 and SEP= 8.23% for the prediction of starch. Results show that a simple and accurate NIR quantification of oil, protein, and starch in intact sugar beet seed is feasible. The non-destructivity of the method is especially important in seed applications: seed composition can be analysed before germination and later on, be related to seedling development. These NIR applications could thus facilitate further studies about the impact from seed energy reserves on sugar beet plants, from germination to yield.

Further information: Quantification of Oil Content in Intact Sugar Beet Seed by Near-Infrared Spectroscopy. R. Martínez-Arias, M. G. Ronquillo-López, A. Schechert. Agronomy 2018. doi:10.3390/agronomy8110254.

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Capturing the heterogeneity of sugar beets by combining a newly developed sample preparation with analysis through Near-Infrared-Spectroscopy

Sugar content not only varies within one beet, but also between beets. For variation of sugar content and impurities within beets, results are shown from two varieties of sugar beets – a higher tonnage variety and a higher sugar content variety. Results for recoverable sugar of more than 400 subsamples of one truckload are also presented and shows the variability between beets.

Current procedures for sampling and analysing sugar beets based on a preparation of a brei sample and subsequent analysis. This requires a central lab, a logistics system for samples and trained employees. An innovative approach to analyse the full heterogeneity of sugar beet in 20 seconds is presented.

The new method in sample preparation consists of a chopper, which chops 20-100 kg of sugar beets in a few seconds in small, uniform pieces. A conveyor belt, equipped with a pressure roll, produces a homogenised and uniform stream of chopped beets. A process spectrometer records a single spectrum every 40 ms, leading to a total of 400 spectra (measurements) per 40 kg sample. Using this approach, the whole heterogeneity of a beet sample is captured.

More than ten years of calibration development have yielded a high accuracy for measuring quality parameters for example as sugar content, content of recoverable sugar, and marc content via NIRS on freshly chopped beets. This technology combines innovative sample preparation and analysis via a diode array-NIRS-spectrometer. The system called KWS BEETROMETER^{TM} works fully automatically, is mobile and can be implemented with less effort.

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Embedded technologies on-field at SESVanderHave

SESVanderHave is presently developing a new mobile tare house embedding different sensors and technologies are under development to assess different quality parameters.

NIRS (Near Infrared Spectroscopy) will be one of the major technologies used in combination with automatic sample preparation for the prediction of the sugar content.

Local NIRS calibrations will be used to better consider the environmental effects on the quantification of sugar content.

Next to this well-known NIRS technology, automated systems like vision technology will be used to measure different root quality parameters like the number of roots per plant, shape, damages and root disease infection.

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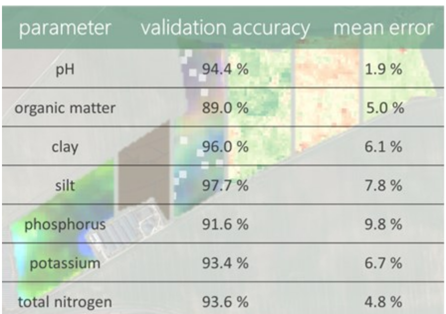
Novel soil data and drone phenotyping platform

AgriCircle is estimating soil properties based on Sentinel 1 and Sentinel 2 data. With the datasets it is possible to identify soil type with % of clay, silt, sand and humus. Since pH, nitrogen, phosphorus, potassium and other nutrients are changing the electrical properties of soil, it is even possible to estimate their levels with high confidence. With this data, AgriCircle can deliver highly accurate soil moisture and soil temperature to optimise fertilisation. Also it has been shown that there is a correlation between soil pH and severity of Cercospora and other sugar beet diseases. The automatically generated lime application maps will help to balance in-field pH and will lead to healthier and higher yielding sugar beets. These solutions have been developed with the European Space Agency, ETH Zürich, LUFA Nord-West, LWK Niedersachsen, GFZ Potsdam, TU Wien, CESBIO and INRA.

With the Institute of Robotics and Intelligent Systems of ETH Zürich, AgriCircle has developed a novel, drone based phenotyping platform. The platform combines a 5MP RGB camera, a Ouster OS-1-64 LIDAR, a FLIR Tau2 640 thermal camera and two hyperspectral cameras, the Photonfocus 600-975nm / 25 bands and the Photonfocus 470-630nm / 16 bands that are combined with an AMS 16 band irradiance sensor prototype to calculate best quality reflectance data. All with GPS RTK accuracy.

With this AgriCircle is able to deliver best-in-class soil and phenotyping data from trial plots to fields to improve sugar beet research and sugar beet production at its best.



parameter	validation accuracy	mean error
pH	94.4 %	1.9 %
organic matter	89.0 %	5.0 %
clay	96.0 %	6.1 %
silt	97.7 %	7.8 %
phosphorus	91.6 %	9.8 %
potassium	93.4 %	6.7 %
total nitrogen	93.6 %	4.8 %

Soil estimates and accuracy

Drone based, novel phenotyping platform

Vista GmbH – Remote Sensing in Geosciences
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Sarah Nolting, Scientific Employee for Talking Fields
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From image to information

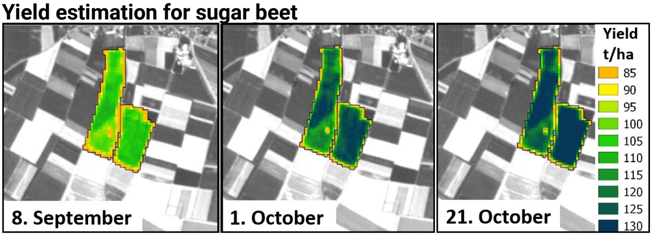
Since 1995, Vista transfers state-of-the-art scientific methods into operational products and services. Our aim is to make satellite data and model calculations useful for our clients. Vista's core competencies lie in agriculture, hydrology and environmental monitoring. We utilise optical and radar satellite data to answer the questions of our customers. Satellite images provide overview, show patterns and allow estimation of in-field heterogeneity. Where satellite data alone reach their limit, our crop growth models guarantee reliably that the information needed is available. Our methods are scalable and globally available.

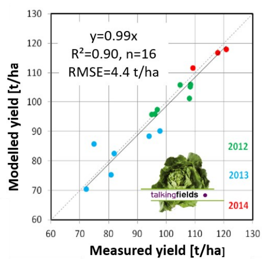
We support sustainable farming. Whether fertilisation, irrigation, variable seeding, soil probing or the application of growth regulators – the TalkingFields® Services allow a perfectly timed, site-specific management of arable fields. Every location in the field gets optimal supply, which allows an even more efficient management. TalkingFields® Services uncover the site-specific and characteristic potential of the farm, quantify current biomass and yield and deliver up-to-date information about the water and nitrogen demand of crops. The TalkingFields® information services are available worldwide for the most commonly planted crops, e.g. wheat, rapeseed, corn, barley and sugar beets.

In terms of sugar beet we will present our yield forecast service that can deliver yield maps, field averages or averages for regions/sugar beet factories.

More information can be found on www.talkingfields.de.

Yield estimation for sugar beet





TalkingFields® Services allow the monitoring of the yield development of sugar beet throughout the growing season. Estimated yield is delivered in t/ha. The estimation can be delivered as field averages or site-specific.

Agvolution GbR

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Application of low power wide area sensor-networks in plant production

The Georg-August-University Göttingen, DNPW Department of Agricultural Engineering, has been awarded a start-up scholarship to enable the use of the Internet of Things (IoT) in agriculture. The founding team Agvolution has developed its own sensors for the measurement of climate and process data. Using innovative wireless sensor networks, data can be transmitted energy-efficiently, permanently and cost-effectively over several kilometres.

Agvolution offers users an easy-to-use IoT platform with integrated hardware and software solutions for controlling agricultural processes. The aim is to limit the use of resources to the necessary extent for each field zone of an arable field and to improve farmers‘ decision making.

This optimises both the economic efficiency and the ecological footprint of agriculture.

xarvio™ – Digital Farming Solutions

BASF Digital Farming GmbH
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Björn Kiepe, Head of Agronomy
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Plant smarter. Grow better.

Better oversight, less risk and more reliability for your planning and decision-making – xarvio™ – Digital Farming Solutions helps you make optimum use of your fields and field zones. Simply and straightforward. You increase efficiency, save time, optimise crop production and crop protection while making a contribution to sustainable agriculture.

xarvio™ Field Manager: From seeding to harvest… the three components Field Monitor, Spray Timer & Zone Spray support you to make better informed field management decisions… all you need is your smart phone. Sugar beets disease prediction and spray timing are covered in several European markets with a focus on Cercospora and Mildew.

xarvio™ Field Manager

xarvio™ Scouting: Detect in-field stress just by taking a photo. xarvio™ SCOUTING determines weeds, classifies and counts insects in the yellow trap, recognises diseases, analyses leaf damage, crop emergence analysis and shows the nitrogen uptake. Simply download for free on App Store or Google Play. Counting plant stand in sugar beets is a new feature available in the 2020 season.

xarvio™ Scouting

xarvio™ HEALTHY FIELDS: HEALTHY FIELDS optimises field- and season specific the application timing, product choice and dosing for your crops. Your contractor automatically receives and implements the decisions and you have full transparency as well as a success guaranty for your fields.

xarvio™ modeling competence in sugar beets across Europe: We are open for strategic collaborations with leading companies who are committed to being part of the digital farming ecosystem of the future. By establishing data partnerships, we provide modelling excellence paired with agronomic decision making via API´s for smart and simple solutions at farm level.

HAIP Solutions GmbH

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HAIP – Hyperspectral Agricultural Imaging Platform

Hyperspectral drone system

For high-resolution recording of hyperspectral data on the field, HAIP offers a lightweight and compact system consisting of a hyperspectral camera and a drone. By using the Skyport adapter on DJIs Matrice 200 Series drones, you can mount the camera via Plug & Play directly on the drone. Afterwards a connection between drone & camera is established. This keeps the effort for creating hyperspectral maps as low as possible.

Analysis software

HAIP offers a software solution for the acquisition and analysis of hyper-spectral data. Hyperspectral images can be displayed clearly and infor-mation can be extracted, e.g. in the form of indices.

Hyperspectral analysis box

The box developed by HAIP allows the acquisition of high-resolution hyper-spectral images in a controlled environment. Through a simple and intui-tive workflow this solution offers the possibility to build up large data sets in a short time.

HAIP Drone

HAIP Box

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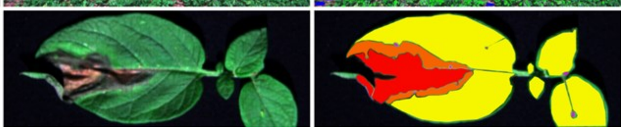
Image-based late blight monitoring system with artificial intelligence

The object of the project is the development of an airborne system which determines the optimal use of fungicides by frequently monitoring potato fields. The proposed solution can determine the status quo using spectral cameras, and GPU (CUDA)-accelerated algorithms (image data processing, spectral analysis, feature extraction and categorisation) provide a solid decision basis for the treatment of potato cultivated areas. First late blight symptoms are detected by an evaluation of the images by AI, much earlier than with usual field controls. These monitoring data are embedded in a software system with local weather data and prognosis models (existing *amagrar* Software).

This software also includes artificial intelligence and autonomously calculates the risks for the local potato fields. On this basis, treatment recommendations are calculated daily with the highest possible efficiency and the lowest possible environmental impact. This system is intended to achieve at least a 30% reduction in the use of fungicides. At the same time, the safety of the crop is to be significantly improved.

Drone in flight over potato plants. Test field at Klein-Altendorf campus, altitude approx. 5 m.



Exemplary sequence of image processing from the drone and photo lab. Raw material, filtered out wavelengths from visible area, annotated image. Green = healthy, yellow = diseased without symptom, orange = chlorotic transition zone, purple = unspecific symptom, blue = soil.

LemnaTec GmbH
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LemnaTec – digital phenotyping and digital seed testing

LemnaTec delivers digital solutions for essential visual inspection tasks in work with plants and seeds reaching from research over product development to commercial applications in agriculture and seed industry.

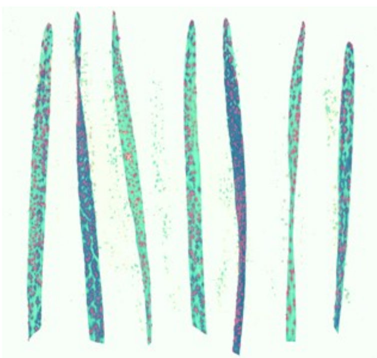
Core expertise of LemnaTec is the image and data acquisition together with their processing via advanced algorithms comprising classical image processing and machine learning.

In combination with dedicated hardware, LemnaTec phenotyping and seed testing solutions are suitable for laboratory, controlled environment, and outdoor measuring tasks.

In plant phenotyping, our solutions address genotype-phenotype linkages, environmental stress responses, as well as resistance to plant pathogens and pests. Our technology allows measurements of roots and shoots, and cameras in visible and non-visible wavelength ranges enable developmental and physiological phenotyping.

In seed testing, we provide solutions for germination and seedling emergence tests that comprise a broad range of parameters for seed and seedling quality assessments.

LemnaTec is part of the Nynomic group of companies, having a broad spectrum of experience in photonics for agricultural and industrial applications.



Digital plant phenotyping – disease scoring with machine learning

Digital seed testing – germination assay with machine-learning based classification

Phenospex

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PHENOSPEX
Smart Plant Analysis

Digital plant phenotyping for every scientist

We build phenotyping sensors to automate plant screening in the lab, greenhouse or field. Our 3D scanner PlantEye and software HortControl automates the capturing of plant parameters and traits.

Our clients daily screen thousands of plants visually or by hand. This is time consuming and not objective. Our sensors solve these problems.

PlantEye is a unique sensor that combines 3D with multispectral data. Within seconds it collects 17 parameters like plant- *Growth, Health, Leaf area, Biomass, Color, NDVI* and many more. It scans plants in a very high resolution and is able to analyse individual plants in trays, plots or fields. This ensures high quality and objective data.

DroughtSpotter provides precision irrigation and measures pot/ plant weight. This enables you to quantify transpiration rates.

HortControl is developed to manage complex experiments and professionally visualise & analyse big data sets.

We actively work with our Academic and Scientific clients to optimise their phenotyping process. We strive to be leaders in digital plant phenotyping. Visit our booth to discuss the possibilities for you.

PlantEye is able to scan your plants every 2 minutes. HortControl visualises the data within seconds.

Growth dynamics (height in mm) visualised over time. Due to the high scan interval you can see clear day & night dynamics.

Octinion bvba

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Thomas Hoeterickx,
Sales- & Business Development Manager
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OCTINION
Engineering the future

Welcome to the home of innovation

Innovation is not just about ideas, it's making ideas happen. And that's exactly what we do at Octinion. We operate at the interface between mechatronics and biology. That can go from observing plant characteristics, picking fruit, analysing animal behaviour to quality monitoring when processing natural products. This makes us a valuable player in the agriculture and food industry, as well as for other industries with the desire to automate or innovate. "Simplicity is complexity resolved". Where others see problems, we are just being challenged. If you want to do something that has not been done before, Octinion is your perfect partner. We love a challenge, thinking out of the box is in our DNA.

At Octinion, we develop robots, machinery and components for third parties and for ourselves, but always with a few things in mind:

- Multidisciplinary approach: by bringing together mechanic, electronic, software and vision specialists, we can offer cost-effective integrated solutions.
- Fixed price: we always handle projects on a fixed price basis. We're no consultants but only go for the full picture.
- Internal R&D: thanks to our own IP we can minimise the cost and are able to share the technological and commercialisation risk. This makes us your long term development partner.

Next to customer projects, we also have our own product line. Thanks to a. o. our fully autonomous strawberry picking robot it is our ambition to be the world leader in agricultural robotics. Discover our full range of products, like a fully autonomous strawberry picking robot, UV robot, scouting robot, logistic platform and other applications on www.octinion.com

Welcome to the home of innovation

Our own product range in agricultural machinery

Zasso GmbH
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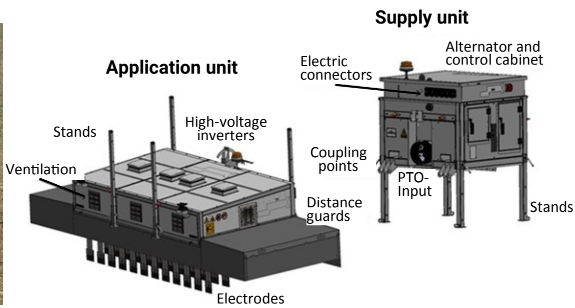
The Electroherb™ — A sustainable crop protection technology

Zassos' advances in technology and crop protection focus on the broad concerns of today's agriculture. In this effort, we aim to provide sugar beet farmers with a timely alternative for restricted and non-approved synthetic-chemical herbicides, to maintain the general operationality and profitability on the farm level. With the Electroherb™ technology we augment the farmers opportunities in crop protection with an environmentally friendly and sustainable weed control system. Advantages of its implementation in already existing management strategies, result in a general reduction of synthetic-chemical herbicides usage, contribute to soil conservation, and moreover, offer a successful advantage to eliminate existing weed resistance problems, when complied wisely into agricultural practice.

With regard to important agricultural crops and weeds, Zasso continuously optimises the application recommendations for Electroherb™ through broad-based field studies. Theoretically, for an effective electro-physical treatment of plants, the minimum lethal energy threshold is related to the energy transferred to a single plant in dependence of number and stability of vascular bundles to be damaged, the electrical resistance of the plant tissue, the electrode contact time and the power dosage (kW ha^{-1}). The efficacy of electrical weed control depends on the one side on plant species, growth density and plant morphology and on the other on soil characteristics. In cooperation with leading international research institutes, we generate independent results about the Electroherb™ technology as it is needed in agriculture now and in the future.

Electroherb use for pre-emergence weed control in sugar beet



Technical illustration of an application unit (3 m) and supply unit

Escarda Technologies GmbH

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Dr. Julio Pastrana, CEO
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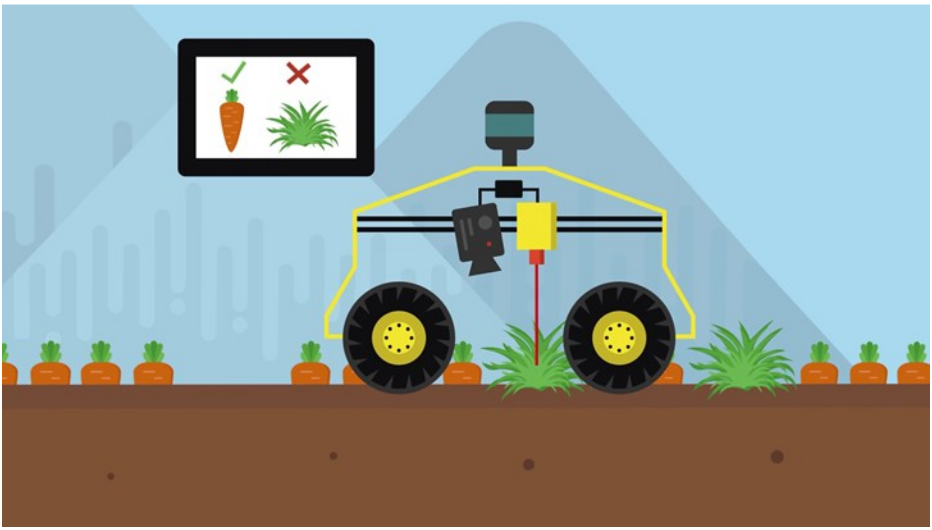
Escarda Technologies

Escarda Technologies GmbH is a Berlin-based start-up company developing a laser-based weed control system, which is an alternative solution that does not require herbicides. Our weed control system uses camera sensors and state-of-the-art computer vision algorithms to detect and classify all plants in the field. Once the weeds have been identified, a laser beam is used to remove the unwanted plants. The mission of Escarda is to ensure that the organic cultivation of plants is not an alternative, but the norm. In this way we promote the protection of our environment and the health of the population.



Identification of weeds in the fields and use of laser technology for their elimination.

Cluster of Excellence PhenoRob

University Bonn
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Natascha Buhl, PR Manager
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PhenoRob — Robotics and phenotyping for sustainable crop production

Crop production is currently under immense pressure to increase crop yields while minimizing the environmental footprint by limiting the use of agrochemicals and reducing soil degradation, water consumption, and pollution. Simultaneously, the decline in arable land and climate change pose additional constraints. Addressing such conflicting demands requires drastic changes in the way we produce crops. In order to achieve this, the University of Bonn together with Forschungszentrum Jülich conducts research to develop methods and new technologies that observe, analyse, better understand and specifically treat plants. PhenoRob, the only Cluster of Excellence in agriculture in Germany, is moving toward sustainable crop production, spanning from monitoring and understanding to assessment and identification of promising solutions to optimise breeding and farming management. We systematically monitor all essential aspects of crop production using sensor networks as well as ground and aerial robots. This enables a more targeted management of inputs (genetic resources, crop protection, fertilisation) for optimizing outputs (yield, growth, environmental impact). We develop novel technologies to enable real-time and automated control of weeds and selective fertilisation. We apply modern machine learning techniques to analyse large amounts of acquired crop data to improve the understanding and models of plant growth, and of nutrient and water use efficiency. And we predict the expected impacts of novel approaches on management decisions at the farm level.

Aerial robot with different sensors

Crop and weed detection

MASKOR Institute

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MASCOR
Mobile Autonomous Systems and Cognitive Robotics
FH AACHEN UNIVERSITY OF APPLIED SCIENCES

ETAROB

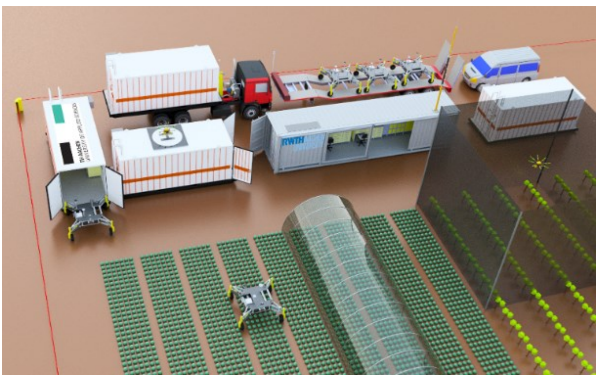
ETAROB is an innovative agricultural robot for the automation of monotonous and physically demanding field work. It reduces soil compaction so that field work can be planned and carried out regardless of weather conditions.

Mechanical weed control and an AI for crop identification offer an economical alternative to chemical crop protection, such as glyphosate.

A necessary technological change for the preservation of high biodiversity among insects and ecological food production.

The compatibility of the sensor module with various attachment tools enables it to be adapted to any work process, such as seeding, weed control, fertilising or harvesting.

ETAROB: Weeding in iceberg lettuce



A path to fully autonomous agriculture